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Effects of COVID-19 on Population, Economic Growth, Logistics Performance, and Quality Management in Africa: Grey Relational Analysis

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Abstract: The research aims to examine the emerging repercussions of the COVID-19 pandemic on population, GDP (Gross Domestic Product), logistics performance, and ISO 9001 certification in most effected African countries: South Africa, Morocco, and Tunisia. The innovative Grey Relational Grade (GRG) modelling approach was applied to analyze the interdependent relationship between COVID-19, economic growth, quality and logistics performance. Furthermore, the authors implemented the conservative (maximin) approach to identify which one of the top three most impacted COVID-19 African nations had the least intensifying effects. The data utilized in the research was obtained from several databases and examined in 2021. The results indicate that the pandemic has a tremendous undesirable influence and impact on the population, GDP, logistics performance, as well as ISO 9001 certification in all three considerably impacted African nations. Whereas South Africa was recorded the most affected in terms of the population due to a high number of fatalities. Moreover, the country has demonstrated substantial negative correlations between COVID-19 and logistic performance, whereas Tunisia and Morocco's GDP showed a downward negative trend due mainly to global trade flow constraints. Besides, in all the countries covered in this research, the number of ISO 9001 certificates has declined dramatically. The study outcomes generate much-needed policy recommendations for international organizations, decision makers and world governments to consider implementing immediate reparative interventions and emergent action plans to protect economic systems from further losses, as well as to improve the logistics, economic, and quality performances. This research pursues a multidimensional structure and explores the emerging impacts of the pandemic on economic growth, population, logistical performance as well as the process of quality production.

Keywords: COVID-19; African economy; population; logistics performance; ISO 9001; grey relational analysis.

1. Introduction

The COVID-19 pandemic created two worldwide crises: the health and economic crises. While human health was well affected in many regions of the world, the pandemic caused widespread social and environmental consequences. Various nations are still grappling with changes and problems in dealing with the sickness and the transmission of coronavirus variations in the

aftermath of the COVID-19 pandemic. While the pandemic outbreak has been well controlled ever since March 2020 (as it is in South Africa, Morocco, as well as Tunisia), several measures were implemented to regulate the disease's impacts have been effectively applied, such as lockdowns, sanitary conditions, and protective measures, unified and consolidated care in the preliminary phase of the pandemic, all moreover, South Africa and Morocco are the top two most afflicted COVID-19 African nations, with 2,910,681 (Nkhoma, 2021) and 938,801 cases (Bentaleb, 2021), respectively. Tunisia has had the fewest COVID-19 cases (709,456 cases) (Georank, 2021) to date due to its tiny population. Some businesses are accustomed to a specific level of volatility in their economic atmosphere or market segment or niche; nevertheless, unplanned situations, such as the COVID-19 pandemic, have never been experienced before. Various nations are still dealing with changes and problems in dealing with the sickness and the transmission of coronavirus variations in the post-COVID-19 pandemic era. Despite the fact that the globe is vaccinating at varying rates, coronavirus strains have emerged in Morocco, Tunisia, and South Africa, posing additional challenges. In contrast to the financial crisis of 2008, when monetary injections into banks were adequate, the COVID-19 health crisis had a severe impact on the actual economy. On the supply side, the Tunisian government has imposed total and directed imprisonment. A decline in supply was caused by the stoppage of major country activities, according to the authors. On the other hand, there is a decrease in demand as a result of lower consumption, out, and exports. Furthermore, efforts to contain the virus's spread have resulted in a significant drop in commodities prices. Prices are falling, particularly for energy items and, to a lesser extent, for other commodities.

Regardless of the fact that online organizations and profitability grew fast as a strategy for supporting the marketing of goods and services in various industries, on-demand delivery logistics rose substantially, placing logistics under strain (Luke, 2020). Manufacturing operations were overwhelmed as a result of the pandemic, harming the world economy during the second quarter of 2020. These restrictions highlighted the need for more resilient and imaginative recovery strategies, particularly because logistics networks are critical for constructing an economic comeback. The nutrition and adequate healthcare sectors are the most important in the middle of the COVID-19 outbreak because of the availability of vital products. Any flaws in these two can lead to significant monetary loss, unfulfilled demand, and supply fulfilment. The prior study revealed empirical and theoretical gaps in the literature about the effects of COVID-19 on the waste supply chain and other industrial sectors. Concurrently, additional studies emphasized the importance of exploring eco-innovation techniques in order to overcome the sustainability challenges caused by COVD-19 in Morocco, South Africa, and Tunisia. Companies, employees, and stockholders in all three countries were hit hard by the outbreak. Both supply and demand were influenced in the case of global supply chain activities, resulting in an unprecedented imbalance in commodity and service trade (Babatunde *et al.*, 2020).

More notably, these repercussions are affecting business activities related to certification of sustainability standards, particularly for ISO 9001. Where accrediting agencies monitor administrations and give expert assistance in analyzing risks and emergency plans of businesses to satisfy the accreditation bodies' environmental targets requirements. The epidemic impacted the auditing services mandated by ISO 9001 in 2015, and so they were postponed or done remotely. Auditors engaging in face-to-face audits were also subjected to sanitary and safety requirements, as was the case in numerous other businesses. Auditors evaluate the effectiveness of the management of organizations and communicate the necessary adjustments and actions to ensure that they can continuously offer products and services that are able to satisfy consumer's needs and wants and applicable legislative and regulatory standards, as well as increase customer satisfaction, which includes operations for optimization and guarantee of conformity to customer, statutory, and regulatory.

