Journal of Cleaner Production 322 (2021) 129050

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The trilemma of innovation, logistics performance, and environmental quality in 25 topmost logistics countries: A quantile regression evidence

Cosimo Magazzino [a], Andrew Adewale Alola [b,c,d,*], Nicolas Schneider [e]

[a] Roma Tre University, Italy
[b] Department of Economics, School of Accounting and Finance, University of Vaasa, 65101, Vaasa, Finland
[c] Department of Economics and Finance, Istanbul Gelisim University, Istanbul, Turkey
[d] South Ural State University (National Research University), Chelyabinsk, Russian Federation
[e] London School of Economics and Political Science, UK

ARTICLE INFO

Handling Editor: M.T. Moreira

JEL classification:
L91
L92
N70

Keywords:
Logistics performance
Green supply chain management
Economic growth
CO_2 emissions
Panel data
Quantile regression

ABSTRACT

While the deployment of technological innovation was able to avert a devastating global supply chain fallout arising from the impact of ravaging COronaVIrus Disease 19 (COVID-19) pandemic, little is known about potential environmental cost of such achievement. The aim of this paper is to identify the determinants of logistics performance and investigate its empirical linkages with economic and environmental indicators. We built a macro-level dataset for the top 25 ranked logistics countries from 2007 to 2018, conducting a set of panel data tests on cross-sectional dependence, stationarity and cointegration, to provide preliminary insights. Empirical estimates from Fully Modified Ordinary Least Squares (FMOLS), Generalized Method of Moments (GMM), and Quantile Regression (QR) model suggest that technological innovation, Human Development Index (HDI), urbanization, and trade openness significantly boost logistic performance, whereas employment and Gross Fixed Capital Formation (GFCF) fail to respond in such a desirable path. In turn, an increase in the Logistic Performance Index (LPI) is found to worsen economic growth. Finally, LPI exhibits a large positive effect on carbon emissions, which is congruent with a strand of the literature highlighting that the modern supply chain is far from being decarbonized. Thus, this evidence further suggest that more global efforts should be geared to attain a sustainable logistics.

1. Introduction

Logistics is the backbone of the global economy as it drives the supply of products connecting them with consumers worldwide (Liu et al., 2018). To this extent, logistics plays a growing role in organizations that seek to adapt to market changes and supply chain integration over the long-run (Meade and Sarkis, 1998). Logistics refers to the overall process through which resources are acquired, stored, and transported to their destination. It involves distributors and suppliers selected based on their effectiveness, accessibility, and prices. To this extent, the logistics sector aims at maintaining a regular movement of goods that require planning processes, managing workers, and organizing the supply of merchandises in a structured and systematic manner (Yazdani et al., 2020). In the literature, it corresponds to the set of integrated activities including freight transport, inventory storage and management, material handling, and information processing that require moving products through efficient supply chain processes (Martel and Klibi, 2016).

Resulting from the elevated combustion of fossil fuels, Greenhouse Gases (GHG) are directly released in the atmosphere, causing harmful damages for health and the environment on the long-run (Zhang et al., 2011; Magazzino et al., 2020b, 2021c). Particularly, it has been shown that logistics operations represent a key contributor to environmental degradation, covering 22% of world carbon dioxide (CO_2) emissions in 2014 (Khan et al., 2018a, 2018b, 2018b). Calling for urgent environmental measures, a transition towards a Green Supply Chain (GSC) is deemed desirable. Otherwise, CO_2 emissions from transport activities could increase by 60% before 2050 (and by 160% from global freight alone) (OECD, 2017). On the other hand, there is no doubt that logistics is a significant driver of employment, consumption, and economic development. Facing this paradox, this paper extends the literature. Through key channels, it asks whether logistics operations may achieve

* Corresponding author. Department of Economics, School of Accounting and Finance, University of Vaasa, 65101, Vaasa, Finland.
E-mail addresses: cosimo.magazzino@uniroma3.it (C. Magazzino), andrew.alola@uwasa.fi (A.A. Alola), n.schneider2@lse.ac.uk (N. Schneider).

https://doi.org/10.1016/j.jclepro.2021.129050
Received 9 June 2021; Received in revised form 7 September 2021; Accepted 14 September 2021
Available online 20 September 2021

both economic and environmental targets. Notwithstanding, this research seeks to draw further insights on how to balance profitability and environmental preservation in a single objective for the logistics sector.

Unquestionably, like energies, logistics activities are essential for the economy as they share vital economic linkages with employment and economic growth (World Economic Forum, 2020; Wong and Tang, 2018; Magazzino and Schneider, 2020). Inversely, poorly managed, inefficient logistics operations increase the operational and capital costs associated with under-utilization and waiting time (Kallionpaa et al., 2015; Windmark and Andersson, 2015). At the firm level, such performance finds explanations in the logistics (inter and intra) organization, and it has been corroborated by several papers (Flynn et al., 2010; Vaccaro et al., 2010; Christopher, 2016). From an international perspective, the globalization process has extended the scale of competitiveness and set outsourcing as a clear competitive edge for firms. This has affected territories and operating systems, while providing also important export opportunities (D'Aleo and Sergi, 2017, 2020a). Consequently, it represented 10 million jobs in the European Union (EU) in 2011, covering 4.5% and 4.6% of total employment and aggregate income, respectively (European Commission, 2015). Meanwhile, logistics operations induce adverse effects on the environment. Indeed, the huge involvement of transportation and long lead-time depends on fossil fuel whose combustion generates toxic emissions (Khan et al., 2016a, 2019). Thus, lacking fuel-efficient activities and green practices may threaten the sustainability of the whole sector, calling for the design of new supply chain networks (Memari et al., 2016).

In response to this economic-environment paradox, a growing trend of research has arisen around the concept of Green Logistics (GL) (Ostrom, 2008; Pålsson et al., 2013). It aims to supply goods in a sustainable manner, while not hindering the long-run economic performance of firms (Neto et al., 2009; Dekker et al., 2012). The concept of GSC can be traced back to Rao and Holt (2005), later extended with a framework proposed in Carter and Rogers (2008). However, a well-known limit remains: the economic profitability constitutes the foreground objective for firms, far in front of environmental concern[1] (Pagell and Shevchenko, 2014). This obstacle can be overcome by building a "green" competitive advantage based on environmental-friendly practices, more adapted to the current climate issues. While creating new export and profit opportunities, sustainable procedures may improve economic efficiency and answer the new consumption behaviours (notably in advanced countries) (Zelbst et al., 2010; Green et al., 2012; Khan et al., 2018a, 2018b). In addition, the way materials are handled, information is processed, and inventory are stored is the subject of crucial discussions (Li et al., 2018). Also, key leverages (tax, import duties, and subsidies implemented by regulatory institutions) are heavily discussed to ensure a transition from logistics to environmental performance. For instance, it can be the case of targeted subsidies for firms that incorporate biofuels and renewable sources of energy in their logistics process (Li, 2014). Besides, Green Supply Chain Management (GSCM) is also a key area in which circular business models can operate as they could cover the reverse effects of logistics (this includes: waste recycling, disposal, and landfills as well as energy recovery) (Yu et al., 2018). Up to now, a range of manufacturing firms have started such transitions (notably in Asia: Boonchai and Beeton, 2016; Xue et al., 2018), although there is a large room for improvements. Representing a fruitful research direction, a literature's domain has emerged on that topic and displayed seminal contributions. Accordingly, the major motivation of this study stands as follows: starting by evaluating the macroeconomic drivers (innovation, infrastructure, education, employment, and capital) of logistics, it appears appropriate to assess their resulting impact on economic growth and environmental pollution.

Looking at the most recent literature, a first strand of the literature investigated the linkages among logistics performance and economic growth, often including trade (Coto-Millán et al., 2013; Martí et al., 2014; Çelebi et al., 2015; Khan et al., 2017a, 2017b, 2017b; Munim and Schramm, 2018; Sharipbekova and Raimbekov, 2018; Tang and Abosedra, 2019; Töngür et al., 2020). Under the current context of just-in-time production systems, improving the logistics operations (in terms of border management, quality of services, and tracking of products) reduces the cost of delivery whilst strengthening its reliability and predictability (Munim and Schramm, 2018). Undoubtedly, this has direct effects on the firms' market shares and profits, turning into employment and income growth. A second group of recent macro-level studies relied on LPI data to analyze the nexus between green logistics operations and environmental sustainability (Khan and Qianli, 2017; Zaman and Shamsuddin, 2017; Khan et al., 2018a, 2019; Liu et al., 2018; Li et al., 2018; Khan, 2019), using CO_2 emissions as the main proxy for environmental damage. Finally, a range of papers examined the macroeconomic drivers of logistics performance (Guner and Coskun, 2012; Marchet et al., 2016; Wong and Tang, 2018), but it remains scarce, and empirical findings are controversial. Calling for further quantitative experiments at the global scale, this paper is innovative as it makes a bridge between these three strand of literatures.

While the productivity role of technologies into the supply chain has been well documented (Will and Blecker, 2012; Wong et al., 2016; Gunasekaran et al., 2017), its linkages with income and CO_2 emissions appear somehow overlooked. Obviously, innovation has drastically modified the trade patterns by upgrading the logistics competence (Lee, 2004; Cheng-Min and Chien-Yun, 2006). Taking the form of data exchange, automated handling systems, but also digital order processing and material management (Wong and Tang, 2018), this has provided a better visibility of goods movements, reducing the operating and transaction costs for the firms, while increasing their demand for electricity. In addition, innovation could play a valuable role in the transition towards a GSC. Undeniably, investing in cleaner technologies may help implementing GSCM practices along the production process. This could not only reduce the environmental externalities but also boost the firms' profitability in the long-run by building a singular competitive edge (Rao and Holt, 2005). For that reason, innovation stands at the heart of the concept of "Green Corridor". Developed through seminal papers (Demir et al., 2014; Khan et al., 2016a, 2016b, 2016b), it aims at controlling the environmental related factors which affect the consumption of fuel. While firm-level analyses on the innovation-logistics performance nexus can be found in the literature (Lin et al., 2010; Cosimato and Troisi, 2015; Piyachat, 2017; Ganesh Kumar and Ashlin Nimo, 2020), macro-level evidence is scarce and needs further inquiries.

Finally, there is a deficit of infrastructure-related insights. Tightly linked to the modern trade processes, networks, and public infrastructure systems (ports, airports, and rail) are important to build a strong supply chain (Limao and Venables, 2001; D'Aleo and Sergi, 2017; Wong and Tang, 2018). Nonetheless, their economic and environmental roles remain unclear from a global perspective. On one hand, well-qualified facilities and related services helps to develop a logistics-friendly environment, which in turn improves income and is congruent with the growth theory (Vilko et al., 2011). On the other hand, expanding the infrastructure's quality for logistics purposes also means developing Information and Communication Technology (ICT) and vehicles, which are critically dependent on energy. In both cases, there is a point in asking whether this may adversely affect the level of carbon emissions at a global scale. Finally, careful attention should be paid to human capital. It has been established that education is positively associated with income which, in turn, might affect the consumption of energy-intensive goods (Fang and Chang, 2016; Salim et al., 2017; Yao et al., 2019; Wang et al., 2020). Hence, one can relevantly ask whether logistics performance is sensitive to human capital, and in which way this could strengthen the implementation of GSC practices. Yet, related statistics

[1] Until recently, cost minimization strategies were at the core of freight transportation attention (Crainic, 2000; Forkenbrock, 2001).

are available and allow for such challenging examinations.

