



## Evaluating Business Environment in Africa Using Grey Number Weights

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### Abstract

*Investing in Africa is a very complex decision-making when considering a lot of forces that affect business operations. This paper proposes a multi-criteria decision making method based on the Grey System Theory to evaluate the business environment in Africa under a group decision environment. We use grey linguistic values represented by grey numbers to evaluate the weights of evaluation criteria. The Grey Relational Analysis (GRA) based on grey numbers is used to aggregate the different weights of experts. Rank Order Centroid (ROC) weights are used to convert the rankings of criteria into weights. After weighting, we use the traditional GRA to rank 17 sample countries using the data obtained from the African Development Bank and the Doing Business Project initiated by the World Bank. These 17 countries are classified into three groups, and South Africa is ranked the first position in Africa based on the preferences of our investors.*

**Keywords:** Business Environment; Grey Relational Analysis (GRA); Grey Number; Rank Order Centroid (ROC); Group Weights; Africa

### 1. Introduction

Africa has a promising economy with increasing national, continental and regional activities towards its development. However, Africa is the sole most insolvent continent that still has difficulties with issues generated as a result of colonial and post-colonial non-African intervention with local and national corruption problems, and with conflicts within the African continent. Each area in Africa has some problems and unique state of affairs. Africa is still developing its own beginning for entering into the world economy as an economic power, aspiring to meet-up with Asia and the USA<sup>[1]</sup>.

According to the International Monetary Fund (IMF), among the 36 countries categorized as Heavily Indebted Poor Countries (HIPC) in 2013, 30 countries are in Africa<sup>[2]</sup>. Now, it is very evident that some African countries are overwhelmed and held back by debt that their financial status and systems have virtually haemorrhaged as they work towards a means of repaying their debts to institutional lenders. These issues emphasize that Africa has a lot to do to make progress. Likewise, it indicates that Africa is dropping from development level, or its

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developmental growth is very slow. The performance of the development in Africa is good when considering the challenges like the social-political crises in North Africa that resulted in revolutions in Libya and Tunisia. Also, the political instability in Egypt and the Northern part of Nigeria affects their neighbouring countries. For example, due to the economic, cultural, governmental, and environmental hitches, life in Kenya and East Africa lingers to be challenging and slightly erratic. There are very few funds remaining to finance inventions and improvement, and this leads to delicate, obsolete, unproductive and unsuccessful political advancement. These predicaments cause great disruptions in systems and methods resulting in the low level of economic growth of individuals and organisations. These governments use the little money and resources to cover elementary needs<sup>[3]</sup>.

Business plays numerous parts in the social and economic growth of poorer countries, but not all countries have equal business credibility level. Business is a creator of wealth that also creates a growth-driven development<sup>[4]</sup>. Business as a method of investment is being portrayed as a sensibly engaged instrument of development and has become a favoured strategy when it comes to lifting people and nations from poverty. More research on where to invest can be done, and this is one of the purposes of this paper. In Africa, there are numerous untapped raw materials and natural resources available to investors, with direct access to the local market, as well as export of excessive domestic products and production technologies. Furthermore, investors can benefit from the African regional and international trade agreements by entering into new foreign markets via exports for their countries<sup>[5]</sup>. For instance, in 2009, China invested more than US\$1.44 billion in Africa and had an accrued stock amounting to over US\$8 billion. In 2011, there were more Chinese firms involved in Africa, and most of them were private enterprises that contributed progressively to the top investments in Africa<sup>[6]</sup>.

Thus, to encourage foreign investors to come to Africa, there must be a very conducive environment for these companies to invest. As there is no ideal economy because every country has weaknesses, the need arises for one to decide on which country to begin investment, and later diffuse into other regions in Africa. In other words, selecting the first economy for investment will be in the best interest of the investor. Answering the question “where do I start investing in Africa?” is a complex decision-making that involves considering multiple criteria for the investor. Furthermore, these criteria have different degrees of importance to an individual investor. In short, this is a Multi-Criteria Decision Making (MCDM) problem. This work would not be dealing with cultural and political issues in these countries, although they affect the bottom-line of the data collected. This paper does not tell an investor where to put their money but focuses on increasing their insight and awareness.

This paper is organized as follows: Section 2 presents some related works, and Section 3 describes our research methods, which involves weighting the evaluation criteria using GRA based on grey numbers and evaluating the countries using traditional GRA. Then, Section 4 presents our results and the analysis with a brief discussion. We conclude this paper by identifying our contributions and limitation of this work.

## 2. Related Works

Evaluating business environment of any country and ranking countries that are relatively conducive for doing business in Africa is a complex decision-making.

The complexities arise from numerous factors associated with different countries, which may include culture, government policies, location and economic factors. Determining the most conducive country to start a business can be viewed as an MCDM process. An MCDM is a decision-making that uses ranking systems in the selection of the best alternatives<sup>[7]</sup>.

### 2.1 Evaluating Business Environment

In evaluating business environment, Kleyle et al.<sup>[8]</sup> proposed an evaluation method for new companies in an unstable economic environment by estimating the fuzzy expected return. Wu et al.<sup>[9]</sup> used Analytical Hierarchical Process (AHP) method to evaluate tourism investment environment in Shaanxi province, P.R. China. Also, Xin et al.<sup>[10]</sup> applied AHP and fuzzy mathematics in evaluating China's international oil investment environment. Wang and Wang<sup>[11]</sup> designed a model for evaluating the performance of an investment. Tsamboulas<sup>[12]</sup> evaluated rail investment in a regulatory environment.

Some researchers have investigated evaluating business environment for Foreign Direct Investment (FDI). Deng et al.<sup>[13]</sup> presented a systematic approach for evaluating foreign investment environment. The approach matches the host and investment characteristics, evaluates policies as well as coordinates the expectation of the investor with the host country. Wang and Zuo<sup>[14]</sup> proposed selection and quantification of evaluation indexes for soft investment environment based on the municipal government efficiency and talent cultivation, comparing Dalian and Shenzhen cities in China. Liu and Jiang<sup>[15]</sup> evaluated the investment environment of old industries in Northeast China based on the factors that affect FDI. Zhou<sup>[16]</sup> proposed a valuator-oriented method for evaluating the investment environment considering the forecast and post investment evaluation. Qing et al.<sup>[17]</sup> applied Principal Component Analysis (PCA) in evaluating regional investment environment in Gansu province. Feng and Zeng<sup>[18]</sup> built an index system and applied the principal component method in evaluating the investment environment of industrial parks. Xu and Wang<sup>[19]</sup> proposed an evaluation system for investment environment optimization based on industry agglomeration for small towns.

These studies evaluated business environment from the host country's perspective and are not suitable to evaluate Africa as a continent. They differ from this work because they all evaluate investment environment in a country. We focus on Africa as a continent, beginning with selecting a sample of countries based on their reported performance, and evaluating these countries based on the weights from a group of investors.

Few indices measure the business environment performance of countries. The Business Environment Ranking (BER) initiated by the Economist Intelligence Unit established in 1946 covers 9 African countries<sup>[20]</sup>. Index of Economic Freedom (IEF) initiated by The Heritage Foundation was founded in 1995<sup>[21]</sup>, and the Global Entrepreneurship Monitor (GEM) index was established in 1999<sup>[22]</sup>. The IEF and GEM indices cover 53 and 6 African Countries, respectively. In 2005, the World Economic Forum developed the Global Competitive Index (GCI) as a comprehensive tool to measure the national competitiveness of micro and macroeconomic foundation<sup>[23]</sup>. The GCI covers 36 countries in Africa. These indices either evaluate very few African countries or data collected from these African countries are not easily available to the public.