Given this backdrop, the purpose of this study is to deliver a substantial contribution to the existing scientific literature by first investigating the COVID-19 epidemic outlays on trade flows as well as logistical effectiveness. ISO 9001 certification in the three most affected African countries: South Africa, Tunisia, and Morocco, expanding on previous research that focused on the virus's

implications and evolving a complex conceptual model to supply the void in the existing literature about this matter. Second, analyzing data linked to COVID-19 cases, operational supply chain, and ISO 9001 certifications in 2020; along with the use of the grey relational grade (GRG) models approach a strategy which offers outstanding and accurate alternatives that are consequently recommended for tiny data samples. GRG models ensure the dataset's reliability, even if it contains some uncertainties, and make it easier to identify the essential factors to be examined in relation to the consequences of the COVID-19 pandemic on the global market in terms of the exchange of goods and services, logistic support, and the value of the ISO 9001 certification. And finally, adding brand new information to existing research platforms by envisioning alternatives for African countries to help them out of the crisis and back on track to economic revival and long-term growth.

This paper is structured as follows: the first half discusses the COVID-19 as well as its effects it had on the GDP (Gross Domestic Product) of the three countries, section 2 talks about the logistics' performance during times of crisis; section 3 discusses the value of the ISO 9001 certification and how it could be affected by the pandemic; section 4 would be a set of guidelines that could possibly be used by these countries for a faster and efficient economic recovery.

2. Background

2.1 Covid-19 and population

The World Health Organization (WHO) identified a cluster of unusual cases of pneumonia in Wuhan, China, as Coronavirus disease 2019 (COVID-19) on February 11, 2020. SARS-CoV-2, a new strain and variant of coronaviruses that has 79 percent genetic similarities with SARS-CoV from the 2003 SARS pandemic, was identified as the causal virus (Anand *et al.*, 2020). WHO designated the outbreak a worldwide pandemic on March 11, 2020. COVID-19, a significant pandemic of the 21st century, has caused unparalleled harm to mental health worldwide. While patients and healthcare staff get emotional assistance, the mental health of the broader population must also be addressed. Not only that, but it also affected the lives of families. People lost their jobs, and directly their social status and quality of living shrunk down, affecting not only households, but the economy in general. All non-essential businesses, including restaurants and retail stores, have been shut down, as have all sporting, cultural, and artistic activities. Until further notice, all mosques and other places of worship are shut down. A curfew on public and private transportation is in effect, as well as limitations on intercity movement, and the military is on the streets to protect citizens.

There has been a lockdown strategy used by the governments of three nations, which has limited the mobility of people save for those who work in critical services such as the police and the military. Everyone else must remain inside, except for those who need medical attention, food from supermarkets, or medicine from pharmacies, in rare instances. These outlets must also guarantee that no more than 50 people are at any one moment on the grounds of the establishment. All religious meetings, education, and social-cultural activities have been halted, in response to the social distancing policy. Temporary shelter for the homeless has been set up in a well-spaced manner. However, the lockdown and social distancing policies created serious obstacles. Gender-based violence (GBV) and violence against children are key issues in South Africa. As of April 3, 2020, 8,700 cases of GBV have been documented throughout the lockdown period.

Another challenger has something to do with alcohol. During the lockdown, alcohol sales and use have been banned in order to reduce social aggravation and conflict, particularly among persons in dysfunctional families and crime-ridden neighborhoods. A minister in charge of police in South Africa claimed that despite the unrest generated by the lockdown and limitations on alcohol sales and use, other forms of crime in the country had decreased. A second issue is the lack of clearly defined infrastructure in rural or informal housing, which makes social distancing hard. Remaining outdoors appears healthier than staying indoors for people who live in densely populated areas. As a result, those who live in congested and informal houses find themselves confronted with police

and army patrols imposing to stay at home. Resulting in tensions that rose between the civilian population and the army, which had been used to assist the police in enforcing and making people respect the lockdown. Numerous social media videos, for example, have surfaced showing security forces forcing military-style exercises on citizens who defied the lockdown order.

The optimistic scenario predicts a rise in poverty in Tunisia of 7.3 % points, while the pessimistic one predicts an increase of 11.9 % points. In the first scenario, the poverty rate rises by more than half, while in the second, it almost doubles, reversing the downward trend in poverty that has been occurring over the previous decade. As a result, more individuals will be at risk of being hungry and succumbing to poverty. Under the optimistic scenario, the poverty gap would rise from 3.2 % to 4.4% , and under the pessimistic one, it would rise from 3.2 % to 5 %.

Households in Tunisia's Center West and Southeast areas, which are home to the country's lowest 20% of the population, will be the most severely affected. For the most vulnerable, they are likely to be women who live in big homes, do not have access to healthcare, and work without a contract. Tunisia's unemployment rate is 42 %, while the epidemic has resulted in 53 % of people falling into poverty, and 47 % of the most vulnerable are working without a contract.

2.2 Covid-19 and GDP

After a health disaster in China, COVID-19 swiftly became a worldwide financial crisis. It is clear from our study that COVID-19 is altering nations' long-term macroeconomic and human development trajectories, aggravating already-existing vulnerabilities. For the millions of individuals who have been afflicted and died as a result of the illness, as well as the tens of millions who have been rendered jobless, the spread of COVID-19 has been disastrous. As the virus has spread, governments and civic society have implemented regulations that limit human contact and inhibit its transmission. Many individuals were nonetheless infected by the coronavirus, and fatality cases were reported throughout the world, despite the safety precautions employed. Many nations' price elasticity increased, which had an impact on the long-term viability of the supply chain. The governmental debt-to-GDP ratio in South Africa has steadily increased over the last decade, from 26% in 2008-2009 to 63.5 percent in 2019-2020. As a result, the Covid-19 emergency occurred. As of March 23, 2020, South Africa's president has stated that the country will be under a 21-day lockdown beginning March 26, 2020 and ending April 16, 2020. In order to slow the spread of Covid-19, which has caused devastation over the globe, and to prepare the healthcare system to take in those who are unwell, a lockdown has been implemented.

Structural vulnerabilities in service delivery, such as such as water supply and sanitary processes, housing, medical assistance, and infrastructural facilities, have been brought to light in communities throughout South Africa with the commencement of COVID-19. COVID-19's spread has also revealed the country's inability to manufacture facial masks, protective gloves, and experimental tools, as well as the readiness of its vital providers for a worldwide public health pandemic like COVID-19, such as COVID-19. A complicated and fast-moving crisis like Ebola has highlighted the effectiveness and reactivity of financial components such as credit life insurance plans, unemployment insurance funds, as well as the overall versatility and strength of South Africa's financial system.