In sum, this paper seeks to contribute to the literature in four ways. First, to our knowledge, this study is the first to create a connection between the technological determinants of logistics performance and their resulting economic and environmental effects from an international perspective. Through key channels, it asks whether innovation can both enhance logistics operations and CO_2 emissions reduction. Second, this research shed a novel light on infrastructure and human capital as a potential contributing factor to the economic and environmental performance-related logistics. Following Wong and Tang (2018), the perceivable importance of these two factors may complement technology, employment, and capital to improve logistics, with direct observable effects on income and CO_2 emissions. Third, providing an international perspective on SCM, this paper performs a macro-level analysis on the top 25 logistics countries ranked by the 2018 World Bank classification. In using nationwide indicators into a global dataset, this study could consistently derive factors affecting logistics from their associated economic and environmental roles, while bringing meaningful insights on national settings. Fourth and finally, from a methodological point of view, this paper contrasts to previous ones as it adopts several recent panel data econometric techniques.

This study empirically examines the dynamic association among technological innovation, infrastructure, education, employment, Gross Fixed Capital Formation (GFCF), logistics performance, economic growth, and CO_2 emissions. Trade openness and urbanization are also included in the multivariate framework. We collected macro-level data on the top 25 ranked logistics countries worldwide and over the 2007–2018 period. Applying a set of panel data econometric techniques (cross-section dependence tests, unit root tests, cointegration tests), the complete causality testing framework comprises three distinct panel data estimators: Generalized Method of Moments (GMM), Fully Modified Ordinary Least Squares (FMOLS), and Quantile Regressions (QR). The selection of the estimators is thought to ensure consistent findings: GMM represents a very common strategy to analyze dynamic panel data with $N > T$; FMOLS was designed to provide optimal estimates of cointegrating relationship; QR express the conditional quantiles of a dependent variable as a linear function of the explanatory variables, allowing us to conduct non-parametric robustness checks of the parametric estimates. Associated findings are thought to provide important guidance to firms' managers, stakeholders, and policymakers in search of practical solutions to economic and environmental challenges in the logistics sector.

The rest of the paper is organized as follows. Section 2 presents the relevant literature. Section 3 describes the data and the empirical methodology. Section 4 displays and discusses the empirical results. Section 5 gives concluding remarks, while Section 6 suggests some policy implications.

2. Literature review

The literature related to supply chain is abundant. Given the explicit aim of this paper, this survey is divided into three components. The first focuses on the relationship between logistics performance and economic growth. The second concentrates on the linkages between logistics operations and environmental sustainability. The third considers the underlying nexus between innovation and logistics performance. Lastly, empirical gaps are highlighted and our research contribution is proposed.

2.1. Logistics performance and growth

Within the context of supply chain, the relationship between LPI and the international economy has been the subject of intense discussions (Çelebi, 2019). Coto-Millán et al. (2013) employed a global aggregate production function to capture the effect of LPI on world economic growth. Collecting data from 2007 to 2012, they estimated that a 1% rise in the LPI index induces an increase of the world economic growth ranging between 0.011% and 0.034%. Martí et al. (2014) used a gravity model finding that improvements in any of the components of the LPI are positively associated with trade flows, and highlighting that the efficiency and quality of logistics operations do matter. Çelebi et al. (2015) confirmed that Foreign Direct Investment (FDI) plays a mediator role in the LPI-economic growth nexus. Khan et al. (2017a) collected LPI and GDP data for 15 selected global ranked logistics countries showing that logistics competence and infrastructure boost economic growth and sectoral value added. Munim and Schramm (2018) considered 91 countries with seaports and inspected the economic effect of seaborne trade, from a port infrastructure quality and logistics performance perspective. Findings demonstrated that the quality of port infrastructure contributes to a better logistics performance. Based on Commonwealth and Independent States (CIS) countries, Sharipbekova and Raimbekov (2018) highlighted that LPI and economic indicators share closed linkages, which is congruent with Tang and Abosedra (2019). Indeed, they concluded that the export-led growth hypothesis is confirmed for 23 Asian countries. Tightly linked to this view, using disaggregated exports data for Turkish trade with 174 countries, Töngür et al. (2020) ended up to the same conclusion using a gravity model. More recently, Goel et al. (2021) explored the nexus between supply chain performance and economic growth, with a specific focus on the implications for public policy and COVID-19 initiatives. Based on data collected for 130 economies, findings suggested that improving supply chain logistics performance imply positive growth. Similarly, Laeeq Razzak Janjua et al. (2021) employed a univariate time series forecasting model and investigated the impact of COVID-19 pandemic on logistics performance and economic growth in Thailand. Results confirmed the strong connections between these two indicators, notably through the channel of tourism flows, predominant in Thailand's GDP. Sergi et al. (2021) assessed the causal relationship between logistics performance and selected factors in the Global Competitiveness Index (GCI), which were grouped into three clusters: infrastructure, human factor, and institutions, with data covering Africa, Asia, and the EU. Evidence drawn from the ANOVA method claim that improving all three clusters increase efficiency, although human factor plays a predominant role.

2.2. Assessing the empirical relationship between logistics operations and environmental sustainability

A strand of the literature discusses the empirical linkages among logistics performance, economic performance, and economic degradation with a macro-level approach. Most of these studies relied on the LPI data provided by the World Bank in 2007. Hence, one well-known drawback is that the short data period has constrained the researchers to rely on a large panel of countries.

Above all, Khan and Qianli (2017) inspected the interactions between environmental indicators on green logistics (GHG emissions, fossil fuel, and renewable energy) and national scale economic variables (FDI inflows, per capita income) for the United Kingdom (UK). Employing an AutoRegressive Distributed Lag (ARDL) bounds model, findings supported the existence of a positive relationship between green logistics and renewable energy, while a negative association between green logistics and fossil fuels is established. Besides, FDI inflows, renewable energy sources, and per capita income are found to positively impact logistics activities. Khan et al. (2018a) built a heterogeneous sample of 43 economies (low-, middle-, and high-income countries). Results of the GMM model highlighted that logistics operations induce an important amount of carbon emissions, indicating that the logistics sector remains highly dependent on fossil fuels. This elevated consumption of non-renewable energy results in adverse effects on economic growth. Inversely, shifting from fossil to renewable sources of energy positively impacts economic growth process. Furthermore, Liu et al. (2018) studied the nexus between logistics performance and CO_2

emissions for 42 Asian countries. They applied a GMM regression model with data covering the 2007–2016 period. The estimates claimed evidence that logistics performance and environmental indicators are closely related in Asia. Indeed, an inefficient frequency with which shipments reach consignees within scheduled or expected delivery times increases CO_2 emissions, while improving international shipment in LPI significantly lowers environmental pollution. This corroborates the role of other sub-LPI (tracking and tracing, services quality and competence, infrastructure quality, and efficiency of customs), which showed a strong mitigating impact on pollution.

Zaman and Shamsuddin (2017) extended this analysis to 27 European countries and investigated the effect of logistics performance on three sets of indicators (i.e., energy, environment, and economic health). With data covering the 2007–2014 period, three distinct GMM estimations have been performed: the effect of logistics performance indicators on energy variables, environmental variables, and health variables. Empirical findings indicated heterogeneous effects with respect to the logistics indicator used. Overall, boosting logistics international shipments increases fossil fuel energy. Along with the multiplication of LPI's utilizations, Lu et al. (2019) assessed the causal linkages among oil consumption from transportation, logistics performance, and CO_2 emissions from transportation, building a relevant Environmental Logistics Performance Index (ELPI) for a sample of 112 countries. The main finding is that ELPI is strongly correlated with LPI, indicating that countries with high logistics performance display high levels of ELPI (especially for advanced economies). Khan et al. (2019) applied GMM and Feasible Generalized Least Squares (FGLS) to examine the association between green logistics operations, social, environmental, and economic indicators for 8 South Asian Association for Regional Cooperation (SAARC) countries. Empirical findings revealed that fossil energy consumption drives environmental pollution, while logistics performance mitigates CO_2 emissions, GHG emissions, health expenditure, and political instability. Khan (2019) showed that poverty and logistics operations have a significant positive relationship with environmental degradation for the Association of Southeast Asian Nations (ASEAN) countries. Focusing on the feedback channel for the same case study, Khan et al. (2020a) demonstrated that lower levels of CO_2 emissions improve economic growth, while the use of renewable energy in logistics operations is found to improve economic and environmental performance.

Lastly, Khan et al. (2020b) identified the interconnections between CO_2 emissions, renewable energy consumption, energy demand, GDP per unit of energy use, FDI, and logistics for 42 selected global ranked countries. OLS findings underlined that logistics performance is positively associated with FDI, renewable energy consumption and energy demand, while it is found to mitigate CO_2 emissions. Suki et al. (2021) explored the effect of logistics performance on economic and environmental indicators. Findings derived from the Cross-Sectionally augmented AutoRegressive Distributed Lag (CS-ARDL) model applied on top 15 Asian countries over the 2010–2018 period show that logistics activities trigger economic growth, and lower carbon emissions. Li et al. (2021) analyzed the growth and environmental effects of green logistics performance for One Belt and Road Initiative (OBRI) countries over the period 2007–2019. GMM results display significant positive impacts on economic growth for OBRI, Europe and Middle East and North Africa (MENA) economies, whereas environmental quality is improved in Europe and East and Southeast Asian regions only. In Larson (2021), the nexus between logistics performance and dimensions of sustainability is examined for 160 countries for the year 2016. Results concluded that a healthy, educated population, equality, good governance, and reasonable income distribution are associated with higher levels of logistics performance. Nonetheless, logistics activities fail to reduce pollution emissions, and still represent a threat to sustainability in its current form. Overall, Sohail et al. (2021) explored the asymmetric impact of air-railway transportation on environmental pollution in Pakistan using annual time series data covering the 1991–2019 period. Results showed that 1% increase in air passenger carried (railway passenger carried) enhances environmental pollution by 0.21% (0.32%) in the long-run, providing insights for the green transportation management in Pakistan. Table 1 summarizes the most recent papers related to this relevant literature.

2.3. Innovation and logistics performance

Mostly with a micro approach, a stream of the literature explored the innovation-logistics performance relationship using surveys. Lin et al. (2010) addressed the drivers of innovation in channel integration in Supply Chain Management (SCM). Based on the analysis of 317 Taiwan qualified high tech manufacturers, market orientation is significantly related to embedding operant resources and resource integration. Piyachat (2017) inspected the relationships among resources' commitment, reverse logistics innovation, reverse logistics performance, and reverse logistics cost savings. Empirical results showed evidence of a positive association between reverse logistics innovation and reverse logistics performance. This corroborates Richey et al. (2005) and Huang and Yang (2014), supporting the idea that innovation requires time and resources.

