

Intensifying effects of COVID-19 on economic growth, Logistics Performance, Environmental Sustainability and Quality Management: Evidence from Asian Countries

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Abstract

Purpose: This study is the first to explore the effects of COVID-19 outbreak on exports of goods & services, logistics performance, environmental management system (ISO 14001) certification and quality management system (ISO 9001) certification in top effected Asian countries of India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan.

Method/Approach: A novel Grey Relational Analysis (GRA) models' approach is employed to examine the inter-relationship between COVID-19 economic growth and environmental performance. Moreover, we applied Conservative (maximin) model to investigate which countries have the least intensifying affected among all of the top affected COVID-19 Asian countries based on SSGRG values. The data used in this study collected from multiple databases during 2020 for analysis.

Findings: Results indicate that the severity of COVID-19, shows a strong negative association and influence of COVID-19 on exportations of goods and services, logistics performance, ISO 9001, and ISO 14001 certifications in all the six highly affected countries during pandemic outbreak. Although the adverse effects of COVID-19 in exporting countries persisted until December 31, 2020, their magnitude decreased over time in Indonesia and Pakistan. During the COVID-19 outbreak, Pakistan showed the comparatively better performance among the six top highly affected Asian countries due to smart locked down strategy and prevents it economy from severe damages. Whereas India and Iran exports drastically go down due to rapid increase in number of COVID-19 cases and deaths.

Implications: The research findings produce a much-required policy suggestions for leaders, world agencies and governments to take corrective measures on emergent basis to prevent the economies from more damages and improve their logistics, environmental, and quality performance during pandemic of COVID-19.

Originality: This study develops a framework and investigates the intensifying effects of COVID-19 effects on economic growth, logistics performance, environmental performance, and quality production processes.

Keywords: COVID-19; Economic growth; logistics performance; ISO 14001; ISO 9001; Asian countries

1. Introduction

The outbreak caused by the COVID-19 responsible for two crises at a global scale, namely, the health and the economic crises. Even though human health in various countries and areas were the most affected, the outbreak also brought severe consequences to the social and environmental systems. The spread of the COVID-19 was accelerated due the globalization of supply chains (Paul *et al.*, 2021; Rahman *et al.*, 2021). While we pursue the efficiency and integration of global organizations on supply chains, the virus is made possible to spread at higher rates. The first solutions to avoid the virus spread and incentivize countries to take responsible actions were the measures taken in

order to enact transportation restrictions, prohibiting social interactions and mobility, and mandating workplace closures (Paul & Chowdhury, 2021) .

As a result of this pandemic, businesses, workers, and business owners experienced an immediate economic shock in all over the world. Considering the global supply chain operation, in particular, both supply and demand sides were affected, and unprecedented imbalance was caused in trading of goods and services. The uncertainty caused by the outbreak threaded businesses involved in export/import activities and those related to international investments. Even though there are companies that are used to a certain degree of uncertainty and their business environment or market niche, exceptional circumstances never faced before like COVID-19 pandemic.

In the post COVID-19 pandemic times, various countries are still facing the changes and challenge to deal with the disease and the spread of coronavirus variants (namely the Delta variant). While the COVID-19 outbreak is under well control since mid-March 2020 in China and other Asian countries (such as Singapore, South Korea and Japan, among others) successfully implemented several measures to control the impacts of the disease, such as lockdowns, hygiene and self-protection measures, unified and centralized treatment in the early stage of the pandemic (Lu *et al.*, 2020), those measures are periodically effective and risks still exist in the long run. In many other European countries, such as Italy, Germany, Spain and France, the pandemic spread and caused thousand deaths, turning these countries the epicenter of the pandemic. As the European countries acted to reduce the effects of the disease, the outbreak hit the US, transforming this country, and lately Brazil and India, as the new epicenters of the pandemic. Until the date this research paper was prepared, the total confirmed COVID-19 cases exceeded 190 million people in the world (Worldometers, 2021). Nowadays, even though the world is vaccinating into different speed rates, the countries are witnessing the emergence of coronavirus variants, causing new uncertainties.

Figure 1 depicts that the India have more than 31 million COVID-19 number of cases and is top among six selected countries in our study (India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan). Moreover, Iran and Indonesia are the top second and third most effected by COVID-19 Asian countries, with 3,548,704 and 2,911,733 number of cases followed by Philippines and Bangladesh with 1,513,996 and 1,117,310 number of cases respectively. Whereas Pakistan has the least number of COVID-cases until now due to smart lockdown strategy during pandemic. The strategy of smart locked down not only prevented the spread of virus further but also protected the livelihoods of hundreds and thousands of the poor people of Pakistan (World Asia, 2020).

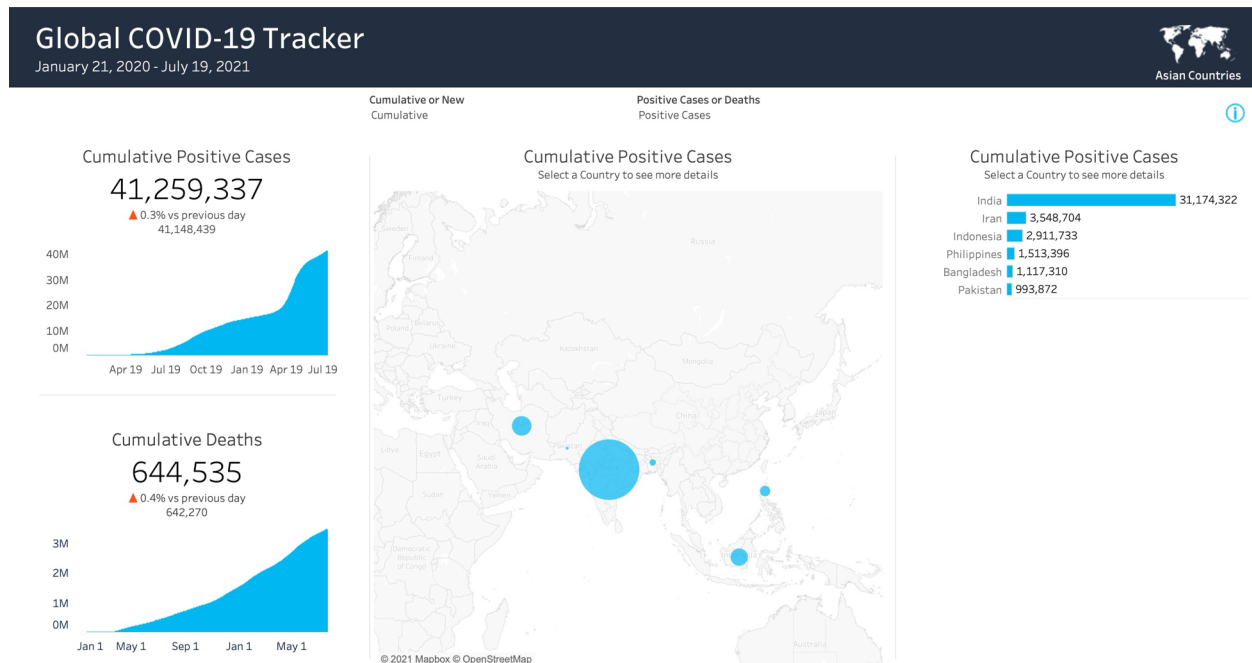


Fig. 1. The COVID-19 total number of cases in top effected Asian countries

The immediately crisis caused by the COVID-19 pandemic is in health. In addition, the negative effects of the pandemic have extended to international trade, where the global trading registered a record being the largest ever in one-period of decline. Since second quarter of 2020, the global trading fell to 14.3% in comparison to same previous periods.

According to World Trade Organization (WTO), it was expected a decline in the international trade and commerce scenario at rates between 13% up to 32%. Additionally, about 44% of companies worldwide do not possess any plan to deal with supply chain disruptions (SCD) along the COVID-19 pandemic. The supply chains (SC) were challenged by pandemic groundbreaking speed and scale for providing critical supplies of masks, sanitizers, medical oxygen, personal protective equipment, and foods (Bappy *et al.*, 2019; Singh *et al.*, 2021). The unbalance witnessed in SC led shut-down of industries, stoppage of manufactured items, and damages of the global SC.

Even though online businesses and sales evolved rapidly as a solution for keeping commercialization of goods in all industries, the logistics for on-demand deliveries increased exponentially making the supply chains and logistics under pressure. SCs and manufacturing operations were overloaded due the outbreak, affecting global SCs during second quarter of 2020 (Chowdhury *et al.*, 2020; Moktadir *et al.*, 2020). These pressures evidenced the need for more resilient SCs and innovative approaches towards recovery (Remko, 2020; Sassanelli *et al.*, 2020) also because

logistics systems are critical for establishing a recovery of SCs (Sassanelli *et al.*, 2019). Among SCs, the food and healthcare SCs are those most critical during the COVID-19 pandemic due to supply of basic products of such industries (Belhadi *et al.*, 2021). Any weakling point in these two SCs can result in revenue loss, unmet demand needs, and supply fulfillment (de Sousa Jabbour *et al.*, 2020). Previous research indicated gaps in literature both empirically and theoretically concerning the impacts of COVID-19 pandemic on SCs and SC sustainability under the pandemic (Chowdhury *et al.*, 2021; Blundo *et al.*, 2019), the impacts of pandemic in the waste supply chain (Appolloni *et al.*, 2021), and in other industrial sectors (Paul and Chowdhury, 2020). Concurrently, other studies underlined the need for considering eco-innovation practices for overcoming the sustainability issues triggered by COVID-19 in India (Marimuthu *et al.*, 2021), and furthermore, how problem-solving approaches (such as Lean Six Sigma's Define-Measure-Analyze-Improve-Control) could improve the practical application of SCs (Blundo *et al.*, 2019; Tay and Loh, 2021).

More importantly, these consequences are also disrupting business activities on certificating sustainability standards (especially for ISO 9001 and ISO 26000 among others) (Ikram *et al.*, 2020a), where accreditations bodies are monitoring governments and providing external advice for assessing risks and the contingency plans of organizations to meet the sustainability standards of such accreditation's bodies. The auditing services preconized by ISO 9001:2015 were affected by the pandemic and were postponed or were conducted at remote mode. As occurring in several other organizations, sanitized and safety protocols were also extended to auditors and those involved in face-to-face audits. Auditors assess how organizations are managing the needed changes and actions aiming their ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements (Auld and Renckens, 2021).

Among several tools that organizations may consider coping environmental challenges and aim sustainability is the Environmental Management Systems (EMSs). One of the most recurrent EMS is the ISO 14001, established in 1996 and updated along the years (Abid *et al.*, 2021; Ikram *et al.*, 2020). The EMSs allow organizations find guidance and rules when dealing with environmental management issues, both at internal and external levels (Ikram *et al.*, 2021). The outbreak caused by COVID-19 and travel restrictions of most countries affected the conformity assessment and accreditations activities, and so for ISO 14001 registration and surveillance auditing processes. The maintenance of

ISO 14001 is essential especially for those organizations that have contractual requirements tied to ISO 14001. Then, the Conformity Assessment Bodies (CABs) and National Accreditations Bodies (NABs) were forced to reorganize the activities due the on-site assessments, audits, and visits for inspections were prohibited due the pandemic (DNVGL, 2020).