COVID–19 crisis has had devastating effects on Morocco's economy, and the country is expected to go into recession in 2020 for the first time in more than two decades. After increasing by 2.5 percent in 2019, real GDP fell by 5.9 percent in 2020. Additionally, a drought in rural areas slashed rural earnings, which in turn lowered domestic demand, making it more difficult to limit the spread of COVID-19. At the end of September 2020, the unemployment rate had risen from 9.2 % to 12.7 %. Morocco's main trading partners (France, Germany, Spain, and Italy) experienced a severe economic downturn, resulting in a 10.1 % decline in international trade during the initial 10 months of 2020. Reduced consumer demand and local output cut imports by 16.6 % during the same time period Remittances, on the other hand, rose by 1.7% in the initial 10 months of 2020. As a result, the existing budget deficit is predicted to rise to 7.6 % in 2020, up from 4.1 % this year.

Through the end of September 2020, tourist arrivals were down by 78%. "Lower tourist profits, combined with dampened domestic market, a reduction in tax receipts at a time when the government was facing significant pandemic related costs and expenses." By 2020, the budget deficit would have roughly quadrupled, from 4.1% to over 8% of GDP. Government debt will increase from 65.8 % of GDP in 2019 to 76.9 % in 2020 as a result of increasing borrowing to cover the deficit. Prior to the epidemic, public debt had already been considerable, particularly due to the government's aggressive infrastructure construction program over the last decade. The low level of inflation is projected to persist. Moroccan authorities increased the range of the dirham's fluctuation on 9 March 2020 to boost the economy's capacity to withstand external shocks and to increase its competitiveness. Telecommunication, financial sectors, agricultural commodities, and chemical products have all been spared the brunt of the economic downturn's impact. Despite reducing its 2.5% reference interest rate by 25 basis points, making it 2% in March 2020 and then another 50 basis points, ending up with a benchmark interest rate of 1.5 %, Bank Al-Maghrib has made very little market interventions in the foreign exchange market. Morocco has secured more than 50 places on the World Bank's Doing Business ranking in the previous decade! Morocco was ranked as the 53rd nation out of 190 other nations in 2020.

The effect of the epidemic on the Tunisian economy became clearer as the year came to a conclusion. Since the start of this crisis, Tunisia's economic growth has been much lower than that of most of its regional rivals. In 2020, the economy will have grown by 8.8% less than it did in 2019. By the conclusion of the first quarter of 2021, the unemployment rate had risen from 15% to 17.8%. Furthermore, it continues to disproportionately afflict women (24,9 percent) and young adults (15-24 percent).

Even though the current account deficit remained significant in 2020, at 6.8% of GDP, imports decreased faster than exports, reducing it (from 8.5% in 2019). By January 2021, the US had $8.3 billion (approximately $26 per person in the US) in foreign currency reserves, compared to $7.4 billion (about $23 per person in the US) at the end of 2019 (equal to 158 days (about 5 months) of import cover). The first quarter of 2021 saw the trade deficit shrink by 10%. Compared to the same time in 2020, exports jumped by 23% and imports rose by 13.7 percent. It dropped from 523 million dinars to 177.5 million dinars in the balance of services, while remittance payments grew by 17 percent to shrink the current account balance by 6.8 percent. Growth in industrial output and exports have contributed to decreased external finance demands and lessening the burden on the country's reserves in the first quarter of this year." However, there is still a major external danger.

2.3 Covid-19 and logistics performance

Many people in Africa are afflicted by natural catastrophes and humanitarian crises, including healthcare and medical emergencies. The worldwide response to West Africa's 2014–2016 Ebola outbreak and the COVID 19 pandemic illustrates the need for efficient and productive logistics and supply chain networks in giving aid to suffering and vulnerable communities.

The subsequent stage of many safety measures to fight COVID-19 spread is the "new normal." It can be defined by e-commerce operations, which involve firms interacting with their consumers via internet technology. E-commerce necessitates tangible distribution, stores, and shipment; therefore, transportation and logistics are highlighted (D'Adamo & Lupi, 2021). It is believed that online sales will continue in the post-COVID-19 age, as customers have shown a good attitude about purchasing online, reinforcing the need for logistical systems. The logistics business will be impacted by the "new normal.". Following the limitation of travel, most of the income for airlines, for example, came from cargo services. To increase efficiency, organizations in the air transportation industry are taking steps slowly but surely to reduce operating costs through business reengineering processes, data science, and business automation. More study is required to comprehend the implications of such acts on company risks (Choi *et al.*, 2021). The transportation industry was hampered due to the constraints imposed by the lockdown measures.

As a result of these constraints, international commerce and fuel usage in logistics have decreased. The lockdowns also impacted transportation freight, which hampered the delivery of commodities. Intermodal transportation of things was suspended in the preliminary stages of the pandemic due to strong lockdown measures in numerous nations but recovered when mobility improved (Zhang *et al.*, 2021). The limits reduced vessel capacity and generated equipment shortages, affecting local and foreign trade. In South Africa, the manufacturing, trading, catering, and accommodation industries, transportation, storage, and communication industries, and mining and quarrying industries all plummeted by 65 to 75%. As a result, transportation and logistics performance suffered. This study provided more evidence that corporations must reform SCs by developing plans with essential partners.

To support Supply chain development, the disruptions produced by the COVID-19 pandemic to transportation and logistics networks necessitate collaborative solutions. In the case of Morocco, reviving shipping and ports might be one approach to restoring pre-pandemic levels. The maritime industry played an essential role in the world trade scene. Because it is the gateway that connects Africa to Europe, it is responsible for linking this country to both local and worldwide markets. Shipping and port traffic and demand decreased as a result of supply/demand contractions. Long-distance trucking experienced a similar drop in shipping. This drop is partly attributable to the fact that many of the vehicles necessary for transporting to various locations are already in low supply, and truck drivers are hesitant to prevent infection.