Cosimato and Troisi (2015) considered the DHL company as a case study and concluded that eco-innovation along the supply chain can reduce its associated environmental impact while improving competitiveness and the global logistics performance. Nonetheless, as reminded in Lin (2007) for China, the adoption of innovative technologies in the logistics sector itself is subject to be highly dependent on the quality of human resources and government support, but also environmental uncertainty. Recently, Ganesh Kumar and Ashlin Nimo (2020) elaborated a conceptual framework for reverse logistics performance and innovation. Arbolino et al. (2017) examined whether the EU regulation on GHG emissions from road transport has induced a policy transfer process. Italian-related estimations showed that northern cities are more actively drawing policy lessons. Therefore, the processes of policy transfer may imply heterogeneous effects across cities and regions. One possible reason is that large cities are more likely to be internationally connected than small municipalities. Using a spatial approach to the Italian regions, Barilla et al. (2020) investigated the main variables affecting the Total Factor Productvity (TFP) in the transport and logistics sectors. They collected data covering the 2007–2015 period, estimating a regional production function. Findings suggested that, in the different Italian regions, a high resilience capacity characterizes the logistics sector. Thus, innovation in the logistics industry can be considered crucial in driving regional exports. Moldabekova et al. (2021) attempted to underline the role of Industry 4.0 in improving logistics activities and inspected the effect of digitalization on logistics performance. Results suggested that improving the generation of human capital, a more sustainable usage of internet services coupled with digital technologies and connectivity drive the performance of the logistics sector. Bai et al. (2021) inspected the effect of Organizational Learning Capacity (OLC) on the relationship between relational embeddedness and innovation performance in freight logistics service. Based on a sample of 236 respondents from freight logistics firms in China, results indicated that OLC and relational embeddedness both drive innovation performance. All in all, Cordova and Coronado (2021) investigated to what extent innovations in supply chain operations may produce unexpected outcomes for firms' strategies. By analyzing four examples of technological innovations under a Balanced Scorecard framework, conclusions highlighted that organizations may have to find optimal trade-off between different dimensions of performance to reach sustainable targets.

Here, several important observations that distinguished the current study from the literature are highlighted. First, in terms of empirical approach, the current study implements the quantile regression approach which is found to be sparsely used in the literature as implied in the aforementioned literature as well as in Table 1. The essence is that the quantile regression considers estimation across the entire length of

Table 1
Summary of previous empirical studies on the relationship between logistics performance, economic and environmental indicators.

Authors	Sample	Data Period	Methodology	Variables	Results
Khan and Qianli (2017)	UK	1981–2016	ARDL	Green Logistics, GHG emissions, fossil fuel, and renewable energy, FDI inflows, per capita income	GL→RE and (FDI, RE, Y)→GL
Zaman and Shamsuddin (2017)	27 European countries	2007–2014	GMM	LPI, FDI, industry value added and 7 distinct independent variables (GDP per unit of energy use, energy price and renewable energy consumption; fossil fuel energy consumption, CO_2 emissions; per capita health expenditure, per capita GDP)	↑LPIST→↑(Y, HE); ↑LPIQTTI→↑RE; ↑LPICCP→↓EP; ↑LPITTC→↑FE; ↑LPIQLS→↑C; ↑LPICPS→↑FE
Khan et al. (2018a)	43 countries	2007–2013	OLS, FE, RE, GMM	LPI, energy demand, renewable energy demand, fossil fuel energy consumption, per capita GDP, health expenditure, GHG emissions, CO_2 emissions, FDI, industry and agriculture value added, export and import of goods and services	↑FE→↑LPI and ↑RE→↓Y
Liu et al. (2018)	42 Asian countries	2007–2016	GMM	LPI, trade openness, CO_2 emissions, urbanization, industrialization	↑LPI→↓C and ↑(TO, URB)→↑C
Lu et al. (2019)	112 countries	2010–2018	RAM-DEA	Environmental LPI, Oil consumption from transportation, LPI, CO_2 emissions from transportation	↑LPI→↑ELPI
Khan et al. (2019)	SAARC countries	2001–2016	GMM, FGLS	LPI, fossil fuel and renewable energy consumption, health expenditure, CO_2 emissions, GHG emissions, political instability index, social globalization index, trade openness, GDP per capita, FDI, agriculture value added, industry value added	↑FEC→↑C, ↓LPI→↑(C, HE, GHG, PII), ↑LPI→↑(TO, Y) and ↑LPI→↓C
Khan (2019)	ASEAN countries	2007–2018	GMM	OLPI, CO_2 emissions, GDP, health expenditure, poverty	↑(LPI, P)→↑C
Khan et al. (2020a)	ASEAN countries	2007–2018	Structural Model	LPI, CO_2 emissions, GHG emissions, renewable energy consumption, health expenditure, FDI, trade openness	↑LPI→↑Y ↓C→↑Y, ↑HE→↓C and ↑HE→↓Y
Khan et al. (2020b)	42 countries	2007–2018	OLS	OLPI, CO_2 emissions, renewable energy consumption, energy demand, GDP per unit of energy use, FDI	↑LPI→↑(FDI, REC, ED) and ↑LPI→↓C
Suki et al. (2021)	15 Asian countries	2010–2018	CS-ARDL	LPI, capital, labor, urbanization, GDP, CO_2 emissions	↑LPI→↑Y and ↑LPI→↓C
Li et al. (2021)	OBRI countries	2007–2019	2SLS, GMM	Green logistics, Industry value-added, fossil fuel consumption, agriculture value-added, FDI, CO_2 emissions	↑LPI→↑Y (OBRI, Europe and MENA economies) and ↑LPI→↓C (Europe and East and Southeast Asian regions)
Larson (2021)	160 countries	2016	OLS	LPI, GDP, GHG, employment, energy use, 10-year change in forest area, income distribution, education, gender equality, health	↑(EMP, ID, EDU, GE, H) →↑LPI and ↑LPI→↑(Y, C)
Sohail et al. (2021)	Pakistan	1991–2019	N-ARDL	GDP, CO_2 emissions, air passenger carried, railway passenger carried, population	↑(APC, RPC) →↑C

Source: our elaborations.
Notes: APC: Air passenger carried; C: CO_2 emissions; ED: Energy demand; EDU: Education; EMP: Employment; EP: Energy price; FDI: Foreign Direct Investment; FE: Fossil energy consumption; GE: Gender equality; GHG: Greenhouse gas emissions; GL: Green logistics; H: Health; HE: Health expenditures; ID: Income distribution; LPI: Logistics performance indexes; OLPI: Overall Logistics performance index; LPIST: Logistics performance index measuring the frequency with which shipments reach consignee within scheduled or expected time; LPIQTTI: Logistics performance index measuring the quality of trade and transport-related infrastructure; LPICCP: Logistics performance index measuring the efficiency of customs clearance process; LPITTC: Logistics performance index measuring the ability to trace and trace consignments; LPIQLS: Logistics performance index measuring the competence and quality of logistics services; LPICPS: Logistics performance index measuring the ease of arranging competitively priced shipments. OBRI: One Belt and Road Initiative. P: Poverty; PII: Political Instability Index; REC: Renewable energy consumption; RPC: Railway passenger carried; TO: Trade openness; URB: Urbanization; Y: economic growth.
Methodologies: 2SLS: 2 Stages Least Squares; ARDL: Auto-Regressive Distributed Lag; CS-ARDL: Cross-Sectionally augmented AutoRegressive Distributed Lag; FE: Fixed Effects; FGLS: Feasible Generalized Least Squares; GMM: Generalized Method of Moments; N-ARDL: Non-Linear AutoRegressive Distributed Lag; OLS: Ordinary Least Squares; RAM-DEA: Range-Adjusted Measure of the Data Envelopment Analysis; RE: Random Effects.

the dataset rather than mean values. Second, the literature devoted to the macroeconomic linkages among innovation and logistics performance is much scarcer. To the best of our knowledge, we denoted no past empirical analysis that attempted to understand the link among innovation, logistics, and other national size indicators, although conducting further inquiry on this topic may represent a fruitful research direction. Third, our review showed that the logistics role of human capital and infrastructure is under-investigated. Fourth, while past studies mostly considered large and heterogeneous samples so far, one must also notice that none of them considered a sample of selected global ranked logistics economies. Lastly, conflicting results can be identified in the research domain. Accordingly, this study seeks to simultaneously bridge these above-mentioned gaps.

3. Data and empirical methodology

3.1. Data collection

To implement our empirical strategy, data for the top 25 ranked logistics countries worldwide (WDI ranking for the year 2018) have been collected. The complete list of countries is given in Table A (in Appendix).

The core variables are: employment, capital, education, innovation, infrastructure, logistics performance, GDP, and CO_2 emissions. Employment data are expressed in total number (WDI, 2019). GFCF data are expressed in constant LCU (WDI, 2019). The tertiary school enrolment (% Gross) is used as a proxy for human capital (WDI, 2019). Innovation is proxied by the total number of patents (all technology domains – patent applications filled under the PCT (Patent Cooperation Treaty) – reference country: inventor's country of residence – reference date: application date) and taken from the OECD Patent Statistics (OECD, 2020a).[2] Infrastructure investment data (inland total) are expressed in % of GDP (WDI, 2019). Following Khan (2019) and Khan et al. (2020b), we relied on the "Overall" Logistics Performance Index

[2] Patent data are available at: https://www.oecd-ilibrary.org/science-and-technology/data/oecd-patent-statistics_patent-data-en.

Table 2
Variables' descriptions.

Indicator	Definition	Source
Employment	Number of employed persons (total)	World Development Indicators (WDI, 2019)
Capital	Gross Fixed Capital Formation (constant LCU)	World Development Indicators (WDI, 2019)
Urbanization	Urban population (% of total population)	World Development Indicators (WDI, 2019)
Innovation	Number of patents (all technology domains) (total)	OECD Patent Statistics (2020)
Trade Openness	Share of exports and imports (% of GDP)	World Development Indicators (WDI, 2019)
Human Capital (proxied by the Human Development Index)	Assessing country's development from health, education, and income (index)	United Nations Development Programme (UNDP, 2020)
Logistics Performance	Overall Logistics Performance Index (LPI) (from 1 = low to 5 = high)	World Development Indicators (WDI, 2019)
GDP	GDP (constant LCU)	World Development Indicators (WDI, 2019)
CO_2 emissions	CO_2 emissions from fuel combustion (thousand tons)	IEA CO_2 Emissions from Fuel Combustion Statistics (2019)

Source: our elaborations.

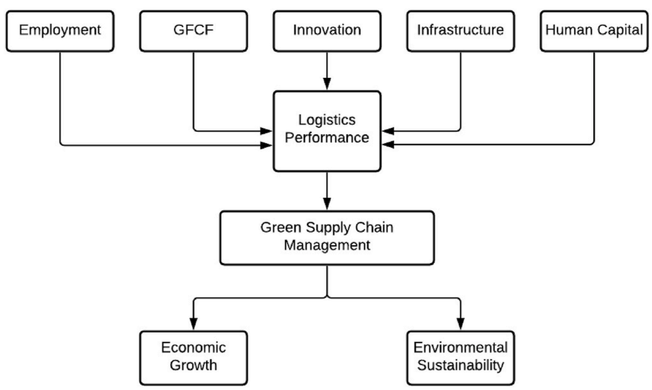

Fig. 1. Relationship among logistics performance determinants, GSCM, economic growth, and environmental sustainability.
Source: our elaborations.