Based on the context mentioned above, this research aims to contribute to the current research by:

- Examining the effects of COVID-19 outbreak on exports of goods and services, logistic performance, ISO 9001 and ISO 14001 certifications in the most affected Asian countries, beyond existing studies which only addressed the effect of COVID-19 on SCs activities;
- Developing a multidimensional framework in order to fulfill the gap found in literature related to this matter. In doing so, data related to COVID-19 cases, logistics performance, ISO 9001 and ISO 14001 certifications in the year range of 2020 were used in analyses;
- Applying the novel GRA models approach, a methodology that provides consistent and unbiased solutions and is recommended for small data sample. By ensuring the accuracy of database with even incomplete information and uncertainties, GRA models allow the identification of the most effective elements to be investigated regarding the effects of COVID-19 pandemic on exportations of goods and services, logistics performance, ISO 9001, and ISO 14001 certifications; Among one of the main advantages of using GRA models is the accuracy and superiority if compared with statistical models (Ikram et al., 2020).
- Contributing to the on-going research by setting paths for future studies on action plans for Asian countries and offering policy implications for the economic recovery and sustainable development of the said countries, particularly considering that the existing literature on COVID-19 effects and the study of variables have not been addressed broadly in the context of Asian countries.

The rest of this paper is structured as follows: Section 2 presents the background of COVID-19 effects on exports of goods & services, logistics performance, ISO 9001 and 14001 certifications; Section 3 describes the data information and construction steps of GRA models; Section 4 indicates the results and discussion. The conclusion, policy implications, and future directions are presented in the last section of this study.

2. Background

2.1 COVID and exports of goods and services

Social distancing and lockdown measures almost ceased people's mobility. Despite undertaken safety measures, many people were still infected by the coronavirus and the death cases were observed globally. These changes affected the SCs of goods by enlarging their elasticity of prices with steeper trending in many countries. Exports activities were also affected by the lockdown and disrupted transportation sectors, resulting in an increase of the exportation, storage at ports, and terminal handling costs.

Taking the petroleum products and byproducts as an example, they were the most affected commodities in exportations from India (declining to circa 32% in January 2021 if compared the same previous period). Six out of seven greatest economies showed economic recession and massive GDP loss in 2020, and a slump in consumption patterns affected international trade scenario (Statista, 2021). The conventional economy needs a transition to Circular Economy (CE) paradigm, or a synergistic view combining ecological and economic systems (Rocca *et al.*, 2020; Sassanelli *et al.*, 2021). Moreover, the organizations should adopt and integrate clean technologies to their business process to facilitate sustainability (D'Adamo *et al.*, 2019, 2020).

Following the lockdowns measures at a global scale, India announced its first lockdown at the end of March 2020; Its blockage of infections chains resulted not only in a decrease of mobility, but also in disproportional impacts in livelihoods, especially those with daily/hourly wages. Among manufacturing industries, the automotive was the one that suffered greatest impacts, alongside the petroleum consumption that also decreased (Kanitkar, 2020).

In Iran, the outbreak provided an ambiguous state. The covid-19 has the long-lasting effects on different sectors of economy. According to data available from FM Global Resilience Index, in 2020, Iran was ranked as 125 of 130 countries. The expenditure for combating COVID-19 pandemic in the country, summed with the falling of oil revenues were responsible for most increases of Iranian fiscal deficit-to-GDP ratio in decades. Due to lower oil exportation volumes and prices, the materialized income from oil trade was only set at 14%. In contrast, the health and social assistance costs caused by the pandemic was 28% year-on-year of total expenditures of Iran. Thus, the Iranian fiscal deficit is estimated to increase at 6% of GDP, and the public debt is expected to be higher than 50% in 2020/2021 (World Bank, 2021).

In Indonesia, the trade deficit was \$345 million reported by (World Bank, 2021), higher than expected. Regarding to exportations and importations activities, it was worse than predicted. Indonesian exportations fell 7% while importations, reflecting the decrease of domestic demand, contracted by 16%. Forecasting for both exportations and importations are in continue trend of downbeat. All Indonesian economic activities are slowing down also due to

partial lockdown measures. For exportations, in May 2020, the total was \$10.53 billion, and importations were at \$8.44 billion. The recorded trade surplus was \$2.09 billion, accumulating a surplus of \$4.31 billion from January to May (Mapa, 2020). The domestic trade faced an inflation increase. As example, rice registered an increase of 3.02% in April 2021. About 2.5 million people lost their jobs between March and May, totaling in more than 12 million unemployed people (Lili Yan Ing, 2020).

In Philippines, the economic recession of 2020 caused by the COVID-19 pandemic contracted GDP at 9.6%, becoming the largest annual decline ever registered since 1946. The Philippines exportations followed the global slump and fell 16.3% YoY in 2020, and 5.2% YoY in 2021. Despite the decrease of exportations, the surplus registered a record of USD 13 billion (3.6% of GDP), explained to the slump of importations due contraction of domestic market. The current surplus projections for 2021, according to the Philippines Central Bank, was set to USD 9.1 billion (2.3% of GDP) (Biswas, 2021).

Bangladesh's economy was hit especially in the readymade garments, that faced a decline of 14.57% in exportations. According to the Exportation Promotion Bureau, the exportations of 2020 fell to US\$ 33.6 billion from US\$ 39.3 billion in previous year. The first lockdown in Bangladesh occurred between March and May 2020, and it was observed that billions of US dollars were lose by canceled exportations. This lockdown was responsible for threatening Bangladeshi economy, especially the readymade garments industry that contributes at 80% of Bangladeshi exportations (EcoTextile, 2021).

Also, in the textile and apparels industry, the Pakistani exportations were facing the same issues caused by the COVID-19 pandemic. This industry is responsible, the largest industry in exportations, for the loss of \$3.5 billion in exportations and 40% of Pakistani textile and apparels are exported worldwide. Another relevant industry, the light manufacturing, was also affected and is expected a decline of \$1.6 billion, while processed food is expected to decrease to \$0.97 billion. The heavy manufacturing industry also witnessed a decrease of USD 205 million (Khan, 2020). Despite these negative results, the services industry showed increase in exportations by \$1.3 billion. Pakistan adopted a market-based exchange rate regime related to exportations, and the country faced a decline in FY2020 due COVID-19 pandemic, and during the period of July/February FY2021, exportations increased by 4.4%.

2.2 COVID-19 and Logistics Performance

The consequent stage of several safety measures for combating COVID-19 spread is named 'new normal'. This period is marked by e-commerce activities, businesses-customers relationships mediated by online technologies. The

e-commerce needs the physical distribution and shipping, then the transportation and logistics are under the spotlights (D'Adamo *et al.*, 2021). It is expected that, in the post-COVID-19 era, the online sales would remain as consumers showed a positive behavior towards buying online, which reinforces the importance of logistics systems. The 'new normal' will also affects logistics industry companies. The airlines, for example, after the prohibition of travels, most revenues came from cargos services. The companies in air transportation are implementing actions to save operational expenses through business process re-engineering, data analytics and business automation aiming enhanced efficiency. More research is needed to understand the effects of such actions on businesses risks (Choi, 2021).

The transportation sector was disrupted due to restrictions caused by the lockdown measures. These restrictions resulted in international trade and fuel consumption decrease in logistics. The lockdowns also affected transportation freights that slowed down the delivery of goods. Intermodal movement of goods was completely halt in initial stage of the pandemic due to severe lockdowns measures in several countries, recovering as the mobility was ease (Zhang *et al.*, 2021). The restrictions caused reductions in vessel capacity and equipment shortages, impacting the domestic and international trade. The air freight volume decreased worldwide, as in India it was expected contracts of 17% to 20% during the pandemic 2020 and 2021. Air freight volume recovered in a faster way, even facing a fall of 45% in its volumes between April and September 2020 in comparison to same previous period (ICRA, 2020). As consequences, the transportation and logistics performances were prejudiced. Another example came from the food and beverage industry of Bangladesh, where COVID-19 pandemic casted the short-term impacts yet the far-reaching and lasting impacts in the medium/long-term are still unknown. This study further evidenced that companies must restructure SCs through establishing strategies with key partners (Chowdhury et al, 2020).

The disruptions caused by the COVID-19 pandemic to transportation and logistics systems require collective responses to support SCs. In the case of India, a revival of shipping and ports can be one solution aiming to levels of pre-pandemic era. In particular, shipping sector played an important role in the global trade scenario and was responsible for linking this country both to domestic and global markets (Sudan and Taggar, 2021). The contractions witnessed in supply/demand caused a reduction in shipping and port traffic and demand. A similar shrunk in shipping was seen in the long-distance truck's modal, which decreased to 30% since January 2020. This decrease is also due to much of trucks required in shipping to different destinations are already often for short supplies, and the hesitation of truck drivers to avoid contamination (Sudan and Taggar, 2021). The analyses of Bangladeshi garment industry through

decision-modeling framework pointed out that disruptions are caused by four different types of accidents that unbalance the SC in this industry (Ali *et al.*, 2021).

Figure 2 presents how COVID-19 pandemic influences the global value chain. As a global value chain breaks up the production process across the Asian countries, firms who specialize in each specific production segment do not produce a whole product. The outbreak of COVID-19 caused the shut-down of many manufacturing units, which created a chain effect on the international trade, even if their production facilities are operational and borders are open to trade.

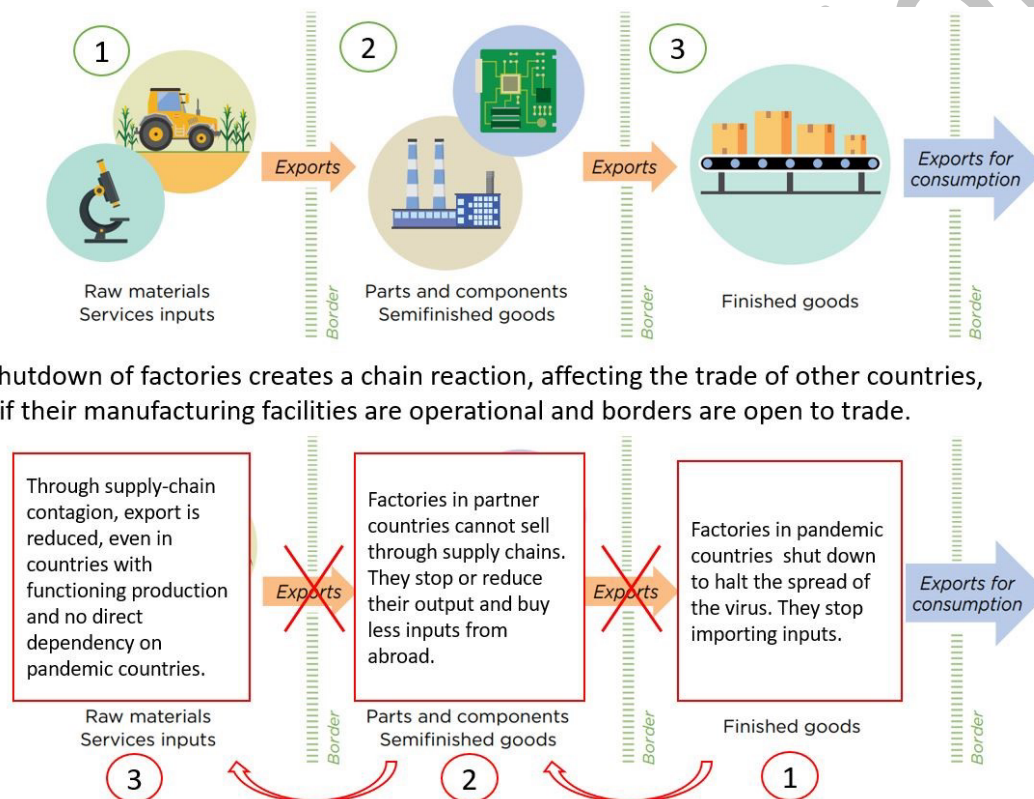


Fig. 2. Effect of COVID-19 of global supply Chain and logistics systems (Source: Solleder & Velasquez, 2020).