The World Bank initiated the Doing Business Project (DBP) in 2002, and it provides objective measures of business regulations and enforcement across 189 economies. The DBP encourages countries to compete towards more efficient

regulations, offers reform benchmarks, provides resources for academic, journalists, researchers as well as those interested in the business environment in the selected countries<sup>[24]</sup>. Also, subnational reports that cover business regulations and reforms in different cities and regions within a nation are provided by the DBP. For instance, on a small scale, Oh et al.<sup>[25]</sup> used the DBP indicators to compare the regional business environment of Jeju Province in South Korea to other nations of the world. In addition, Tokuoka<sup>[26]</sup> used India as a case study to demonstrate that better business environment stimulate corporate investment by examining the cost of doing business using the firm level and micro data from the World Bank.

The United Nations Millennium Project believed that the failure or bleak performance of one country in Africa may have negative economic, political and developmental effects in neighbouring countries, and this believe still holds today<sup>[1]</sup>. Africa has been experiencing remarkable economic transformation, which is a potential for great change in development. The primary objective of the DBP is not to suggest a country of starting or doing business, but “to provide an objective basis for understanding and improving the regulatory environment for business around the world.”<sup>[27]</sup> The DBP ranking method uses an equal weight for all evaluation criteria or indicators and uses the average of the percentile ranking for the overall ranking of the countries. The problem of equal weights has been outlined by Stillwell et al.<sup>[28]</sup>

Reviewing existing literature and indices of evaluating business environment, the DBP presents itself as the base indicators for evaluating African business environment. The main reason we use the DBP indicators is twofold. First, they provide objective measures of business regulation and their enforcement for all African countries. Second, the data that have been collected over the years from all African countries are made available to the public. After acknowledging that all indicators for evaluating the business environment in Africa cannot possibly have equal weights, we use grey linguistic values represented by grey numbers to evaluate the weights of evaluation criteria.

The Grey System Theory (GST) has been used in various evaluation processes. Wu et al.<sup>[29]</sup> used Grey Relational Analysis (GRA) in determining the weights of business performance of wealth management banks. Shuai and Wu<sup>[30]</sup> employed grey entropy in evaluating hotel performance as the influence of E-marketing. Zhang and Jia<sup>[31]</sup> used GST in the measurement of business synergy by analysing the coordinating degree of resource subs system and performance subsystem, thereby pointing out coordination among different business systems that can be improved. Bai and Sarkis<sup>[32]</sup> used GST in conjunction with Decision Making Trial and Evaluation Laboratory (DEMATEL) in evaluating business process critical success factors. Primarily, grey number is used for linguistic measurement for the respondents’ assessments. Yin<sup>[33]</sup> showed there has been an increasing use of GST in decision-making. Grey numbers can be used in measuring qualitative and quantitative features that can represent complex systems with insufficient information. We use grey numbers to evaluate the weights of evaluation criteria.

## **2.2 Aggregating Criteria Weights Under Group Decision-Making Environment**

In MCDM problem, the weight of each criterion plays a major role in the overall results. For example, Wu et al.<sup>[34]</sup>, Lin and Juan<sup>[35]</sup> as well as Xie and Liu<sup>[36]</sup> applied AHP to estimate the weights for ranking. A group of people jointly make a decision that try to reflect the fair preferences of all the decision-makers with the expectation that the group decision is better than an individual decision. A key issue in group decision-making is how to aggregate the various preferences of

decision-makers, which may be represented by grey linguistic values or other forms of expressions.

The common methods for aggregating group grey linguistic values are: arithmetic mean, geometric mean, correlative and harmonic operators. The arithmetic mean is the sum of grey numbers divided by the numbers of the collection, and this technique can easily be susceptible to outliers<sup>[37,38]</sup>. Similarly, the geometric mean is the  $n^{th}$  root of the product of all the grey numbers, where  $n$  is the number of experts in the group<sup>[39]</sup>. Jin et al.<sup>[40]</sup> used harmonic aggregation as an operator for group decision-making, introducing Interval Grey Linguistic Weighted Harmonic Aggregation (IGLWHA) operator, Interval Grey Linguistic Ordered Weighted Harmonic Aggregation (IGLOWHA) operator, and Interval Grey Linguistic Hybrid Weighted Harmonic Aggregation (IGLHWA) operator. Another method for aggregating grey linguistic values is using the correlative operator<sup>[41]</sup>. Zhang<sup>[42]</sup> proposed the Interval Grey Linguistic Variables Ordered Weighted Aggregation (IGLOWA) operator and developed the Interval Grey Linguistic Correlated Ordered Arithmetic Aggregation (IGLCOA) operator, and the Interval Grey Linguistic Correlated Ordered Geometric Aggregation (IGLCOGA) operator. Table 1 shows some case studies and the techniques used for aggregating grey group linguistic values.

In this paper, we present an alternative method for aggregating the preferences of the decision-makers. Different weights of experts represented by grey numbers are aggregated using GRA based on grey numbers in ranking the criteria, and ROC weights are used to convert the ranking of criteria into weights. After weighting, we use the traditional GRA to rank 17 sample countries using the data obtained from African Development Bank (AFDB) and DBP. Then, we classify these countries into three groups: upper, middle, and lower rank.

**Table 1** Some Techniques for Aggregating Grey Group Linguistic Values

Technique	Study	No. Decision-makers/ Experts	Case
Arithmetic Mean	Li et al. <sup>[43]</sup>	4	Supplier selection
	Wang <sup>[44]</sup>		Personnel selection
	Wu et al. <sup>[38]</sup>	15	ERP system providers
	Kuang et al. <sup>[45]</sup>	3	Water protection
	Bai and Sarkis <sup>[32]</sup>	3	Business process
	Kose et al. <sup>[46]</sup>		Sniper selection
Geometric Mean	Mehrjerdi <sup>[37]</sup>	5	Systems selection
	Kang et al. <sup>[39]</sup>	3	Selection of restaurants
Correlative Operator	Zhang <sup>[42]</sup>	>1	Technological innovations evaluation
	Ma et al. <sup>[41]</sup>	3	Investment options
Harmonic Operator	Jin et al. <sup>[40]</sup>	3	Technological innovations evaluation

### 3. Methodology

We decompose the evaluation problem into a hierarchical structure to simplify the evaluation of the business environment. Below, we will define the criteria affecting a business environment as given by DBP<sup>[47]</sup> and African Development Bank (AFDB). The AFDB have data platforms across all 54 African Countries<sup>[48]</sup>. The criteria (indicators) are shown in the hierarchical structure in

Figure 1.

### 3.1 Evaluation Criteria

Below we explain the indicators as given by DBP. Readers are recommended to visit the DBP methodology web page, which has a comprehensive explanation, for more details<sup>1</sup>. Emphasis on this paper is the method that we arrived in suggesting a place to starting a business in Africa legally. The goal of “Evaluating business in Africa” is at the top of the hierarchy. The structure consists of 10 first-level indicators ( $A_1$  to  $A_{10}$ ) and 37 second-level indicators ( $A_{1-1}$  to  $A_{10-4}$ ). Below is a summary of DBP indicators:

1) Starting a Business ( $A_1$ ): This indicator measures the processes of starting a business in an African country, which includes the number of Procedures ( $A_{1-1}$ ), Time ( $A_{1-2}$ ), Cost ( $A_{1-3}$ ) and the Paid-in Minimum Capital ( $A_{1-4}$ ) to get a local limited liability company up and running.

2) Dealing with Construction Permits ( $A_2$ ): This indicator estimates the number of Procedures ( $A_{2-1}$ ), Time ( $A_{2-2}$ ) and Cost ( $A_{2-3}$ ) to build a warehouse in a country, with the assumption that the construction company has fully been licensed and insured to carry out construction projects. The construction company should have a registered architect or engineer as its employee.

