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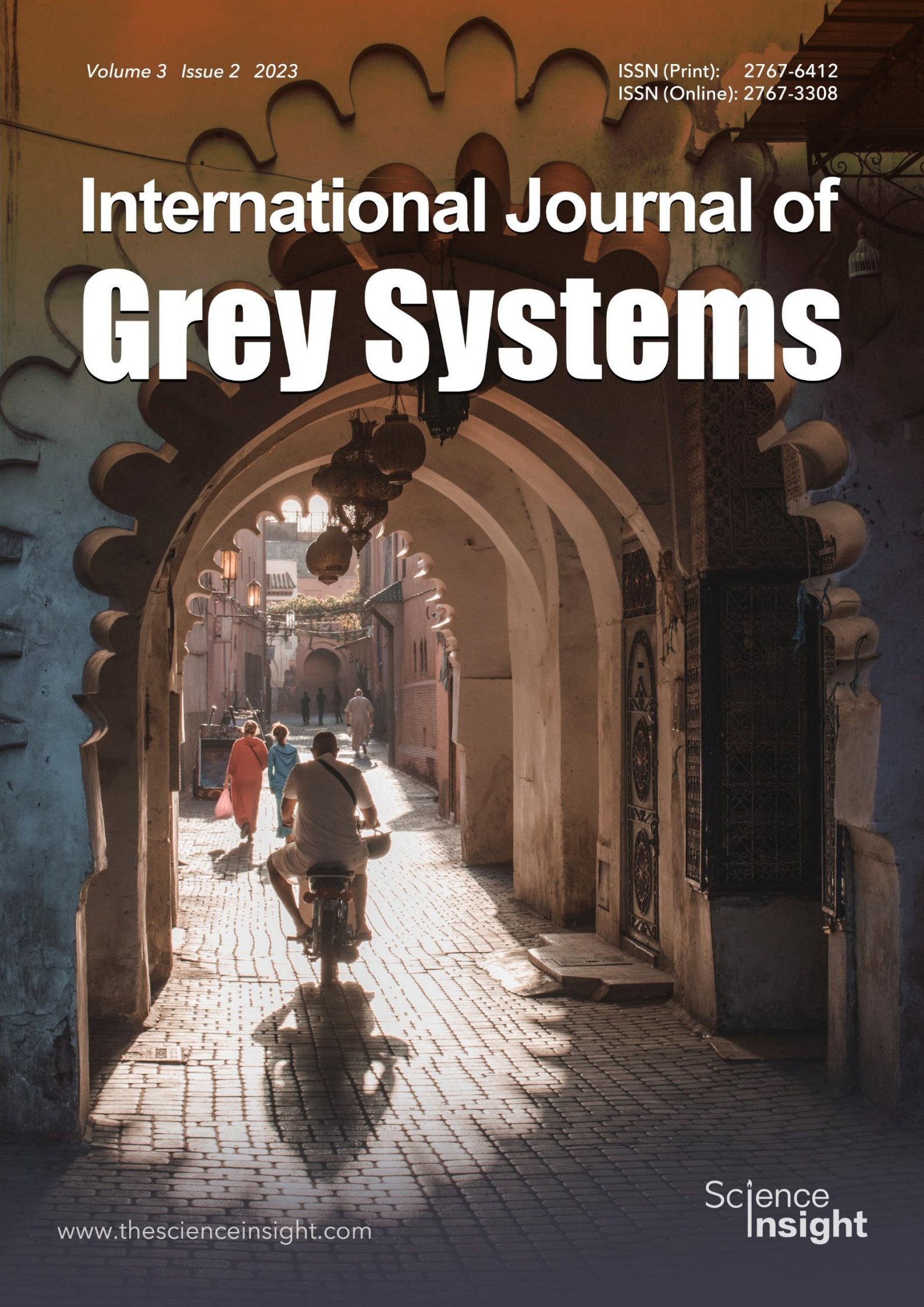

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In the memory of Professor Deng Julong (1933 - 2013),

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Grey Assessment

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Abstract: The assessment of human activities is an important task, because it helps to correct mistakes and to improve the overall performance of a group. Frequently, however, the individual assessment of the members of a group is performed not with numerical scores, but with qualitative grades (linguistic expressions). This happens either because the existing data are not exact, or for reasons of elasticity (e.g. teacher for students). In such cases the mean performance of the group cannot be assessed by applying the traditional method of calculating the mean value of the individual scores of its members. In this short communication, a method developed recently by the author is presented for evaluating the mean performance of a group in such cases, using grey numbers as tools. The method is illustrated by an example concerning the assessment of the mean performance of a class of students.

Keywords: Qualitative assessment; mean performance of a group; linguistics; grey number; grey assessment

1. Introduction

Frequently in everyday life the assessment of a group's performance takes place by using qualitative grades (linguistic expressions) instead of numerical scores. This is due to various reasons, the main of which is either the existence of non-exact data, or the will for more elasticity (e.g. from teacher to students).

In this short communication, we present a method, developed in the author's earlier works (e.g. Voskoglou, 2019: section 6.2), for evaluating the mean performance of a group, when qualitative grades are used for assessing the individual performance of its members. This method uses grey numbers (GNs) as tools and is illustrated by an example concerning the assessment of the mean performance of a class of students.

The theory of grey systems (GSs) (Deng, 1982) is an alternative to the theory of fuzzy sets (Zadeh, 1965) for handling approximate data. A GS is defined to be any investigated system with poor information concerning its structure message, operation mechanism, behaviour document, etc. The theory of GSs was developed mainly in China and has found many important applications to everyday life, science and engineering, including medicine diagnostics, psychology, sociology, control systems, economics, agriculture, opinion polls, etc., where the data cannot be easily determined and estimates of them are used in practice. For general facts on GSs we refer to Liu and Lin (2010).

The main tool for handling the approximate data of a GS is the use of GNs. A GN T, denoted with $\otimes T$, is understood to be a real number with known range given by a closed real interval of

the form $[a, b]$, but with unknown exact value. The GN $\otimes T$, however, may differ from the interval $[a, b]$ with respect to the presence of a whitenization function $f: [a, b] \to [0,1]$, such that the closer is $f(t)$ to 1, the better $t \in [a, b]$ approximates the unknown value of $\otimes T$. When no such function exists, it is logical to consider as the crisp representative (kernel) of $\otimes T$ the real number

$$\mathrm{V}(\otimes T) = \frac{a+b}{2} \tag{1}$$

The known arithmetic of the real intervals (Moore *et al.*, 1995) is used to perform the basic arithmetic operations between GNs. Let $\otimes T_1 \in [a_1, b_1]$ and $\otimes T_2 \in [a_2, b_2]$ be given GNs and let r be a positive number. In this paper we will make use only of the addition and of the scalar product of GNs, which are defined respectively by the relations,

$$\otimes T_1 + \otimes T_2 \in [x_1 + y_1, x_2 + y_2] \tag{2}$$

and

$$r \otimes T_1 \in [rx_1 + ry_1]. \tag{3}$$

2. Methodology

A commonly used scale of qualitative grades in assessment processes is: A = *excellent*, B = *very good*, C = *good*, D = *fair* and F= *fail*. In certain cases, the grade E is also inserted between D and F, or intermediate grades like A_-, B_+, B_-, etc. are used, but this does not affect the generality of our method.

We assign the numerical scale $1 - 100$ to the previous qualitative grades as follows: $A \to [85, 100]$, $B \to [75, 84]$, $C \to [60, 74]$, $D \to [50, 59]$, $F \to [0, 49]$. This assignment, although it is compatible with the common sense, is not unique. For a stricter assessment, for example, one could consider instead the assignment $A \to [90, 100]$, $B \to [80, 89]$, $C \to [70, 79]$, $D \to [60, 69]$, $F \to [0, 59]$, etc. Neither this fact, however, affects the generality of our method.

We now introduce the following GNs, denoted for simplicity with the same letters: $\otimes A \in [85, 100]$, $\otimes B \in [75, 84]$, $\otimes C \in [60, 74]$, $\otimes D \in [50, 59]$, $\otimes F \in [0, 49]$.

Let us consider a group G of n objects under assessment. Assume that the performance of n_A of these objects was evaluated with A, of n_B with B, of n_C with C, of n_D with D and of n_F objects with F, so that $n_A + n_B + n_C + n_D + n_F = n$. With the help of equations (2) and (3) we define the mean value of the corresponding GNs to be the GN

$$\otimes M = \frac{1}{n}(n_A \otimes A + n_B \otimes B + n_C \otimes C + n_D \otimes D + n_F \otimes F) \tag{4}$$

Then the mean performance of the group G can be estimated, with the help of equation (1), by the real value $V(\otimes M)$.