2.3 COVID-19 effects on retention of ISO 9001 and 14001 Certifications

Environmental Management Systems (EMSs) are the environmental sustainability tools which help organization to cope with environmental challenges and ensures environmental sustainability. There are various EMSs, but ISO 14001 is the most adopted management standard worldwide. In addition, ISO 14001:2015 shows an upgraded set of requirements that an organization must fulfill to improve its environmental performance (Ikram *et al.*, 2019). Whereas QMS ISO 9001 is one of the tools ensuring the quality of production processes. ISO 9001:2015 underlines the risk-

based thinking is targeted to products and services offered by a given company, for guaranteeing the continuity of processes for supplying products and services and fulfilling customers' requirements (Zimon *et al.*, 2021).

Nevertheless, businesses are striving to keep the same quality levels when their ISO 9001 and ISO 14001 certifications expired during the COVID-19 pandemic. The UK Accreditation Service (UKAS) is drafting a policy for firms affected by travel restrictions and home working due COVID-19, and how these firms can deal with certification bodies in the context of the pandemic. Among the measures, the use of remote assessments allows the inspection of documents, even though not fully addressing the same goals in the on-site visits. Accredited CABs and NABs could face issues regarding the decisions related to stopping providing certain services or even deviating temporarily to fulfill the requirements of standards and accreditation rules. EA's members as well as CAV's are advising the need of responsible acts and transparently for analyzing risks when providing services that are slightly different from requirements, as well as not providing services that jeopardize technical validities (ISO, 2021). Now the certification bodies are requiring a plan for disasters including weather-related incidents, pandemics, and other man-made caused issues.

The COVID-19 has urged the need for creating the propitious environment for revising, updating, and testing the said plans. When one specific industry requires the on-site assessments, the execution of remote audits via information and communication technologies (ICT) will ease the assessments processes. The ICT tools allowed several activities during the pandemic and gained popularity as a solution for many companies during the pandemic. However, the on-site measures preclude the use of safety measures, such as the use of masks, social distancing, and quarantine for auditors. The use of remote audits is not new. The ANAB approval processes already used often remote audits when assessing companies that had remote workers, or even the businesses in the software development industry. The remote assessments have some requirements from certification bodies. Among them are defined and approved processes, training of auditors, and up-front planning for assessment performance. The adoption of home working by several businesses was a measure to avoid the exposure of employees to the coronavirus and ease the decrease of infections and illness people. Then, the accreditation bodies are also seeing in the remote assessments a good solution for keeping the assessment activities (Kerri Williams, 2020). The dashboard of most effected COVID-19 Asian countries with respect to exports of goods & services, logistics performance, ISO 9001 and ISO 14001 certifications is presented in figure 3.

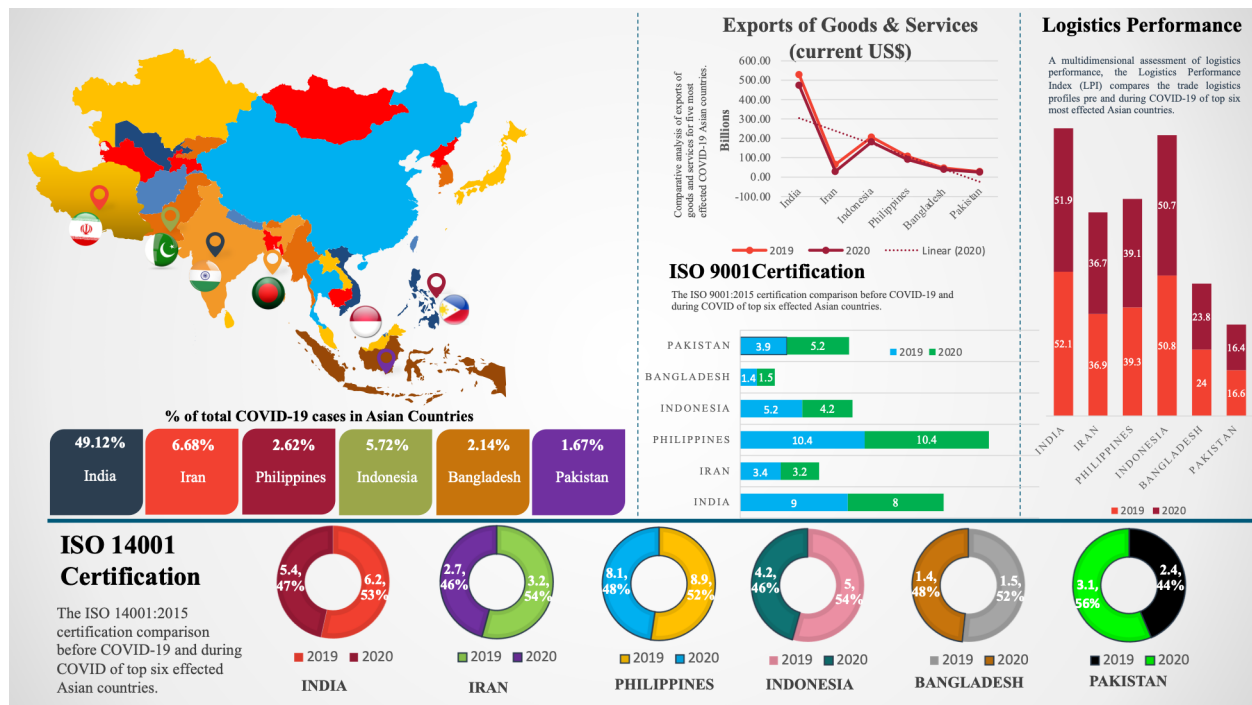


Fig. 3. Dashboard of most effected COVID-19 Asian countries (Source: authors own drawing)

3. Research Methodology

This study aims to explore the potential impact of COVID-19 on exportations of goods and services (current US\$), EMS (ISO 14001), logistics performance and QMS (ISO 9001) certifications in highly COVID-19 effected Asian countries such as India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan. To capture the environmental and quality performance, this study has used ISO 14001 and ISO 9001 certifications which implies that ISO 14001 represents the number of certifications in selected countries that have implemented EMS. Whereas, ISO 900 depicts, how the quality of production processes affected during pandemic represents by number of ISO 9001 certificates. Exportations of goods and services value is taken in terms of current USD. The logistics performance shows the multidimensional assessment of logistics performance, the Logistics Performance Index (LPI) compares the trade logistics profiles of selected countries and rates them on a scale of 1 (worst) to 5 (best). Finally, the total number of COVID-19 cases from January 01, 2020, to December 31, 2020, were accumulated in top-six Asian countries. A full description of variables and data collection sources are reported in Table 1.

Table. 1 Description of study variables

Variables (Code)	Description of variables	Measurement	Data sources
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COVID	COVID-19 cases	Total number of COVID cases	Our World in data
EXP	Exportations of goods and services	Exportations of goods and services in current USD	World Bank
LGP	Logistics Performance	Performance measurement based on Logistics Performance Index (LPI) by using scale of 1 (worst) to 5 (best)	Global Innovation Index
EMS	ISO 14001 certification	ISO 14001:2015 sets out the criteria for an environmental management system	Global Innovation Index
QMS	ISO 9001 certification	ISO 9001:2015 sets out the criteria for a quality management system	Global Innovation Index

3.1 Grey Relational Analysis (GRA)

Grey relational models, known as the GRA models, received enormous recognition in the past two decades. The GRA models are applied in different fields of study, including management, engineering, economics, environmental science, and medicines (Xu & Li, 2018). GRA efficiently handle the small data set and also deal with grey values and provides optimum results (Ikram et al., 2021).

In the present study, GRA models constitute four stages. For the analysis, data has been extracted from multiple databases during 2020, and subject to normalization in the first stage. In the second stage, GRA models run on the data to examine the relations of COVID-19 cases and exportations of goods and services, logistics performance, ISO 14001, and ISO 9001 (COVID and EXP, LGT, EMS, QMS) in highly effected Asian countries. The third stage involves employing the GRA ranking approach, which used the weights generated on stage two, and after defining the decision criteria, it is assigned to the alternatives. At the final stage, the conservative model runs over the analysis results to find the best optimal solution (the variable or set of variables), which substantially shows how Asian countries were affected by COVID 19- pandemic. There are three types of proximities in GRA models. If Deng's GRA model relates to partial closeness/proximity, absolute GRA, then, relates to integral closeness/proximity between two data sequences. Whereas, the second synthetic GRA aims to reveal a more comprehensive closeness /inclusive proximity (Ikram et al., 2020).

In 1982, Deng developed the theory of the grey system (Ju-Long, 1982). The GRA models, also known as Grey Incidence Analysis (GRA), are considered core elements of Deng's grey system theory (Badri Ahmadi *et al.*, 2017). These models are superior to other approaches in tackling data issues whether it contains missing values or if the data

sources are unreliable (Ikram et., 2019). It also handles the small dataset with maximum efficiency (Rehman et al., 2020). According to Dai et al. (2014), GRA models provide better grounds to understand the complexity of the conceptual model. Recently, Mahmoudi et al. (2018) explained the systematic process and steps to measure Deng's GRA model of two datasets represented as ω_0 and ω_η . This analysis is composed by five phases:

Stage 1 – to measure the Deng's GRA, it presents the equation of our two datasets δ_0 and δ_i , $i=1, 2, 3, \dots, m$, where

$$\omega'_\eta = \frac{\omega_\eta}{\omega_\eta(1)} = (\omega'_\eta(1), \omega'_\eta(2), \dots, \omega'_\eta(n)); \eta = 0, 1, 2, 3, 4, \dots, m. \quad (1)$$

Stage 2 - it involves the calculation of difference in the δ'_0 and δ'_i sequence, where $\eta=1, 2, 3, 4, \dots, m$ and presented as

$$\eta(1) = ||\omega'_0(1) - \omega'_\eta(1)||, \Delta = (\Delta\omega(1), \Delta\omega(2), \dots, \Delta\omega(n)), \eta = 1, 2, 3, \dots, m. \quad (2)$$

Stage 3 - it attempts to find the difference (maximum and minimum), where

$$\mathbb{M} = \max_\eta \max_i \Delta_\eta(\mathfrak{T}), \quad (3)$$

$$\mathfrak{m} = \max_\eta \max_i \Delta_\eta(\mathfrak{T}), \quad (4)$$

Stage 4 – it measures the grey incidence co-efficient using the following formula where ς is distinctive coefficient and having the value of 0.5.