3) Getting Electricity ( $A_3$ ): This indicator documents the number of Procedures ( $A_{3-1}$ ), Time ( $A_{3-2}$ ) spent and Cost ( $A_{3-3}$ ) in getting standard electricity supply to the warehouse, which includes inspection and utility bill contract, with the assumption that it is a permanent connection with one electricity meter.

4) Registering Property ( $A_4$ ): This indicator documents the number of Procedures ( $A_{4-1}$ ) Time ( $A_{4-2}$ ) and Cost ( $A_{4-3}$ ) required for a business to buy a property from another business or transfer of ownership to the buying business, to grant the buyer the right to resell it or use it as collateral in getting a loan.

5) Getting Credit ( $A_5$ ): This indicator measures the legal right of borrowers and lenders with regards to secured transaction and sharing credit information by measuring Legal Right Index ( $A_{5-1}$ ), Credit Information Index ( $A_{5-2}$ ), Public Credit Registry Coverage ( $A_{5-3}$ ) and Private Credit Bureau Coverage ( $A_{5-4}$ ) with the assumption that the lender and borrower are domestic, and their headquarters are in the largest business city.

6) Protecting Investors ( $A_6$ ): This indicator rates the strength of the minority of shareholders, to prevent director’s misuse of corporate assets for their personal gain by trying to measure the transparency of transactions, legal responsibility for self-dealing and shareholders’ capacity to charge directors for misconducts, through Disclosure Index ( $A_{6-1}$ ), Director Liability Index ( $A_{6-2}$ ) as well as Shareholder Suit Index ( $A_{6-3}$ ).

7) Paying Taxes ( $A_7$ ): This indicator measures the Payments ( $A_{7-1}$ ), Time ( $A_{7-2}$ ), Profit or Corporate Income Tax ( $A_{7-3}$ ), Labour Tax and Contributions Social ( $A_{7-4}$ ), and Other Taxes ( $A_{7-5}$ ) mandatory by the government that are required for standard business practices.

8) Trading Across Borders ( $A_8$ ): This indicator counts the Document for Export ( $A_{8-1}$ ) and Import ( $A_{8-4}$ ), the Cost to Export ( $A_{8-3}$ ) and Import ( $A_{8-6}$ ) and Time for Export ( $A_{8-2}$ ) and Import ( $A_{8-5}$ ) for an international trade, using a standard full 20-foot container of a domestic company. The exportation of goods includes the packing and loading of the container at the warehouse to the port of exit, and importation of goods include the arrival of the vessel at the port of entry to the

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<sup>1</sup> The Doing Business methodology. <http://www.doingbusiness.org/methodology>

cargo's delivery warehouse.

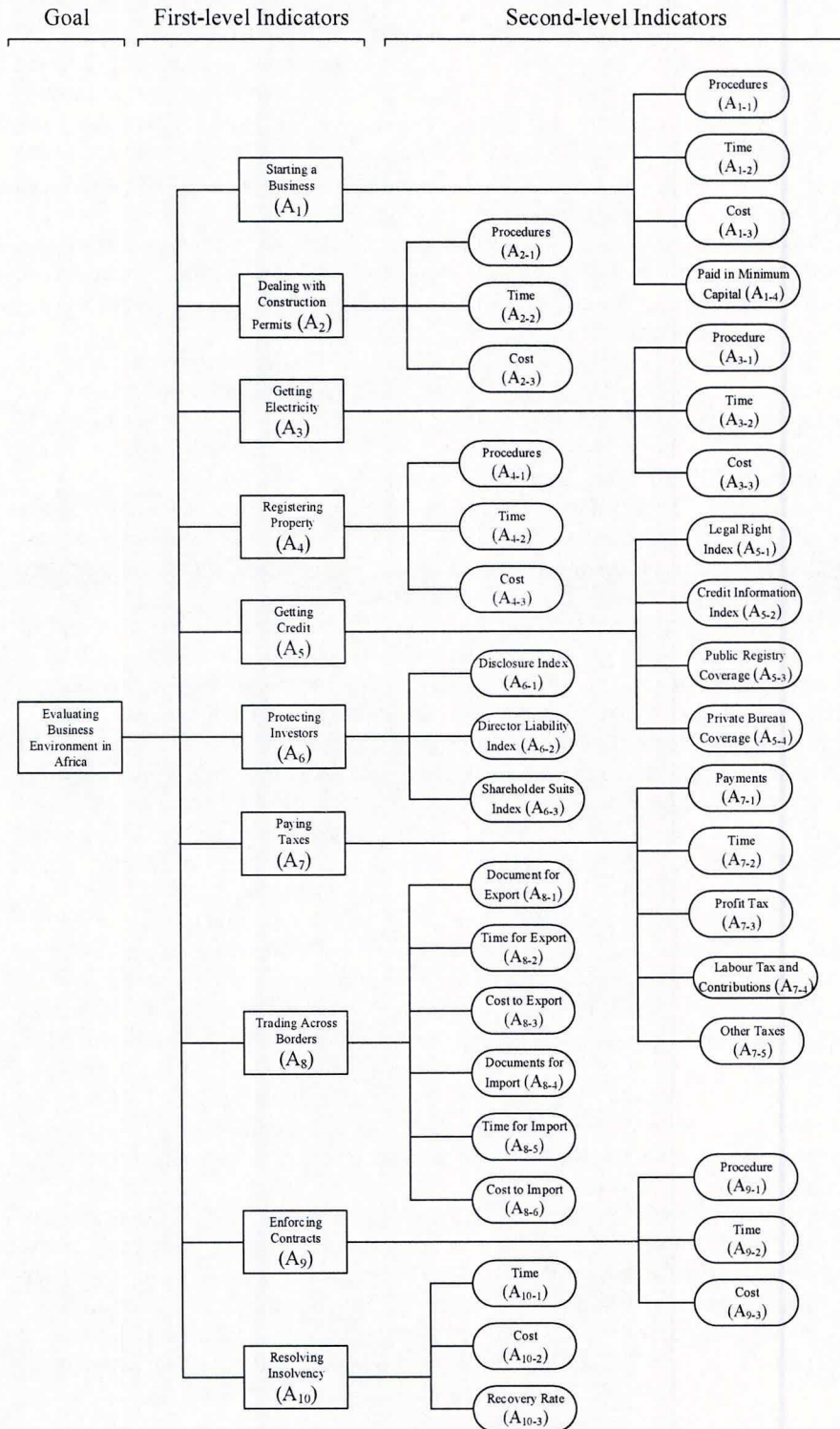


Figure 1 Hierarchical structure

9)Enforcing Contracts ( $A_9$ ): This indicator appraises the judicial system in resolving a commercial dispute by studying the codes of civil Procedure ( $A_{9-1}$ ), Time ( $A_{9-2}$ ), and Cost ( $A_{9-3}$ ). The court regulations and information are gotten from local lawyers and judges.

10)Resolving Insolvency ( $A_{10}$ ): This indicator is the domestic legal way of addressing a bankruptcy case of a business by considering the Time ( $A_{10-1}$ ), Cost ( $A_{10-2}$ ) and Recovery Rate ( $A_{10-3}$ ) of the insolvency proceed, through information gotten from insolvency practitioners, laws and regulations, as well as public information.

Nevertheless, the indicators proposed by DBP have their limitations. First, the DBP does not totally account for the running cost of a business<sup>[49]</sup>. Second, the DBP does not measure the indirect cost incurred on infrastructure and services in poor African countries<sup>[50]</sup>. Third, growth and development in micro-enterprises are poorly represented<sup>[51]</sup>. Fourth, the DBP is a general assessment that uses equal weights for all indicators. Lastly, the DBP have no index for consumer market size, and no business can survive without a market.

### 3.2 Weighting Indicators Using GRA Based on Grey Numbers

Professor Deng<sup>[52]</sup> in 1982 founded the GST that deals with small samples and poor information, which can be described as partially known or incomplete information. The GST deals with information that are between white and black parts, where the white part is complete information, and the black part is unknown information. The GST has been applied in solving numerous scientific and engineering problems<sup>[53,54]</sup>.