3. Numerical example

Our previous assessment method is illustrated here with the following example:

EXAMPLE: The teacher of a class of twenty students assessed the performance of his students as follows: Students $s_1 - s_3$ with A, $s_4 - s_7$ with B, $s_8 - s_{10}$ with C, $s_{11} - s_{16}$ with D, and the remaining four students with F. Evaluate the mean performance of the class.

SOLUTION: With the help of equation (4) one finds that the mean value of the grades obtained by the students of the class is equal to

$$\otimes M = \frac{1}{20}\{3[85, 100] + 4[75, 84] + 3[60, 74] + 6[50,59] + 4[0,49]\}.$$

Therefore, with the help of equations (2) and (3), it turns out that

$$\otimes M = \frac{1}{20}[1035, 1408] = [51.75, 70.4].$$

Thus, by equation (1), one finds that $V(\otimes M) = \frac{51.75+70.4}{2} = 61.075$, which shows that the student class demonstrated a good (C) mean performance.

The closed network diagram (Figure 1) explains our methodology very well showing that the algorithm starts from linguistic input (linguistic scale) and ends with a linguistic output (in our example with C = good performance).

Linguistics → Grey Numbers → Mean of corresponding Grey Numbers → Kernel → Linguistics

Fig 1. A graphical representation of our assessment methodology

4. Discussion and conclusion

In the current study, we presented a method using GNs as tools, for estimating the mean performance of a group of objects with respect to a certain activity, when their individual performance is assessed with qualitative grades. In such cases the group's mean performance cannot be evaluated by applying the traditional method of calculating the mean value of the individual scores. An alternative method for estimating a group's mean performance in such cases is by using triangular fuzzy numbers (TFNs) as tools, instead of GNs. We have shown, however, that these two methods are equivalent to each other (Voskoglou, 2019: paragraphs 5.2 and 6.2), the method with the GNs being simpler.

A similar method using GNs can be also applied for decision making (DM) (Voskoglou, 2023). This method improves an earlier DM method of Maji *et al.* (2002) using soft sets as tools.

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Studying Foreign Trade and Economic Growth of Morocco using Regression and Grey Relational Analyses

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Abstract: The study conducts an empirical examination of the relationship between foreign trade and economic growth in Morocco, employing two distinct analytical models: The Dynamic Grey Relational Analysis (GRA) model and the Multiple Regression model. The empirical outcomes reveal that foreign trade exerts a statistically significant and positive influence on the economic growth of Morocco, a relationship consistently substantiated by both the GRA and regression models. Nevertheless, it is important to emphasize that the linkage between these variables is characterized by a high degree of dynamism, influenced by a diverse array of economic determinants. Furthermore, the results point to the primary pathway through which foreign trade impacts economic growth in Morocco, highlighting its role in fostering capital accumulation and technological progress. Consequently, this study implies that strategic policies oriented toward the promotion of foreign trade and foreign investment have the potential to significantly bolster sustained economic growth within the Moroccan context.

Keywords: Economic growth; foreign trade, foreign investment; Morocco; grey relational analysis.

1. Introduction

Morocco has been experiencing significant economic growth over the past few decades, which has been largely driven by its foreign trade activities. As a result, the evaluation of foreign trade's impact on economic growth has become a crucial topic in Morocco's economic policy discussions. The economy of Morocco is among the largest economies in the African continent and fourth largest in the Arab world. The country's Gross Domestic Product (GDP) is around US$130 billion, making it one of the largest economies in Africa. Its per capita GDP is US$4,500, ranking 34 out of 133 countries.

According to a report by the World Bank, Morocco's economic growth has been driven by its openness to foreign trade and investment. The report states that "Morocco's integration into the world economy has been a key driver of economic growth over the past two decades" (World Bank, 2020). The role of government intervention in promoting foreign trade and economic growth in Morocco is reflected in the country's trade policies, which include export promotion and import substitution strategies (UNCTAD, 2020). According to the Moroccan Ministry of Economy

and Finance, the country's GDP growth rate averaged 3.9% between 2010 and 2019, with foreign trade contributing significantly to this growth (MMEF, 2021). Moreover, the Moroccan Ministry of Economy and Finance has reported that the country's trade balance has improved in recent years, with a steady increase in the value of exports and a decline in the value of imports (MMEF, 2021).

The International Monetary Fund (IMF) reported that Morocco's real GDP growth rate has been robust in recent years, averaging around 5% in 2000s, supported by strong physical capital accumulation, generally favorable external conditions, reform implementation, and economic diversification (IMF, 2019). According to a report by the World Trade Organization (WTO), Morocco's foreign trade policies have been focused on export promotion and import substitution strategies in recent years, with the government implementing policies to support the development of export-oriented industries (WTO, 2019).

In Morocco, the evaluation of the impact of foreign trade on economic growth has also been influenced by regional and global economic developments. For example, the implementation of the African Continental Free Trade Area (ACFTA) in 2021 is expected to create new trade opportunities for Morocco, as it opens up access to a market of 1.3 billion people and a combined GDP of $3.4 trillion. Similarly, the ongoing negotiations with the European Union over a new fisheries agreement will have significant implications for Morocco's foreign trade activities, particularly in the seafood sector.

Overall, the impact of foreign trade on economic growth in Morocco is a complex issue that requires a multidisciplinary approach. While theoretical frameworks can provide useful insights, empirical evidence is also needed to inform policy decisions. Some recent studies have highlighted the positive impact of foreign trade on Morocco's economic growth, particularly in the agriculture and manufacturing sectors. However, other studies have pointed out the challenges associated with trade openness, such as the risk of dependence on external markets, unequal distribution of benefits, and environmental degradation. Therefore, a balanced approach that takes into account the social, economic, and environmental dimensions of foreign trade is crucial for sustainable development in Morocco.

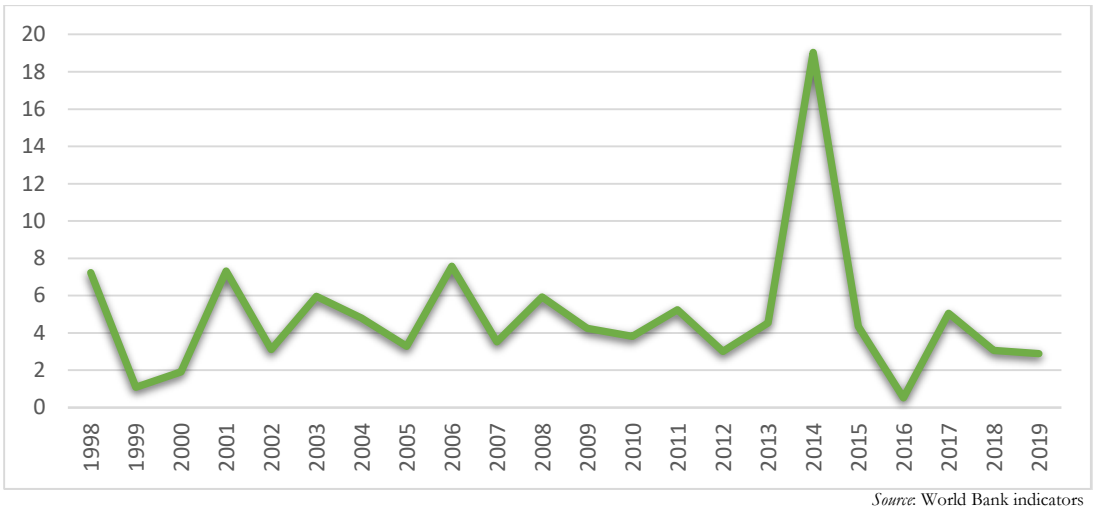
In this context, this paper aims to evaluate the impact of foreign trade on economic growth in Morocco using both the Dynamic Grey Relational Analysis and the Multiple Regression Analysis models. By analyzing the country's foreign trade policies and economic indicators, such as GDP growth and trade balance, this paper seeks to provide a comprehensive evaluation of the impact of foreign trade on Morocco's economic growth. Ultimately, this analysis will contribute to a better understanding of the factors driving Morocco's economic growth and provide policymakers with valuable insights for future economic planning.