Stage 5 – it is measuring Grey relational degree (GRG) according to the following equation

$$\xi_0\eta = \sum \mathfrak{T} = 1/n(\xi_0\eta(\mathfrak{T}) \times \omega_l); \eta = 1, 2, 3, 4, \dots, m. \quad (5)$$

In equation (5), $\sum \omega_l=1$ and $\frac{1}{n}$ represent equally distributed criteria (Sarıkaya and Güllü, 2015).

3.1.1 Absolute degree of GRA model

The relations among study variables are better performed using Deng's GRA model than traditional statistical methods (Ikram et al., 2021), and it is known as the Absolute GRA model or Absolute degree of GRA (ADGRA) (Zhicai and Li, 2018). Using this rigorous econometric technique in an investigation permits to have insights on geometric proximity between the sequential study setup and the information on study parameters and their association with the designed framework. Analyzing the GRA in the study model requires access to the two separate time periods ω_0 and ω_η . This analysis is composed by three phases:

Stage 1 - Using the different time intervals ω_0 and ω_η to measure the base point ω_0^0 and ω_1^0 .

Stage 2 - Estimating $|\gamma_0|, |\gamma_1|$ and $|\gamma_1 - \gamma_0|$.

Stage 3- Calculating the μ_{01} ADGRA different time span using the δ_0, δ_1 sequence. Then, the formula to estimate ADGRA is given below:

$$\mu_{01} = \frac{1+|\gamma_0|+|\gamma_1|}{1+|\gamma_0|+|\gamma_1|+|\gamma_1-\gamma_0|}. \quad (6)$$

3.1.2 Deng's degree of GRA

In the next step of analysis, Deng's proposed GRA model suggests employing Deng's degree known as Grey Relational Grade (GRG) or Degree of Grey Incidence Analysis (DGRA). The mathematical representation of DGRA is given below in equations (7) and (8), in which $\xi_{0\eta}(\mathfrak{T})$ is grey relational coefficient (GRC).

$$\xi_{0\eta} = \sum_{l=1}^n (\xi_{0\eta}(\mathfrak{T}) \times \lambda_l); \eta = 1, 2, 3, 4 \dots, m, \quad (7)$$

Or

$$\xi_{0\eta} = \frac{1}{n} \sum_{l=1}^n (\xi_{0\eta}(\mathfrak{T})); \eta = 1, 2, 3, 4 \dots, m, \quad (8)$$

Equation (7) represent the weighted GRA/DGRA, and the equation (8) shows the non-weighted scheme.

This study used the ADGRA model to estimate the weights of technological innovation, energy, environmental management systems, population growth, and green growth for Pakistan's case. The formula for weight measurements is given below,

$$\beta_{01} = \frac{1 + |\gamma_0| + |\gamma_1|}{1 + |\gamma_0| + |\gamma_1| + |\gamma_1 - \gamma_0|} \quad (9)$$

Considering that the data sequence of the system behavior is represented as $\omega_\eta = (\omega_\eta(1), \omega_\eta(2), \dots, \omega_\eta(n))$ and that $\mathcal{C}$ denotes the operator of the sequence, such that satisfies $\delta_\eta(L)c = (\omega_\eta(L)c - \omega_\eta(1)); \mathfrak{T} = 1, 2, 3, \dots, n$. Then, $\mathcal{C}$ is a point operator starting from zero and $\delta_i \mathcal{C}$ known as zero-scale point image of δ_i . $\delta_i \mathcal{C}$ is often written:

$$\omega_\eta \mathcal{C} = \omega_1^0 = (\omega_\eta^0(1), \omega_\theta^0(2), \dots, \omega_\eta^0(n)) \quad (10)$$

According to Liu et al. (2017), we suppose that the length of variables δ_i and δ_j are same of one-time-interval sequences and δ_i and δ_j are zero-starting point images follow as:

$$\omega_\eta^0 = (\omega_\eta^0(1), \omega_\eta^0(2), \omega_\eta^0(3) \dots, \omega_\eta^0(n)) \quad (11)$$

$$\omega_\theta^0 = (x_\theta^0(1), \omega_\theta^0(2), \omega_\theta^0(3) \dots, \omega_\theta^0(n)). \quad (12)$$

Then it is considered that:

$$|\varsigma_{\eta}| = \left[\sum_{l=2}^{n-1} \omega_{\eta}^0(\mathfrak{T}) + \frac{1}{2} \omega_{\eta}^0(n) \right] \quad (13)$$

$$|\varsigma_{\theta}| = \left[\sum_{l=2}^{n-1} \omega_{\theta}^0(\mathfrak{T}) + \frac{1}{2} \omega_{\theta}^0(n) \right], \quad (14)$$

$$\begin{aligned} |\varsigma_{\eta} - \varsigma_{\theta}| &= \left[\sum_{l=2}^{n-1} (\omega_{\theta}^0(\mathfrak{T}) - \omega_{\eta}^0(\mathfrak{T})) + \frac{1}{2} (\omega_{\eta}^0(n) - \omega_{\theta}^0(n)) \right], |\varsigma_{\theta}| \\ &= \left[\sum_{l=2}^{n-1} \omega_{\theta}^0(\mathfrak{T}) + \frac{1}{2} \delta_{\eta}^0(n) \right], \end{aligned} \quad (15)$$

3.1.3 Second Synthetic Degree of Grey Incidence Analysis model

Second Synthetic Degree of Grey Incidence Analysis (SSDGRA) model is the next stage to calculate the proximity between two curves using the two data sequences mentioned before. This model presents the whole proximity of the factor's series. SSDGRA is measured by incorporating the integral and partial points of the proximity among the curves. This model is proposed by Javed and Liu (2018) and can be estimated through the following equation:

$$\beta_{\eta\theta} = \delta \epsilon_{\eta\theta} + (1 - \delta) \varpi_{\eta\theta}; \delta \in [0,1], \quad (16)$$

in which $\beta_{\eta\theta}$ = SS degree of grey relation (SSGRG), $\epsilon_{\eta\theta}$ = Absolute Degree of grey relation (absolute GRG) and $\varpi_{\eta\theta}$ = Deng's degree of grey incidence/grey relation (GRG). In figure 4 we present the framework of this study.

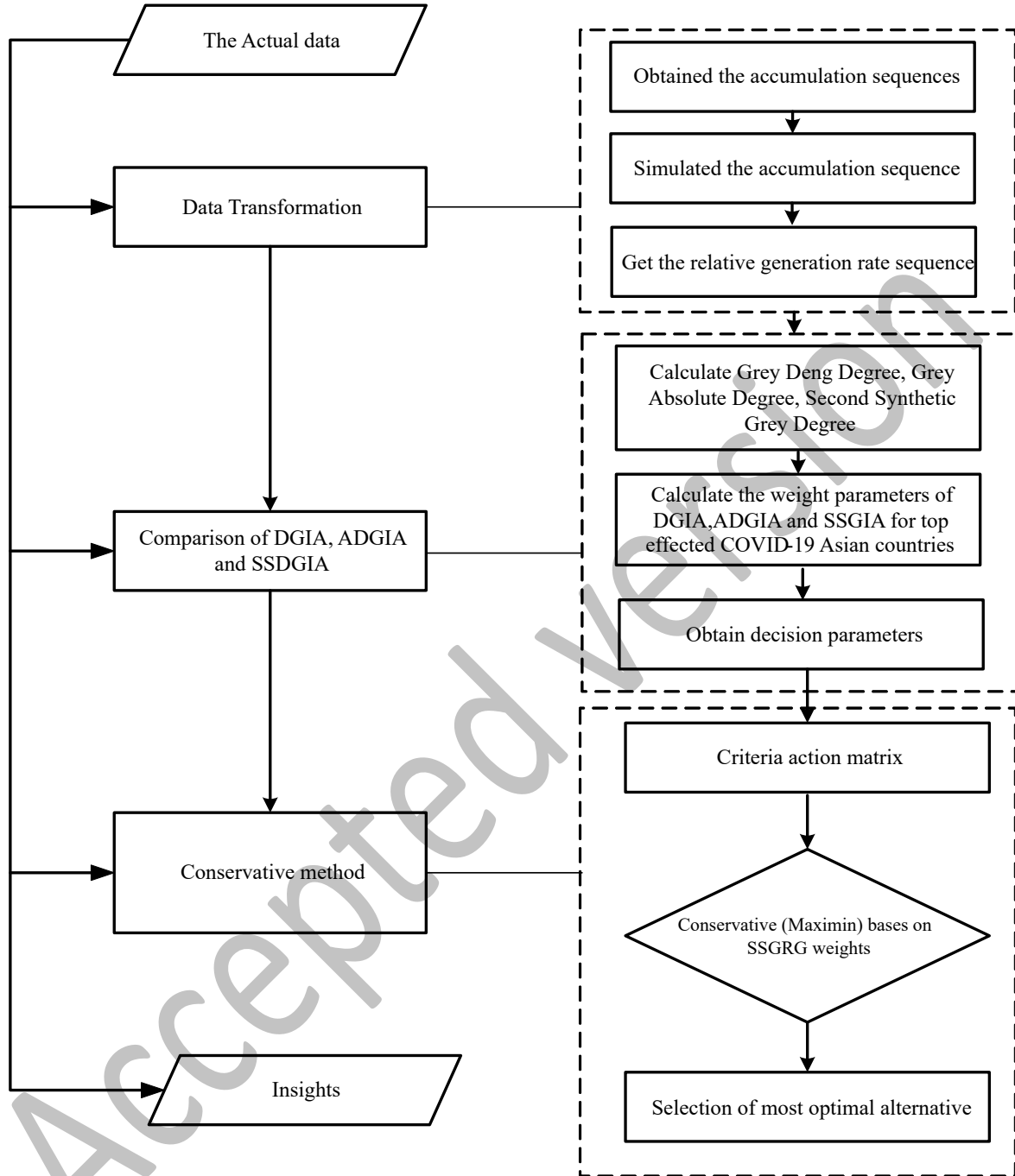


Fig. 4. General framework of study

4. Results and Discussion

GRA models are employed in this study to analyze the relations among COVID-19, exportations of goods and services, logistics performance, ISO 14001, and ISO 9001 certification of top-six highly affected Asian countries such as India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan. GRA models' efficiency makes it a better technique

since it deals with endogeneity issues and grey values and provides an optimal solution (Badri Ahmadi *et al.*, 2017). The analysis results for GRA models, Deng's GRG, SSGRG, and absolute GRG, are displayed in tables 2 to 5.

GRA models help us evaluate the association among COVID-19 (number of cases), exportations of goods and services (current value in USD), logistics performance (measured by LPI), EMS (ISO 14001), and QMS (ISO 9001 certifications) in top affected Asian countries during the entire year of 2020. GRA models show the influence, association and both these parameters using Deng's GRA, absolute GRA and SSRA. The relation strength is measured using a scale point from 0 to 1, where 0 depicts the weakest and values towards 1 indicates the most substantial relations for absolute GRG model. In this study, higher score value implies high intensifying effects of COVID-19. The Deng GRG model's scale has a standardized value from 0.5 to 1, in which influence towards 0.5 is an indication of weak, while it shows the strong influence among study variables when it is towards 1. Whereas, SSGRG is the average of Deng's GRG and absolute GRG showing both association and influence (Javed *et al.*, 2019). The assessment of COVID-19 (number of cases), exportations of goods and services (current value in USD), logistics performance (measured by LPI), EMS (ISO 14001), and QMS (ISO 9001 certifications) are presented in figure 5.