The COVID-19 pandemic has an impact on the worldwide value chain. Because a global value chain divides the production process among African nations, enterprises specializing in each production sector do not generate a complete product. Even though their production facilities are operating, and borders are reopened to trade, the breakout of COVID-19 triggered the closure of numerous manufacturing units, resulting in a chain reaction in international commerce.

2.4 Covid-19 effects on maintaining ISO 9001

QMS ISO 9001 is one of the tools used to ensure the quality of manufacturing methods. ISO 9001:2015 emphasizes that risk-based thoughts is directed toward the goods and services provided by a specific company in order to ensure the consistency of processes for providing goods and services and meeting the needs of customers (Zimon *et al.*, 2021).

Despite this, companies are struggling hard to maintain the same quality rates that they had before their ISO 9001 certification lapsed during the COVID-19 flu epidemic. The UK Accreditation Service is developing legislation for businesses that were affected by COVID-19 travel requirements and teleworking, as well as methods by which these businesses can interact with accreditation bodies in the specific situation of the disease outbreak.

Among some of the metrics, the use of remote evaluations permits the investigation of documents, even though it does not adequately cover the same objectives as on-site visits. Certified CABs, as well as NABs accreditations, may face problems if they decide to stop supplying some services or even deviate temporarily in order to meet criteria and certification regulations. Members of the European Cooperation for Accreditation, as well as certified administrators of volunteer services, advise on the importance of acting responsibly and transparently when offering services which become subtly different from requirements, as well as not delivering assistance that endangers technical validity (ISO, 2021). Now, regulatory agencies demand emergency plans, which include weather-related events, epidemics, and other human-made concerns.

COVID-19 has emphasized the importance of providing a conducive environment for revising, updating, and testing the aforementioned strategies. When a particular industry necessitates on-site evaluations, the use of information and communication technologies (ICT) to conduct distant evaluations will facilitate the evaluation process. During the flu epidemic, ICT tools enabled numerous operations and grew in popularity as a remedy for several businesses. On-site measures, on the other hand, demand for the employment of preventative measures such as masks, social separation, and quarantine for auditors. Remote auditing is not a novel notion. The ANSI National

Accreditation Board certification processes previously employed distant assessments regularly when evaluating firms with teleworkers or even organizations in the technology industry.

3. Research methodology

The study aims to analyze the prospective effects of COVID-19 on population, GDP, logistics performance, as well as QMS ISO 9001 certifications mainly in the top three affected African countries with high COVID-19 prevalence such as Morocco, Tunisia, and South Africa. To have a clear idea about the quality performance, this study used ISO 9001 Quality Management System which is one of the methods for assuring the quality of manufacturing operations, these certifications emphasize the application of risk-based thinking to a company's goods and services in order to ensure the consistency of procedures and operations for delivering products and services and meeting customers' requirements. The LPI (Logistics Performance Index), which stands for logistics performance index, evaluates the trade supply chain characteristics related to the chosen nations and scores them out of a range of 1 that represents the worst score to 3 which represents the best score. Finally, from March 1 of 2020, up to December 31 of 2020, the total number of COVID-19 cases in the top three African nations was rising exponentially.

In the current study, data analysis involved four phases. In the first stage, data was gathered from several databases for the research from January 1, 2020, to December 31, 2020, and is normalized. In the second step, GRA models are used to investigate the link between COVID-19 instances and population, GDP, Logistics Performance, and ISO 9001. The GRG-based ranking is utilized in the third step, which uses the weights/scores yielded in the second stage, and is allocated alternatives, after specifying the decision criteria. The conservative model then goes through the analytical findings to identify the most optimal solution (the variable or combination of variables), which demonstrates how African nations were affected by the pandemic. In Figure 1, we present the framework of the study.

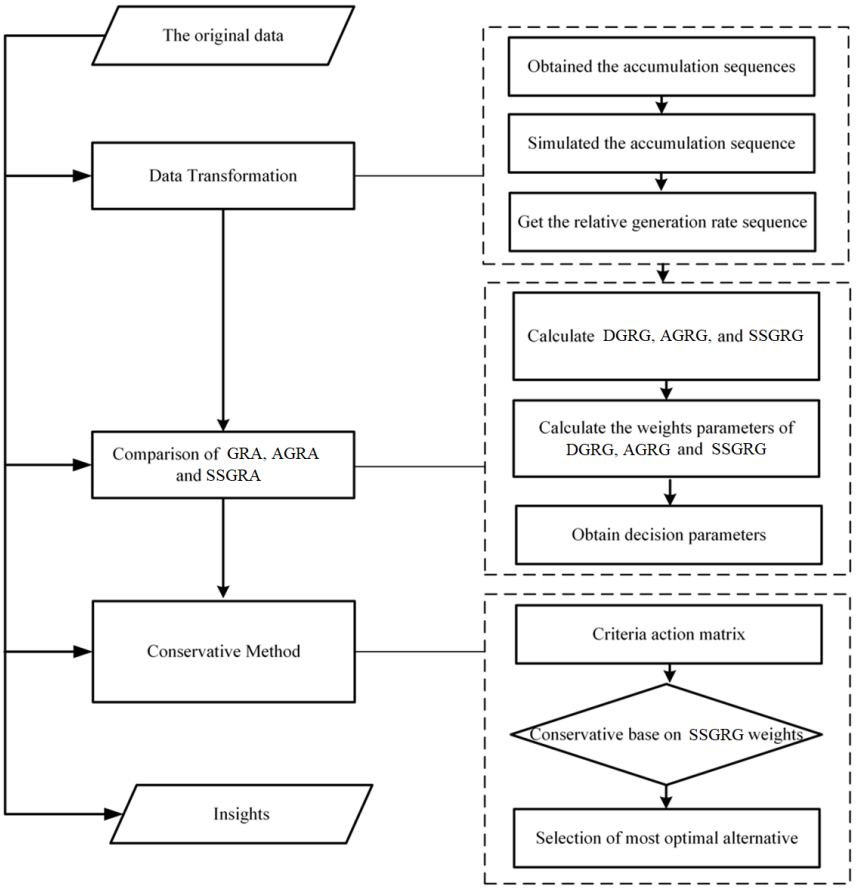

Figure 1. Schematic framework of the study (Adapted from Ikram *et al.*, 2021)