(LPI) that is defined as the arithmetic average of the 6 LP sub-indexes (i.e., LPITTC, LPIQLS, LPICPS, LPICCP, LPIST, and LPIQTTI) provided by the World Bank (2019). LPI is set up on a 1 to 5 scale (1 = low to 5 = high). It encompasses: 1) LPITTC: the ability to trace and trace consignments; 2) LPIQLS: the competence and quality of logistics services; 3) LPICPS: the ease of arranging competitively priced shipments; 4) LPICCP: the efficiency of the customs clearance process; 5) LPIST: the frequency with which shipments reach consignee within scheduled or expected time; 6) LPIQTTI: the quality of trade and transport-related infrastructure. To proxy the economic performance, we use the real GDP series expressed in constant LCU (WDI, 2019).[3] Moreover, as a proxy for environmental pollution, we collected data on CO_2 emissions from fuel combustion (in thousand tons) from the 'IEA CO_2 Emissions from Fuel Combustion Statistics of The Organisation for Economic Co-operation and Development (OECD,2020b) database.[4] Constrained by the availability of LPI data, the study covers the most recent period (from 2007 to 2018), totalling 300 observations. The main information on the data are outlined in Table 2; while the relationships tested in this study have been pictured in Fig. 1.

3.2. Model specification

In the extant literature, logistic performance has been investigated from the aspects of its determinants and effects on socioeconomic aspects. However, this paper combines the different dimensions of the aspects of logistic performance in Zaman and Shamsuddin (2017), Khan et al. (2018a), and Liu et al. (2018) to formulate a new model illustrated in Fig. 1.

There are three aspects to highlight in Fig. 1: the determinants of logistics performance, the role of logistic performance in economic growth, and the role of logistic performance in driving the environmental sustainability trend. Thus, the aforementioned models (A, B, C) are represented in equations (1)–(3), such that:

$$LPI = f(HDI, LGFCF, LLF, LP, LUP, LTO) \quad (1)$$

$$LGDP = f(HDI, LPI, LUP, LTO) \quad (2)$$

$$LCEM = f(HDI, LPI, LUP, LTO) \quad (3)$$

Considering the desirability of preliminary tests – such as those on stationarity and cointegration – we proceed to investigate the determinants of logistic performance, economic growth, and environmental quality, and apply FMOLS, GMM, and QR estimators. Indeed, the selection of different estimators ensures the robustness of the applied findings.

The QR approach is employed for each of the models in equations (1)–(3). It considers the entire distribution while controlling time-variant issues of heterogeneity and outliers (Asongu and Odhiambo, 2019; Zaman and Shamsuddin, 2017; Lasisi et al., 2021). Additionally, the lack of evidence of normality for all the variables support the desirability of the QR approach. Moreover, the QR estimator has a superior advantage in estimating the complete description other than the conditional mean and median distribution (Mosteller and Tukey, 1977). Given, that time $t = 2007, 2008, \ldots, 2018$, and $i = 1, 2, \ldots, 25$, the first model (equation (1)), is presented with a modified QR approach as:

$$E[LPI_{it}|(HDI_{it}, LGFCF_{it}, LLF_{it}, LP_{it}, UP_{it}, TO_{it}), \alpha_i] = (HDI_{it}^T, LGFCF_{it}^T, LLF_{it}^T, LP_{it}^T, UP_{it}^T, TO_{it}^T)\beta + \alpha_i \quad (4)$$

such that:

[3] Employment, capital, education, infrastructure, LPI, and GDP data are available at: https://databank.worldbank.org/source/world-development-indicators.

[4] Data on CO_2 emissions from fuel combustion are available at: https://www.oecd-ilibrary.org/energy/data/iea-co2-emissions-from-fuel-combustion-statistics/co2-emissions-by-product-and-flow_data-00430-en.

$$Q_{LPI_{it}}[\tau|(HDI_{it}, LGFCF_{IT}, LLF_{it}, LP_{it}, UP_{it}, TO_{it}), \alpha_i] = \beta_{1\tau}HDI_{it} + \beta_{2\tau}LGFCF_{it} + \beta_{3\tau}LLF_{it} + \beta_{4\tau}LP_{it} + \beta_{5\tau}UP_{it} + \beta_{6\tau}TO_{it} + \alpha_i \quad (5)$$

where unobserved country effect is represented by α_i.

By extending the least squares in the framework of Koenker and Bassett Jr. (1978), the $\widehat{\beta}(\tau)$ in equation (5) is estimated as the τ^{th} ($\tau = 0.10, 0.25, 0.50, 0.75, 0.90$) of different conditional quantile functions through the following expression:

$$\widehat{\beta}(\tau) = argmin_{\beta \in R^k}\left[\sum_{i \in \{i:y_i \geq x_i\beta\}} \tau\, |y_i - x_i\beta| + \sum_{i \in \{i:y_i < x_i\beta\}} (1-\tau)|y_i - x_i\beta|\right] \quad (6)$$

Moreover, the τ (parameter size) ranges within $0 < \tau < 1$, such that there is a minimization of the weighted sum of absolute deviations, which provides the conditional quantile of the logistic performance index for the explanatory variables x_i through:

$$Q_{LPI}(\tau|(HDI_i, LGFCF_i, LLF_i, LP_i, UP_i, TO_i) = (HDI_i, LGFCF_i, LLF_i, LP_i, UP_i, TO_i)\beta_\tau \quad (7)$$

Similarly, the aforementioned step-by-step procedures are repeated for the other two models (equations (2) and (3)). Although these procedures are not indicated here because of space constraint, the entire distribution of the *LPI*, *LGDP*, and *LCEM* for each category quantile results are compared with the conditional distribution of the FMOLS and QR approaches.

4. Empirical results and discussion

In Figure A in the Appendix we reported the scatterplot matrices of the variables, while in Table B some descriptive statistics are shown.

Cross-section dependence is one of the main diagnostics to be analyzed prior to conduct panel data econometric investigations. Indeed, panel data may be affected by influential cross-sectional dependence, through which all units in the same cross-section are correlated, due to some unobserved common factors, or to spatial or spillover effects.

In Table 3, we show the results of panel cross-section dependence tests for our sample. The null hypothesis (H_0) of these tests is the absence of cross-sectional dependence. Here, for all variables we clearly reject the null hypothesis at any level of significance, concluding that cross-section dependence should be taken into account in the subsequent analysis.

Since we observed that cross-section dependence emerges in the series, we proceed performing the panel unit root tests in presence of

Table 3
Panel cross-section dependence tests.

Test	LPI	LGDP	LCEM	HDI	LGFCF	LLF	LP	LUP	LTO
[a]. Pesaran (2021)	4.792***	37.709***	10.195***	10.564***	26.346***	9.385***	10.935***	11.319***	30.811***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
[b]. Friedman (1937)	28.279	95.644***	33.332*	50.935***	81.384***	46.248***	47.513***	64.499***	85.390***
	(0.2485)	(0.0000)	(0.0973)	(0.0011)	(0.0000)	(0.0041)	(0.0029)	(0.0000)	(0.0000)
[c]. Frees (1995)	1.797***	3.526***	0.979***	0.796***	2.467***	0.390**	1.098***	4.094***	3.720***
	(0.3429)	(0.3429)	(0.3429)	(0.3429)	(0.3429)	(0.3429)	(0.3429)	(0.3429)	(0.3429)
[d]. Chudik and Pesaran (2015)	0.6629	29.1248***	−1.6582*	7.0319***	1.1558	−0.9271	−0.9484	−0.4828	4.2757***
	(0.5074)	(0.0000)	(0.0973)	(0.0000)	(0.2477)	(0.3539)	(0.3429)	(0.6292)	(0.0000)
[e]. Pesaran (2021) CD	4.2453***	43.9485***	12.0055***	56.0180***	24.4174***	36.3851***	15.0958***	38.4903***	19.5669***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
[f]. Breusch and Pagan (1980)	777.4648***	2461.087***	1470.005***	3147.431***	1470.389***	2322.808***	949.6058***	2203.866***	1143.517***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
[g]. Pesaran (2021) LM	19.4924***	88.2260***	47.7653***	116.2459***	47.7809***	82.5808***	26.5200***	86.7266***	34.4364***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
[h]. Baltagi et al. (2012)	18.3561***	87.0896***	46.6289***	115.1095***	46.6446***	81.4444***	25.3837***	85.6811***	33.3001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.
Sources: our calculations.
Notes.
[a] Pesaran (2021). General Diagnostic Tests for Cross. Section Dependence in Panels.
[b] Friedman (1937) test for cross-sectional dependence by using Friedman's χ^{b} distributed statistic.
[c] Frees (1995) test for cross-sectional dependence by using Critical Values from Frees' Q distribution (T-asymptotically distributed).
[d] Chudik and Pesaran (2015) test for weak cross sectional dependence.
[e] Pesaran (2004) CD test for cross-section dependence in panel time-series data.
[f] Breusch and Pagan (1980) LM test of independence.
[g] Pesaran (2004) scaled LM test.
[h] Baltagi et al. (2012) bias-corrected scaled LM test.

Table 4
Panel unit root tests in presence of cross-section dependence.

Variable	Specification	
	Constant	Constant and trend
Pesaran's CADF test		
LPI	−4.016*** (0.000)	−1.651** (0.049)
LGDP	0.710 (0.761)	−2.749*** (0.003)
LCEM	1.194 (0.884)	1.049 (0.853)
HDI	−8.832*** (0.000)	0.590 (0.722)
LGFCF	−6.880*** (0.000)	−0.048 (0.481)
LLF	2.510 (0.994)	2.849 (0.998)
LP	2.836 (0.998)	−3.403*** (0.000)
LUP	−5.196*** (0.000)	−1.772** (0.038)
LTO	3.801 (1.000)	0.714 (0.763)
Pesaran (2007) test		
LPI	−1.925	−2.098
LGDP	−1.329	−1.696
LCEM	−1.911	−2.035
HDI	−2.264**	−1.569
LGFCF	−1.560	−2.132
LLF	−1.947	−1.838
LP	−2.208**	−2.522
LUP	−1.434	0.097
LTO	−1.298	−2.079

Notes: for Pesaran (2003) test, *Z-t*-bar or *t*-bar statistics are reported; P-Values in parentheses. For Pesaran (2007) test, deterministic chosen: constant: Critical Values: -2.07 (10%), −2.17 (5%), −2.34 (1%); deterministic chosen: constant and trend: Critical Values: -2.59 (10%), −2.69 (5%), −2.88 (1%).
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

cross-section dependence. These are also known as second generation of panel unit root tests, where the presence of cross-section dependence among the residuals is allowed within the panel. The results in Table 4, in general, highlight that it is difficult to reject the null hypothesis according to which all series are non-stationary. Only for *LPI* and *LUP* variables we are able to reject the null – with both deterministic specifications – using the Pesaran (2003) Cross-Sectionally Augmented Dickey–Fuller (CADF) test. However, these results are not confirmed by Pesaran (2007) test. Therefore, we can assume that all variables in the dataset share cross-section dependence and are non-stationary.

Afterwards, to perform the cointegration analysis, three different tests are run. Table 5 shows the outcomes of Kao's residual cointegration test, Padroni's test for cointegration, and Westerlund error-correction-based cointegration test for the three specifications in equations (1)–(3).

In general, for all three different equations the results indicate the existence of a long-run (cointegrating) relationship among the variables.