2. Literature review

2.1 The economy of Morocco

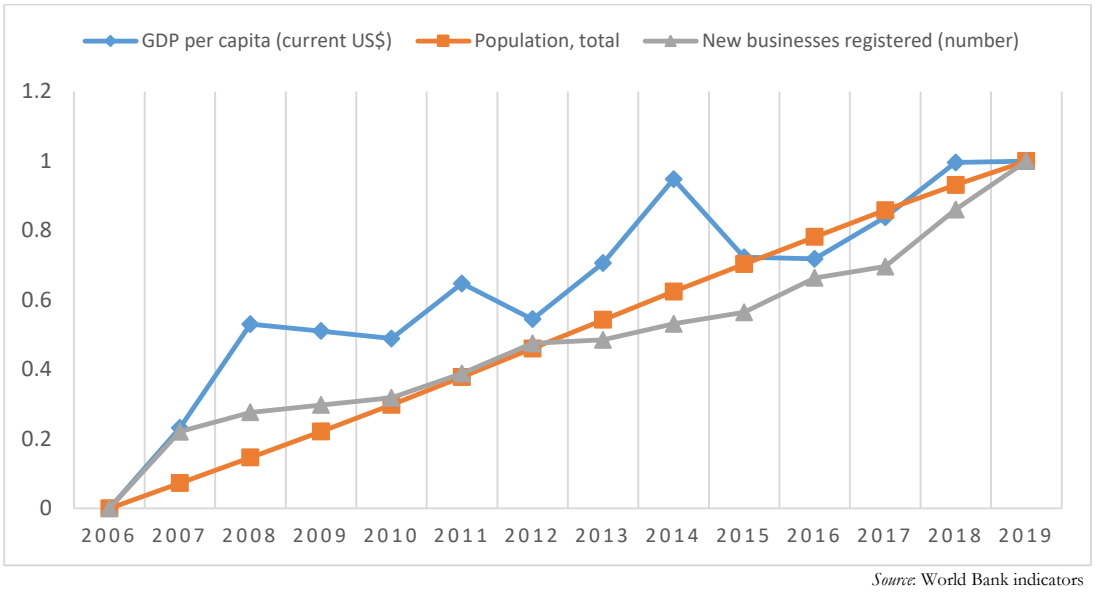
Morocco's economy is characterized by a mix of traditional agriculture, modern industry, and a growing services sector. The country has made significant strides in recent years to modernize its economy and attract foreign investment. According to the World Bank, Morocco has implemented "a comprehensive policy and institutional reform agenda" aimed at boosting economic growth, reducing poverty, and improving living standards for its citizens. These reforms have included measures to liberalize the economy, encourage foreign investment, and modernize the financial sector. Despite these efforts, however, Morocco still faces challenges related to unemployment, income inequality, and regional disparities (World Bank, 2021a; 2021b). However, even though the annual GDP growth (%) has not shown significant improvement over the years (see Figure 1), the GDP per capita, population and entrepreneurships have shown increasing trends over the years (see Figure 2).

One of Morocco's main economic strengths is its strategic location at the crossroads of Europe, Africa, and the Middle East. The country has historically been a trading hub, and it continues to



Source: World Bank indicators

Fig 1. Annual GDP growth of Morocco between 1995 and 2019 (annual %)



Source: World Bank indicators

Fig 2. Moroccan GDP per capita, population, and new businesses registered

benefit from its proximity to major markets in Europe and Africa. Morocco has also invested heavily in infrastructure in recent years, including modern ports, highways, and high-speed rail links. These investments have helped to improve transportation links within the country and with neighbouring regions, making Morocco an increasingly attractive destination for foreign investment (UNCTAD, 2021; AfDB, 2021).

Another key sector of the Moroccan economy is tourism, which has grown rapidly in recent years. According to the World Travel and Tourism Council, travel and tourism accounted for 8.1% of Morocco's GDP in 2019, and the sector is expected to continue to grow in the coming years (WTTC, 2021). The country's rich cultural heritage, stunning landscapes, and diverse cuisine make it an attractive destination for visitors from around the world. The Moroccan government has also made efforts to promote sustainable tourism, including through the development of eco-tourism projects and the implementation of policies aimed at reducing the environmental impact of tourism activities (Idrissi, 2023; Zhu, 2023).

2.2 Foreign direct investment

Foreign direct investment (FDI) is an important source of capital for a country's economic development. FDI provides a range of profits to the local economy, including increased work

opportunities, transfer of new technologies and ideas, and promotion of exports. It is a key factor in boosting the country's capacity to attract foreign investors and expand domestic businesses. Therefore, it is important for governments to have policies in place to ensure that FDI brings maximum benefits to the local economy while minimizing negative impacts (OECD, 2002).

According to the World Bank, Morocco has attracted significant FDI inflows in recent years, reaching $3.8 billion in 2019. FDI has played a crucial role in the country's economic development, contributing to job creation, export promotion, and technology transfer. However, challenges remain, such as the need to improve the investment climate and promote domestic value-added activities. The Moroccan government has implemented various measures to promote FDI, including legal and institutional reforms, tax incentives, and investment promotion activities (Mouline & El Alami, 2020). Some scholars have studied the effects of total FDI on economic growth and the trade balance, and found that the effects of neither were significant (Echcharfi & Fayou, 2016). While some studies have examined the relationship between FDI and economic growth in Morocco, there is still much research to be done to fully understand the impact of FDI on the country's economy (see Table 1).

2.3 Foreign trade

Morocco has been striving to enhance its foreign trade by pursuing a policy of economic liberalization and trade diversification. The country's strategic location, close proximity to Europe, and its access to major markets in Africa and the Middle East have made it an attractive destination for foreign investors. The government has implemented a number of measures to facilitate trade, including the reduction of tariffs and the simplification of customs procedures. Despite these efforts, however, Morocco's trade deficit remains a challenge.

According to the World Bank, Morocco's exports have been gradually increasing over the past few years, reaching USD 28.6 billion in 2019. The country's main exports include agricultural products, textiles, and phosphates. In recent years, Morocco has also been seeking to diversify its export base by developing new sectors such as renewable energy and automobile manufacturing. The country has attracted significant foreign investment in these sectors, with major automakers like Renault and Peugeot investing in production facilities in Morocco (World Bank, 2021a; 2021b).

Morocco's main trading partners are the European Union (EU) and the United States. In 2019, the EU accounted for 59% of Morocco's exports, while the United States accounted for 14%. The country has also been expanding its trade ties with other regions, including Asia and Africa. Morocco has signed a number of free trade agreements, including with the United States and several Arab countries. The country is also a member of the African Continental Free Trade Area, which is expected to boost intra-African trade (European Commission, 2020). Despite these positive developments, Morocco's trade deficit remains a challenge. In 2019, the country's imports totalled USD 47.6 billion, resulting in a trade deficit of USD 19 billion. The government has been taking steps to address this issue, including promoting exports and implementing measures to reduce import dependency. The COVID-19 pandemic has also had an impact on Morocco's trade, with a decline in exports and a reduction in tourism revenues (World Bank, 2021a; 2021b).

2.4 Imports and exports

Exports and imports play a significant role in the economy of Morocco. Morocco's exports are diverse and include phosphates, agricultural products, textiles, clothing, and automobiles. In 2020, the country's total exports were valued at $23.7 billion. In 2022, Morocco exported goods worth about $41.15 billion and imported goods worth about $71.51 billion (Statista, 2023a; 2023b).
The top export partners of Morocco, according to the World Bank, are Spain, France, Italy, and the United States. Spain accounted for around 20% of Morocco's total exports, while France accounted for around 17%. Italy and the United States accounted for around 7% and 5% of Morocco's total exports, respectively.