Table 2: GRA assessment for COVID-19 and exportations of goods and services in Asian countries

Country	Absolute GRG	Deng GRG	SSGRG
India	0.9889	0.6995	0.8513
Iran	0.9487	0.7088	0.8288
Indonesia	0.7690	0.8202	0.6299
Philippines	0.9476	0.7550	0.8442
Bangladesh	0.9470	0.6218	0.7844
Pakistan	0.5520	0.7078	0.7946

In Table 2, the relations of COVID-19 number of cases are analyzed with exportations of goods and services in top affected Asian countries. Absolute GRG results show that India's exportations of goods and services received the highest ranking by obtaining the weight score 0.9889, which implies that the Indian's exportations of goods and services are negatively affected due to COVID-19 in the year of 2020. Whereas Iran and Philippines come in row on second and third position, respectively, by receiving the association score value of 0.9487, and 0.9476. These countries are followed by Bangladesh (0.9470), Indonesia (0.7690) and Pakistan (0.5520). There was a record decline of 34.57% in India's exportations during the first wave of COVID-19 in March 2020.

According to Deng's GRG results, Indonesia and Philippines got the highest-ranking value of 0.820189 and 0.75499, respectively, implying that these countries' exportations are drastically decreased due to influence of COVID-19 number of cases. The COVID-19 pandemic around the world and the resulting restrictions in production supply chains and global trade flow led to the decline in Philippine's trade in March 2020. The Philippine Statistics Authority reported that the country's total merchandise trade dropped to US\$11.44 billion its lowest level in two years. This trade performance is 25.7% lower than the US\$15.40 billion recorded in the same month of the previous year. Both exportations and importations registered declines of 24.9% and 26.2%, respectively (NEDA, 2020). Similarly, Iran and Pakistan trade showed the declined trend due to COVID 19 transmissibility by obtaining values of 0.7088 and 0.7078, respectively, followed by India (0.6995) and Bangladesh (0.6218).

The SSGRG model showed the same sequence of ranking pattern between COVID-19 number of cases and exportations of goods and services in Asian top-six most affected countries. Table 2 shows that India and Iran received the heights score value of 0.8513 and 0.8288, respectively. They were followed by Philippines (0.8441), Bangladesh (0.7844), Pakistan (0.7946), and Indonesia (0.6299). Pakistan's exportations in April 2020 decreased to \$960 million, a 54% reduction compared to April 2019. Exportations of knitwear, bedwear and ready-made garments were also adversely impacted in March 2020. However, exportations of surgical goods and instruments and certain leather products (such as gloves) reported positive growth rates in March 2020, both month-on-month as well as year-on-year (Dawn, 2020).

Our findings on COVID-19 outbreak and exportations of goods and services of top affected Asian countries are in line with the findings of Verschuur et al. (2021) and Hayakawa and Mukunoki (2021), which revealed in their study that COVID-19 drastically slow down the growth of exportations of goods and services.

Table 3: GRA assessment for COVID-19 and ISO 14001 in Asian countries

Country	Absolute GRG	Deng GRG	SSGRG
India	0.7792	0.7531	0.7667
Iran	0.7125	0.7202	0.7163
Indonesia	0.5447	0.5856	0.6489
Philippines	0.8506	0.7018	0.7762
Bangladesh	0.8757	0.6666	0.7306
Pakistan	0.9282	0.7542	0.7974

The transmission of COVID-19 disrupts business activities on sustainability certifications and especially create hurdles in the implementation of ISO 14001 certification. Table 3 shows the relations between COVID-19 number of cases and ISO 14001 certification in top affected Asian countries. The result of absolute GRG reveals that ISO 14001 certifications registration in Pakistan and Bangladesh propose the highest score value of 0.9282 and 0.8757, respectively. This indicates a negative relation with COVID 19 number of cases. The other not-good performances are associated to Philippines (0.8506), India (0.7792), and Iran (0.7125). Whereas Indonesia showed the comparatively better performance of ISO 14001 certification by receiving score of 0.5447 among all six countries during the pandemic.

Deng's GRG model shows the slightly different sequence of ranking results for top affected Asian countries during the COVID-19 pandemic outbreak. The ISO 14001 certifications of organizations in Pakistan affected the most by obtaining the highest score of 0.7542, which implies that the certification process or ISO 14001 was slowed down and its effects the compliance of ISO 14001 due to COVID-19. The ongoing COVID-19 pandemic has had a significant impact on the certification and auditing services of sustainability standards. The traditional approach to auditing on-site visits has been significantly curtailed, and it is unclear when, and under what conditions, it might resume in full (Castka *et al.*, 2020). Similarly, the performance of ISO 14001 was low also in India and Iran with score values of 0.7531 and 0.7202 during the pandemic outbreak. More negative results were registered for Philippines, Bangladesh, and Indonesia with score value of 0.7018, 0.6666 and 0.5856, respectively. Unfortunately, however, travel restrictions, as well as the practice of social distancing, that have emerged throughout the COVID-19 crisis have affected the very core of Voluntary Sustainability Standards' (VSS) operations, i.e., on-site auditing and inspections, which are the foundations of VSS certification and accreditation (Castka *et al.*, 2020).

In the SSGRG model, Pakistan and Indonesia recorded the same sequence of ranking like Deng's GRG. Absolute GRG is presented in table 3. Pakistan comes in row at first position by receiving the score of 0.7974 and its ISO 14001 operations effected drastically due to COVID-19 crises. This country is followed by Philippines (0.7762), India (0.7667), Bangladesh (0.7306), Iran (0.7163), and Indonesia (0.6489). Due to restrictions on travel and business activities for personal health and safety reasons, certification bodies have had to consider adjustments to their auditing practices. Shifts to new types of audits, such as remote or virtual audits, may partly compensate for some of these challenges (Auld and Renckens, 2021).

Table 4: GRA assessment for COVID-19 and Logistics Performance in Asian countries

Country	Absolute GRG	Deng GRG	SSGRG
India	0.8770	0.9494	0.9132
Iran	0.6204	0.7170	0.6687
Indonesia	0.9663	0.6203	0.7933
Philippines	0.8726	0.7168	0.7947
Bangladesh	0.6055	0.5619	0.5837
Pakistan	0.5653	0.4589	0.512

GRA results of COVID-19 and logistics performance are presented in Table 4. The result of absolute GRG reveals that COVID-19 outbreak have an adverse and long-lasting effects on logistics systems of Indonesia and India by obtaining the highest score value of 0.9664 and 0.8770, respectively. Other countries registered the values, such as Philippines (0.8727), Iran (0.6204), Bangladesh (0.6055), and Pakistan (0.5653). Due to strict lockdown measures, the manufacturing and logistics activities have been suspended, and it has affected the demand and supply of various products because of restrictions imposed on shopkeepers and retailers. All sectors are connected through a complex network of supply chains and logistics, but hardly any activities evidenced during the COVID-19 pandemic (Singh *et al.*, 2021; Miceli *et al.*, 2021).

Deng's GRG model and SSGRG showed the similar sequence of ranking results for top affected Asian countries during the COVID-19 pandemic outbreak. In Deng's GRG and SSGRG models, India recorded the most vulnerable and affected country in terms of logistic performance among all six top affected countries by obtaining the value of 0.9494 and 0.9132, respectively. Whereas the logistics performance during the COVID-19 outbreak in Pakistan appeared slightly better among six countries by receiving the score values of 0.4589 and 0.5121045 utilizing Deng's GRG and SSGRG models, respectively. Pakistan has been ranked at number 3 after Hong Kong and New Zealand with a score of 84.4 in terms of handling COVID-19 among 50 countries tracked by the Economist magazine for return to pre-pandemic life (Recorder, 2021).

According to the report prepared by United Nations, 'COVID-19 Socio-economic Impact Assessment and Response', the pandemic caused a deep contraction of the Pakistani manufacturing sector in the first quarter of 2020. All three key sectors, i.e., agriculture, industry and services, experienced economic losses during the first quarter of 2020. The pandemic has impacted the sectors unequally, however, the services sector has been hit the hardest, followed

by the manufacturing and the agriculture sectors. The score values of logistics performance for all the six countries are presented in table 4.

Quality standards such as ISO 9001 certification imply changes in routines, processes and managers' and employees' roles in order to be able to transform the complete organization (Ikram, Sroufe, *et al.*, 2020). The outbreak of COVID-19 disrupts the effective implementation of ISO 9001, due to travel restrictions and social distances. In this study we analyzed how the emergency like COVID-19 create a hurdle in the implementation of QMS, and how the organizations can continue their production processes and assuring quality standards during unexpected events. Table 5 presents the relations of COVID with ISO 9001 in top highly affected Asian countries. Similar sequence of ranking results is obtained like ISO 14001, the number of ISO 9001 certifications trends goes towards downward for all the countries selected in this study. Pakistan appeared first in the row by obtaining the highest score of 0.972664 computed by absolute GRG, followed by Bangladesh (0.9264), Philippines (0.8770), India (0.6204), Iran (0.6055), and Indonesia (0.5653), respectively.

Table 5: GRA assessment for COVID-19 and ISO 9001 certification in Asian countries

Country	Absolute GRG	Deng GRG	SSGRG
India	0.6204	0.4589	0.5636
Iran	0.6055	0.6204	0.6129
Indonesia	0.5653	0.5619	0.5396
Philippines	0.8770	0.7170	0.7970
Bangladesh	0.9264	0.7768	0.8516
Pakistan	0.9727	0.8494	0.9110

Likewise, Deng's GRG and SSGRG showed the similar sequence of ranking results between COVID-19 and ISO 9001 certifications for top six highly affected Asian countries is presented in table 6. Pakistan shows the most affected and strong negative relation between pandemic outbreak and QMS certification obtaining the highest value of 0.8494 and 0.9110, respectively. Whereas Bangladesh and Philippines are the second most affected countries during pandemic in terms of ISO 9001 certification process. Moreover, Iran, India, and Indonesia position change in Deng's and SSGRG models. The association results between COVID-19 and ISO 9001 certification are presented in table 5.

As a whole analysis of this study, India showed strong negative relations between COVID-19 and exportations of goods and services, and logistic performance, whereas Pakistan showed a strong negative association

between ISO 14001 and ISO 9001 certification among all the six highly affected COVID-19 Asian countries. The trade balance of India has shown a deficit of USD 9.8 bn in March 2020. According to the survey conducted by the Institute for Supply Chain Management in March 2020, the COVID-19 outbreak drastically impacted the global supply chains. As per the survey, nearly 75% of companies were affected and faced supply chain disruptions and it is expected to rise further in the coming time.