Concerning the determinants of logistics performance, and the subsequent roles of logistic performance in both economic expansion and environmental quality, the results are indicated in Table 6.

4.1. Determinants of logistic performance

From the results in Table 6 (see Model A), the investigation revealed that an increase in HDI is responsible for a significant improvement in the logistic performance. Specifically, the QR findings reveal that the improvement in human's life expectancy, literacy level through education, and income aspects (reflected in the HDI) spur the logistic performance in the panel such that the impact of HDI also decreases toward the higher quantile (25th quantile = 1.356, and 75th quantile = 1.371). This confirms that human development is an important determinant of logistic performance, since logistics performance is tied to a more robust improvement in the human's life expectancy, education level, and income factors. Importantly, this finding is in line with Zaman and Shamsuddin (2017). Specifically, Zaman and Shamsuddin (2017) highlighted the positive relationship between health expenditures per capita (a useful proxy for life expectancy) and logistics performance. In addition, as evidenced in the ongoing distribution of the Corona-Virus (COVID-19) vaccines, Agueh et al. (2016) argued that economic health via immunization program is significantly related with logistic performance.

Table 5
Panel cointegration tests.

LPI = f (HDI, LGFCF, LLF, LP, LUP, LTO)		
Kao's residual cointegration test		
Modified Dickey-Fuller *t*	2.4548*** (0.0070)	
Dickey-Fuller *t*	0.3885 (0.3488)	
Augmented Dickey-Fuller *t*	−3.1532*** (0.0008)	
Unadjusted modified Dickey-Fuller *t*	−6.9415*** (0.0000)	
Unadjusted Dickey-Fuller *t*	−7.0807*** (0.0000)	
Pedroni's test for cointegration		
Tests	**Constant**	**Constant and trend**
Modified Phillips-Perron *t*	7.6937*** (0.0000)	8.3280*** (0.0000)
Phillips-Perron *t*	−10.9212*** (0.0000)	−15.1332*** (0.0000)
Augmented Dickey-Fuller *t*	−7.0541*** (0.0000)	−11.4302*** (0.0000)
Westerlund error-correction-based cointegration test		
Tests	**Constant**	**Constant and trend**
Variance ratio	−0.2464 (0.4027)	2.7190*** (0.0033)
LGDP = f (HDI, LPI, LUP, LTO)		
Kao's residual cointegration test		
Modified Dickey-Fuller *t*	1.5132* (0.0651)	
Dickey-Fuller *t*	−1.1360 (0.1280)	
Augmented Dickey-Fuller *t*	0.8625 (0.1942)	
Unadjusted modified Dickey-Fuller *t*	0.3108*** (0.3780)	
Unadjusted Dickey-Fuller *t*	−2.1832** (0.0145)	
Pedroni's test for cointegration		
Tests	**Constant**	**Constant and trend**
Modified Phillips-Perron *t*	6.0670*** (0.0000)	6.1619*** (0.0000)
Phillips-Perron *t*	−1.3368* (0.0906)	−4.4046*** (0.0000)
Augmented Dickey-Fuller *t*	−1.7747** (0.0380)	−6.2565*** (0.0000)
Westerlund error-correction-based cointegration test		
Tests	**Constant**	**Constant and trend**
Variance ratio	1.3909* (0.0821)	1.5698* (0.0582)
LCEM = f (HDI, LPI, LUP, LTO)		
Kao's residual cointegration test		
Modified Dickey-Fuller *t*	2.3904*** (0.0084)	
Dickey-Fuller *t*	0.7676 (0.2214)	
Augmented Dickey-Fuller *t*	2.5116*** (0.0060)	
Unadjusted modified Dickey-Fuller *t*	−1.0605 (0.1445)	
Unadjusted Dickey-Fuller *t*	−2.5234*** (0.0058)	
Pedroni's test for cointegration		
Tests	**Constant**	**Constant and trend**
Modified Phillips-Perron *t*	5.1017*** (0.0000)	5.7931*** (0.0000)
Phillips-Perron *t*	−9.2441*** (0.0000)	−14.6687*** (0.0000)
Augmented Dickey-Fuller *t*	−9.4766*** (0.0000)	−13.1086*** (0.0000)
Westerlund error-correction-based cointegration test		
Tests	**Constant**	**Constant and trend**
Variance ratio	−0.9811 (0.1633)	−0.2714 (0.3931)

Notes: for Kao's test, the deterministic component is: constant. For Westerlund's test the *Z*-Values are reported. For all tests the P-Values are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Furthermore, the impact of GFCF on logistic performance is negative and statistically significant for all the estimators adopted. Across the quantile, increase in GFCF deplete the logistic performance, but the negative impact is dampened and overturned at the end of the quantile. Thus, at the 90th quantile, a 1-unit increase in GFCF reduces logistic performance by 0.047 units in the panel. The economic intuition is that massive capital investment is likely to overwhelm the essential logistic procedures, thus causing an undesirable effect until a maximum level of logistic performance is attained due to an increasing level of investment. This perspective coincides with the logistic performance-FDI nexus illustrated by Khan et al. (2018a), and Zaman and Shamsuddin (2017).

Moreover, in FMOLS and GMM estimates, employment (*LLF*) significantly worsens logistic performance with an impact of 0.187 and 0.056, respectively. However, the negative impact of employment on

Table 6
Results of FMOLS, GMM, and Quantile Regressions (with 100 bootstraps).

Variable	FMOLS	GMM	Quantile Regressions				
			0.10	0.25	0.50	0.75	0.90
Model A, Dep. Var.: LPI							
HDI	1.308 (1.594)	1.331*** (0.514)	0.900 (1.643)	1.356*** (0.404)	1.738*** (0.548)	1.371* (0.801)	0.133 (0.770)
LGCF	−0.044 (0.300)	−0.069*** (0.013)	−0.092*** (0.017)	−0.089*** (0.010)	−0.071*** (0.015)	−0.060*** (0.023)	−0.047 (0.034)
LLF	−0.187 (0.828)	−0.056 (0.041)	−0.213** (0.106)	−0.100* (0.051)	−0.057 (0.047)	−0.114* (0.062)	−0.082* (0.048)
LP	0.168 (0.195)	0.227*** (0.033)	0.450*** (0.152)	0.302*** (0.055)	0.226*** (0.043)	0.263*** (0.051)	0.206*** (0.040)
LUP	0.005 (0.017)	0.004*** (0.001)	0.005 (0.003)	0.005*** (0.002)	0.004** (0.002)	0.003 (0.002)	−0.000 (0.002)
LTO	0.003** (0.001)	0.001*** (0.000)	0.001 (0.001)	0.001 (0.498)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Model B, Dep. Var.: LGDP							
HDI	0.244** (0.100)	−2.406 (2.095)	1.020 (2.272)	3.619** (1.800)	−0.456 (0.961)	2.113 (2.237)	13.870*** (4.883)
LPI	−0.018** (0.007)	0.002 (0.265)	−0.618*** (0.216)	0.327 (0.272)	0.122 (0.230)	−0.488* (0.280)	−0.431 (0.601)
LUP	0.050*** (0.003)	0.035*** (0.006)	0.002 (0.004)	0.012*** (0.003)	0.026*** (0.004)	0.038*** (0.006)	0.078*** (0.005)
LTO	−0.001*** (0.000)	−0.005*** (0.001)	−0.003*** (0.001)	−0.004*** (0.000)	−0.004*** (0.001)	−0.003*** (0.001)	−0.007*** (0.001)
Model B, Dep. Var.: LCEM							
HDI	−0.406 (0.397)	−5.211*** (1.184)	−2.233* (1.214)	−7.043*** (1.000)	−3.155** (1.567)	0.250 (1.496)	1.389 (1.433)
LPI	0.037* (0.021)	0.588*** (0.150)	0.354** (0.146)	0.816*** (0.206)	0.220 (0.181)	0.195 (0.135)	0.367*** (0.110)
LUP	0.009* (0.005)	0.016*** (0.004)	−0.002 (0.612)	0.013*** (0.003)	0.021*** (0.003)	0.020*** (0.005)	0.025*** (0.010)
LTO	−0.000 (0.000)	−0.004*** (0.000)	−0.002***(0.000)	−0.003*** (0.001)	−0.005*** (0.000)	−0.005*** (0.000)	−0.005*** (0.001)
Diagnostic		Model A		Model B		Model C	
Sargan		$\chi^2_{252} = 247.49$ (0.169)		$\chi^2_{237} = 277.40$** (0.037)		$\chi^2_{237} = 232.40$ (0.579)	
Hansen		$\chi^2_{252} = 19.25$ (1.000)		$\chi^2_{237} = 24.53$ (1.000)		$\chi^2_{237} = 23.57$ (1.000)	
AR(1)		$Z = -1.38$ (0.169)		$Z = -3.77$*** (0.000)		$Z = -3.79$*** (0.000)	
AR(2)		$Z = -1.96$* (0.053)		$Z = -2.25$*** (0.001)		$Z = 0.75$ (0.456)	

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

logistic performance is not the same across the quantile. The negative impacts decrease toward the upper quantiles and are statistically significant. Similarly, an increase in technological innovation (measured by the number of technological patents, *LP*) is responsible for an improvement in logistic performance in the estimated panel. Although the positive nexus between the number of patents and logistic performance is registered by FMOLS, GMM, and partially by QR approach, the relationship is positive but declining towards the upper quantile. Lastly, trade openness and urban population significantly contribute to the improvement of logistic performance, even with a smaller effect.

4.2. The role of logistic performance in the economic expansion

Given the result in Model B of Table 6, the increase in human development is responsible for the expansion of the economy. FMOLS and QR estimates show that logistic performance triggers economic growth from the lower to the upper quantile. Interestingly, Khan et al. (2018a) and Zaman and Shamsuddin (2017) share similar views in respect of the relationship between economic growth and logistic performance. Specifically, Khan et al. (2018a) implies that logistic performance exerts a differential effect on the income per capita *vis-à-vis* the economic growth increase through an increase in FDI (Ekwueme et al., 2021) and industrial value-added. Moreover, urbanization influences economic expansion across the quantile (a result also illustrated by FMOLS and GMM findings), whilst trade openness is shown to exert a small but significant negative impact on economic growth.

4.3. The role of logistic performance in environmental quality

Finally, results in Model C of Table 6 show the determinants of environmental quality. While the improvement in human development largely mitigates environmental damage, logistic performance exhibits a largely positive and significant effect on environmental degradation across the quantile, as well as GMM estimates. However, the magnitude of this effect is greater in the lower quantiles. This observation shares the perspective in the extant studies that logistic performance and environmental sustainability could be either positively or negatively related, largely depending on the nature of energy source utilization (Ibrahim and Alola, 2020) in the supply chain, and other logistic related aspects of the economy (Khan et al., 2018a; Liu et al., 2018). Specifically, Liu et al. (2018) employed six indicators of logistic performance for the case of Asian countries. Interestingly, the study found that two of the logistic indicators increase environmental degradation while the adoption of another different indicator causes improvement in environmental quality. In the use of the remaining three indicators, there are no significant environmental aspects. Meanwhile, in a significant dimension, urbanization and trade openness respectively increase and mitigate CO_2 emissions. Although Shahbaz et al. (2017) pinpointed that trade openness hampers environmental quality, energy demand could be mitigated by trade openness (Sbia et al., 2014), thus causing improvement in environment quality. However, Wang and Zhang (2021) infer that the impact of trade openness on both economic growth and carbon emission is heterogeneous across a panel of 182 countries. Alola et al. (2021) found that urbanization spur carbon emissions, while Zhang et al. (2017) and Onifade et al. (2021) found that urbanization exhibits a U-shaped and negative relationship with carbon emissions.