Table 1. The review of selected literature

Year	Summary	Literature
1999	The paper investigated the relationship between real exchange rate behavior and economic growth in four North African countries, namely Egypt, Jordan, Morocco, and Tunisia. It used a time-series analysis to examine the causal relationship between these two variables and to identify the factors that influence this relationship.	Domac and Shabsigh (1999)
2013	The paper explored the relationship between international tourism and economic growth in Morocco and Tunisia. The study used a panel data analysis to investigate the causal relationship between these two variables and to identify the factors that influence this relationship.	Bouzahzah and El Menyari (2013)
2014	The paper explored the relationship between stock market performance and economic growth in Morocco. The study used a time-series analysis to examine the causal relationship between these two variables and to identify the factors that influence this relationship.	Wild and Lebdaoui (2014)
2015	The paper investigated the relationship between remittances, economic growth, and exchange rate regime in Morocco. The authors used an econometric analysis to examine the causal relationship between these variables and to identify the factors that influence this relationship.	Marzovilla and Mele (2015)
2016	The paper examined the relationship between trade liberalization, foreign direct investment (FDI) inflows, environmental quality, and economic growth in Tunisia and Morocco. The study used a comparative analysis to investigate the impact of these variables on the two countries' economies.	Hakimi and Hamdi (2016)
2016	The paper studied the relationship between tourism expansion and economic growth in Morocco and Tunisia. The study used both time series and panel data analysis to examine the causal relationship between these two variables and to identify the factors that influence this relationship.	Tang and Abosedra (2016)
2017	The paper investigated the relationship between export diversification and economic growth in Morocco. The study used an econometric analysis to examine the causal relationship between these two variables and to identify the factors that influence this relationship.	Lotfi and Karim (2017)
2019	The paper investigated the relationship between foreign direct investment (FDI), domestic investment, and economic growth in three Maghreb countries: Tunisia, Algeria, and Morocco. The authors used an econometric analysis to examine the causal relationship between these variables and to identify the factors that influence this relationship.	Ali and Mna (2019)
2019	The research examined the relationship between tax revenue and economic growth in Morocco using the Autoregressive Distributed Lag (ARDL) approach. The study tested the long-run and short-run impact of tax revenue on economic growth, as well as the causality between the two variables.	Fahim and Bourdane (2019)
2021	The paper examined the connection between renewable energy consumption and economic growth in Morocco. The study used a time-series analysis to investigate the causal relationship between these two variables and to identify the factors that influence this relationship.	Bouyghrissi *et al.* (2021)
2021	The paper examined the relationship between tourism FDI, international tourism, and economic growth in Morocco. The study used an ARDL bound testing approach to investigate the causal relationship between these variables and to identify the factors that influence this relationship.	El Menyari (2021)
2021	It explored the relationship between the quality of the education system and economic growth in Morocco. The study used a time-series analysis to examine the causal relationship between these variables and to project future trends.	Bouzahzah (2021)
2021	The study investigated the impact of foreign direct investment (FDI) and international trade on economic growth in Morocco and Senegal. The study used econometric analysis to examine the causal relationship between these variables.	Bakkacha and Touhami (2021)
2022	The study conducted a multivariate analysis to examine the relationship between openness to international trade and economic growth in Morocco from 1980 to 2019. It explores whether openness to international trade contributes to economic growth in Morocco. And the analytical approach involves the use of the ARDL model of Pesaran and the causality test of Toda-Yamamoto.	Louardy and Moussamir (2022)
2023	The study focused on FDI and their potential positive impact on the economic and social development of emerging countries, emphasizing the importance of attracting appropriate investors. It concentrates on the FDI attractiveness in Turkey and Morocco, conducting a comparative examination between the two countries. Using an ARDL econometric model for the period 1980 to 2020, it identified key determinants influencing FDI inflows in both countries.	Bendriouch and Uslu (2023)

The main imports into Morocco, according to the World Bank, are petroleum products, textile fabrics, and equipment (see Table 2). Spain is the largest source of imports into Morocco, accounting for around 16% of the country's total imports. France is the second-largest source of imports, accounting for around 13%. China and the United States are also important import partners, accounting for around 11% and 6% of Morocco's total imports, respectively.

Overall, exports and imports are critical components of the Moroccan economy, with Spain and France being the country's most significant trading partners. Morocco's diverse exports and imports have helped to create jobs and drive economic growth, but the country's heavy reliance on imports of petroleum products remains a significant challenge.

3. Research design and methodology

3.1 Data collection and analysis

The current study sampled fourteen years (2006 to 2019) of Morocco's annual time series data for its analysis. The data collected was obtained from the World Development Indicators. The year 2020 and 2021 eliminated because of COVID-impact on the Morocco's economy and the world's economy. The study examines the impact of foreign trade on economic growth in Morocco. We used the Dynamic Grey Relational Analysis (Dynamic GRA) and the Multiple Regression model. We divided the Data collected from World Bank into two main groups, Economic growth and Foreign Trade group, then we classify them into Dependent variables (DVs) and Independent Variables (IVs), respectively.

The study applied the Dynamic GRA on a dynamic system involving 12 (3+9) variables. For comparative analyses, a Multiple Regression model was built based on variables. Both models were executed on 2016 Microsoft Excel.

3.2 Variables

Economic growth and foreign trade are two important variables that are frequently studied together in economics. Economic growth is the gradual increase in a country's total output of goods and services, whereas foreign trade is the exchange of goods and services between countries. Several key variables are commonly used to measure economic growth, including GDP per capita, new business registrations, and population. These variables provide an indication of a country's overall economic performance and can be used to compare different countries' economic growth over time.

In contrast, foreign trade variables include metrics such as imports, exports, and trade balance. These variables shed light on a country's role in the global economy and can aid in the identification of patterns in international trade relationships. Complete list of variables is shown in Table 3.

Economic growth and foreign trade have a complex and multifaceted relationship. Because of increased access to markets, technology, and resources, countries that engage in foreign trade tend

Table 2. Exports and Imports and the main partners of Morocco in 2021

	Industry	**Mainly Partners**
Exports	Cars ($5.19B) Mixed Mineral or Chemical Fertilizers ($5.18B) Insulated Wire ($3.58B) Phosphoric Acid ($2.25B) Calcium Phosphates ($1.62B) Legumes ($929M)	Spain ($7.87B) France ($7.9B) Italy ($2.01B) India ($2.1B) Germany ($1.31B) Brazil ($2.06B)
Imports	Refined Petroleum ($5.02B) Motor vehicles; parts and accessories (8701 to 8705) ($1.92B) Cars ($2.12B) Wheat ($1.36B) Petroleum Gas ($1.68B) Sulphur ($932M)	Spain ($11.1B) China ($6.43B) France ($5.42B) Germany ($2.60B) United States ($3.60B) Turkey ($3.14B)

Source: wits.worldbank.org

Table 3. Dependent and independent variables

Dimension	Code	Variable
Economic Growth	DV1	GDP per capita (current US$)
	DV2	Population, total
	DV3	New businesses registered (number)
Foreign Trade	IV1	Real effective exchange rate index (2010 = 100)
	IV2	Export volume index (2000 = 100)
	IV3	Import unit value index (2015 = 100)
	IV4	Merchandise imports (current US$)
	IV5	Merchandise exports (current US$)
	IV6	Net barter terms of trade index (2000 = 100)
	IV7	Foreign direct investment, net outflows (BoP, current US$)
	IV8	Foreign direct investment, net inflows (BoP, current US$)
	IV9	Commercial service imports (current US$)

Source: World Bank indicators

to experience higher levels of economic growth. Foreign trade's effects on economic growth, however, can vary depending on factors such as trade policies, exchange rates, and the competitiveness of domestic industries.

3.3 Dynamic grey relational analysis

Grey system theory was developed by Julong Deng in 1982 and includes the Grey Relational Analysis (GRA) model as an important component (Julong, 1989). GRA has become a popular choice due to its superior performance compared to other techniques in handling limited data collection and grey values, resulting in optimal results (Ikram *et al.*, 2020; Liu *et al.*, 2022). The use of GRA models has gained significant attention in various fields, such as management, engineering, economics, and medicine. For instance, Abifarin (2021) utilized the GRA for optimizing engineering parameters. Tsoy (2022) used GRA to identify the key expectations of Russians from the increased supplies of Russian natural gas to Europe. Ivanova (2022) used GRA to identify the main factors affecting the food safety of the Russian supply chain. Kharipzhanova and Irfan (2022) used GRA to identify and evaluate multiple barriers to the development of GB's travel & tourism industry in Pakistan. Oyedeji *et al.* (2022) used GRA for optimization of the mechanical properties of the palm oil processing plant in Nigeria.

The Grey Relational Analysis (GRA) is a correlation measure that has become popular in multiple criteria decision-making (MCDM), data clustering, and optimization, particularly in mechanical engineering. It is a crucial component of Grey Systems Theory (GST) and has gained widespread use alongside other methods such as the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS). However, the GRA method has some drawbacks, such as the subjective selection of the distinguishing coefficient and the mandatory normalization of input data. In 2022, Javed *et al.* (2022) proposed a Dynamic GRA model that overcomes these drawbacks. The model effectively improved the precision and accuracy of Deng's GRA model (Ervural, 2023). When all data points are equally weighted, the Dynamic GRA model estimates the Grey Relational Grade (GRG) (Γ_{0k}) as:

$$\Gamma_{0k} = \frac{1}{n}\sum_{j=1}^{n} \gamma_{0k}(j) \tag{1}$$

where, the Grey Relational Coefficient (GRC) ($\gamma_{0k}(j)$) is:

$$\gamma_{0k}(j) = \frac{\Delta_{min} + \xi(j)\Delta_{max}}{|\Delta_{0k}(j)| + \xi(j)\Delta_{max}}, k = 1,2,\ldots.m \tag{2}$$

where,

$$|\Delta_{0k}(j)| = |x_0(j) - x_k(j)| \tag{3}$$

$$\Delta_{min} = min_k min_j |x_0(j) - x_k(j)| \quad (4)$$

$$\Delta_{max} = max_k max_j |x_0(j) - x_k(j)| \quad (5)$$

$$\xi(j) = \{\xi(1), \xi(2), \dots, \xi(n)\}, \xi(j) \in (0, 1] \quad (6)$$

Here, $\xi(j)$ is the vector of the Dynamic Distinguishing Coefficients. The approximate method proposed by Javed *et al.* (2022) was used to estimate $\xi(j)$. In the current study, the Dynamic GRA model was built and executed on Microsoft Excel.

