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Nexuses Between Energy Efficiency, Renewable Energy Consumption, Foreign Direct Investment, Energy Consumption, Global Trade, Logistics and Manufacturing Industries of Emerging Economies: In the Era of COVID-19 Pandemic

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This study aims to find the nexuses among energy efficiency, renewable energy consumption, foreign direct investment, logistics industry, manufacturing industry and global trade during the COVID-19 pandemic and their impact on global supply chains in exporting nations of the world. The data for this study has been extracted from the World Development Indicators and Statista 2021 for 13 years ranging from 2007-to 2020 for nine top exporting countries. The fixed effect panel estimation technique was implied to examine and analyze the data. The results of our study revealed that highly risky diseases significantly impact supply chain operations globally. Global supply chains, logistics and manufacturing industries significantly influence global trade operations. Our results implicate that the overall international trade and logistics can be enhanced by improving the manufacturing and logistics industries by coping with the risk of pandemic diseases. Moreover, by utilizing cost-effective, renewable and efficient energy resources companies address sustainability issues of global trade and operations. By exerting further attention to the proficiency of the levies approval process, competence and quality of logistics services, and ease of assembling competitively priced shipments, the governments can significantly enhance the export from the logistics industry. Also, increasing manufacturing and agricultural value-added healthier consequences might be acquired in global supply chain operations from the manufacturing industry.

Keywords: environmental sustainability, developing and emerging economies, energy consumption, sustainability, and development, COVID-19 pandemic

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INTRODUCTION

The supply chain is the backbone of every financial and non-financial activity across the world. Due to its immense importance in the operational perspective, supply chain management has always been a delicate deal to perform, especially across borders. Researchers worldwide agree that certain risks are associated with the supply chain, and these risks can mainly be differentiated into operational and disruption-related risks (Tang, 2006; Tomlin, 2006; Choi et al., 2019; Farahani et al., 2020; Xu et al., 2020). The operational risks are related to a day-to-day disturbance in supply chain activities. However, on the other hand, disruption risks are related to rare disturbances in supply chain activities with a higher magnitude of risks (Hosseini et al., 2019; Kinra et al., 2019; Ivanov, 2020a). These risks generally include natural disasters like floods, earthquakes, scarcity of raw materials in the international market, and catastrophic human activities. These risks immediately and adversely affect the supply chain network structures, restricting the suppliers and factories to fulfil the demand in the global market. This restricted performance of suppliers causes the delay and shortage of material in the supply chain stream, which impacts the performance of the organizations and economies in terms of revenue generation, provision of service, and decrease in productivity through ripple effect (Ivanov, 2017; Pavlov et al., 2019; Ivanov, 2020a; Dolgui et al., 2020; Goldbeck et al., 2020; Li and Zobel, 2020). In addition to these risk factors, the outbreak of communicable diseases is a unique risk for global supply chain operations. This risk's spatiality is the prolonged and unpredictable disruption in the supply chain stream and logistics infrastructure, which leads to a disturbance of the supply-demand gap. In contrast to other risk factors, the pandemic outbreak starts with a low scale but propagates fast and spread over many geographic territories. The most common examples of the pandemic outbreak include the Ebolavirus, Swine flu, SARS, MERS, and most recent and the most destructive COVID-19/SARS CoV2.

SARS CoV2, commonly known as COVID-19, is believed as the most horrible pandemic of this century. In the beginning, China's production and exports were severely affected by this deadly virus, which interrupted the world demand due to supply unavailability from China to around the world (Araz et al., 2020). Later on, the spread of COVID-19 across the world resulted in the closure of borders, and all transportation means as the source of the spread of the virus were human beings and surfaces. This stoppage in the movement of goods and humans across the borders severely affected the availability of materials in the international markets and resulted in scarcity and shortages. Due to the leaned and globalized nature of the supply chain, the supply chains of 94% of the fortune 1,000 companies were reported to be affected by the spread of this pandemic (Fortune, 2020). Since China is a leading producer and exporter of products and services, and its supply chains were severely affected by this virus, it interrupted the global supply chains. According to Dun and Bradstreet (2020), 51,000 companies worldwide have one or more than one major direct tier 1 supplier in the city of Wuhan, China, which was the epicentre of this disease. That number increases to 5 million companies globally when second (tier 2) suppliers in the impacted region are included. In addition to it, approximately 938 out of 1,000 fortune companies' suppliers exist in Wuhan city only.