5. Concluding remarks

While extensively studied, the relationship between logistics performance and the environment is unclear. Suffering from conflicting evidence, this topic remains actual and critical for researchers as it deals with sustainable practices, green growth, and the climate targets recently ratified by the international community. Moreover, the role of innovation along each stage of the supply chain has been widely ignored in previous empirical investigations, and almost always disconnected from economic and environmental indicators. Accordingly, there is a point in asking whether innovative applications may mediate the effect of logistics performance on economic growth and polluting emissions, using an illustrative selected panel of logistics economies.

In sum, this paper investigates the above-research question by estimating three distinct models:

- The determinants of logistics performance (namely: technological innovation, infrastructure, education, employment, and GFCF) (Model A).
- The effects of logistics performance, human capital, urban population, and trade openness on GDP (Model B).
- The effects of logistics performance, human capital, urban population, and trade openness on CO_2 emissions from fuel combustion (Model C).

A macro-level dataset on the top 25 ranked logistics countries has been constructed, spanning the 2007–2018 period, for a total of 300 observations. Our causality testing framework comprises a set of panel cross-section dependence tests, second generation panel unit root tests, and cointegration procedures. Finally, the estimation strategy employs three different panel data estimators, as they display advantageous features.

Empirical findings revealed that improving technological innovation (captured by the number of patents recorded) and human capital (literacy level proxied by the HDI), urbanization, and trade openness are all associated with a positive and significant effect on logistics performance. Conversely, both employment and GFCF are found to negatively influence LPI, highlighting that the supply chain is naturally less labour-intensive than capital-intensive. However, when they overcome a certain threshold level, the present evidence emphasizes that massive capital investments are likely to induce adverse effects on the performance of the logistic chain. Furthermore, while the well-established HDI-growth relationship is confirmed, results suggest that both economic expansion and environmental sustainability are negatively affected by logistics performance. This latter element is in line with a strand of the literature, which underlines that this linkage may display a negative magnitude when the main resource used to generate power is non-renewable. In this view, our findings stress that a more performing supply chain does not prevent threats to sustainability and economic inefficiencies. In our case, this analysis on the top 25 ranked logistic countries sheds light on the necessity to further expand the shift towards low-carbon sources of energy along the supply chain. To this extent, a relevant policy perspective can be provided.

5.1. Policy recommendations

Above all, processes in logistics and supply chains should be managed in a resource-effective manner. Green practices should be applied to the logistic sector, starting by enhancing the operational use of energy by international shipment and improving its efficiency through modal split. Regarding the global logistics business, significant efforts should be made to lower the carbon content of the power sourced to suppliers and settle a more efficient utilization of energy along each stage constituting the logistic process. This would not only reduce the energy cost for suppliers, but also trigger FDI in search of more sustainable allocations. In the long-run, one may see a reconciliation between profitability and sustainability targets in logistic activities. Secondly, a specific attention should be paid to the reliability and the timeliness of shipment, thought to lay at the centre of environmental issues, but at the core of carbon savings. Thus, decision-makers should implement measures aiming at reducing the risk of congestion zones in harbour entrances, because they induce additional energy costs and economic losses. Third, an active and global government regulation is required to limit carbon leakages and opportunity behaviours. How challenging it is, the emergence of a GSC across international locations is conditioned by the ability of public institutions to anticipate, prevent and disincentivize companies to relocate and outsource a share of the manufacturing process abroad. A global and strong public response is thus crucial to send timely credible signals to polluting suppliers while minimizing the emergence of an environmental gap between countries applying strict sustainability standards and the others. All in all, one cannot conclude without mentioning the growing role played by technologies in reaching the above-mentioned objectives. Whether it is taking the form of drones for delivering goods to customers (Carlsson and Song, 2018), robotics for automating warehousing applications (Azadeh et al., 2019), or blockchain processes to ensure data and supply chain transparency for customers (Choi et al., 2019), key applications are expected to radically transform the operational efficiency and the competitiveness of the logistic sector. Nonetheless, we recommend policymakers to accelerate their deployment without overlooking their associated externalities on resource and low-skilled employment.

Some empirical caveats limit the scope of the present manuscript. For instance, relevant empirical technique could be directed at understudying each of the enlisted countries in order to unearth those country-specific dimensions of logistic performance-environmental sustainability nexus. Additionally, future research should be conducted at the sectoral level, with a specific aim of distinguishing which technological applications induce windfall economic and environmental benefits for the logistic sector. Furthermore, country-specific insights should enlarge the literature on this topic. Finally, the use of Machine Learning (ML) and Artificial Neural Networks (ANNs) algorithms should be further expanded on this topic. It may confirm the present econometric findings while overcoming the statistical inferences associated with standard linear models (Magazzino et al., 2020a, 2020b, 2020c, 2021a, 2021b, 2021d, 2021b; Mele et al., 2021a, 2021b).

CRediT authorship contribution statement

Cosimo Magazzino: Data curation, Writing – review & editing, Supervision, Writing, Writing – review & editing, Formal analysis, Investigation, Methodology, Validation, Supervision. **Andrew Adewale Alola:** Writing – review & editing, Formal analysis, Investigation, Methodology, Visualization, Validation. **Nicolas Schneider:** Data curation, Writing, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A
Top 25 logistics countries.

World ranking for the year 2018		
1. Germany	2. Sweden	3. Belgium
4. Austria	5. Japan	6. Netherlands
7. Singapore	8. Denmark	9. United Kingdom
10. Finland	11. United Arab Emirates	12. Hong Kong
13. Switzerland	14. United States	15. New Zealand
16. France	17. Spain	18. Australia
19. Italy	20. Canada	21. Norway
22. Czech Republic	23. Portugal	24. Luxembourg
25. Republic of Korea		

Source: WDI (2019).

Table B
Descriptive statistics.

Variable	Mean	Median	Std. Dev.	Skewness	Kurtosis	Range	IQR	CV
LPI	3.8414	3.8600	0.2308	−0.8493	3.9128	1.2000	0.2851	0.0601
LGDP	12.2586	12.2344	0.9596	1.5229	5.7020	4.6227	0.8479	0.0783
LCEM	5.1426	5.0203	0.6150	0.4814	2.8146	2.8253	0.9461	0.1196
HDI	0.9010	0.9055	0.0291	−0.8603	3.6128	0.1440	0.0370	0.0323
LGFCF	11.6001	11.5282	0.9868	1.5306	5.8340	4.8802	0.7908	0.0851
LLF	6.9321	6.7324	0.5787	−0.0960	3.4322	2.8844	0.8344	0.0835
LP	3.2207	3.2452	0.7565	−0.1054	2.7793	3.4691	0.7468	0.2349
LUP	1.9119	1.9151	0.0558	−0.8570	3.9459	0.2432	0.0490	0.0292
LTO	1.9631	1.9112	0.2940	0.6187	3.0037	1.2570	0.3632	0.1498

Notes: Std. Dev., Standard Deviation; IQR, Inter-Quartile Range; CV, Coefficient of Variation.
Sources: our calculations.

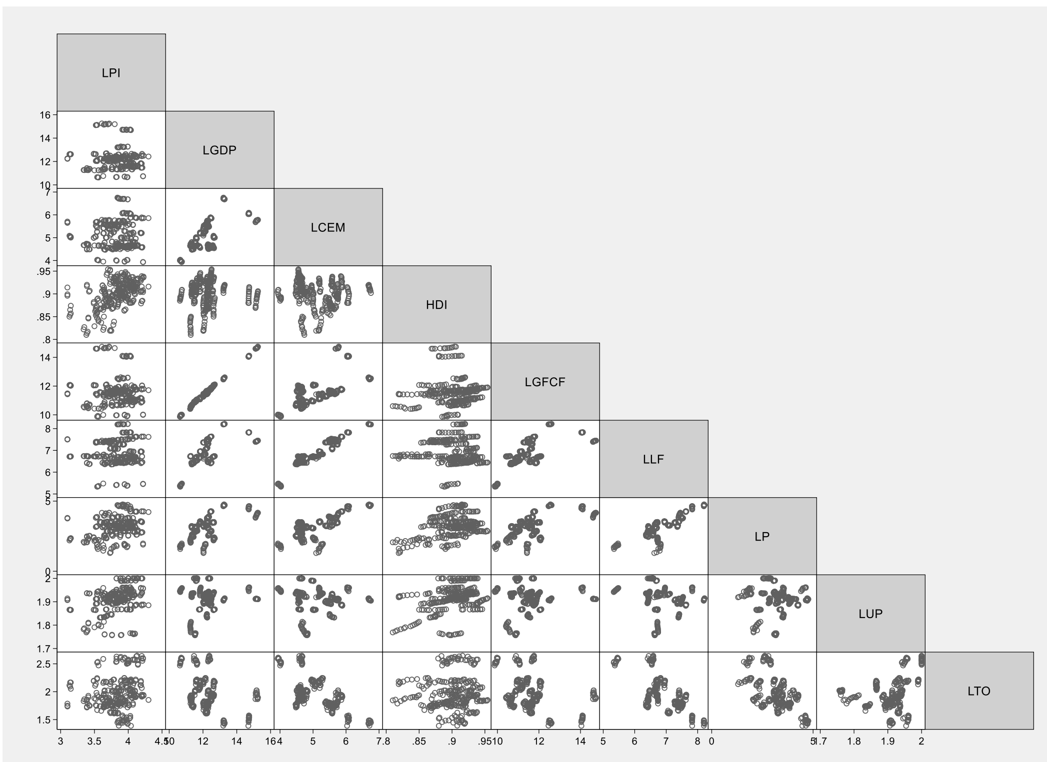

Fig. A. Scatterplot matrices (log-scale).
Sources: our elaborations..

Nomenclature

2SLS 2 Stages Least Squares
ARDL Auto-Regressive Distributed Lag
CO_2 Carbon Dioxide
CS-ARDL Cross-sectionally augmented Auto-Regressive Distributed Lag
FDI Foreign Direct Investment
FE Fixed Effects
FGLS Feasible Generalized Least Squares
GHG Greenhouse Gas
GL Green Logistics
GMM Generalized Method of Moments
GSC Green Supply Chain
GSCM Green Supply Chain Management
ICT Information and Communication Technology
LPI Logistics Performance Index
N-ARDL Non-Linear AutoRegressive Distributed Lag
OLS Ordinary Least Squares
PII Political Instability Index
RAM-DEA Range-Adjusted Measure of the Data Envelopment Analysis
RE Random Effects

SEM Structural Equation Model
TFP Total Factor Productivity

References

Agueh, V., Jerome, C., Nyametso, D., Paraiso, M., Azandjemè, C., Metonou, C., Ouédraogo, L.T., 2016. Evaluation of the performance of expanded immunization programme supply chain and logistics management in Southern Benin rural health district. Univ. J. Public Health 4 (4), 160–70.