3.4 Spearman's rank correlation

Spearman's rank correlation is a useful statistical tool for analyzing the relationship between variables in a variety of research fields. It is especially useful when the variables are non-parametric or non-normally distributed, rendering other parametric methods inapplicable.

The method entails ranking the values of each variable and then computing the correlation coefficient based on the rankings. The resulting correlation coefficient, denoted as rho (ρ), ranges from -1 to 1, with values close to -1 indicating a strong negative or positive correlation and values close to 0 indicating no correlation (Spearman, 1961). It is given by

$$\rho = 1 - \frac{6 \sum D^2}{N(N^2 - 1)} \quad (7)$$

where N is the number of data points of the two variables and D is the difference in their ranks.

3.5 Multiple regression analysis

The Multiple regression is extensively employed in statistics for assessing a linear relationship between a dependent (response) variable and several independent (explanatory) variables (Baltagi, 2011). Multiple regression is a research technique that is commonly used to identify the factors that influence a specific outcome or dependent variable. It is also used to create predictive models. Its equation is expressed as

$$y_j = \beta_0 + \beta_1 x_{1j} + \beta_2 x_{2j} + \cdots + \beta_m x_{mj} + \varepsilon_j \quad (8)$$

where, y_j denotes depends variable, x_j denotes independent variable(s), β_0 denotes the y-intercept, β_m denotes regression coefficients, and ε_j denotes the model error.

4. Results and discussion

In this section, we will be presenting the results of our analysis of the data that was collected for this study. The data was collected through the World Bank. Before conducting any analysis, the raw data were first processed and converted into normalized forms to ensure that the data was consistent and comparable. Through our analysis, we were able to derive several key findings that shed light on the objectives of this study. These findings will be discussed in detail in this chapter, along with their implications and significance.

4.1 Grey relational analysis

In our study, we used the Dynamic GRA to explore the relationships between several independent variables (IVs) and dependent variables (DVs). To ensure that we obtained a comprehensive understanding of the relationships between these variables, we executed the dynamic GRA three times. Each time, we selected one DV and several IVs and then ran the analysis on Excel.

Executing the Dynamic GRA three times allowed us to gain a deeper understanding of the relationships between the variables under different scenarios. By selecting different combinations of DVs and IVs, we were able to explore the effects of different factors on the DVs. This approach also allowed us to identify commonalities and differences between the analyses, which provided better understanding of the relationships between the variables being studied (see Table 4).

Based on the Dynamic GRA, in column DV1 in Table 4, we identified that IV1, IV2, IV5, and IV8 have high Grey Relational Grade (GRG) values. This indicates that these variables are significantly related to DV1 (GDP per capita), the dependent variable being analyzed. It is important to note that these variables are not independent of each other, and their relationships with DV1 (GDP per capita) may vary based on the context of the analysis. Also, the model shows that IV4 has the lowest GRG value among all the independent variables in the model, it suggests that IV4 is least related to the dependent variable (DV1) as compared to the other independent variables (see Figure 3).

The Dynamic GRA have revealed that IV2, IV5, IV6, and IV9 have high GRG values, which suggests that these variables are significantly related to DV2 (population). This highlights the importance of these variables in understanding the behavior of the dependent variable being analyzed. However, it is important to note that the relationships between these variables and DV2 (population) may be complex, and further analysis may be required to fully understand the nature of these relationships. The model indicates that IV4 has the lowest GRG value among all the independent variables. This suggests that IV4 is least related to the dependent variable DV2 (population) (see Table 4 and Figure 4).

The findings of the Dynamic GRA have shown that IV2, IV3, IV5, and IV7 have high GRG values, which suggests that these independent variables are significantly related to DV3 (new business registered), the dependent variable being examined. The analysis revealed that IV4 has the smallest GRG value among all the independent variables, and thus IV4 is least related to the dependent variable DV3 when compared to the other independent variables (see Table 4 and Figure 5).

To gain a deeper understanding of the impact of these independents variables on DV1 (GDP per capita), DV2 (population) and DV3 (new businesses registered), further analysis and interpretation of the results are required. This may involve conducting sensitivity analyses to assess the stability of the results, exploring potential interactions between the variables, or using additional statistical techniques to identify potential causal relationships. Additionally, it is important to consider external factors that may be influencing the relationships between these variables, such as changes in the economic or social environment. Overall, the findings of Dynamic GRA provide valuable insights into the grey correlation between the independent variables and the three dependent variables. To see detailed calculations behind Table 4, *Appendix* should be consulted.

4.2 Rank correlational analysis

Spearman's rank correlation was applied to estimate the correlational degree between the three rankings reported in Table 4. The correlations between the three rankings are shown in Table 5.

Table 4. Dynamic grey relational grades and corresponding ranks in the three cases

	DV1		**DV2**		**DV3**	
	GRG	**Rank**	**GRG**	**Rank**	**GRG**	**Rank**
IV1	0.747	2	0.694	5	0.702	5
IV2	0.724	4	0.778	3	0.837	2
IV3	0.712	6	0.676	7	0.712	4
IV4	0.578	9	0.532	9	0.612	9
IV5	0.836	1	0.843	1	0.859	1
IV6	0.719	5	0.700	4	0.616	8
IV7	0.663	7	0.679	6	0.724	3
IV8	0.727	3	0.613	8	0.652	6
IV9	0.612	8	0.831	2	0.627	7