3.1 Data Collection

To conduct this research, a set of secondary data was used to draw conclusions and comparisons. The data related to population and GDP was obtained from the website of World Bank (www.worldbank.org). Moreover, the data related to Logistic Performance and ISO 9001 was collected from the website of Global Innovation Index (https://www.globalinnovationindex.org). While procedures differ depending on the field, the focus on ensuring accurate and honest collecting remains constant. The variables, units and time scale of the data involved in the current study is shown in Table 1. The statistics reported in the current study mostly came from published reports such as ADB (2021), NICD (2021), dailymorocco.com, Gerorank (2021), World Bank (2022), among others.

3.2 Grey Relational Analysis

Professor Julong Deng created the grey system theory in 1982 (Ju-Long, 1982). His GRA model is an important components of the grey system theory. The Grey Relational Analysis (GRA) models have gained a lot of attention in the last two decades. Management, engineering, economics, and medicine are just a few of the disciplines where GRG models are used (Xu & Li, 2018). GRA have become a popular choice since they outperform other techniques in a variety of ways. GRA is capable of handling limited data collection as well as grey values and delivering optimal results (Ikram *et al.*, 2021; Liu *et al.*, 2017). The GRA models outperform other techniques when it comes to dealing with data problems, such as missing values or inaccurate data sources (Ikram et., 2019b). It also maximizes the efficiency of the limited dataset (Rehman *et al.*, 2020). GRA models, give stronger foundations for understanding the conceptual model's complexity (Dai *et al.*, 2014). Recently, many scholars have used the GRA models in different industries. Tsoy (2022) used the GRA for evaluating the expectations of the Russian citizens from increasing gas exports to Europe. Ivanova (2022) used it to evaluate risks to food supply chains. Kharipzhanova and Irfan (2022) used it to evaluate the barriers to tourism in Gilgit Baltistan. Sheikh *et al.* (2019) used the GRA models to analyse the key factors influencing process quality during construction projects in Pakistan. A detailed discussion on the GRA models can be found in Liu *et al.* (2017). The three important GRA models are defined below (Javed & Liu, 2018).

3.2.1 Deng's Grey Relational Analysis: Let $X_0 = \left(x_0(1), x_0(2), \dots, x_0(n)\right)$is the reference data sequence and $X_k = \left(x_k(1), x_k(2), \dots, x_k(n)\right)$ is the alternative data sequence then the Deng's Grey Relational Grade (DGRG) between the two data sets is given by (Javed *et al.*, 2022),

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

Table 1. The variables, units and time scale of the data

Code	Variables	Units	Time scale	Source of data
X_0	COVID-19 cases	Total number of COVID cases	January 2020 to Dec 2021	WHO (2022)
X_1	Population	Number of people	2020-2021	World Bank (2022)
X_2	GDP	Per Capita	2020-2021	World Bank (2022)
X_3	Logistic performance	Performance measurement based on Logistics Performance Index (LPI) by using scale of 1 (worst) to 5 (best)	2020-2021	Global Innovation Index (2022)
X_4	ISO 9001 certifications	ISO 9001:2015 sets out the criteria for a quality management system	2020-2021	Global Innovation Index (2022)

where,

$$\gamma_{0k}(j) = \frac{\Delta_{min} + \xi * \Delta_{max}}{|\Delta_{0k}(j)| + \xi * \Delta_{max}}, k = 1,2, \dots, m \quad (2)$$

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

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

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

Here, ξ represents the Distinguishing Coefficient, m denotes the total number of comparative data sequences, and n denotes the total number of data points in each data sequence. In the current study, $\xi = 0.5$ and $w(j)$ was replaced by $\frac{1}{n}$ since all data values were equally weighted.

3.2.2 Absolute Grey Relational Analysis: Let $X_0 = \big(x_0(1), x_0(2), \dots, x_0(n)\big)$ is the reference data sequence and $X_k = \big(x_k(1), x_k(2), \dots, x_k(n)\big)$ is the alternative data sequence, and their zero-point starting images are $X_0^0 = \big(x_0^0(1), x_0^0(2), \dots, x_0^0(n)\big)$ and $X_k^0 = \big(x_k^0(1), x_k^0(2), \dots, x_k^0(n)\big)$, then Absolute Grey Relational Grade (AGRG) is given by (Javed & Liu, 2019),

$$\varepsilon_{0k} = \frac{1 + |s_0| + |s_k|}{1 + |s_0| + |s_k| + |s_0 - s_k|} \quad (6)$$

where,

$$|s_0| = \left| \sum_{j=2}^{n-1} x_0^0(j) + \frac{1}{2} x_0^0(n) \right| \quad (7)$$

$$|s_k| = \left| \sum_{j=2}^{n-1} x_k^0(j) + \frac{1}{2} x_k^0(n) \right| \quad (8)$$

$$|s_0 - s_k| = \left| \sum_{k=2}^{n-1} (x_0^0(j) - x_k^0(j)) + \frac{1}{2} (x_0^0(n) - x_k^0(n)) \right| \quad (9)$$

3.2.3 Second Synthetic Grey Relational Analysis: Let $X_0 = \big(x_0(1), x_0(2), \dots, x_0(n)\big)$ is the reference data sequence and $X_k = \big(x_k(1), x_k(2), \dots, x_k(n)\big)$ is the alternative data sequence. Let Γ_{0k} denotes Deng's Grey Relational Grade, and ε_{0k} denotes Absolute Grey Relational Grade, then the Second Synthetic Grey Relational Grade (SSGRG) is their weighted mean and is given by (Javed & Liu, 2018),

$$\varrho_{0k} = \theta * \varepsilon_{0k} + (1 - \theta) * \Gamma_{0k} \quad (10)$$

where, θ is a coefficient whose value ranges between 0 and 1. Generally, its value is taken as 0.5.