Alola, A.A., Lasisi, T.T., Eluwole, K.K., Alola, U.V., 2021. Pollutant emission effect of tourism, real income, energy utilization, and urbanization in OECD countries: a panel quantile approach. Environ. Sci. Pollut. Control Ser. 28 (2), 1752–1761.

Arbolino, R., Carlucci, F., Cirà, A., Ioppolo, G., Yigitcanlar, T., 2017. Efficiency of the EU regulation on greenhouse gas emissions in Italy: the hierarchical cluster analysis approach. Ecol. Indicat. 81, 115–123.

Asongu, S.A., Odhiambo, N.M., 2019. Environmental degradation and inclusive human development in sub Saharan Africa. Sustain. Dev. 27 (1), 25–34.

Azadeh, K., De Koster, R., Roy, D., 2019. Robotized and automated warehouse systems: review and recent developments. Transport. Sci. 53 (4), 917–945.

Bai, P., Wu, Q., Li, Q., Xue, C., Zhang, L., 2021. Mediating Effect of Organizational Learning Capacity on the Relationship between Relational Embeddedness and Innovation Performance in Freight Logistics Service. Complexity.

Baltagi, B.H., Feng, Q., Kao, C., 2012. A Lagrange Multiplier test for cross-sectional dependence in a fixed effects panel data model. J. Econ. 170 (1), 164–177.

Barilla, D., Carlucci, F., Cirà, A., Ioppolo, G., Siviero, L., 2020. Total factor logistics productivity: a spatial approach to the Italian regions. Transport. Res. Pol. Pract. 136, 205–222.

Boonchai, C., Beeton, R.J., 2016. Sustainable development in the Asian century: an inquiry of its understanding in Phuket, Thailand. Sustain. Dev. 24 (2), 109–123.

Breusch, T.S., Pagan, A.R., 1980. The Lagrange multiplier test and its applications to model specification in econometrics. Rev. Econ. Stud. 47 (1), 239–253.

Carlsson, J.G., Song, S., 2018. Coordinated logistics with a truck and a drone. Manag. Sci. 64 (9), 4052–4069.

Carter, C.R., Rogers, D.S., 2008. A framework of sustainable supply chain management: moving toward new theory. Int. J. Phys. Distrib. Logist. Manag.

Çelebi, D., 2019. The role of logistics performance in promoting trade. Marit. Econ. Logist. 21 (3), 307–323.

Çelebi, Ü., Civelek, M.E., Çemberci, M., 2015. The mediator effect of foreign direct investments on the relation between logistics performance and economic growth. J. Global Strat. Manag. 17.

Cheng-Min, F., Chien-Yun, Y., 2006. The impact of information and communication technologies on logistics management. Int. J. Manag. 23 (4), 909.

Choi, T.M., Wen, X., Sun, X., Chung, S.H., 2019. The mean-variance approach for global supply chain risk analysis with air logistics in the blockchain technology era. Transport. Res. E Logist. Transport. Rev. 127, 178–191.

Christopher, M., 2016. Logistics & Supply Chain Management. Pearson UK.

Chudik, A., Pesaran, M.H., 2015. Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. J. Econ. 188 (2), 393–420.

Cordova, M., Coronado, F., 2021. Supply chain innovation and sustainability frontiers: a balanced scorecard perspective. The Palgrave Handbook of Corporate Sustainability in the Digital Era. Palgrave Macmillan, Cham, pp. 479–501.

Cosimato, S., Troisi, O., 2015. Green supply chain management: practices and tools for logistics competitiveness and sustainability. The DHL case study. The TQM Journal 27 (2), 256–276.

Coto-Millán, P., Agüeros, M., Casares-Hontañón, P., Pesquera, M.Á., 2013. Impact of logistics performance on world economic growth (2007–2012). World Rev. Intermodal Transp. Res. 4 (4), 300–310.

Crainic, T.G., 2000. Service network design in freight transportation. Eur. J. Oper. Res. 122 (2), 272–288.

D'Aleo, V., Sergi, B.S., 2017. Does logistics influence economic growth? The European experience. Management Decision.

Dekker, R., Bloemhof, J., Mallidis, I., 2012. Operations Research for green logistics–An overview of aspects, issues, contributions and challenges. Eur. J. Oper. Res. 219 (3), 671–679.

Demir, E., Bektaş, T., Laporte, G., 2014. A review of recent research on green road freight transportation. Eur. J. Oper. Res. 237 (3), 775–793.

Ekwueme, D.C., Zoaka, J.D., Alola, A.A., 2021. Carbon emission effect of renewable energy utilization, fiscal development, and foreign direct investment in South Africa. Environ. Sci. Pollut. Control Ser. 1–13.

European Commission (2015). https://op.europa.eu/en/publication-detail/-/publication/50a60344-af85-4083-81b6-386643f1c79c. (Accessed 10 May 2021).

Fang, Z., Chang, Y., 2016. Energy, human capital and economic growth in Asia Pacific countries–Evidence from a panel cointegration and causality analysis. Energy Econ. 56, 177–184.

Flynn, B.B., Huo, B., Zhao, X., 2010. The impact of supply chain integration on performance: a contingency and configuration approach. J. Oper. Manag. 28 (1), 58–71.

Forkenbrock, D.J., 2001. Comparison of external costs of rail and truck freight transportation. Transport. Res. Pol. Pract. 35 (4), 321–337.

Frees, E.W., 1995. Assessing cross-sectional correlation in panel data. J. Econ. 69 (2), 393–414.

Friedman, M., 1937. The use of ranks to avoid the assumption of normality implicit in the analysis of variance. J. Am. Stat. Assoc. 32 (200), 675–701.

Ganesh Kumar, R., Ashlin Nimo, J.R., 2020. A conceptual framework for reverse logistics performance and innovation. Int. J. Supply Chain Manag. 9 (1), 430.

Goel, R.K., Saunoris, J.W., Goel, S.S., 2021. Supply chain performance and economic growth: the impact of COVID-19 disruptions. J. Pol. Model. 43 (2), 298–316.

Green, K.W., Zelbst, P.J., Meacham, J., Bhadauria, V.S., 2012. Green supply chain management practices: impact on performance. Supply Chain Manag.: Int. J. 17 (3), 290–305.

Gunasekaran, A., Subramanian, N., Papadopoulos, T., 2017. Information technology for competitive advantage within logistics and supply chains: a review. Transport. Res. E Logist. Transport. Rev. 99, 14–33.

Guner, S., Coskun, E., 2012. Comparison of impacts of economic and social factors on countries' logistics performances: a study with 26 OECD countries. Research in Logistics & Production 2, 330–343.

Huang, Y.C., Yang, M.L., 2014. Reverse logistics innovation institutional pressures and performance. Manag. Res. Rev. 37 (7), 615–641.

Ibrahim, M.D., Alola, A.A., 2020. Integrated analysis of energy-economic development-environmental sustainability nexus: Case study of MENA countries. Sci. Total Environ. 737, 139768.

Kallionpaa, E., Helander, N., Rantala, J., 2015. Managing tomorrow's daily consumer goods logistics value network. Int. J. Supply Chain Operations Resil. 1 (2), 201–218.

Khan, S.A.R., 2019. The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from southeast Asian countries. Environ. Sci. Pollut. Control Ser. 26 (13), 13210–13220.

Khan, S.A.R., Dong, Q., Zhang, Y., Khan, S.S., 2017b. The impact of green supply chain on enterprise performance: in the perspective of China. J. Adv. Manuf. Syst. 16 (3), 263–273.

Khan, S.A.R., Dong, Q.L., Yu, Z., 2016a. Research on the measuring performance of green supply chain management: in the perspective of China. Int. J. Eng. Res. Afr. 27, 167–178.

Khan, S.A.R., Dong, Q.L., Yu, Z., 2016b. Study of logistics and manufacturing industry integration from the perspective of Pakistan. Int. J. Eng. Res. Afr. 24, 172–180.

Khan, S.A.R., Jian, C., Zhang, Y., Golpîra, H., Kumar, A., Sharif, A., 2019. Environmental, social and economic growth indicators spur logistics performance: from the perspective of South Asian Association for Regional Cooperation countries. J. Clean. Prod. 214, 1011–1023.

Khan, S.A.R., Qianli, D., 2017. Does national scale economic and environmental indicators spur logistics performance? Evidence from UK. Environ. Sci. Pollut. Control Ser. 24 (34), 26692–26705.

Khan, S.A.R., Qianli, D., SongBo, W., Zaman, K., Zhang, Y., 2017a. Environmental logistics performance indicators affecting per capita income and sectoral growth: evidence from a panel of selected global ranked logistics countries. Environ. Sci. Pollut. Control Ser. 24 (2), 1518–1531.

Khan, S.A.R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., Qianli, D., 2018a. Green supply chain management, economic growth and environment: a GMM based evidence. J. Clean. Prod. 185, 588–599.

Khan, S.A.R., Zhang, Y., Golpîra, H., Dong, Q., 2018b. The impact of green supply chain practices in business performance: evidence from Pakistani FMCG firms. J. Adv. Manuf. Syst. 17 (2), 267–275.

Khan, S.A.R., Zhang, Y., Kumar, A., Zavadskas, E., Streimikiene, D., 2020b. Measuring the Impact of Renewable Energy, Public Health Expenditure, Logistics, and Environmental Performance on Sustainable Economic Growth. Sustainable Development.

Khan, S.A.R., Zhang, Y., Nathaniel, S., 2020a. Green supply chain performance and environmental sustainability: a panel study. LogForum 16, 1.

Koenker, R., Bassett Jr., G., 1978. Regression quantiles. Econometrica 46 (1), 33–50.

Laeeq Razzak Janjua, F.M., Sukjai, P., Rehman, A., Yu, Z., 2021. Impact of COVID-19 pandemic on logistics performance, economic growth and tourism industry of Thailand: an empirical forecasting using ARIMA. Brazilian J. Operations Prod. Manag. 18 (2), e2021999.

Larson, P.D., 2021. Relationships between logistics performance and aspects of sustainability: a cross-country analysis. Sustainability 13 (2), 623.

Lasisi, T.T., Eluwole, K.K., Alola, U.V., Aldieri, L., Vinci, C.P., Alola, A.A., 2021. Do tourism activities and urbanization drive material consumption in the OECD countries? A quantile regression approach. Sustainability 13 (14), 7742.

Lee, H., 2004. The triple-A supply chain. Harv. Bus. Rev. 1–12. OnPoint 8096.

Li, X., Sohail, S., Majeed, M.T., Ahmad, W., 2021. Green logistics, economic growth, and environmental quality: evidence from one belt and road initiative economies. Environ. Sci. Pollut. Control Ser. 1–11.

Li, Y., 2014. Environmental innovation practices and performance: moderating effect of resource commitment. J. Clean. Prod. 66, 450–458.

Li, Y., Shi, X., Emrouznejad, A., Liang, L., 2018. Environmental performance evaluation of Chinese industrial systems: a network SBM approach. J. Oper. Res. Soc. 69 (6), 825–839.

Limao, N., Venables, A.J., 2001. Infrastructure, geographical disadvantage, transport costs, and trade. World Bank Econ. Rev. 15 (3), 451–479.

Lin, C.Y., 2007. Factors affecting innovation in logistics technologies for logistics service providers in China. J. Technol. Manag. China 2 (1), 22–37.