Weighting indicators based on GRA and grey numbers is a method we propose for aggregating the weight values for a group of experts, and the aggregated weights are used in evaluating the business environment in Africa. In human reasoning, crisp data are not always represented in decision-making, especially in measuring preferences because of vagueness in judgement from the information available<sup>[55]</sup>. Today, linguistic values are being used in numerous systems that require measurement of the decision-makers' preferences in words<sup>[56]</sup>. Generally, in dealing with uncertain problems such as determining weights, probability and statistics, and fuzzy mathematics come to mind. Probability and statistics deals with determining the weights from a large sample of random data, which should correspond to a distinct type of distribution. Furthermore, fuzzy mathematics deals with a cognitive uncertainty that is usually expressed in fuzzy membership function drawn from experiences. We choose to use the GST because we have poor information about the weights, the number of experts is small, and the number of years which the World Bank have collected data from these countries is equally small.

A grey number is an unknown number, but with a known range of the exact number. There are six types of grey numbers<sup>[57,58]</sup>:

- 1) Grey numbers with only a lower bound;
- 2) Grey numbers with only an upper bound;
- 3) Interval grey numbers;
- 4) Continuous and discrete grey numbers;
- 5) Black and white numbers;
- 6) Essential and non-essential grey numbers.

In this work, interval grey numbers are used for measuring the preferences of the decision-makers. The concept and operations of interval numbers and interval grey numbers are relatively the same. An interval grey number denoted by  $\otimes$  is

usually represented by an interval number. That is,  $\otimes \in [\underline{a}, \bar{a}]$ ,  $\underline{a} < \bar{a}$ , where  $\underline{a}$  and  $\bar{a}$  are the lower and upper limits/bounds of the grey number, respectively<sup>[59]</sup>.

Mathematically, let  $\otimes A = [\underline{a}, \bar{a}]$  and  $\otimes B = [\underline{b}, \bar{b}]$ , where  $\underline{a} < \bar{a}$  and  $\underline{b} < \bar{b}$ . Some basic operations of grey number are as follows<sup>[60,61,62]</sup>:

Addition:

$$\otimes A + \otimes B = [\underline{a} + \underline{b}, \bar{a} + \bar{b}]$$

Subtraction:

$$\otimes A - \otimes B = [\underline{a} - \bar{b}, \bar{a} - \underline{b}]$$

Multiplication:

$$\begin{aligned} \otimes A \times \otimes B &= [\underline{a}, \bar{a}] \times [\underline{b}, \bar{b}] \\ &= [\min(\underline{a}\underline{b}, \underline{a}\bar{b}, \bar{a}\underline{b}, \bar{a}\bar{b}), \max(\underline{a}\underline{b}, \underline{a}\bar{b}, \bar{a}\underline{b}, \bar{a}\bar{b})] \end{aligned}$$

Division:

$$\otimes A \div \otimes B = [\underline{a}, \bar{a}] \times \left[ \frac{1}{\bar{b}}, \frac{1}{\underline{b}} \right]$$

And the distance between two arbitrary interval numbers from  $\otimes A = [\underline{a}, \bar{a}]$  to  $\otimes B = [\underline{b}, \bar{b}]$  is:

$$|\otimes A - \otimes B| = \max(|\underline{a} - \underline{b}|, |\bar{a} - \bar{b}|)$$

The basic idea behind evaluating the weights of criteria is as follows: First, we use grey linguistic values represented by grey numbers to evaluate the weights of evaluation criteria. Raw weight data are obtained for the hierarchy structure in Figure 1, and the grey weight matrix is constructed, which is subsequently standardized. The reference weights of the indicators for the decision-makers are determined, then the differences between the reference weights and all indicators weights are calculated. From the Grey Relational Coefficients (GRC), the Grey Relational Grades (GRG) are calculated and transformed to ROC weights. Next, these ROC weights are used as the weights of evaluation criteria in the traditional GRA ranking method. Below are the steps for calculating the GRA weights based on grey numbers, which are similar to Zhang et al.<sup>[62]</sup> and other references in the literature. We further extend the steps by converting the rank values to ROC weights. Also, note that Zhang et al.<sup>[62]</sup> used GRA for evaluation purpose, and the weights were specified by experts, but we use GRA for estimating the aggregated group weights.

Step 1: Construct an objective hierarchy structure and obtain the raw weight data. This step is to determine the criteria to be evaluated. The hierarchical structure of indicators to be evaluated is shown in Figure 1. A questionnaire was first developed in English during the pilot test. The questionnaire was re-designed in Chinese to increase the reliability and accuracy of the data obtained from the Chinese experts. A grey linguistic scale of 5 is used, which corresponds to: Unimportant (U) = [0, 0.2], Somewhat Important (S) = [0.2, 0.4], Moderately Important (M) = [0.4, 0.6], Important (I) = [0.6, 0.8], and Extremely Important (E)

= [0.8, 1].

Step 2: Construct the grey weight matrix. The grey weight matrix puts the data in a rectangular array for easy expression.

$$X = \begin{pmatrix} \otimes x_{11} & \otimes x_{12} & \cdots & \otimes x_{1n} \\ \otimes x_{21} & \otimes x_{22} & \cdots & \otimes x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \otimes x_{m1} & \otimes x_{m2} & \cdots & \otimes x_{mn} \end{pmatrix}$$

where element  $\otimes x_{ij} = [x_{ij}, \bar{x}_{ij}]$  is the grey number weight given by the  $j^{\text{th}}$  decision-maker about the  $i^{\text{th}}$  indicator or criterion, for which  $1 \leq i \leq m$  and  $1 \leq j \leq n$ , where  $m$  and  $n$  are the numbers of indicators and decision-makers, respectively.

Step 3: Standardization of weight matrix. A standardized weight matrix  $S$  is calculated, with the standardized element  $\otimes S_{ij} = [s_{ij}, \bar{s}_{ij}]$ . In GRA, interval numbers are standardized through norm based on minimization of maximum distance<sup>[62]</sup>.

$$[s_{ij}, \bar{s}_{ij}] = \left[ \frac{x_{ij}}{\|x_j\|}, \frac{\bar{x}_{ij}}{\|x_j\|} \right] \tag{1}$$

where

$$\|x_j\| = \max_{1 \leq i \leq m} \bar{x}_{ij} \tag{2}$$

Step 4: Determine the reference weight for the decision-makers. The reference weight can become the ideal weight, which is the optimal weight indicated by the decision-makers<sup>[60]</sup>. For a set of decision-makers,  $DM = \{DM_1, DM_2, \dots, DM_m\}$ , the standardized weight reference of indicators is:

$$S_0 = \{\otimes S_{01}, \otimes S_{02}, \dots, \otimes S_{0n}\} \tag{3}$$

where  $\otimes S_{0j} = \left[ \max_{1 \leq i \leq m} s_{ij}, \max_{1 \leq i \leq m} \bar{s}_{ij} \right]$

Step 5: Calculate the difference between the reference weight and every weight given by the decision-maker.

$$\Delta_{ij} = \left| \otimes S_{0j} - \otimes S_{ij} \right|$$

Step 6: Calculate the Grey Relational Grade (GRG). The GRG is calculated from the Grey Relational Coefficient (GRC) of the weight using the following formula:

$$r_i = \frac{1}{n} \sum_{j=1}^n \xi_{ij} \tag{4}$$

where the GRC is

$$\xi_{ij} = \frac{\min_{1 \leq i \leq m} \min_{1 \leq j \leq n} \Delta_{ij} + \rho \max_{1 \leq i \leq m} \max_{1 \leq j \leq n} \Delta_{ij}}{\Delta_{ij} + \rho \max_{1 \leq i \leq m} \max_{1 \leq j \leq n} \Delta_{ij}} \tag{5}$$

The distinguishing coefficient  $\rho \in [0, 1]$  reflects the relative degree to which

the minimum score to the maximum score is emphasized. The distinguishing coefficient is usually 0.5<sup>[63]</sup>. In this study, we let  $\rho = 0.5$ .