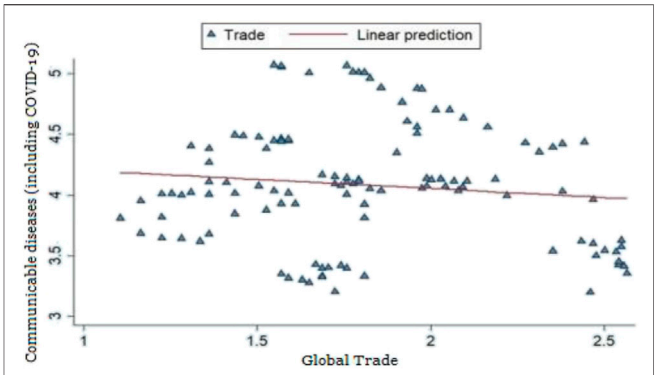

FIGURE 1 | Global trade and communicable diseases (including Covid-19) (Authors own work).

Generally, most significant companies' production exists in different countries of the world to get a competitive advantage. However, after the outbreak of COVID-19, this competitive advantage became a major hurdle in managing supply chains in a globally dynamic environment. There exists a strong nexus between the logistics industry and the manufacturing industry. Hence the global output mainly depends on the smooth and uninterrupted logistics and manufacturing of materials and provision of services. The volume of international production depends strongly on fast and smooth supply chains and production facilities, and therefore, global trade is directly connected with smooth and uninterrupted logistics. The pandemic has influenced the global supply chains and also enhanced the chances of economic collapse (Goel et al., 2021). United Nations trade and development conference has announced that the US $ 3 trillion has been vanished due to the pandemic outbreak and the global trade has reduced to 1.5pp. This pandemic has potentially damaged the logistics of trade across the borders that ultimately compromised the manufacturing industry. The economic growth of the countries mostly relies on their production (Goel et al., 2021). Similarly, the global output depends on the contribution of the nation's production. The outbreak of pandemics has impacted the global supply chains, especially the logistics industry. The world's output mainly depends on the exports of exporting nations. Communicable diseases especially COVID-19 has first and foremost attack on the movement of goods and services. Hence, the requirement of goods across the world was escalating manifold. The pandemic outbreak decreases the supply of goods and services across the borders. Mainly, the supplies of health equipment were shortened in different regions of the world (Qin et al., 2021a). There exists a gap in the literature regarding the evaluation of disruption impact on global logistics, global manufacturing, and supply chains. From the COVID-19 perspective, the impact of the pandemic on logistics and

manufacturing industries has not been evaluated properly, especially in the context of exporting countries. Previous literature has empirically evaluated the impact of COVID-19 on these and many other industries (Qin et al., 2021a; Goel et al., 2021; Hilmola and Lähdeaho, 2021; Khan et al., 2021; Sun et al., 2021) but this study evaluated the impact of communicable diseases especially COVID-19 with the help of secondary data of 13 years **Figure 1** depicts the scenario of global trade and communicable diseases.

Moreover, to get a location advantage, companies targeted those areas which are cost-effective, have cheap and skilled labor, and have an abundance of raw material. This trend attracted the geographical and functional integration of production, distribution, and consumption. A complex logistic framework came into existence to fulfil the international needs that involved the flow of commodities, information, parts, and finished goods from one geographical area to another. At the same time, globalization has already increased the interconnection of trade activities that consists of delicate, complex, and interdependent networks of logistics activities. The presence of Global Production Networks (GPN) and Global Commodity Chains (GSS) provided the integrated sets of trade, production, and services in supply chains which involved in the transportation of raw material and finished goods internationally (Dicken et al., 2001; Coe et al., 2004; Grida et al., 2020). According to raw material availability, manufacturing facilities, service provision, and technological aspects, the world has been partitioned into different segments. One geographical territory is favorable in production, and the other is appropriate for the service industry, and some areas are specialized in information technology. Therefore, there is a dire need for multidimensional and strong logistic services that can handle the mobility of raw material, information, services, and finished goods worldwide. Due to this huge network, global trade at different times has been severely affected by various disruption risks, and one of the major disruption risks has been the outbreak of communicable diseases. In the past, the spread of the Ebola virus, Swine flu, MERS, and SARS disrupted the logistics and manufacturing industry and, eventually, the global trade. Presently, the spread of SARS CoV 2 also puts the business activities and especially supply chains to test. The spread of COVID -19 challenged the global movement of goods and blocked the world borders completely. Similar to other communicable diseases, this pandemic has also affected the global supply chains, manufacturing industry, and ultimately the global trade. However, the present study is aimed to analyze the relationship between energy efficiency, renewable energy consumption, foreign direct investment, energy consumption, global trade, logistics and manufacturing industries during the COVID-19 pandemic. Therefore, this study tries to answer the following questions:

1. How have communicable diseases especially the COVID-19 pandemic impacted the logistics industry?
2. How have communicable diseases especially COVID-19 impacted the manufacturing industry?
3. How do the compromised logistics and manufacturing capabilities due to COVID-19 influence global trade?