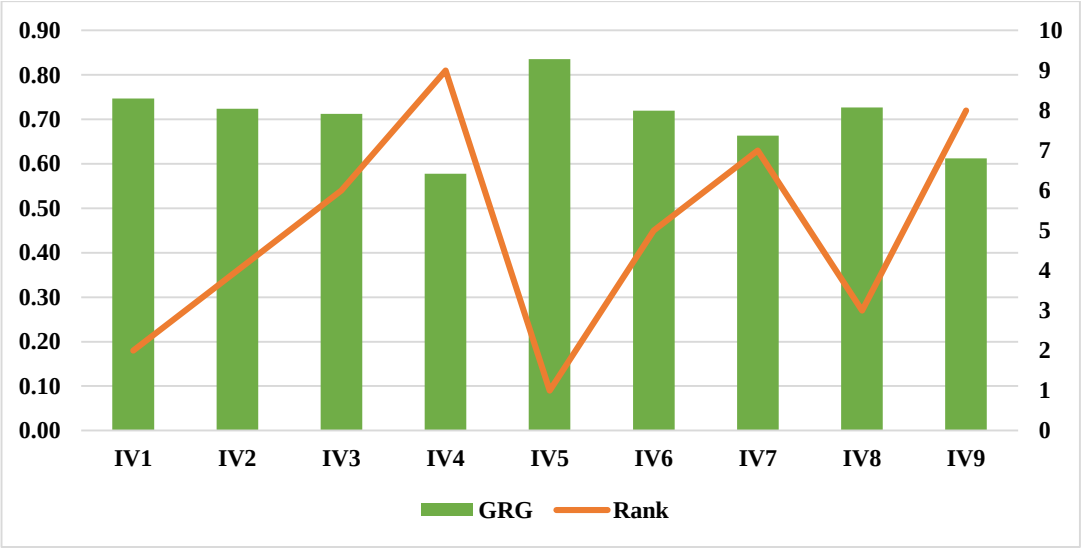


Fig 3. The dynamic grey relational grades and ranks of IVs w.r.t. DV1

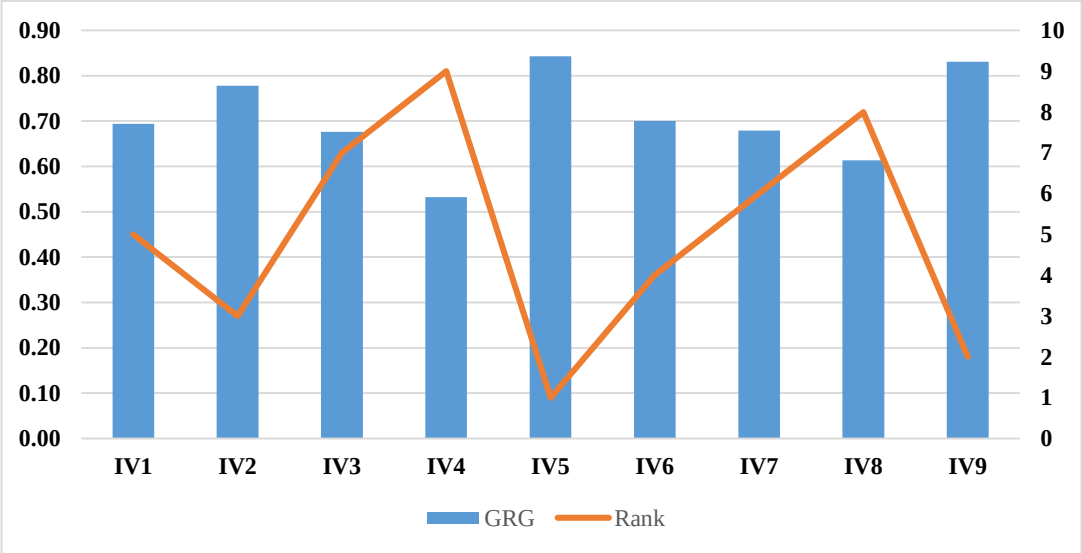


Fig 4. The dynamic grey relational grades and ranks of IVs w.r.t. DV2

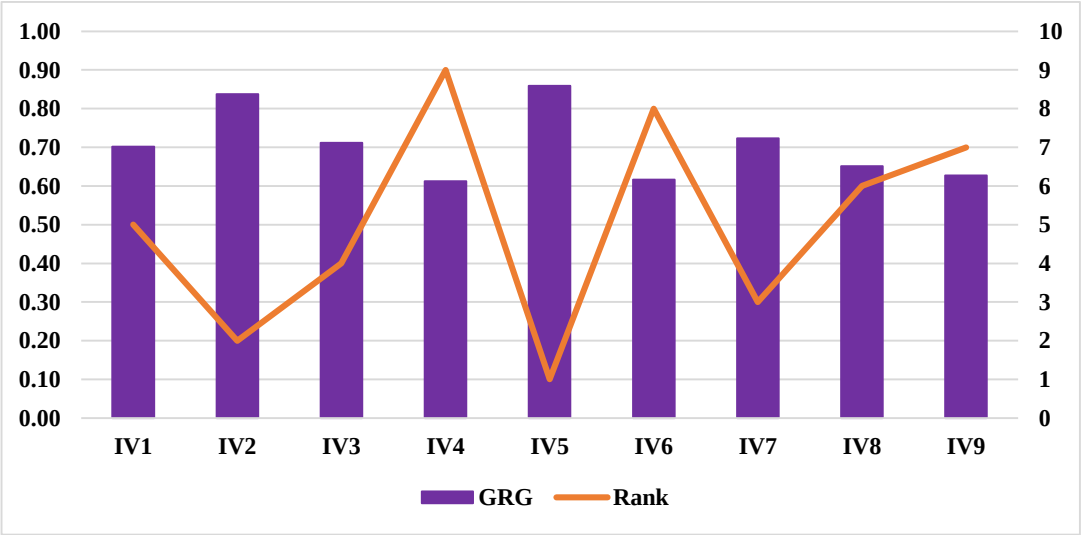


Fig 5. The dynamic grey relational grades and ranks of IVs w.r.t. DV3

Table 5. Spearman's rank correlational analysis on the three rankings reported in Table 4

	DV1	**DV2**	**DV3**
DV1	1.000	0.383	0.567
DV2		1.000	0.467
DV3			1.000

Based on the results of Spearman's ranking correlation, it was found that there is a weak correlation of 0.383 between the rankings when DV1 (GDP per capita) and DV2 (population) are considered as the dependent variables. The rankings obtained against DV2 (population) and DV3 (new business registered) have a moderate positive correlation (0.467), indicating that these two variables share moderate similarity. The rankings obtained against DV1 (GDP per capita) and DV3 (new business registered) reported relatively strongest rank correlation (0.567). This suggests that these two variables share some similarity in their role as dependent variables. Therefore, policymakers need to carefully consider the potential consequences of any adjustments to these variables.

In conclusion, Spearman's rank correlational analysis suggest that the rankings obtained against DV1 (GDP per capita), DV2 (population), and DV3 (new business registered) are correlated, but to varying degrees. This information is important for policymakers who need to make decisions related to these variables and their potential impacts. By understanding the strength of these relationships, policymakers can develop effective strategies to influence these variables and achieve their policy objectives while minimizing unintended consequences.

4.3 Regression analysis

If $\ln DV1$, $\ln DV1$, and $\ln DV1$ denotes three measures of economic growth (dependent variables), and IV1, IV2,…, and IV9 denotes the independent (explanatory) variables, then the multiple regression models developed for this study are

$$\ln DV1 = \beta_0 + \beta_1(IV1) + \beta_2(IV2) + \beta_3(IV3) + \beta_4(IV4) + \beta_5(IV5) + \beta_6(IV6) + \beta_7(IV7) + \beta_8(IV8) + \beta_9(IV9) \quad (9)$$

$$\ln DV2 = \beta_0 + \beta_1(IV1) + \beta_2(IV2) + \beta_3(IV3) + \beta_4(IV4) + \beta_5(IV5) + \beta_6(IV6) + \beta_7(IV7) + \beta_8(IV8) + \beta_9(IV9) \quad (10)$$

$$\ln DV3 = \beta_0 + \beta_1(IV1) + \beta_2(IV2) + \beta_3(IV3) + \beta_4(IV4) + \beta_5(IV5) + \beta_6(IV6) + \beta_7(IV7) + \beta_8(IV8) + \beta_9(IV9)) \quad (11)$$

The output of multiple regression analysis model is shown in Tables 6 and 7. The regression model consists of ten independent variables (IVs) and three dependent variable DV1, DV2 and DV3, with each IV having a corresponding coefficient that represents the change in DV for a one-unit increase in that IV while holding all other IVs constant. The negative and positive values of each coefficient reveal the direction and magnitude of the relationship between the independent and dependent variables. A positive coefficient indicates that an increase in the corresponding IV is associated with an increase in DV, while a negative coefficient indicates that an increase in the corresponding IV is associated with a decrease in DV. By fixing the corresponding explanatory variables coefficients into the model above, the three equations are further rewritten as

$$\ln DV1 = 1.088 - 0.137(IV1) - 0.233(IV2) - 0.040(IV3) + 0.062(IV4) + 0.260(IV5) + 0.136(IV6) - 0.026(IV7) - 0.033(IV8) - 1.003(IV9) \quad (12)$$

$$\ln DV2 = 0.920 + 0.155(IV1) + 1.119(IV2) - 0.091(IV3) - 0.141(IV4) - 0.995(IV5) + 0.207(IV6) - 0.071(IV7) - 0.107(IV8) - 0.779(IV9) \quad (13)$$

$$\ln DV3 = 1.215 + 0.053(IV1) + 1.344(IV2) - 0.206(IV3) - 0.776(IV4) - 1.483(IV5) + 0.181(IV6) - 0.018(IV7) - 0.116(IV8) - 0.331(IV9) \quad (14)$$

Equation (12) shows that the coefficient of IV5 is positive (0.260), which implies that an increase in IV6 by one unit is associated with an increase in DV1 by 0.260 units while holding all other variables constant. This result suggest that IV5 has a significant positive effect on DV1, and it is an essential variable to consider when predicting or explaining the variation in DV1. Conversely, the coefficient of IV9 is negative (-1.003), indicating that an increase in IV9 by one unit is associated with a decrease in DV1 by 1.003 units while holding all other variables constant. This result could suggest that IV9 has a significant negative effect on DV1, and it is a crucial factor to consider when predicting or explaining the variation in DV1.

Equation (13) displays that the coefficient of IV2 is positive (1.119), indicating that an increase in IV2 by one unit is associated with an increase in DV2 by 1.119 units while holding all other variables constant. This result could imply that IV2 has a significant positive impact on DV2 and is an essential variable to consider when predicting or explaining the variation in DV2. Conversely, the coefficient of IV5 is negative (-0.995), indicating that an increase in IV5 by one unit is associated with a decrease in DV2 by 0.995 units while holding all other variables constant. This result could suggest that IV5 has a significant negative effect on DV2, and it is an essential factor to consider when predicting or explaining the variation in DV2.