Step 7: Transform to ROC weights. The indicators for each level are ranked using the grey relational grade of each indicator. Then, the ranks are transformed to ROC weights using the function below<sup>[64]</sup>:

$$W_{ROC} = \frac{1}{n} \cdot \sum_{q=1}^n \frac{1}{q} \tag{6}$$

where  $q$  is the rank position of the indicators.

The rank values of the first-level indicators are transformed to ROC weights of the first-level indicators, and they are called the first-level weights ( $W_F$ ). Then, the second-level indicators belonging to the same first-level indicator are ranked among themselves and transform to ROC weights too, and they are called the second-level indicator weights ( $W_S$ ).

Step 8: Calculate the effective weights of all the indicators. The effective weight gives a visual representation of how each second-level indicator impacts the overall goal, i.e. evaluation of the business environment. The effective weight ( $W_E$ ) is the product of the first-level indicator weight ( $W_F$ ) and second-level indicator weight ( $W_S$ ) relative to its first-level indicator, called local weight.

$$W_E = W_F \times W_S \tag{7}$$

### 3.3 Ranking Using GRA

The steps used in this section are the traditional GRA<sup>[63,65]</sup>. The steps are quite similar to weighing indicators using GRA based on grey number in the previous section, instead of standardizing the data matrix, it is normalized. Standardization helps in spreading data collected to a uniform scale while normalization helps in making the data of different directions of preference uniform usually ranging from 0 to 1. GRA Steps for ranking are given below.

Step 1: Determine the evaluation sample and obtain raw data to construct a data matrix. The raw data for all African countries was obtained from the DBP. The sub-section 4.1 shows how the sample size is determined.

$$Y = \begin{pmatrix} y_1(1) & y_1(2) & \cdots & y_1(v) \\ y_2(1) & y_2(2) & \cdots & y_2(v) \\ \vdots & \vdots & \ddots & \vdots \\ y_u(1) & y_u(2) & \cdots & y_u(v) \end{pmatrix} \tag{8}$$

where  $y_i(k)$  is the precise data of the  $k^{th}$  second-level indicator about the  $i^{th}$  countries,  $1 \leq k \leq v$  and  $1 \leq i \leq u$ , where  $u$  and  $v$  are the numbers of countries and second-level indicators, respectively.

Step 2: Normalization of the data. Two formulas are used to normalize the data for the two different directions of preference:

When larger values are better values, we use equation (9).

$$y_i^*(k) = \frac{x_i(k) - \min_{1 \leq k \leq v} x_i(k)}{\max_{1 \leq k \leq v} x_i(k) - \min_{1 \leq k \leq v} x_i(k)} \tag{9}$$

When the smaller values are better values, we use equation (10).

$$y_i^*(k) = \frac{\max_{1 \leq k \leq v} x_i(k) - x_i(k)}{\max_{1 \leq k \leq v} x_i(k) - \min_{1 \leq k \leq v} x_i(k)} \tag{10}$$

Thus the normalized data matrix is:

$$Y^* = \begin{pmatrix} y_1^*(1) & y_1^*(2) & \dots & y_1^*(v) \\ y_2^*(1) & y_2^*(2) & \dots & y_2^*(v) \\ \vdots & \vdots & \ddots & \vdots \\ y_u^*(1) & y_u^*(2) & \dots & y_u^*(v) \end{pmatrix}$$

Then the comparative series for matrix  $Y^*$  can be written as:

$$\begin{aligned} Y_1^* &= \{y_1^*(1), y_1^*(2), \dots, y_1^*(v)\} \\ Y_2^* &= \{y_2^*(1), y_2^*(2), \dots, y_2^*(v)\} \\ &\vdots \\ Y_u^* &= \{y_u^*(1), y_u^*(2), \dots, y_u^*(v)\} \end{aligned}$$

Step 3: Obtain the normalized weight data. The effective weight ( $W_E$ ) obtained from the group grey ROC weights is used to multiply the normalized data series ( $Y_i^*$ ). That is

$$W_i(k) = W_E(k) \times y_i^*(k)$$

where  $W_E(k)$  is the effective weight of the kth indicator. The weight series can be written as:

$$\begin{aligned} W_1 &= \{w_1(1), w_1(2), \dots, w_1(v)\} \\ W_2 &= \{w_2(1), w_2(2), \dots, w_2(v)\} \\ &\vdots \\ W_u &= \{w_u(1), w_u(2), \dots, w_u(v)\} \end{aligned}$$

Step 4: Determine the reference data. For the normalized weights  $W_1, W_2, \dots, W_u$ , the reference normalized weight is

$$W_0 = \{w_0(1), w_0(2), \dots, w_0(v)\}$$

where  $w_0(k) = \max_{1 \leq i \leq u} w_i(k)$

Step 5: Determine the difference series. The difference between the reference country and the sample is calculated to obtain the minimum and maximum difference:  $\Delta_i(k) = w_0(k) - w_i(k)$

Step 6: Calculate the Grey Relational Grade (GRG). The GRG is calculated from the Grey Relational Coefficient (GRC) of the countries using the following formula:

$$r_i = \frac{1}{v} \sum_{k=1}^v \gamma(w_0(k), w_i(k))$$

where 
$$\gamma(w_0(k), w_i(k)) = \frac{\min_{1 \leq i \leq u} \min_{1 \leq k \leq v} \Delta_i(k) + \rho \times \max_{1 \leq i \leq u} \max_{1 \leq k \leq v} \Delta_i(k)}{\Delta_i(k) + \max_{1 \leq i \leq u} \max_{1 \leq k \leq v} \Delta_i(k)}$$

The distinguishing coefficient  $\rho = 0.5$ <sup>[63]</sup>.

## 4. Results and Analysis

### 4.1 Sample Size

In conducting the analysis for suggesting a country to start a business, we use a biased sampling technique from the population of 54 countries in Africa, then reducing it to 17 countries. In addition to the 2015 Doing Business report, we obtained our data from AFDB from the year 2008 to 2014. The sample covers a period of 8 years (2008 - 2015). African countries DBP rankings are given in Section 4.2 of the "African Statistics Yearbook." For each indicator, countries that are below the 160<sup>th</sup> rank value, as presented by the AFDB, are majority of African countries. Only countries above the 160<sup>th</sup> rank value in all the indicators for at least one year between years 2008 - 2015 were selected. The samples used for this work are given in Table 2. In Table 2, the checked box for some country in year  $y$  represents the country meets the selection requirements for year  $y$ . That is, all the indicators of the country are above the 160<sup>th</sup> rank value in year  $y$ . Taking Egypt as an example, the year 2008 is not checked because indicator  $A_2$  has a world rank of 165<sup>th</sup>, and year 2010 is checked because all indicators of that year are above the 160<sup>th</sup> rank position. We choose to use the 160<sup>th</sup> rank position for filtering because in suggesting a country we do not want to evaluate any country that is performing too poorly in any indicator, and the best country to invest should at least have a good performance in at least one year of these 8 years. This mutually exclusive process resulted in a drastic reduction of the countries selected from 54 sample countries to 17 countries, which are about one-third of the total number of countries in Africa. The year 2011 has the largest numbers of the sample with 14 countries and the year 2013 with the least sample of 7 countries. Another example, Nigeria is not part of our sample because at least one of its indicators in any of these 8 years is below the 160<sup>th</sup> rank position. Countries that are not part of our sample are not shown in Table 2.