4. Results and discussion

The links between COVID-19, population, GDP (current value in USD), logistics performance, as well as QMS ISO 9001 certification in the three highly affected African nations, namely South Africa, Morocco, and Tunisia, are investigated using GRG models. GRA models are a superior

strategy since they confront endogeneity concerns as well as grey values while offering the optimum answer. Tables 2 to 5 display the analytical outcomes for DGRG, AGRG and SSGRG.

Using GRA models, we may evaluate and investigate the relation between COVID-19, population, GDP, logistics performance, as well as QMS ISO 9001 certifications in the highly impacted African countries in 2020. DGRG, AGRG and SSGRG exhibit the relationship between these components. The AGRG model rates the strength of linkages on a scale of 0 to 1, with 0 representing the weakest links and values closer to 1 representing the strongest. In this study, a higher score value indicates that COVID-19 has a strong intensifying impact. The DGRG model uses a scale of 0.5 to 1, with 0.5 representing a moderate effect and 1 indicating a high influence among study variables. SSGRG, on the other hand, represents the sum of AGRG and DGRG, indicating both association and implications. Figure 2 evaluates COVID-19, population, GDP, logistical performance, and QMS (ISO 9001 certifications).

As seen in Table 2, the Grey Relational Analyses scores for COVID-19, as well as population are measured for the top three highly affected African countries. According to the AGRG data, South Africa had the highest rating of 0.9297, meaning that COVID-19 had a deleterious influence on the South African population in the year of 2020. Followed by Tunisia with an absolute GRG score of 0. 9286. While Morocco has scored the lowest absolute GRG with a value of 0.7536. Referring to the DGRG, Morocco and Tunisia received the highest-ranking scores of 0.8119 and 0.7474, respectively, succeeded by South Africa with the lowest score of 0.7017 suggesting that these three countries' population has been severely affected owing to the effect of COVID-19 confirmed cases of contamination and mortality. The SSGRG model, on the other hand, has revealed a quite similar ordering trend between population and the viruse's number of cases with Tunisia scoring the highest value of 0.8186, the main difference in this model if that South Africa scored the second value, respectively, while Morocco came last with the lowest score of 0.7811.

The association between COVID-19 cases and GDP in the top afflicted African countries is explored in Table 3. With a weight score of 0.9096, Tunisia's GDP received the highest position in the AGRG, meaning that COVID-19 will have a negative influence on Tunisia's GDP in 2020. With association values of 0.8581 and 0.8336 respectively, Morocco and South Africa are rated second and last, respectively. As shown by DGRG findings, Tunisia as well as South Africa received the highest values of 0.7466 and 0.7456, respectively, implying that the effect of COVID-19 number of instances has reduced drastically the GDP of these three countries. The worldwide COVID-19 pandemic, the consequent production as well as the global trade flow limitations, resulted in a drop in South Africa's commerce in March 2020. In the top-three most afflicted African nations, the SSGRG model revealed the similar ordering trend between the number of cases and GDP. Morocco and Tunisia got heights scores of 0.8993 and 0.8377, respectively, followed by South Africa with the lowest score of 0.7708.

Table 4 displays the Grey Relational Assessment scores for COVID-19, as well as the logistical performance. The AGRG demonstrates that the coronavirus pandemic has had a negative and long-term impact on the logistical systems of South Africa, Morocco, and Tunisia, which are ranked first and second in Africa, respectively. In fact, South Africa has the greatest AGRG of "0.8662." The other two nations recorded "0.5933" for Morocco and "0.5540" for Tunisia. Lockdown and

Table 2. Grey Relational Assessment for COVID-19 and Population

	AGRG	DGRG	SSGRG
South Africa	0.92970405	0.70175754	0.79516658
Morocco	0.75359648	0.81198711	0.78118801
Tunisia	0.92869504	0.74744010	0.81865925

Table 3. Grey Relational Assessment for COVID-19 and GDP (Current US$)

	AGRG	DGRG	SSGRG
South Africa	0.83360368	0.74560464	0.77084981
Morocco	0.85818835	0.71297424	0.89931074
Tunisia	0.90966922	0.74662434	0.83773708

Table 4. Grey Relational Assessment for COVID-19 and Logistics Performance

	AGRG	DGRG	SSGRG
South Africa	0.85521072	0.70985376	0.79419744
Morocco	0.59336256	0.61416531	0.60538044
Tunisia	0.55403712	0.70960923	0.61070994

Table 5. Grey Relational Assessment for COVID-19 and ISO 9001 certification

	AGRG	DGRG	SSGRG
South Africa	0.60802434	0.70985376	0.69137806
Morocco	0.59336256	0.76900923	0.65512594
Tunisia	0.55403712	0.84094164	0.79716963

safety measures have had a substantial impact on industrial and logistical activities, which have a direct impact on product demand and supply. As a result of the logistics industry's interconnectedness, operations were weak or non-existent (Singh *et al.*, 2021; Miceli *et al.*, 2021). According to the SSGRG model, South Africa suffered the most damage of the three countries, reporting an SSGRG of "0.7941," which is higher than the "0.6107" and "0.6053" achieved by Tunisia and Morocco, respectively.

Quality standards, taking in this case ISO 9001 certifications, necessitate adjustments in habits, methods, as well as the responsibilities of management and workers in order to completely overhaul an organization (Ikram *et al.*, 2019a). Due to travel constraints and social hurdles, the development of COVID-19 hinders the successful and lasting of ISO 9001. We looked at how unplanned events like COVID-19 might hinder QMS implementation and how firms can keep their production processes operating while meeting quality standards in this study. Table 4 shows the COVID-ISO 9001 relationship in the top three most affected African nations. For all of the nations included in this analysis, the number of ISO 9001 certificates is on the decline. South Africa came in top in the row, with an AGRG score of 0.6080, followed by Morocco with a score of 0.5933 and Tunisia with a score of 0.5540, respectively.