Lin, Y., Wang, Y., Yu, C., 2010. Investigating the drivers of the innovation in channel integration and supply chain performance: a strategy orientated perspective. Int. J. Prod. Econ. 127 (2), 320–332.
Liu, J., Yuan, C., Hafeez, M., Yuan, Q., 2018. The relationship between environment and logistics performance: evidence from Asian countries. J. Clean. Prod. 204, 282–291.
Lu, M., Xie, R., Chen, P., Zou, Y., Tang, J., 2019. Green transportation and logistics performance: an improved composite index. Sustainability 11 (10), 2976.
Magazzino, C., Mele, M., Schneider, N., 2020a. The relationship between air pollution and COVID-19-related deaths: an application to three French cities. Appl. Energy 279, 115835.
Magazzino, C., Mele, M., Schneider, N., 2020b. The relationship between municipal solid waste and greenhouse gas emissions: evidence from Switzerland. Waste Manag. 113, 508–520.
Magazzino, C., Mele, M., Schneider, N., Vallet, G., 2020c. The relationship between nuclear energy consumption and economic growth: evidence from Switzerland. Environ. Res. Lett. 15.
Magazzino, C., Schneider, N., 2020. The causal relationship between primary energy consumption and economic growth in Israel: a multivariate approach. Int. Rev. Environ. Res. Econ. 14 (4), 417–491.
Magazzino, C., Mele, M., Schneider, N., 2021a. A D2C algorithm on the natural gas consumption and economic growth: challenges faced by Germany and Japan. Energy 219, 19586.
Magazzino, C., Mele, M., Schneider, N., 2021b. A Machine Learning approach on the relationship among solar and wind energy production, coal consumption, GDP, and CO_2 emissions. Renew. Energy 167, 99–115.
Magazzino, C., Mele, M., Schneider, N., Sarkodie, S.A., 2021c. Waste generation, Wealth and GHG emissions from the waste sector: is Denmark on the path towards Circular Economy? Sci. Total Environ. 755 (1), 142510.
Magazzino, C., Mele, M., Schneider, N., Shahbaz, M., 2021d. Can biomass energy curtail environmental pollution? A quantum model approach to Germany. J. Environ. Manag. 287, 112293.
Marchet, G., Melacini, M., Perotti, S., Tappia, E., 2016. Shaping the international logistics strategy in the internationalisation process. Int. J. Supply Chain Operations Resil. 2 (1), 72–93.
Martel, A., Klibi, W., 2016. Supply chains: issues and opportunities. Designing Value-Creating Supply Chain Networks. Springer, Cham, pp. 1–43.
Martí, L., Puertas, R., García, L., 2014. The importance of the Logistics Performance Index in international trade. Appl. Econ. 46 (24), 2982–2992.
Meade, L., Sarkis, J., 1998. Strategic analysis of logistics and supply chain management systems using the analytical network process. Transport. Res. E Logist. Transport. Rev. 34 (3), 201–215.
Mele, M., Gurrieri, A.R., Morelli, G., Magazzino, C., 2021a. Nature and climate change effects on economic growth: an LSTM experiment on renewable energy resources. Environmental Science and Pollution Research.
Mele, M., Magazzino, C., Schneider, N., Nicolai, F., 2021b. Revisiting the dynamic interactions between economic growth and environmental pollution in Italy: evidence from a gradient descent algorithm. Environmental Science and Pollution Research.
Memari, A., Rahim, A.R.A., Ahmad, R., Hassan, A., 2016. A literature review on green supply chain modelling for optimising CO_2 emission. Int. J. Oper. Res. 26 (4), 509–525.
Moldabekova, A., Philipp, R., Reimers, H.E., Alikozhayev, B., 2021. Digital technologies for improving logistics performance of countries. Transport and Telecommunication 22 (2), 207–216.
Munim, Z.H., Schramm, H.J., 2018. The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. J. Admin. Business Stud. 3 (1), 1.
Mosteller, F., Tukey, J.W., 1977. Data Analysis and Regression: a Second Course in Statistics. Pearson.
Neto, J.Q.F., Walther, G., Bloemhof, J., Van Nunen, J.A.E.E., Spengler, T., 2009. A methodology for assessing eco-efficiency in logistics networks. Eur. J. Oper. Res. 193 (3), 670–682.
OECD (2017). https://www.itf-oecd.org/tags/freight. (Accessed 10 May 2021).
OECD, 2020a. Patent Statistics. https://stats.oecd.org/Index.aspx?DataSetCode=PATS_IPC (Accessed 20 April 2021).
OECD, 2020b. IEA CO2 Emissions from Fuel Combustion Statistics. https://www.oecd-ilibrary.org/energy/data/iea-co2-emissions-from-fuel-combustion-statistics_co2-data-en (Accessed 20 April 2021).
Onifade, S.T., Alola, A.A., Erdoğan, S., Acet, H., 2021. Environmental aspect of energy transition and urbanization in the OPEC member states. Environ. Sci. Pollut. Control Ser. 28 (14), 17158–17169.
Ostrom, E., 2008. The challenge of common-pool resources. Environment 50 (4), 8–21.
Pagell, M., Shevchenko, A., 2014. Why research in sustainable supply chain management should have no future. J. Supply Chain Manag. 50 (1), 44–55.
Pålsson, H., Finnsgård, C., Wänström, C., 2013. Selection of packaging systems in supply chains from a sustainability perspective–The case of Volvo. Packag. Technol. Sci. 26 (5), 289–310.
Pesaran, M.H, 2003. A simple panel unit root test in the presence of cross section dependence. University of Cambridge DAE Working Paper Number 0346.
Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econo. 22 (2), 265–312.
Pesaran, M.H., 2021. General diagnostic tests for cross-sectional dependence in panels. Empir. Econ. 60, 13–50.
Pesaran, M.H., 2004. General diagnostic tests for cross section dependence in panels (IZA Discussion Paper No. 1240). Institute for the Study of Labor (IZA).
Piyachat, B., 2017. The relationships among resources' commitment reverse logistics innovation reverse logistics performance and reverse logistics cost savings: manufacturing vs service industry. J. Admin. Business Stud. 3 (3), 122–135.
Rao, P., Holt, D., 2005. Do green supply chains lead to competitiveness and economic performance? Int. J. Oper. Prod. Manag. 25 (9), 898–916.
Richey, R.G., Chen, H., Genchev, S.E., Daugherty, P.J., 2005. Developing effective reverse logistics programs. Ind. Market. Manag. 34 (8), 830–840.
Salim, R., Yao, Y., Chen, G.S., 2017. Does human capital matter for energy consumption in China? Energy Econ. 67, 49–59.
Sbia, R., Shahbaz, M., Hamdi, H., 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Econ. Modell. 36, 191–197.
Sergi, B.S., D'Aleo, V., Konecka, S., Szopik-Depczyńska, K., Dembińska, I., Ioppolo, G., 2021. Competitiveness and the logistics performance index: the ANOVA method application for Africa, Asia, and the EU regions. Sustainable Cities and Society 69, 102845.
Shahbaz, M., Nasreen, S., Ahmed, K., Hammoudeh, S., 2017. Trade openness–carbon emissions nexus: the importance of turning points of trade openness for country panels. Energy Econ. 61, 221–232.
Sharipbekova, K., Raimbekov, Z.S., 2018. Influence of logistics efficiency on economic growth of the CIS countries.
Sohail, M.T., Ullah, S., Majeed, M.T., Usman, A., 2021. Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis. Environ. Sci. Pollut. Control Ser. 1–10.
Suki, N.M., Suki, N.M., Sharif, A., Afshan, S., 2021. The Role of Logistics Performance for Sustainable Development in Top Asian Countries: Evidence from Advance Panel Estimations. Sustainable Development.
Tang, C.F., Abosedra, S., 2019. Logistics performance, exports, and growth: evidence from Asian economies. Res. Transport. Econ. 78, 100743.
Töngür, Ü., Türkcan, K., Ekmen-Özçelik, S., 2020. Logistics Performance and Export Variety: Evidence from Turkey. Central Bank Review.
Vaccaro, A., Parente, R., Veloso, F.M., 2010. Knowledge management tools, inter-organizational relationships, innovation and firm performance. Technol. Forecast. Soc. Change 77 (7), 1076–1089.
Wang, Q., Zhang, F., 2021. The effects of trade openness on decoupling carbon emissions from economic growth–evidence from 182 countries. J. Clean. Prod. 279, 123838.
Vilko, J., Karandassov, B., Myller, E., 2011. Logistic infrastructure and its effects on economic development. China-USA Bus. Rev. 10 (11).
Wang, T., Wen, Y., Lin, B., 2020. Energy consumption and the influencing factors in China: a nonlinear perspective. J. Clean. Prod. 249, 119375.
WDI (2019). https://data.worldbank.org/indicator. (Access 20 April 2021).
World Economic Forum, 2020. On the Agenda / SDG 08: Decent Work and Economic Growth. World Economic Forum. weforum.org (Accessed 10 May 2021).
Will, T., Blecker, T., 2012. RFID-driven process modifications in container logistics: SOA as a solution approach. Int. J. Logist. Res. Appl. 15 (2), 71–86.
Windmark, C., Andersson, C., 2015. Cost models of inbound logistics activities: supporting production system design. Int. J. Supply Chain Operations Resil. 1 (2), 181–200.
Wong, W.P., Soh, K.L., Goh, M., 2016. Innovation and productivity: insights from Malaysia's logistics industry. Int. J. Logist. Res. Appl. 19 (4), 318–331.
Wong, W.P., Tang, C.F., 2018. The major determinants of logistic performance in a global perspective: evidence from panel data analysis. Int. J. Logist. Res. Appl. 21 (4), 431–443.
Xue, L., Weng, L., Yu, H., 2018. Addressing policy challenges in implementing sustainable development goals through an adaptive governance approach: a view from transitional China. Sustain. Dev. 26 (2), 150–158.
Yao, Y., Ivanovski, K., Inekwe, J., Smyth, R., 2019. Human capital and energy consumption: evidence from OECD countries. Energy Econ. 84, 104534.
Yazdani, M., Chatterjee, P., Pamucar, D., Chakraborty, S., 2020. Development of an integrated decision making model for location selection of logistics centers in the Spanish autonomous communities. Expert Syst. Appl. 148, 113208.
Yu, Z., Golpîra, H., Khan, S.A.R., 2018. The relationship between green supply chain performance, energy demand, economic growth and environmental sustainability: an empirical evidence from developed countries. LogForum 14, 4.
Zaman, K., Shamsuddin, S., 2017. Green logistics and national scale economic indicators: evidence from a panel of selected European countries. J. Clean. Prod. 143, 51–63.
Zelbst, P.J., Green, K.W., Abshire, R.D., Sower, V.E., 2010. Relationships among market orientation, JIT, TQM, and agility. Ind. Manag. Data Syst. 110 (5), 637–658.
Zhang, N., Yu, K., Chen, Z., 2017. How does urbanization affect carbon dioxide emissions? A cross-country panel data analysis. Energy Pol. 107, 678–687.
Zhang, X.P., Cheng, X.M., Yuan, J.H., Gao, X.J., 2011. Total-factor energy efficiency in developing countries. Energy Pol. 39 (2), 644–650.