### 4.2 Grey ROC Weights

First, we obtain the weights using the steps mentioned in Section 3.

Step 1 and 2: The raw weight data are given in Table 3. These are the data provided by the decision-makers, through a questionnaire designed for experts. Decision-makers ( $DM_1$  to  $DM_7$ ) are Chinese investors hoping to make an investment in Africa. This represents some Chinese preferences that aspire to do business in Africa. The raw weight data are converted to grey number using the linguistics scale of Unimportant ( $U$ ) = [0, 0.2], Somewhat Important ( $S$ ) = [0.2, 0.4], Moderately Important ( $M$ ) = [0.4, 0.6], Important ( $I$ ) = [0.6, 0.8], and Extremely Important ( $E$ ) = [0.8, 1]. Then, the grey weight matrix is obtained. For simplicity, we begin with the second-level indicators  $A_{1-1}$ ,  $A_{1-2}$ ,  $A_{1-3}$  and  $A_{1-4}$ , as shown in Table 4.

$$A_1 = \begin{pmatrix} \otimes a_{1-1,1} & \otimes a_{1-1,2} & \cdots & \otimes a_{1-1,7} \\ \otimes a_{1-2,1} & \otimes a_{1-2,2} & \cdots & \otimes a_{1-2,7} \\ \otimes a_{1-3,1} & \otimes a_{1-3,2} & \cdots & \otimes a_{1-3,7} \\ \otimes a_{1-4,1} & \otimes a_{1-4,2} & \cdots & \otimes a_{1-4,7} \end{pmatrix} = \begin{pmatrix} [0.6, 0.8] & [0.4, 0.6] & \cdots & [0.6, 0.8] \\ [0.8, 1.0] & [0.4, 0.6] & \cdots & [0.6, 0.8] \\ [0.4, 0.6] & [0.0, 0.2] & \cdots & [0.4, 0.6] \\ [0.4, 0.6] & [0.8, 1.0] & \cdots & [0.4, 0.6] \end{pmatrix}$$

Step 3: Standardization of the weight matrix  $A_1$  to make the grey weight data matrix a scale of 0-1. Using Equation (2), we have  $\|A_{1-1}\| = 1$ ,  $\|A_{1-2}\| = 1$ ,  $\|A_{1-3}\| = 1$ ,  $\|A_{1-4}\| = 0.8$ ,  $\|A_{1-5}\| = 1$ ,  $\|A_{1-6}\| = 1$ ,  $\|A_{1-7}\| = 0.8$ .

Then, the standardized weights matrix  $S$  using Equation (1) is

$$S = \begin{pmatrix} [0.6, 0.8] & [0.4, 0.6] & [0.6, 0.8] & [0.75, 1] & [0.8, 1] & [0.6, 0.8] & [0.75, 1] \\ [0.8, 1] & [0.4, 0.6] & [0.6, 0.8] & [0.75, 1] & [0.8, 1] & [0.6, 0.8] & [0.75, 1] \\ [0.4, 0.6] & [0.0, 0.2] & [0.8, 1] & [0.75, 1] & [0.4, 0.6] & [0.8, 1] & [0.5, 0.75] \\ [0.4, 0.6] & [0.8, 1] & [0.6, 0.8] & [0.75, 1] & [0.4, 0.6] & [0.4, 0.6] & [0.5, 0.75] \end{pmatrix}$$

Step 4: Determine the reference weight of the indicators for every expert. From equation (3), the optimal interval value associated with the experts is

$$S_0 = \{[0.8, 1], [0.8, 1], [0.8, 1], [0.75, 1], [0.8, 1], [0.8, 1], [0.75, 1]\}$$

Step 5: Determine the difference between the reference weight and every weight by the decision-maker. The differences are shown in Table 5 and we have  $\min_{1 \leq i \leq m} \min_{1 \leq j \leq n} \Delta_{ij} = 0$  and  $\max_{1 \leq i \leq m} \max_{1 \leq j \leq n} \Delta_{ij} = 0.8$

Table 2 Sample Countries

Countries	2008	2009	2010	2011	2012	2013	2014	2015
Botswana	✓	✓	✓	✓	✓	✓	✓	✓
Egypt			✓	✓	✓		✓	✓
Ethiopia	✓	✓	✓	✓	✓			
Gabon	✓	✓		✓	✓			
Ghana	✓	✓	✓	✓	✓		✓	
Kenya	✓	✓						✓
Lesotho	✓	✓	✓		✓	✓	✓	
Mali			✓	✓			✓	
Morocco					✓		✓	✓
Mauritius	✓	✓	✓	✓	✓	✓	✓	✓
Mozambique		✓	✓	✓	✓	✓	✓	
Namibia	✓	✓	✓	✓	✓			
South Africa	✓	✓	✓	✓	✓	✓	✓	✓
Togo				✓				
Tunisia	✓		✓	✓	✓		✓	✓
Uganda			✓	✓		✓		
Zambia	✓	✓	✓	✓	✓	✓		

Step 6: Calculate the GRC from Equation (5) as follows:

$$\xi_{1j} = (0.6667, 0.5000, 0.6667, 1.0000, 1.0000, 0.6667, 1.000)$$

$$\xi_{2j} = (1.0000, 0.5000, 0.6667, 1.0000, 1.0000, 0.6667, 1.000)$$

$$\xi_{3j} = (0.6667, 0.3333, 1.0000, 1.0000, 0.5000, 1.000, 0.6154)$$

$$\xi_{4j} = (0.5000, 1.0000, 0.6667, 1.0000, 0.5000, 0.5000, 0.6154)$$

GRG is calculated using Equation (4):

$$r_1 = 0.7857, \quad r_2 = 0.8333, \quad r_3 = 0.7308, \quad r_4 = 0.6832$$

$$A_{1-4} > A_{1-3} > A_{1-1} > A_{1-2}$$

**Table 3** Raw Data from Questionnaire

Decision-makers/ Criteria	DM <sub>1</sub>	DM <sub>2</sub>	DM <sub>3</sub>	DM <sub>4</sub>	DM <sub>5</sub>	DM <sub>6</sub>	DM <sub>7</sub>
A1	I	E	I	E	S	M	E
A2	I	I	I	I	S	M	I
A3	I	S	I	I	S	I	M
A4	M	E	E	E	I	M	E
A5	I	I	I	E	M	I	E
A6	E	E	E	E	E	E	E
A7	E	I	E	E	M	I	M
A8	I	M	I	E	I	M	E
A9	I	I	E	I	E	E	E
A10	M	M	E	I	M	M	E
A1-1	I	M	I	I	E	I	I
A1-2	E	M	I	I	E	I	I
A1-3	I	U	E	I	M	E	M
A1-4	M	E	I	I	M	M	M
A2-1	I	S	I	I	E	E	I
A2-2	E	I	M	I	E	I	I
A2-3	I	E	E	I	M	I	M
A3-1	I	U	I	I	E	E	E
A3-2	E	I	I	I	E	E	E
A3-3	I	E	I	I	M	M	I
A4-1	I	U	I	I	E	E	E
A4-2	E	I	I	I	E	E	E
A4-3	I	E	I	I	M	M	I
A5-1	E	E	E	E	E	E	E
A5-2	I	E	E	E	E	I	I
A5-3	M	I	M	E	I	I	I
A5-4	M	S	I	E	I	I	E
A6-1	E	I	I	E	I	E	I
A6-2	E	E	E	I	I	E	E
A6-3	M	I	E	I	E	E	E
A7-1	M	M	I	E	E	M	I
A7-2	M	M	M	I	M	I	M
A7-3	E	I	E	I	I	I	I
A7-4	E	E	E	I	I	I	I
A7-5	E	M	I	I	M	I	I
A8-1	M	I	I	I	S	M	E
A8-2	E	E	I	I	E	E	E
A8-3	E	E	E	E	E	I	E
A8-4	M	M	I	I	M	M	E
A8-5	E	I	I	I	E	E	E
A8-6	E	I	E	E	I	I	E
A9-1	M	I	I	I	I	E	E
A9-2	I	M	I	M	E	I	E
A9-3	E	E	I	I	M	M	E
A10-1	M	M	I	I	I	M	I
A10-2	M	E	I	M	E	I	E
A10-3	M	I	E	E	E	E	E