Table 6: GRA Assessment ranking of highly affected COVID-19 Asian countries

Variables	Grey Relational Model	Ranking
Exports of Goods and Services	Absolute GRG	India>Iran> Philippines> Bangladesh> Indonesia> Pakistan
	Deng GRG	Indonesia> Philippines>Iran>Pakistan>India> Bangladesh
	Second Synthetic GRG	India>Iran> Philippines> Bangladesh>Pakistan>Indonesia
ISO 14001	Absolute GRG	Pakistan> Bangladesh> Philippines> India> Iran> Indonesia
	Deng GRG	Pakistan> India> Iran> Philippines> Bangladesh> Indonesia
	Second Synthetic GRG	Pakistan> Philippines> India> Bangladesh>Iran> Indonesia
Logistics Performance	Absolute GRG	Indonesia> India> Philippines> Iran> Bangladesh> Pakistan
	Deng GRG	India> Iran> Philippines> Indonesia> Bangladesh> Pakistan
	Second Synthetic GRG	India> Philippines> Indonesia> Iran> Bangladesh> Pakistan
ISO 9001	Absolute GRG	Pakistan>Bangladesh> Philippines>India>Iran>Indonesia
	Deng GRG	Pakistan>Bangladesh> Philippines>Iran>Indonesia>India
	Second Synthetic GRG	Pakistan>Bangladesh> Philippines>India>Iran>Indonesia

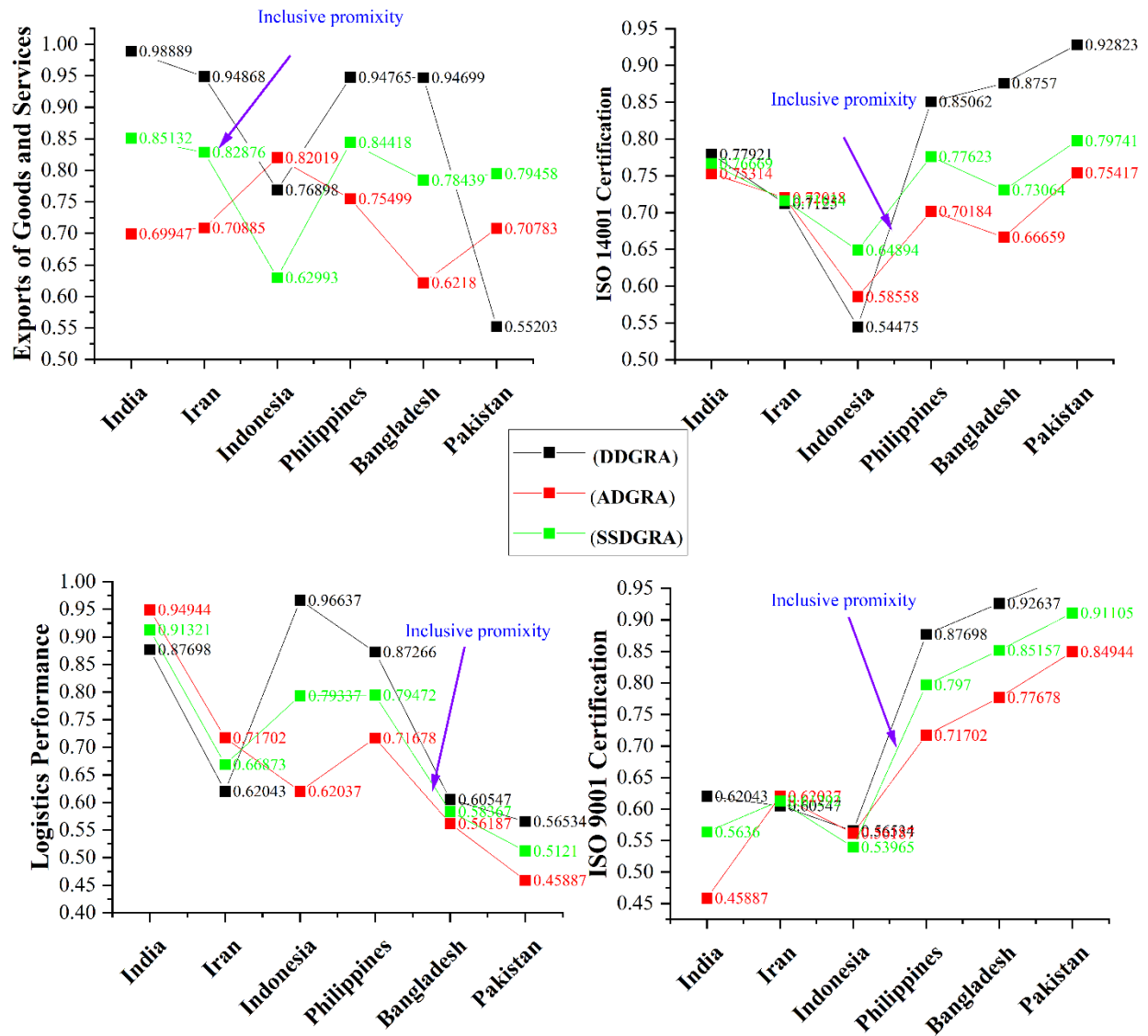


Fig. 5. GRA based evaluation of COVID-19, economic growth, environmental performance, and quality production

Table 7: Decision Parameters description

Goal	Measuring Grey Relation (Association) between exportations of goods and services, ISO 14001, logistic performance, ISO 9001 within highly affected COVID-19 Asian Countries
State of Nature/Criteria (X_j); $N = 1, 2, \dots, k$	India (X_1) Iran (X_2) Indonesia (X_3) Philippines (X_4) Bangladesh (X_5) Pakistan (X_6)
Alternative Actions (O_i); $p=1, 2, \dots, m$	Grey Relation was superior between COVID-19 cases and exportations of goods and services (O_1)

Grey Relation was superior between COVID-19 cases and ISO 14001 certifications (O_2)
Grey Relation was superior between COVID-19 cases and logistic performance(O_3)
Grey Relation was superior between COVID-19 cases and ISO 9001 certification (O_4)

After computation of weight scores, it was possible to rank top six Asian countries based on exportations of goods and services, logistics performance, ISO 9001, and ISO 14001 certifications. The next step analyzes which country have the least intensified effect of COVID-19 on its economy, environmental performance, and quality production based on GRA models. To do so, we constructed the decision parameters, which detail description is provided in table 7. $O=4$, $X=6$, outcome = $v(O_i, X_j)$, whereas $i = 1, 2, 3, 4$ and $j = 1, 2, 3, \dots, 6$. Let S_1, S_2, S_3 and S_4 show the GRA of exportations of goods and services, ISO 14001 certifications, logistics performance, and ISO 9001 certifications in top six highly affected COVID-19 Asian countries.

The SSDGRA is presented in table 8, which unfolds the relations among the study factors to arrange the variables and conclude the criteria response. Then, a decision-making model is applied to evaluate the impact of COVID-19 on exportations of goods and services, logistic performance, and ISO 14001, and ISO 9001 certifications in India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan are presented in table 8.

Table 8: SSGRG criteria-based matrix

SSGRG	X1	X2	X3	X4	X5	X6
K_1	0.8513	0.8288	0.6299	0.8442	0.7844	0.7946
K_2	0.7667	0.7163	0.6489	0.7762	0.7306	0.7974
K_3	0.9132	0.6687	0.7934	0.7947	0.5837	0.512
K_4	0.5636	0.6129	0.5396	0.7970	0.8516	0.9110

Finally, we have applied Conservative (maximin) model (Rehman *et al.*, 2020; Ikram *et al.*, 2019) to obtain which countries have the least intensifying affected among all of the top affected COVID-19 Asian countries based on SSGRG values, as presented in table 8. In this study, we emphasize on lowering the better criteria, in which the minimum value of V for each country was taken from SSGRG matrix model. The conservative model of lowering the better criteria shows the following optimal solution:

$$\min O_i \{ \max O_k V(O_i, X_j) \} = \min O_p \left\{ \begin{matrix} 0.8513 \\ 0.7974 \\ 0.9132 \\ 0.9110 \end{matrix} \right\} = 0.7974 \text{ (Pakistan)}$$

This article evaluates the effects of COVID-19 on exportations of goods and services, ISO 14001 environmental sustainability certificates, logistics performance, and ISO 9001 quality management systems in a multiframework for most COVID-19 affected top-six Asian countries. The study has individually analyzed the potential influence of individual independent variables on dependent variables. Figure 6 illustrates that Pakistan showed the better performance during the COVID-19 outbreak, whereas India's and Iran's economy suffered drastically, and our analysis showed a strong negative effect between COVID-19 number of cases and exportations of goods and services, logistics performance, ISO14001, and ISO 9001 certifications. The other countries should adopt the smart lockdown strategy like Pakistan to prevent their economy from more damages, and simultaneously, sustain the environmental performance and quality production processes during the COVID-19 outbreak. Moreover, there is an emergent need to find a solution for companies in providing a quick response to critical operational issues. In doing so, the companies should adopt the new technologies providing in-time and accurate information of uncertain situation and also protect them from cyber-attacks (D'Adamo *et al.*, 2021).

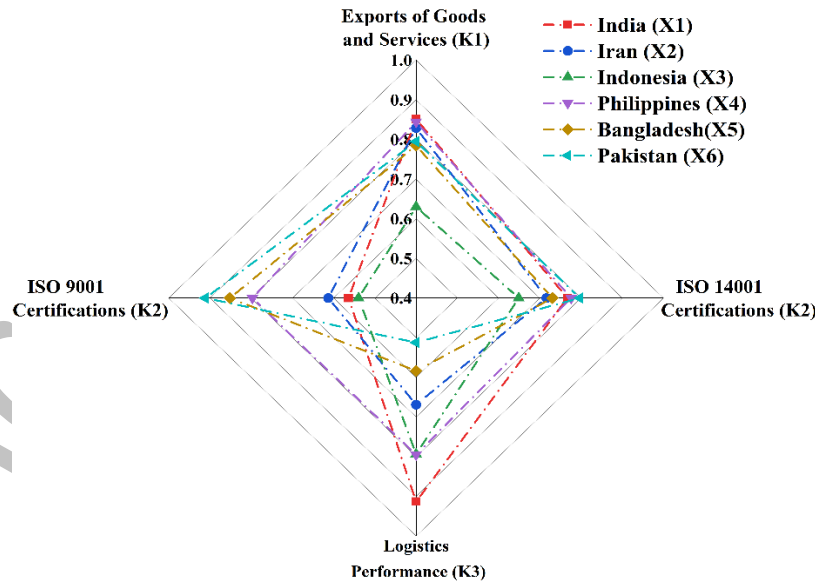


Fig. 6. Conservative (Maximin) based evaluation of COVID-19 in Asian countries

5. Conclusion and Policy Implications

This article focuses on the effects of COVID-19 of exportations of goods and services, logistics performance and ISO 14001 and 9001 certifications in top-six highly affected Asian countries (India, Iran, Indonesia, Bangladesh, Philippines, and Pakistan) using novel advanced mathematical modelling, namely GRA approach. We employed Absolute Degree of GRA (ADGRA), Deng's Degree of GRA (DDGRA), and Second Synthetic Degree of GRA (SSDGRA) to investigate the potential association among different parameters to further explore the extent to which COVID-19 has influenced on country economic system.