Equation (14) indicates that the coefficient of IV2 is positive (1.344), indicating that an increase in IV3 by one unit is associated with an increase in DV3 by 1.344 units while holding all other variables constant. This result suggests that IV2 has a significant positive impact on DV3, and it is an essential variable to consider when predicting or explaining the variation in DV3. Conversely,

Table 6. Regression analysis output for the response and explanatory variables

		DV1	DV2	DV3
Intercept	*Coef*	1.088	0.920	1.215
	Std. Err	1.002	0.727	0.678
IV1	*Coef*	-0.137	0.155	0.053
	Std. Err	0.182	0.132	0.123
IV2	*Coef*	-0.233	1.119	1.344
	Std. Err	2.361	1.713	1.598
IV3	*Coef*	-0.040	-0.091	-0.206
	Std. Err	1.147	0.832	0.776
IV4	*Coef*	0.062	-0.141	-0.776
	Std. Err	0.679	0.493	0.460
IV5	*Coef*	0.260	-0.995	-1.483
	Std. Err	2.797	2.029	1.893
IV6	*Coef*	0.136	0.207	0.181
	Std. Err	0.640	0.465	0.433
IV7	*Coef*	-0.026	-0.071	-0.018
	Std. Err	0.276	0.200	0.187
IV8	*Coef*	-0.033	-0.107	-0.116
	Std. Err	0.152	0.111	0.103
IV9	*Coef*	-1.003	-0.779	-0.331
	Std. Err	0.441	0.320	0.298

Table 7. The summary of regression analyses for the response and explanatory variables

	DV1	DV2	DV3
R^2	0.949	0.980	0.973
Adjusted R^2	0.835	0.935	0.913
F	8.302	21.735	16.222
Significance F	0.028	0.005	0.008
Observations	14		
Years	2006 - 2019		

the coefficient of IV5 is negative (-1.483), indicating that an increase in IV5 by one unit is associated with a decrease in DV3 by 1.483 units while holding all other variables constant. This result could imply that IV5 has a significant negative effect on DV3, and it is an essential factor to consider when predicting or explaining the variation in DV3.

From the multiple regression equations (12), (13), and (14), we can conclude that IV5 (merchandise exports), and IV2 (export volume index) are the most influential variables in predicting the outcomes related to DV1, DV2, and DV6. IV5 has the most significant impact on DV1, while IV2 has the most impact on DV2 and DV6.

To further elaborate on this conclusion, we can consider the economic significance of IV5 and IV2. IV5 represents a variable that has a positive impact on DV1, while IV2 represents a variable that has a negative impact on DV2 and DV3. This suggests that increasing the level of IV5 could lead to an increase in DV1 while reducing the level of IV2 could potentially lead to improvements in outcomes related to DV2 and DV3.

The practical implication of this result is that policymakers, managers, and stakeholders can focus their efforts and resources on improving or manipulating these variables to achieve their desired outcomes. For instance, if the Moroccan government aims to increase DV1 (GDP per capita), it can focus on strategies that boost IV5 (merchandise exports), such as improving product quality, increasing marketing and promotional activities, or expanding its distribution channels. On the other hand, if the Moroccan government plans to improve outcomes related to DV2 (population) and DV3 (new businesses registered), it can focus on strategies that enhance IV2 (export volume index), such as reducing operating costs, improving efficiency, or optimizing resource allocation.

4.4 Discussion

Morocco's economic growth is not only positively influenced by FDI and trade but also by new businesses registered and population growth. According to the World Bank (2021a; 2021b), Morocco's GDP per capita has been steadily increasing over the past decade, which can be attributed to the country's ability to attract foreign investment, promote trade, and create a conducive environment for businesses to thrive.

New businesses registered have a significant impact on economic growth in Morocco. A study by Krichene (2020) found that the number of new businesses registered is positively correlated with economic growth in Morocco. The study also found that the growth of the business sector in Morocco can be attributed to the country's investment in infrastructure, education, and innovation. This investment has resulted in an increase in the number of businesses being established, which has led to job creation and increased productivity, ultimately leading to economic growth.

While a larger population can increase the size of the labor force, and expand the market for (and consumption of) goods and services, there are also potential drawbacks of overpopulation (resource constraints, etc.). Thus, the current study found that the relationship between population growth and economic growth is non-linear, meaning that there is an optimal level of population growth that maximizes economic growth.

In addition, Morocco's economic growth has been positively influenced by its investment in renewable energy. According to the IREA (2021), Morocco has become a leader in renewable energy in Africa, with a goal of achieving 52% of its electricity production from renewable sources by 2030. This investment has not only led to a reduction in greenhouse gas emissions, but also to job creation and increased economic growth.

Overall, Morocco's economic growth can be attributed to a combination of factors, including FDI, trade, new businesses registered, population growth, and investment in renewable energy. By continuing to prioritize these factors, Morocco can sustain its economic growth and continue to be one of the fastest-growing economies in Africa.

Additionally, the outcomes of the Dynamic Grey Relational Analysis and the multiple regression provided evidence of trade positively affecting the GDP and economic growth of Morocco. It is because of increased production and the global prices for Morocco's key export commodities, such

as phosphates, textiles, and agricultural products. With the African Continental Free Trade Agreement and Morocco's strategic location as a gateway to Europe and Africa, the country is in a good position to enhance its trade relationships and expand its production capabilities, which will further boost its economic growth.

To put it simply, Morocco's economic growth is positively influenced by FDI, trade, population, and the establishment of new businesses. To maintain sustainable economic growth, it is crucial to address issues such as inflation, investment in education and innovation, and the promotion of private sector development. With these measures in place, Morocco can continue to be one of the fastest-growing economies in Africa.

5. Conclusion and recommendations

The aim of this study was to assess the dimensions and interrelationships between FDI, trade, and economic growth in Morocco using annual data from 2006 to 2019 to achieve this goal, the study employed the Dynamic Grey Relational Analysis (Dynamic GRA) and an econometric model such as Multiple Regression Analysis. The study aimed to investigate the dynamic relationships between foreign direct investment (FDI), trade, and economic growth in Morocco, with a focus on understanding the impact of FDI and trade on the country's economic performance.

The study employed the Dynamic GRA technique, which is a powerful tool for analyzing complex systems with multiple variables and complex interdependencies. This technique allowed the researchers to identify the most important factors that influence economic growth in Morocco and to measure the strength of their relationships. Additionally, the study utilized the Multiple Regression Analysis to support the results obtained from the Dynamic GRA model. The Multiple Regression Analysis enabled the researchers to estimate the individual and collective effects of FDI and trade on Morocco's economic growth while controlling for other relevant factors. The findings of this study are expected to inform policymakers in Morocco on the most effective policies and measures that can attract more FDI, enhance trade, and promote economic growth in the country. Furthermore, the study may provide a basis for future research on similar topics and in different contexts.

The Dynamic GRA revealed that merchandise exports are significantly important for GDP per capita, total population, and new businesses registered in Morocco. Additionally, real effective exchange, commercial service imports, and exports were found to be significantly associated with GDP per capita, total population, and new businesses registered in Morocco, respectively. On the other hand, the Multiple Regression Analysis indicated, merchandise exports and exports are exerting positive impact on GDP per capita, population, and new businesses registered. These variables play a crucial role in influencing the three dependent variables in Morocco. The findings provide valuable information for policymakers who are interested in developing strategies that can enhance economic growth and improve living standards. By prioritizing these variables, policymakers can create a favourable environment that can help them achieve their economic and social goals.

Based on the findings, this study suggests that the Moroccan government should implement more policies and measures to attract additional FDI. Furthermore, Morocco's participation in the African Continental Free Trade Agreement should be highly effective and efficient. This research can also assist future researchers in examining the impact of other variables on Morocco's economic growth and distinguishing between long-term and short-term projections to assess the impact of the current situation on the Moroccan economy. Additionally, before generalizing the findings, it is important to conduct a similar analysis on larger datasets, and on different countries.

Acknowledgement

This work is a derivative of the thesis written by the author at Nanjing University of Information Science and Technology under the supervision of Yang Fang. Later, during his stay at Nanjing University, the author improved the work and prepared this manuscript in its current form.