**Table 4** Conversion of Grey Linguistic Weights to Grey Numbers

Second-level Indicators	DM <sub>1</sub>	DM <sub>2</sub>	DM <sub>3</sub>	DM <sub>4</sub>	DM <sub>5</sub>	DM <sub>6</sub>	DM <sub>7</sub>
A <sub>1-1</sub>	[0.6, 0.8]	[0.4, 0.6]	[0.6, 0.8]	[0.6, 0.8]	[0.8, 1]	[0.6, 0.8]	[0.6, 0.8]
A <sub>1-2</sub>	[0.8, 1]	[0.4, 0.6]	[0.6, 0.8]	[0.6, 0.8]	[0.8, 1]	[0.6, 0.8]	[0.6, 0.8]
A <sub>1-3</sub>	[0.6, 0.8]	[0, 0.2]	[0.8, 1]	[0.6, 0.8]	[0.4, 0.6]	[0.8, 1]	[0.4, 0.6]
A <sub>1-4</sub>	[0.4, 0.6]	[0.8, 1]	[0.6, 0.8]	[0.6, 0.8]	[0.4, 0.6]	[0.4, 0.6]	[0.4, 0.6]

**Table 5** Difference Between the Standardized Weight and Reference Weight

	DM <sub>1</sub>	DM <sub>2</sub>	DM <sub>3</sub>	DM <sub>4</sub>	DM <sub>5</sub>	DM <sub>6</sub>	DM <sub>7</sub>	Min $\Delta_{ij}$ $1 \leq j \leq n$	Max $\Delta_{ij}$ $1 \leq j \leq n$
$\Delta_{1j}$	0.2	0.4	0.2	0	0	0.2	0	0	0.4
$\Delta_{2j}$	0	0.4	0.2	0	0	0.2	0	0	0.4
$\Delta_{3j}$	0.2	0.8	0	0	0.4	0	0.25	0	0.8
$\Delta_{4j}$	0.4	0	0.2	0	0.4	0.4	0.25	0	0.4

**Table 6** Rank Order Centroid Weights Transformation

Criteria	q	1	2	3	4	Weights
A <sub>1-4</sub>	1	1	0.5	0.3333	0.25	0.5208
A <sub>1-3</sub>	2		0.5	0.3333	0.25	0.2708
A <sub>1-1</sub>	3			0.3333	0.25	0.1458
A <sub>1-2</sub>	4				0.25	0.0625

Step 7: Now, we transform the ranking above to Rank Order Centroid weights as shown in Table 6.

Similarly, the Grey ROC weights of the other indicators are calculated using exactly the same method.

Step 8: Then the effective weights of the indicators are calculated using Equation (7). The results are given in Table 7. The local weight is the weight of a second-level indicator relative to its first-level indicator, and the effective weight is the fraction of contribution by the second-level indicator to the overall weight in relations to the top level hierarchy.

**4.3 GRA Steps for Ranking**

The first step is to construct the sample data matrix, using 2015 Doing Business Data (<http://www.doingbusiness.org/data>). From Equation (8), we have:

$$Y = \begin{pmatrix} y_1(1) & y_1(2) & \dots & y_1(37) \\ y_2(1) & y_2(2) & \dots & y_2(37) \\ \vdots & \vdots & \ddots & \vdots \\ y_{17}(1) & y_{17}(2) & \dots & y_{17}(37) \end{pmatrix} = \begin{pmatrix} 9 & 60 & \dots & 61.9 \\ 7 & 8 & \dots & 16.9 \\ \vdots & \vdots & \ddots & \vdots \\ 5 & 6.5 & \dots & 37.1 \end{pmatrix}$$

Then getting to the final step for the GRA ranking of countries leads to:

$$r_1 = 0.9226, r_2 = 0.8777, r_3 = 0.8428, r_4 = 0.8798, r_5 = 0.9323, r_6 = 0.8475,$$

$$r_7 = 0.8751, r_8 = 0.8867, r_9 = 0.9323, r_{10} = 0.9068, r_{11} = 0.9136, r_{12} = 0.9136,$$

$$r_{13} = 0.9468, r_{14} = 0.8894, r_{15} = 0.8901, r_{16} = 0.8668, r_{17} = 0.8735.$$

The above results lead to the inequality below:

$$r_{13} > r_9 > r_3 > r_1 > r_{12} > r_{11} > r_{10} > r_{15} > \tag{11}$$

$$r_{14} > r_8 > r_4 > r_2 > r_7 > r_{17} > r_{16} > r_6 > r_3$$

From inequality (11) and Table 8, the 1<sup>st</sup> suggested country of starting a business in Africa is South Africa, the 2<sup>nd</sup> is Mauritius, the 3<sup>rd</sup> is Ghana, and Ethiopia is at the 17<sup>th</sup> position. From Table 7 the most important second-level indicator is the Disclosure Index (A<sub>6-1</sub>) of Protecting Investor (A<sub>6</sub>) indicator with the highest effective weight value of 0.1790. In contrast, the least important second-level indicator is the Time (A<sub>3-2</sub>) in Getting Electricity (A<sub>3</sub>) with an

effective weight value of 0.0011, next is the Time ( $A_{2-2}$ ) in Dealing with Construction Permit ( $A_2$ ) with an effective value of 0.0023. The most important indicator shows that the investors are not in haste to make any investment in Africa but are more focused on the protection of their investment. Also, the weight shows that the judiciary system should protect their investment so that contract are not bridged in the process of running the business.

**Table 7** Effective Weights of Indicators

First-level Indicator	Weight	Second-level Indicators (v)	Local weight	Effective Weight
A1	0.0846	A1-1 (1)	0.1458	0.0123
		A1-2 (2)	0.0625	0.0053
		A1-3 (3)	0.2708	0.0229
		A1-4 (4)	0.5208	0.0441
A2	0.0211	A2-1 (5)	0.2778	0.0059
		A2-2 (6)	0.1111	0.0023
		A2-3 (7)	0.6111	0.0129
A3	0.0100	A3-1 (8)	0.2778	0.0028
		A3-2 (9)	0.1111	0.0011
		A3-3 (10)	0.6111	0.0061
A4	0.1429	A4-1 (11)	0.2778	0.0397
		A4-2 (12)	0.1111	0.0159
		A4-3 (13)	0.6111	0.0873
A5	0.0646	A5-1 (14)	0.0625	0.0040
		A5-2 (15)	0.1458	0.0094
		A5-3 (16)	0.5208	0.0336
		A5-4 (17)	0.2708	0.0175
A6	0.2929	A6-1 (18)	0.6111	0.1790
		A6-2 (19)	0.1111	0.0325
		A6-3 (20)	0.2778	0.0814
A7	0.1096	A7-1 (21)	0.0900	0.0099
		A7-2 (22)	0.0400	0.0044
		A7-3 (23)	0.2567	0.0281
		A7-4 (24)	0.4567	0.0501
		A7-5 (25)	0.1567	0.0172
A8	0.0479	A8-1 (26)	0.0828	0.0043
		A8-2 (27)	0.2032	0.0106
		A8-3 (28)	0.3143	0.0164
		A8-4 (29)	0.0606	0.0032
		A8-5 (30)	0.1477	0.0077
		A8-6 (31)	0.1106	0.0058
A9	0.1929	A9-1 (32)	0.2778	0.0536
		A9-2 (33)	0.6111	0.1179
		A9-3 (34)	0.1111	0.0214
A10	0.0336	A10-1 (35)	0.6111	0.0205
		A10-2 (36)	0.2778	0.0093
		A10-3 (37)	0.1111	0.0037