Economic growth depends on national and global production and smooth supply chain operations. Moreover, addressing the sustainability goals is also a challenge for the countries. This study contributed to the literature by providing comprehensive nexuses among the most debatable variables. This study provides the influence of supply chain disruptions and production on the logistics industry, manufacturing industry and global trade. Moreover, this study also addresses the issues of sustainability among exporting nations. The utilization of cost-effective, renewable and efficient energy resources in business operations during the pandemic provides implications to other nations to address the sustainability concerns. Therefore, this study implicates that the incorporation of eco-friendly operations to enhance economic growth and sustainability are crucial for global trade, global output and logistics across the borders.

The rest of the paper is organized as follows. In section two, we discuss the literature on communicable diseases (including COVID-19), the logistics industry, the manufacturing industry, and their impact on global trade. In section three, we discuss the methodology of this study. Section four comprised of results and their discussion. The paper is summarized in section five by providing a comprehensive conclusion and policy implications for the supply chain and governments' strategic thinkers.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The globalization of products and services is a competitive strategy of multinational firms in the current century, and this compels the firms to segregate their operations across the borders to get a competitive advantage through global production. Besides competitive advantages, operating globally has some serious concerns, including the Political, Economic, Social, Technological, and legal (PESTL) environment. Additionally, an approach to achieve more economic growth enhances the utilization of nonrenewable energy resources that causes environmental degradation due to CO_2 emission (Tufail et al., 2021). Recent research showed that technological advancement and exports negatively affect the use of carbon (Wahab, 2021; Wahab et al., 2021). Financial development is a key element of economic growth however, financial growth negatively affects environmental sustainability (Wahab, 2021). More importantly, economic growth largely depends on the availability and abundance of natural resources in a locality or their smooth logistics across the nations. There exists a strong nexus between resource abundance and economic growth (Yang and Ni, 2022). Industrial growth depends mainly on the utilization and availability of affordable and renewable energy resources. The nexuses between the availability, consumption and price of energy resources mainly electricity is crucial for industrial production and global output (Rahim et al., 2021). As the companies are part of delicate and complex supply chains, a robust, eco-friendly, innovative and risk-free global supply chain needs a well-coordinated and structured flow of goods, services, information, and cash within and across the borders (Henderson et al., 2002). To get maximum benefit, companies import raw

materials from advantageous location regions or install production plants in cheap labor localities to manufacture and assemble parts. Later on, these products' sales and marketing are made in potentially high-demand regions (Mentzer et al., 2001). Hence, maximization of profit through well-designed supply chain operations has been the main objective of supply chain management for decades (AlHashim, 1980; Hise, 1995).

The supply chain's guiding principle is to maintain a balance between efficiency and effectiveness through the seamless and timely movement of goods, materials, information, and services across borders to expedite profit maximization (Nelson and Toledano, 1979; Schmidt and Wilhelm, 2000). The implementation of effective, well-designed, and well-coordinated supply chain operations globally is a key challenge for the strategic thinkers of supply chains and international trade due to differences in the economic, political, legal, social, and infrastructural environment (Schmidt and Wilhelm, 2000). Besides these operational risks, certain disruption risks have also remained part of supply chain operations throughout history. Natural disasters, floods, earthquakes, and human-created catastrophes had affected supply chain operations many times in previous decades. The most important disruption risk includes SARS, Ebola virus, Swine flu, MERS, and recently the COVID-19 pandemic.