Our findings can be summarized as follows. First, regardless of which measure is applied to estimate the severity of COVID-19, we have found a strong negative influence of COVID-19 on exportations of goods and services, logistics performance, ISO 9001, and ISO 14001 certifications in all the six highly affected countries during pandemic outbreak. Although the adverse effects of COVID-19 in exporting countries persisted until December 31, 2020, their magnitude decreased over time in Indonesia and Pakistan. During the COVID-19 outbreak, Pakistan showed the comparatively better performance among the six top highly affected Asian countries. Whereas India and Iran exportations drastically go down due to rapid increase in number of COVID-19 cases and deaths. Although COVID-19 has a long-lasting effect on economic system of all the selected Asian countries, Pakistan adopted the smart lockdown strategy to prevent its economy from severe damage. Second, outbreak of COVID-19 pandemic has been reported as an exceptional case that having a pernicious effect globally because of the suspension of almost all the manufacturing and logistics activities. The logistics activities of all the selected countries shut down during the COVID-19 transmissibility, thousands of orders cancelled and prolonged which turn into huge loss and negative effect on economic growth. All the six countries showed the negative economic growth due to COVID-19. Moreover, as a comparative analysis among the top six affected Asian countries, the SSDGRA model depicts that Pakistan and Indonesia logistics activities showed least disruption during COVID-19 outbreak. Whereas India and Philippines supply chain and logistics network badly damaged during the COVID-19 pandemic. This result implies that disruption of logistics activities due to COVID-19 it has also negative effect on job market in logistics sector.

Third, the sustainability plans of organizations are also disrupted due to COVID-19 outbreak. The certification of EMS ISO 14001 ensures the environmental sustainability regarded as one of the most effective tools to guide quality systems management, ISO 9001 is affected brutally. The certification bodies are failed to follow up the surveillance audits in COVID-19 which effected the organizations environmental performances and quality standards during production processes. Among the six Asian countries, the certification process of ISO 9001 and ISO 14001 in Pakistan

and Bangladesh affected the most during the pandemic followed by Philippines, India, Iran, and Indonesia. Due to cross boarder travel restrictions, social distances measures, thousands of companies have lost their certification of ISO 9001 and ISO 14001 during COVID-19 spread out, tending to lose the opportunity to target the international markets. To date, there is no action plan or agenda to cover this issue and provide some extension by certification bodies.

This study has some theoretical and practical implications. This study is first of its kind in developing a framework and investigating the intensifying effects of COVID-19 effects on economic growth, logistics performance, environmental performance, and quality production processes. Until now, prior studies have limited set of analysis, but no one cover the ISO 9001 and 14001 certifications in their COVID-19 scenario. This study fills the literature gap by utilizing the GRA models to analyze the effects of COVID-19 on exportations of goods and services, logistics performance, ISO 9001, and ISO 14001 certifications in topmost affected Asian countries (India, Iran, Indonesia, Philippines, Bangladesh, and Pakistan). The adopted methodology (ADGRA, DDGRA and SSDGRA) proved to be relevant for analyzing countries classified as economies under development to foster their exportations. We recommend the use of such methods for analyzing other economies under development and comparing the results with our research.

There are some policy points the leaders, world agencies and governments should take in consideration at emergent basis to prevent the economies from more damages and improve their logistics, environmental, and quality performance during pandemic of COVID-19. The policy points are as follows.

For governments, the basic solution that different countries are targeting is the obvious control of the pandemic not only by the safety measures but the growing rates of vaccination. This will allow societies to go back to a normality and a faster recovery of economies, also supported by recovery plans of national governments. Second, governments and certification bodies could easy the certification processes to not affect exportations/importations activities beyond the remote audits. One solution would be the extensions of certifications renewal up to the end of the pandemic situation for the companies that already possess such certifications.

Third, the on-site auditing/inspections operations conducted by certification bodies could be reduced to the extremely necessary and regarding safety measures taken in each country, according to different levels of the pandemic effects. This solution may support the remote audits to not stopping the certification processes. Fourth, benchmarking practices related to smart lockdowns strategies, such as those implemented by Pakistan, could be addressed by those

countries, like India and Iran, that present economic damages, loss of environmental performance and quality production.

Fifth, national governments must include, in their economic recovery plan, the transportation and logistics allowing supply chains to be reestablish in the post-pandemic period. The countries that are dependent on maritime logistics would target its recovery due to its importance of international trade and, consequently, exportations result to GDP. Considering that the economies under development are experiencing a devaluation of their currencies, which favors exportations, the exportations of these countries are key for recovering the economy disruption caused by COVID-19. Then, national governments must pay attention to support exportations especially through easing the logistics and its infrastructure, which can help exporters to trade even faster in the international market.

There are some limitations of this study. We included only six top COVID-19 affected Asian countries and undertake a comparative analysis based on exportations of goods and services, logistics performance, certifications of ISO 9001 and 14001. The data used in this study was from whole 2020 year because dependent variables data available till 2020. We employed GRA models such as Absolute GRA, Deng's GRA, and Second Synthetic GRA model to investigate the intensifying effects of COVID-19 on economic growth, logistics and environmental performance, and quality of production processes. The future research can be conducted on different countries, such as South Asian countries, SAARC. Moreover, the comparative analysis can be conducted between developed and developing countries in future to investigate how the countries responded to COVID-19 outbreak. Further, the effects of COVID-19 can be investigated by using the different methods of analysis on other factors like social certification, health and safety certification, renewable energy production, access to electricity and so on.

References

- Abid, N., Ikram, M., Wu, J. and Ferasso, M. (2021), 'Towards environmental sustainability: Exploring the nexus among ISO 14001, governance indicators and green economy in Pakistan', *Sustainable Production and Consumption*, Vol. 27, pp. 653–666.
- Appolloni, A., D'Adamo, I., Gastaldi, M., Santibanez-Gonzalez, E.D.R. and Settembre-Blundo, D. (2021), 'Growing e-waste management risk awareness points towards new recycling scenarios: The view of the Big Four's youngest consultants', *Environmental Technology & Innovation*, Vol. 23, p. 101716.
- Arce, M.E., Saavedra, Á., Míguez, J.L. and Granada, E. (2015), 'The use of grey-based methods in multi-criteria decision analysis for the evaluation of sustainable energy systems: A review', *Renewable and Sustainable Energy Reviews*, Vol. 47, pp. 924–932.
- Auld, G. and Renckens, S. (2021), 'Private sustainability governance, the Global South and COVID-19: Are changes to audit policies in light of the pandemic exacerbating existing inequalities?', *World Development*, Vol. 139, p. 105314.
- Badri Ahmadi, H., Hashemi Petrudi, S.H. and Wang, X. (2017), 'Integrating sustainability into supplier selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry', *International Journal of Advanced Manufacturing Technology*, Vol. 90 No. 9–12, pp. 2413–2427.

- Bappy, M.M., Ali, S.M., Kabir, G. and Paul, S.K. (2019), 'Supply chain sustainability assessment with Dempster-Shafer evidence theory: Implications in cleaner production', *Journal of Cleaner Production*, Vol. 237, p. 117771.
- Belhadi, A., Kamble, S., Jabbour, C.J.C., Gunasekaran, A., Ndubisi, N.O. and Venkatesh, M. (2021), 'Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries', *Technological Forecasting and Social Change*, Elsevier, Vol. 163, p. 120447.
- Biswas, R. (2021), 'Philippines Economy Hit by Rising COVID-19 Wave', *Ihsmarkit.Com*.
- Castka, P., Searcy, C. and Fischer, S. (2020), 'Technology-enhanced auditing in voluntary sustainability standards: The impact of COVID-19', *Sustainability (Switzerland)*, Vol. 12 No. 11, p. 4740.
- Choi, T.M. (2021), 'Risk analysis in logistics systems: A research agenda during and after the COVID-19 pandemic', *Transportation Research Part E: Logistics and Transportation Review*, Vol. 145, available at: <https://doi.org/10.1016/j.tre.2020.102190>.
- Chowdhury, M.T., Sarkar, A., Paul, S.K. and Moktadir, M.A. (2020), 'A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry', *Operations Management Research*, available at: <https://doi.org/10.1007/s12063-020-00166-9>.
- Chowdhury, P., Paul, S.K., Kaisar, S. and Moktadir, M.A. (2021), 'COVID-19 pandemic related supply chain studies: A systematic review', *Transportation Research Part E: Logistics and Transportation Review*, Elsevier, Vol. 148, p. 102271.
- D'Adamo, I., Ferella, F., Gastaldi, M., Maggiore, F., Rosa, P. and Terzi, S. (2019), 'Towards sustainable recycling processes: Wasted printed circuit boards as a source of economic opportunities', *Resources, Conservation and Recycling*, Vol. 149, pp. 455–467.
- D'Adamo, I., Gastaldi, M. and Rosa, P. (2020), 'Recycling of end-of-life vehicles: Assessing trends and performances in Europe', *Technological Forecasting and Social Change*, Vol. 152, p. 119887.
- D'Adamo, I., González-Sánchez, R., Medina-Salgado, M.S. and Settembre-Blundo, D. (2021), 'E-Commerce Calls for Cyber-Security and Sustainability: How European Citizens Look for a Trusted Online Environment', *Sustainability*, Vol. 13 No. 12, p. 6752.
- Dai, J., Liu, X. and Hu, F. (2014), 'Research and application for grey relational analysis in multigranularity based on normality grey number', *The Scientific World Journal*, Vol. 2014, available at: <https://doi.org/10.1155/2014/312645>.
- Dawn. (2020), 'Pakistan's exports and COVID-19', *Pakistan's Top Export Destinations Have Been Devastated by Covid-19. What Does It Mean for Our Trade?*
- DNVGL. (2020), 'Certification during COVID-19', *DNV GL - Business Assurance: Continue Operations through COVID-19*.
- EcoTextile. (2021), 'COVID-19 impact on Bangladesh exports revealed'.
- Hayakawa, K. and Mukunoki, H. (2021), 'The impact of COVID-19 on international trade: Evidence from the first shock', *Journal of the Japanese and International Economies*, Elsevier, Vol. 60, p. 101135.
- ICRA. (2020), 'No Title Road transport corporations' revenues to contract up to 40% in FY21 due to COVID-19', *ICRA*.
- Ikram, M., Mahmoudi, A., Shah, S.Z.A. and Mohsin, M. (2019), 'Forecasting number of ISO 14001 certifications of selected countries: application of even GM (1,1), DGM, and NDGM models', *Environmental Science and Pollution Research*, Vol. 26 No. 12, pp. 12505–12521.
- Ikram, M., Sroufe, R., Rehman, E., Shah, S.Z.A. and Mahmoudi, A. (2020), 'Do Quality, Environmental, and Social (QES) Certifications Improve International Trade? A Comparative Grey Relation Analysis of Developing vs. Developed Countries', *Physica A: Statistical Mechanics and Its Applications*, Elsevier, Vol. 545, p. 123486.
- Ikram, M., Zhang, Q., Sroufe, R. and Ferasso, M. (2020), 'The Social Dimensions of Corporate Sustainability: An Integrative Framework Including COVID-19 Insights', *Sustainability*, Vol. 12 No. 20, p. 8747.
- Ikram, M., Zhang, Q., Sroufe, R. and Ferasso, M. (2021), 'Contribution of Certification Bodies and Sustainability Standards to Sustainable Development Goals: An Integrated Grey Systems Approach', *Sustainable Production and Consumption*, Vol. 28, pp. 326–345.
- Ikram, M., Zhang, Q., Sroufe, R. and Shah, S.Z.A. (2020), 'Towards a sustainable environment: The nexus between ISO 14001, renewable energy consumption, access to electricity, agriculture and CO2 emissions in SAARC countries', *Sustainable Production and Consumption*, Elsevier, Vol. 22, pp. 218–230.
- Ikram, M., Zhou, P., Shah, S.A.A.A.A. and Liu, G.Q.Q. (2019), 'Do environmental management systems help improve corporate sustainable development? Evidence from manufacturing companies in Pakistan', *Journal of Cleaner Production*, Elsevier, Vol. 226, pp. 628–641.
- ISO. (2021), *AUDITING ISO 9001:2015 IN THE CONTEXT OF A DISRUPTIVE EVENT*.
- Javed, S.A., Mahmoudi, A. & Khan, A.. (2018), 'Investigation of drilling parameters on hybrid polymer composites