Table 5 delivers an identical raking sequence outcomes for COVID-19 in relation with QMS ISO 9001 certifications in the three most impacted African nations, as shown by DGRG and

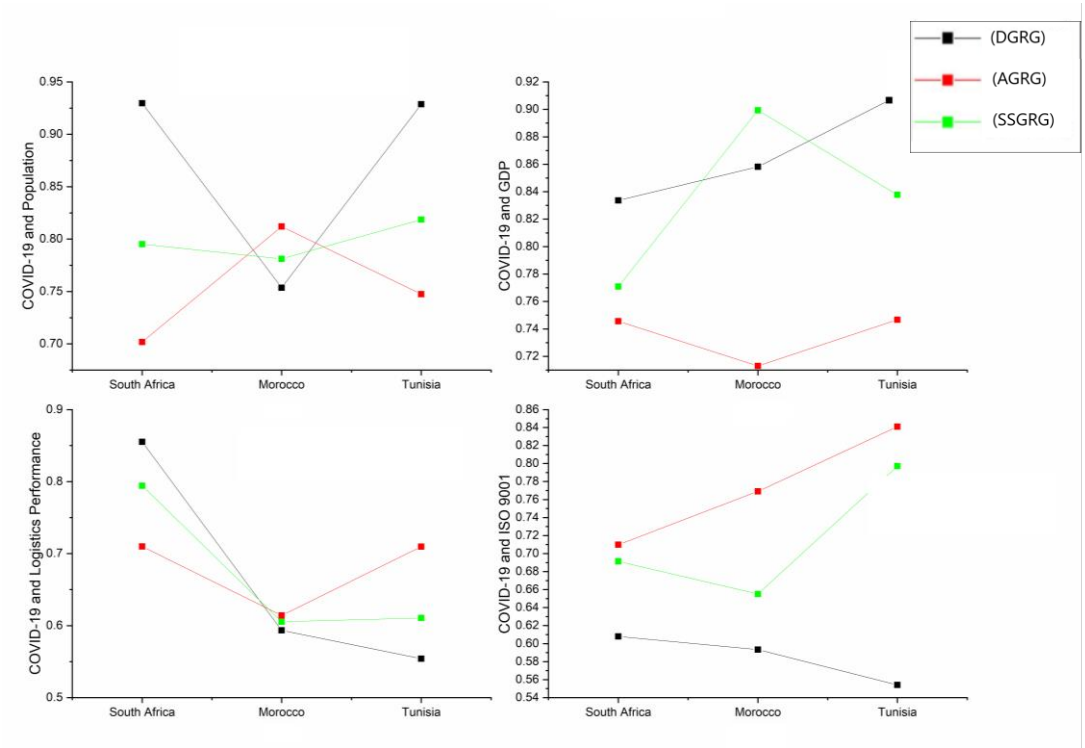

Figure 2. GRG based evaluation of COVID-19 population, economic growth, logistic performance, and quality management

SSGRG. South Africa scored the highest values of 0.8494 and 0.9110 and has the most influenced and unfavorable link between pandemic outbreak and ISO 9001 certifications. In terms of the QMS ISO 9001 certification procedure, Morocco is the second most affected, followed by Tunisia, which was the most affected nation during the pandemic crisis. Furthermore, the position of the top three highly affected African countries changes in DGRG and SSGRG models. As in DGRG, Tunisia is ranked first, while Morocco and South Africa are ranked second and last, respectively. Table 5 displays the results of the correlation between COVID-19 and ISO 9001 certification.

As an overall analysis of this research, Tunisia, like Morocco, exhibited a substantial negative relationship between COVID-19 and the GDP of these countries. Whereas, among all the top three highly affected African countries, South Africa exhibited a substantial negative relationship between COVID-19 and population along with the logistic performance of this country.

Following the calculation of weighted values and scores, the top three African nations may be ranked based on population, GDP, logistics performance, and ISO 9001 certifications. Furthermore, based on the GRA models, the upcoming phase of this process analyses which country has the least amplified impact of COVID-19 on its population, economic growth, logistics performance, and quality management system requirements. To do so, we established the assessment and decision parameters, which detailed description is outlined in Table 6. Here, m = 4, n = 3, outcome = $v(a_i, S_j)$, whereas i = 1, 2, 3, 4 and j = 1, 2, 3. Let a_1, a_2, a_3 and a_4 show the SSGRG of population, GDP, logistics performance, and ISO 9001 certifications in the top three highly affected COVID-19 African nations is presented in Table 6.

Table 7 shows the decision parameters. Table 8 shows the SSGRG, which explains the relationships between the study elements in order to organize the variables and conclude the criteria answer. The influence of COVID-19 on population, GDP, logistic performance, and ISO 9001 certifications in South Africa, Morocco, and Tunisia is then evaluated using a decision-making model, as shown in Table 7.

Finally, based on SSGRG results, we used the conservative (MiniMax and MiniMin) model (Javed & Liu, 2018; Ikram *et al.*, 2019a; 2019b) to determine which nation(s) have the least (or highest) intensifying impacted among all of the top three affected COVID-19 African countries, as shown in Table 8. In this study, we emphasize decreasing the better criterion, with the minimal value of V obtained from the SSGRG matrix model for each nation. The MiniMax model yields,

$$\min a_i \{\max S_j \ v(a_i, S_j)\} = \max a_i \begin{Bmatrix} 0.8187 \\ 0.8993 \\ 0.7942 \\ 0.7972 \end{Bmatrix} = 0.7942 \text{ (South Africa)}$$

The results indicate that the overall grey relation between the factors is strongest for South Africa, i.e., the grey relation between the COVID-19 and other factors is generally strongest for it.