To understand how the weight affects the decision-making process, a comparison of the 2015 DBP rankings to the rankings presented in this paper is shown in Table 8. Mauritius was ranked the 1<sup>st</sup> and South Africa is ranked the 2<sup>nd</sup> by the DBP in the year 2015 while South Africa is ranked the 1<sup>st</sup> and Mauritius is ranked the 2<sup>nd</sup> using Grey ROC weights. Ghana that is the 4<sup>th</sup> position by the DBP ranking in 2015 is the 3<sup>rd</sup> position by Grey ROC weights ranking. Tunisia is ranked the 3<sup>rd</sup> by the DBP in the year 2015 but the 8<sup>th</sup> position by Grey ROC weights ranking. It is not unusual for different ranking methods to produce different positions. Togo turns out to be the country with the highest ranking difference between the DBP and the Grey ROC as shown in Table 8. This reflects the role that the weight plays in the ranking method.

The countries are classified into 3 groups based on their GRGs. The 3 groups are obtained by dividing the minimum to maximum GRG into equal one-thirds.

**Table 8** Comparison of Rankings Between 2015 DBP and Grey ROC Weights

Countries	2015 World Ranking	DBP	GRG	Grey ROC	Absolute Difference between DBP and Grey ROC
Botswana	74	6	0.9226	4	2
Egypt	112	9	0.8777	12	3
Ethiopia	132	12	0.8428	17	5
Gabon	144	14	0.8798	11	3
Ghana	70	4	0.9323	3	1
Kenya	136	13	0.8475	16	3
Lesotho	128	11	0.8751	13	2
Mali	146	15	0.8867	10	5
Mauritius	28	1	0.9323	2	1
Morocco	71	5	0.9068	7	2
Mozambique	127	10	0.9089	6	4
Namibia	88	7	0.9136	5	2
South Africa	43	2	0.9468	1	1
Togo	149	16	0.8894	9	7
Tunisia	60	3	0.8901	8	5
Uganda	150	17	0.8668	15	2
Zambia	111	8	0.8735	14	6

1)Upper Rank (UR): These are the countries highly suggested with their GRGs varying from 0.9121 to 0.9468 i.e.,  $0.9121 \leq GRG \leq 0.9468$ . In Figure 2, these are the countries in the region above the horizontal solid line. These countries are South Africa, Mauritius, Ghana, Botswana and Namibia. South Africa is ranked the 1<sup>st</sup> position. However, it should not be a surprise when South Africa slips from the 1<sup>st</sup> position in the future, since protecting investor criterion is the most important indicator with a weight value of 0.2929. With the repeated xenophobic attacks on foreigners, not only are foreign investments vandalized, but foreign investors are at the risk of losing their lives<sup>[66-69]</sup>.

2)Middle Rank (MR): These are countries that perform averagely with GRG value between 0.8775 and 0.9121 i.e.,  $0.8775 \leq GRG \leq 0.9121$ . In Figure 2, these are the region between the horizontal solid and dash lines. The middle rank consists of 7 countries: Mozambique, Morocco, Tunisia, Togo, Mali, Gabon, and Egypt. They all perform averagely, but can still strengthen their protection for investors.

3)Lower Rank (LR): These are countries that are below the MR with their GRGs varying from 0.8428 to 0.8775, i.e.,  $0.8428 \leq GRG \leq 0.8775$ . In Figure 2, these are the countries in the region below the horizontal dash line. They are 5 countries: Lesotho, Zambia, Uganda, Kenya, and Ethiopia. These countries poorly protect investors as indicated by the low Disclosure Index ( $A_{6-1}$ ). From the experts' preferences, they are slow in making an investment where there is a low level of protection. The approach of using the sampling method to obtain the 17 sample countries is a measure to ascertain that only countries with a reasonable minimal performance in relations to all African countries are assessed. Although, Ethiopia is the 17<sup>th</sup> position in this evaluation, yet it is better than some other African countries that have very poor performance in several DBP indicators.

The result presented by the DBP is relatively acceptable because one of the simplest ways to evaluate all countries in the world is to use equal weights. Nevertheless, when dealing with a small group of investors, the weights of the first and second-level indicators cannot be overlooked because the weight accounts for the marginal contribution per indicator. Also, every indicator cannot make an equal contribution, especially in a group decision. In summary, all indicators have relative importance to each other, and this was not captured by the DBP. Our method puts weights into consideration.

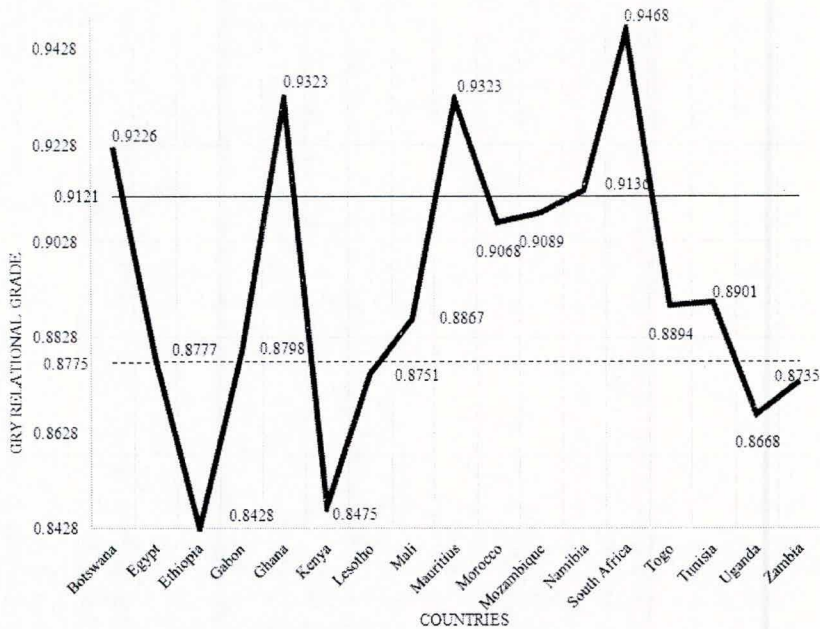


Figure 2 Grey Relational Grade for sample countries

### 5. Conclusion

Evaluating the business environment in Africa include a huge amount of

uncertainties. Foreign investors would want to make a wise decision on where to invest, and reduce the potential for running into an enormous loss. The indicators provided by the DBP of the World Bank cannot cover all the concerns of these investors, especially in a group decision-making process.

In this paper, we use the GST in aggregating group decision-maker preferences, and transforming them to ROC weights. The group preferences of the decision-makers are measured through a questionnaire using grey linguistic values represented by grey numbers to estimate the weights of evaluation criteria. ROC weights are used to convert the ranking of the criteria into weights. 17 sample countries drawn from the AFDB are ranked using traditional GRA in conjunction with the data obtained from the DBP, and South Africa is the most preferred place to start a business. The results presented in this paper are different from the ranking of the DBP, and it is more preferred to the investors because the weights of their preferences are put into consideration.

Since most decision techniques are mathematical representations of reality, the business environment in Africa cannot be totally accounted for because some factors for business cannot be quantified. It is highly recommended that investors should equally pay a visit to the African country that they want to invest. They should try to understand the culture, not just choosing the alternative with the highest GRG because this paper does not cover the national culture of the suggested countries. Future work should be conducted to take into account of new indicators, such as those related with natural minerals, tourism, technology, power and human resources. Market size should be also considered as an indicator of the DBP, which is very important to investors because enterprises would collapse without a market.

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