- using grey relational analysis, regression, fuzzy logic, and ANN models: a critical note', *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, Vol. 40 No. 5, available at: <https://doi.org/https://doi.org/10.1007/s40430-018-1470-4>.
- Javed, S., Khan, A., Dong, W., Raza, A. and Liu, S. (2019), 'Systems Evaluation through New Grey Relational Analysis Approach: An Application on Thermal Conductivity—Petrophysical Parameters' Relationships', *Processes*, Vol. 7 No. 6, p. 348.
- Javed, S.A. and Liu, S. (2018), 'Evaluation of outpatient satisfaction and service quality of Pakistani healthcare projects: Application of a novel synthetic grey incidence analysis model', *Grey Systems: Theory and Application*, Emerald Publishing Limited, Vol. 8 No. 4, pp. 462–480.
- Ju-Long, D. (1982), 'Control problems of grey systems', *Systems and Control Letters*, Vol. 1 No. 5, pp. 288–294.
- Kanitkar, T. (2020), 'The COVID-19 lockdown in India: Impacts on the economy and the power sector', *Global Transitions*, Elsevier, Vol. 2, pp. 150–156.
- Kerri Williams. (2020), 'Conducting ISO Certifications in COVID-19 Times'.
- Khan, M.A. (2020), *COVID-19 and Pakistan's Trade*.
- Lili Yan Ing. (2020), 'How COVID-19 Impacts Indonesia's Trade', *How COVID-19 Impacts Indonesia's Trade*.
- Liu, S., Zhang, H. and Yang, Y. (2017), 'Explanation of terms of grey incidence analysis models', *Grey Systems: Theory and Application*, Emerald Publishing Limited, Vol. 7 No. 1, pp. 136–142.
- Lopes de Sousa Jabbour, A.B., Chiappetta Jabbour, C.J., Hingley, M., Vilalta-Perdomo, E.L., Ramsden, G. and Twigg, D. (2020), 'Sustainability of supply chains in the wake of the coronavirus (COVID-19/SARS-CoV-2) pandemic: lessons and trends', *Modern Supply Chain Research and Applications*, Emerald Publishing Limited, Vol. 2 No. 3, pp. 117–122.
- Lu, N., Cheng, K.-W., Qamar, N., Huang, K.-C. and Johnson, J.A. (2020), 'Weathering COVID-19 storm: Successful control measures of five Asian countries.', *American Journal of Infection Control*, Elsevier, Vol. 48 No. 7, pp. 851–852.
- Mapa, N. (2020), 'Indonesia: Exports Retreat as Covid-19 Hits', *ING: Economic and Financial Analysis*.
- Marimuthu, R., Sankaranarayanan, B., Ali, S.M. and Karuppiah, K. (2021), 'Green recovery strategies for the mining industry of India: lessons learned from the COVID-19 pandemic', *Journal of Asia Business Studies*, Emerald Publishing Limited, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/JABS-05-2021-0179>.
- Miceli, A., Hagen, B., Riccardi, M.P., Sotti, F. and Settembre-Blundo, D. (2021), 'Thriving, Not Just Surviving in Changing Times: How Sustainability, Agility and Digitalization Intertwine with Organizational Resilience', *Sustainability*, Vol. 13 No. 4, p. 2052.
- Mithun Ali, S., Paul, S.K., Chowdhury, P., Agarwal, R., Fathollahi-Fard, A.M., Jose Chiappetta Jabbour, C. and Luthra, S. (2021), 'Modelling of supply chain disruption analytics using an integrated approach: An emerging economy example', *Expert Systems with Applications*, Vol. 173, p. 114690.
- Moktadir, M.A., Dwivedi, A., Rahman, A., Chiappetta Jabbour, C.J., Paul, S.K., Sultana, R. and Madaan, J. (2020), 'An investigation of key performance indicators for operational excellence towards sustainability in the leather products industry', *Business Strategy and the Environment*, Wiley Online Library, Vol. 29 No. 8, pp. 3331–3351.
- National Economic and Development Authority, P. (2020), 'Exports and COVID-19', *PH TRADE DROPS IN MARCH 2020 DUE TO COVID-19 RESTRICTIONS – NEDA*.
- Paul, S.K. and Chowdhury, P. (2020), 'Strategies for Managing the Impacts of Disruptions During COVID-19: an Example of Toilet Paper', *Global Journal of Flexible Systems Management*, Vol. 21 No. 3, pp. 283–293.
- Paul, S.K. and Chowdhury, P. (2021), 'A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19', *International Journal of Physical Distribution & Logistics Management*, Emerald Publishing Limited, Vol. 51 No. 2, pp. 104–125.
- Paul, S.K., Chowdhury, P., Moktadir, M.A. and Lau, K.H. (2021), 'Supply chain recovery challenges in the wake of COVID-19 pandemic', *Journal of Business Research*, Vol. 136, pp. 316–329.
- Rahman, T., Taghikhah, F., Paul, S.K., Shukla, N. and Agarwal, R. (2021), 'An agent-based model for supply chain recovery in the wake of the COVID-19 pandemic', *Computers & Industrial Engineering*, Vol. 158, p. 107401.
- Ramanujam, R., Muthukrishnan, N. and Raju, R. (2011), 'Optimization of cutting parameters for turning Al-SiC(10p) MMC using ANOVA and Grey relational analysis', *International Journal of Precision Engineering and Manufacturing*, Vol. 12 No. 4, pp. 651–656.
- Recorder, B. (2021), 'Covid-19 handling', *Covid-19 Handling: Pakistan Ranked among Best-Performing States*.
- Rehman, E., Ikram, M., Feng, M.T. and Rehman, S. (2020), 'Sectoral-based CO2 emissions of Pakistan: a novel Grey Relation Analysis (GRA) approach', *Environmental Science and Pollution Research*, Vol. 27 No. 23, pp.

29118–29129.

- Remko, van H. (2020), 'Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice', *International Journal of Operations & Production Management*, Emerald Publishing Limited, Vol. 40 No. 4, pp. 341–355.
- Rocca, R., Rosa, P., Sassanelli, C., Fumagalli, L. and Terzi, S. (2020), 'Integrating Virtual Reality and Digital Twin in Circular Economy Practices: A Laboratory Application Case', *Sustainability*, Vol. 12 No. 6, p. 2286.
- Sarıkaya, M. and Güllü, A. (2015), 'Multi-response optimization of minimum quantity lubrication parameters using Taguchi-based grey relational analysis in turning of difficult-to-cut alloy Haynes 25', *Journal of Cleaner Production*, Vol. 91, pp. 347–357.
- Sassanelli, C., Rosa, P. and Terzi, S. (2021), 'Supporting disassembly processes through simulation tools: A systematic literature review with a focus on printed circuit boards', *Journal of Manufacturing Systems*, Elsevier, Vol. 60, pp. 429–448.
- Sassanelli, C., Rossi, M., Pezzotta, G., Pacheco, D.A.D.J. and Terzi, S. (2019), 'Defining lean product service systems features and research trends through a systematic literature review', *International Journal of Product Lifecycle Management*, Inderscience Publishers, Vol. 12 No. 1, pp. 37–61.
- Sassanelli, C., Urbinati, A., Rosa, P., Chiaroni, D. and Terzi, S. (2020), 'Addressing circular economy through design for X approaches: A systematic literature review', *Computers in Industry*, Elsevier, Vol. 120, p. 103245.
- Settembre Blundo, D., García-Muiña, F.E., Pini, M., Volpi, L., Siligardi, C. and Ferrari, A.M. (2019), 'Sustainability as source of competitive advantages in mature sectors', *Smart and Sustainable Built Environment*, Emerald Publishing Limited, Vol. 8 No. 1, pp. 53–79.
- Singh, S., Kumar, R., Panchal, R. and Tiwari, M.K. (2021), 'Impact of COVID-19 on logistics systems and disruptions in food supply chain', *International Journal of Production Research*, Taylor & Francis, Vol. 59 No. 7, pp. 1993–2008.
- Solleder, O. and Velasquez, M. (2020), 'Blog: The Great Shutdown: How COVID-19 disrupts supply chains', *International Trade Center*.
- Statista. (2021), 'International trade during COVID-19', *Impact from the Coronavirus (COVID-19) on Exports from India*.
- Sudan, T. and Taggar, R. (2021), 'Recovering Supply Chain Disruptions in Post-COVID-19 Pandemic Through Transport Intelligence and Logistics Systems: India's Experiences and Policy Options', *Frontiers in Future Transportation*, Frontiers, Vol. 2, p. 7.
- Tay, H.L. and Loh, H.S. (2021), 'Digital transformations and supply chain management: a Lean Six Sigma perspective', *Journal of Asia Business Studies*, Emerald Publishing Limited, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/JABS-10-2020-0415>.
- Verschuur, J., Koks, E.E. and Hall, J.W. (2021), 'Observed impacts of the COVID-19 pandemic on global trade', *Nature Human Behaviour*, Nature Publishing Group, Vol. 5 No. 3, pp. 305–307.
- World Asia. (2020), 'COVID-19: Pakistan's smart', *COVID-19: Pakistan's Smart Lockdown Strategy Acknowledged by Bill Gates*.
- World Bank. (2021), 'COVID-19 and Iran's economy', *The Outbreak of COVID-19 Has Plunged the Iranian Economy into a State of Ambiguity*.
- Worldometers. (2021), 'Worldometerse'.
- Xu, J. and Li, Y. (2018), 'Grey incidence analysis model of classification variables and its application on innovation & entrepreneurship education in Jiangsu', *Journal of Grey System*, Vol. 30 No. 1, pp. 123–128.
- Zhang, J., Hayashi, Y. and Frank, L.D. (2021), 'COVID-19 and transport: Findings from a world-wide expert survey', *Transport Policy*, Elsevier, Vol. 103, pp. 68–85.
- Zhicai, Z. and Li, C. (2018), 'Analysis on decision-making model of plan evaluation based on grey relation projection and combination weight algorithm', *Journal of Systems Engineering and Electronics*, BIAI, Vol. 29 No. 4, p. 789.
- Zimon, D., Madzik, P., Dellana, S., Sroufe, R., Ikram, M. and Lysenko-Ryba, K. (2021), 'Environmental effects of ISO 9001 and ISO 14001 management system implementation in SSCM', *The TQM Journal*, Emerald Publishing Limited, Vol. ahead-of-p No. ahead-of-print, available at: <https://doi.org/10.1108/TQM-01-2021-0025>.