Table 6. Grey Assessment Ranking of highly effected COVID-19 African countries

Variables	Grey Relational Model	Ranking
Population	AGRG	South Africa > Tunisia > Morocco
	DGRG	Morocco > Tunisia > South Africa
	SSGRG	Tunisia > South Africa > Morocco
GDP	AGRG	Tunisia > Morocco > South Africa
	DGRG	Tunisia > South Africa > Morocco
	SSGRG	Morocco > Tunisia > South Africa
Logistics Performance	AGRG	South Africa > Morocco > Tunisia
	DGRG	South Africa > Tunisia > Morocco
	SSGRG	South Africa > Tunisia > Morocco
ISO 9001	AGRG	South Africa > Morocco > Tunisia
	DGRG	Tunisia > Morocco > South Africa
	SSGRG	Tunisia > South Africa > Morocco

Table 7. The decision parameters

Goal	Measuring Grey Relation (Association) between Population, GDP (Current $) , logistic performance, ISO 9001 within highly effected COVID-19 African Countries
State of Nature (S_j); $j = 1,2,\dots,n$	South Africa (S_1) Morocco (S_2) Tunisia (S_3)
Alternative Actions (a_i); $i = 1,2,\dots,m$	Grey Relation was superior between COVID-19 cases and Population (a_1) Grey Relation was superior between COVID-19 cases and GDP (a_2) Grey Relation was superior between COVID-19 cases and logistic performance(a_3) Grey Relation was superior between COVID-19 cases and ISO 9001 certification (a_4)

Table 8. The criteria-actions matrix based on the SSGRG values

	S_1	S_2	S_3
a_1	0.7952	0.7812	0.8187
a_2	0.7708	0.8993	0.8377
a_3	0.7942	0.6054	0.6107
a_4	0.6914	0.6551	0.7972

The MiniMin model yields,

$$\min a_i \{\min S_j \ v(a_i, S_j)\} = \min a_i \begin{Bmatrix} 0.7812 \\ 0.7709 \\ 0.6054 \\ 0.6551 \end{Bmatrix} = 0.6054 \text{ (Morocco)}$$

The results indicate that the overall grey relation between the factors is weakest for Morocco, i.e., the grey relation between the COVID-19 and other factors is generally weakest for it. Thus, Morocco's system is more resilient, while that of Tunisia lies between the two countries.

This paper examines the impact of COVID-19 on population, GDP, logistics performance, and ISO 9001 quality management systems in a multi-framework for the most COVID-19 afflicted top three African nations. Individual independent factors have been investigated for their possible impact on dependent variables in the study.

5. Conclusion and implications

Using unique advanced mathematical modelling, particularly the GRA technique, this research examines the impacts of COVID-19 on population, GDP, logistics performance, and ISO 9001 certifications in the three heavily affected African nations (South Africa, Morocco, and Tunisia). To focus on the extent to which COVID-19 has altered the economic system of these countries we employed AGRG, DGRG, and SSGRG to investigate the possible link between various metrics.

The following is a summary of our findings. First, regardless of whether the metric is used to quantify the severity of COVID-19, we have observed that during a pandemic epidemic, COVID-19 has a severe negative impact on the population, GDP, logistics performance, and ISO 9001 certifications in all three heavily afflicted nations.

During the COVID-19 disease transmission, all the designated nations' logistical activities were shut down, resulting in thousands of transactions being abandoned or delayed, resulting in large losses and detrimental consequences on economic growth. COVID-19 caused negative economic development in all three nations. This finding shows that the disruption of logistics activity caused by COVID 19 has a detrimental impact on the logistics employment market. Organizational sustainability goals are also jeopardized as a result of the COVID-19 epidemic. ISO 9001, one of the most effective instruments for guiding quality system management, has been severely harmed.

The certifying body failed to follow up on the COVID-19 surveillance audits, affecting the firms' environmental performance and quality requirements throughout manufacturing operations.

This study implies some theoretical as well as practical implications. This is the first research of its kind in Morocco, establishing a framework and analyzing the escalating impacts of COVID-19 on population, GDP, logistic performance, and ISO 9001 certification. Until now, studies have confined their research to GDP, but no one has addressed the population, logistic performance, and ISO 9001 certification in connection to the current scenario. This study addresses a void in the literature by analyzing the impacts of COVID-19 on the population, GDP, logistic performance, and ISO 9001 certification in connection to the COVID-19 scenario utilizing GRG models in the top 3 top affected African countries. The technique used (AGRG, DGRG, and SSGRG) proved useful for studying nations classed as developing economies in order to encourage growth. We advise using such methodologies to analyze other developing economies and compare the outcomes to our findings.

There are several policy considerations that leaders, international agencies, and countries should consider while developing an emergency strategy to protect economies from further damage and enhance logistics and quality performance during the COVID-19 pandemic.

These policy points are presented as follows: One of the primary goals of government is to keep the pandemic under control, and various nations are focusing their efforts on this goal in unusual ways. These measures will enable a quicker return to normalcy, as well as assistance for national governments' recovery strategies. It is also possible to ease the procedure of certification so that commercial activities are not affected beyond the remote audit. One option is to extend certification renewals for organizations that currently have them until the conclusion of the pandemic emergency. They should also take into consideration the lack of reserves they can eventually face, especially after the lockdown because of the extremely limited trade countries are open to. To avoid that, some agreement among other nations should be made to secure a smooth and satisfying consumer experience for the citizens and avoid any uncontrollable inflation that could damage the country heavily in the future.

This study does have some limitations. We only listed three of Africa's most impacted countries and conducted a comparison based on population, GDP, logistic performance, and ISO 9001 certification. Since data was only available until 2021, data from the entire year (2020-2021) was utilized in this analysis. To explore the escalating impacts of COVID-19 on population, economic growth, logistic performance, as well as the ISO 9001 certification, we employed GRG models such as Absolute GRG, Deng's GRG, and the Second Synthetic GRG model.

Future studies may be undertaken on many countries, such as those in the Arab world. Furthermore, in the future, a comparison investigation between industrialized and developing nations might be undertaken to evaluate how the countries faced the COVID-19 epidemic. Also, the impacts of COVID-19 on other criteria such as social certification, health and safety certification, renewable energy generation, and access to power may be explored using various techniques of analysis.

Data availability

Data will be made available on a reasonable request to the corresponding author.

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