Appendix

Table A. The raw data

	2013	2014	2015	2016	2017	2018	2019
DV1	3117.52	3430.55	3139.24	3132.94	3288.50	3492.67	3498.57
DV2	33803527.00	34248603.00	34680458.00	35107264.00	35528115.00	35927511.00	36304408.00
DV3	33278.00	34766.00	35840.00	39030.00	40088.00	45399.00	49909.00
IV1	97.01	97.08	96.84	98.98	98.65	99.42	100.20
IV2	147.60	163.05	174.58	182.53	198.48	212.91	225.61
IV3	111.49	111.37	100.00	96.47	104.84	114.79	110.11
IV4	45190000000.00	46283000000.00	38100000000.00	41391000000.00	44490000000.00	51038000000.00	50734000000.00
IV5	21972000000.00	23920000000.00	22334000000.00	22661000000.00	25272000000.00	28609000000.00	29132000000.00
IV6	122.76	121.11	117.63	118.34	111.67	107.62	107.79
IV7	444699296.22	431221073.45	656593012.79	579110734.91	1012160431.61	780869404.77	893137828.48
IV8	3360909924.36	3525384612.44	3252913902.36	2153363904.94	2680109856.21	3544387229.28	1720825003.13
IV9	6417575571.84	7896294672.68	6983863459.39	7247769655.75	8708205814.51	9256596939.88	8637626582.77

2006	2007	2008	2009	2010	2011	2012
2200.97	2501.22	2889.22	2863.60	2835.22	3041.15	2907.45
30833022.00	31232633.00	31634992.00	32042877.00	32464865.00	32903699.00	33352169.00
17601.00	24734.00	26531.00	27221.00	27892.00	30157.00	32951.00
104.53	103.61	103.35	104.81	100.00	97.50	95.38
127.34	138.09	132.77	112.12	132.25	138.20	142.28
91.74	103.85	121.51	108.26	117.79	137.34	111.94
23980000000.00	32010000000.00	42366000000.00	32881000000.000	35381000000.00	44272000000.00	44872000000.00
12744000000.00	15340000000.00	20345000000.00	14054000000.00	17771000000.00	21654000000.00	21446000000.00
100.30	98.35	115.96	106.46	104.89	104.89	123.81
450871214.59	631979636.90	315929282.80	479023684.00	579978089.16	248022127.52	359562920.66
2460787164.18	2825801376.44	2466288357.37	1970323920.01	1240625859.11	2521362080.66	2841954371.38
3561640068.57	4527459779.76	5611736503.94	5301076144.69	5659545492.73	6712503456.28	6577898949.34

Table B. The normalized data

	DV1	DV2	DV3	IV1	IV2	IV3	IV4	IV5	IV6	IV7	IV8	IV9
2019	1.00	1.00	1.00	0.49	1.00	0.60	0.99	0.00	0.37	0.84	0.21	0.11
2018	1.00	0.93	0.86	0.57	0.89	0.49	1.00	0.03	0.36	0.70	1.00	0.00
2017	0.84	0.86	0.70	0.65	0.76	0.71	0.76	0.24	0.52	1.00	0.62	0.10
2016	0.72	0.78	0.66	0.62	0.62	0.90	0.64	0.39	0.79	0.43	0.40	0.35
2015	0.72	0.70	0.56	0.85	0.55	0.82	0.52	0.41	0.76	0.53	0.87	0.40
2014	0.95	0.62	0.53	0.82	0.45	0.57	0.82	0.32	0.89	0.24	0.99	0.24
2013	0.71	0.54	0.49	0.83	0.31	0.57	0.78	0.44	0.96	0.26	0.92	0.50
2012	0.54	0.46	0.48	1.00	0.27	0.56	0.77	0.47	1.00	0.15	0.70	0.47
2011	0.65	0.38	0.39	0.78	0.23	0.00	0.75	0.46	0.26	0.00	0.56	0.45
2010	0.49	0.30	0.32	0.51	0.18	0.43	0.42	0.69	0.26	0.43	0.00	0.63
2009	0.51	0.22	0.30	0.00	0.00	0.64	0.33	0.92	0.32	0.30	0.32	0.69
2008	0.53	0.15	0.28	0.16	0.18	0.35	0.68	0.54	0.69	0.09	0.53	0.64
2007	0.23	0.07	0.22	0.13	0.23	0.73	0.30	0.84	0.00	0.50	0.69	0.83
2006	0.00	0.00	0.00	0.03	0.13	1.00	0.00	1.00	0.08	0.27	0.53	1.00

Table C. The dynamic distinguishing and grey relational coefficients w.r.t. DV1

	IV1	**IV2**	**IV3**	**IV4**	**IV5**	**IV6**	**IV7**	**IV8**	**IV9**	**ξ**
2019	0.655	1.000	0.707	0.496	1.000	0.607	0.862	0.551	0.521	0.97
2018	0.676	0.892	0.639	0.471	0.970	0.584	0.748	0.995	0.471	0.89
2017	0.750	0.878	0.815	0.481	0.882	0.637	0.774	0.722	0.427	0.55
2016	0.807	0.811	0.702	0.537	0.788	0.862	0.596	0.566	0.535	0.42
2015	0.727	0.654	0.773	0.572	0.703	0.905	0.634	0.685	0.502	0.33
2014	0.861	0.613	0.676	0.506	0.748	0.937	0.528	0.947	0.527	0.79
2013	0.816	0.576	0.794	0.522	0.789	0.680	0.544	0.715	0.721	0.54
2012	0.513	0.632	0.974	0.602	0.973	0.513	0.546	0.761	0.866	0.48
2011	0.840	0.617	0.509	0.628	0.866	0.632	0.509	0.880	0.770	0.67
2010	0.942	0.530	0.854	0.797	0.659	0.603	0.866	0.418	0.711	0.35
2009	0.523	0.523	0.815	0.777	0.565	0.744	0.729	0.743	0.753	0.56
2008	0.529	0.547	0.697	0.668	0.864	0.723	0.488	0.996	0.794	0.42
2007	0.854	0.996	0.545	0.561	0.892	0.723	0.690	0.569	0.502	0.60
2006	0.967	0.870	0.473	0.473	1.000	0.921	0.772	0.629	0.473	0.90

Table D. The dynamic distinguishing and grey relational coefficients w.r.t. DV2

	IV1	**IV2**	**IV3**	**IV4**	**IV5**	**IV6**	**IV7**	**IV8**	**IV9**	**ξ**
2019	0.609	1.000	0.664	0.446	1.000	0.559	0.837	0.502	0.880	0.80
2018	0.629	0.934	0.583	0.396	0.943	0.518	0.723	0.899	0.899	0.61
2017	0.675	0.814	0.745	0.408	0.819	0.559	0.750	0.646	0.903	0.42
2016	0.722	0.725	0.787	0.500	0.707	0.990	0.550	0.524	0.760	0.42
2015	0.661	0.645	0.706	0.552	0.702	0.837	0.622	0.620	0.731	0.28
2014	0.704	0.726	0.895	0.509	0.890	0.633	0.547	0.558	0.772	0.46
2013	0.611	0.659	0.949	0.577	0.957	0.517	0.610	0.542	0.915	0.45
2012	0.486	0.723	0.840	0.687	0.878	0.486	0.618	0.685	0.880	0.51
2011	0.537	0.756	0.549	0.782	0.736	0.791	0.549	0.722	0.725	0.46
2010	0.576	0.705	0.689	0.507	0.971	0.875	0.679	0.492	0.804	0.29
2009	0.645	0.645	0.491	0.472	0.740	0.805	0.832	0.808	0.827	0.40
2008	0.979	0.924	0.682	0.712	0.576	0.441	0.882	0.528	0.669	0.43
2007	0.919	0.800	0.485	0.497	0.879	0.895	0.592	0.503	0.866	0.62
2006	0.957	0.834	0.403	0.403	1.000	0.898	0.718	0.560	1.000	0.67

Table E. The dynamic distinguishing and grey relational coefficients w.r.t. DV3

	IV1	IV2	IV3	IV4	IV5	IV6	IV7	IV8	IV9	ξ
2019	0.641	1.000	0.694	0.480	1.000	0.711	0.854	0.536	0.506	0.91
2018	0.700	0.961	0.649	0.440	0.862	0.750	0.805	0.829	0.440	0.68
2017	0.907	0.863	0.961	0.474	0.857	0.651	0.574	0.852	0.405	0.41
2016	0.905	0.910	0.649	0.585	0.881	0.490	0.652	0.618	0.582	0.43
2015	0.540	0.959	0.564	0.792	0.941	0.506	0.917	0.516	0.666	0.33
2014	0.648	0.865	0.933	0.599	0.779	0.555	0.645	0.535	0.644	0.53
2013	0.573	0.727	0.849	0.630	0.855	0.508	0.668	0.513	0.972	0.46
2012	0.476	0.695	0.853	0.659	0.895	0.501	0.592	0.685	0.990	0.48
2011	0.558	0.755	0.557	0.779	0.759	0.579	0.557	0.745	0.894	0.49
2010	0.686	0.748	0.792	0.617	0.973	0.497	0.784	0.568	0.573	0.42
2009	0.635	0.635	0.604	0.581	0.704	0.574	0.991	0.965	0.566	0.52
2008	0.697	0.746	0.797	0.863	0.597	0.897	0.597	0.520	0.520	0.28
2007	0.888	0.989	0.588	0.603	0.922	0.485	0.722	0.611	0.546	0.73
2006	0.967	0.870	0.473	0.473	1.000	0.921	0.772	0.629	0.473	0.90

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