Communicable Diseases and International Trade

A vast body of literature is available on the research conducted to find out the impact of communicable diseases on logistics (2,39–42) but the literature on the impact of the pandemic outbreak on global trade is scarce. This research study focuses on the impact of communicable diseases, including COVID-19, on global trade and supply chain operations. As it is evident global trade is the backbone of the globalized world, but at the same time, global trade is also held responsible for the spread of communicable diseases like H1N1, HIV/AIDS, SARS, MERS, Ebola virus, and swine flu. The transportation of goods, shipping, and humans witnessed the spread of infectious diseases (Gubler and Rosen, 1976; Mack et al., 2011). Fidler (Fidler, 1996) considers the global movement of goods and humans without public health safety a great risk of disease transmission across the borders, and this was evidenced recently in the case of COVID-19 spread, which entirely halted global trade. Similarly, previous literature on the outbreak of SARS in 2002–2003 indicates adverse effects on the airline industry, and the major impact was in Taiwan, where around 30% of the local and international flights were suspended (Chou et al., 2004). Similarly, the Ebola virus spread negatively impacted international supply chain operations (BSI, 2014).

Since globalization was in its initial stages in the early nineties and the distribution of production and networks of supply chain operations was not much flourished in different countries, the SARS effect was negligible on international trade and global supply chain operations as compared to the present decade. Certain studies have been conducted to provide the lessons learned from the Ebola outbreak and suggest the formulation of the decision–support framework that can inhibit the impact of the pandemic outbreak on supply chain operations and provide insight to coordinate the operational and logistics-related policies during and after the pandemic crises (BSI, 2014; Ilbahar et al., 2019). In this scenario Dmitry Ivanov (50) has recently discussed the concept of a viable supply chain and provides a helpful model for the managers in decision making regarding the formulation and recovery of global supply chain operations after disruptions like the COVID-19 pandemic.

The SARC CoV-2, known as COVID-19 was originated from the city of Wuhan, China, in mid of December 2019 and spread throughout the world in a couple of months. This virus threatened the health care system and severely impacted the global supply chain operations and international trade by having closed international borders and domestic manufacturing. Moreover, COVID-19 ceased most business sectors and inhibited the routine flow of goods, humans, services, and capital within and among the nations. This de-globalization of production, manufacturing, supply chains, and international trade continues to date and severely affects global supply chain operations (Chou et al., 2004) as global supply chain operations are performed all over the world but mostly performed by exporting countries like China, Italy, the United States, United Kingdom, and France, etc. The sudden drop in operational performance, shortage of material, and fluctuation in prices caused by this pandemic outbreak were heavily affected by these exporting countries. Coronavirus statistics approve that the German Post declared an EBIT reduction in the range between 60 and 70 million Euro, similarly a 21.9% rise in retail prices in China was reported (BSI, 2014). Apple announced an unexpected drop in quarterly earnings, and at the same time, by the end of February 2020, the pandemic had made 9% of shipping fleets inactive. Due to the suspension of manufacturing activities, the Chinese industry faced its lowest point at the beginning of the COVID-19 outbreak (Ivanov, 2020b).

Moreover, at the start of the COVID-19 pandemic spread, WTO had predicted the drop in global trade by 13–32%, which is worst compared to the financial crises of 2007–2008. The recent data of WTO confirms their claim regarding the drop in global trade by indicating the Goods Trade Barometer at 95 in December 2019, which is lower than in previous months. Therefore, it is confirmed that communicable diseases (including COVID-19) have affected the global supply chain operations worldwide, especially the developing and exporting countries. Previous studies only focused on the effect of natural disasters and financial crises on global trade (Gassebner et al., 2006; Escaith et al., 2011; Ando and Kimura, 2012). However, the impact of communicable diseases (including COVID-19) on global trade has not been adequately addressed. Recent studies regarding the COVID-19 pandemic only focused on the financial markets (Ali et al., 2020; Apergis and Apergis, 2020; Gil-Alana and Monge, 2020; Haroon and Rizvi, 2020; Liu et al., 2020; Phan and Narayan, 2020; Qin et al., 2020). However, one of the aims of this study is to analyze the impact of the communicable diseases including COVID-19 pandemic on global trade. Hence, we proposed a hypothesis that:

H1: Communicable diseases (including COVID-19) negatively and significantly impact global trade.

Logistics Industry and Global Trade

The logistics of materials is the backbone of global production and the literature of various disciplines has shown strong dependence on the supply of raw materials on production activities (Sabel et al., 1987; Slack, 1991; Christopher, 1992; Schonberger, 2008). Especially the manufacturing and logistics of top exporting countries including China, the United States, Germany, the Netherland, Japan, France, Korea, Italy, and the United Kingdom are strongly dependent on the logistics activities of multinational enterprises (Lorenzoni and Ornati, 1988; Womack, 1990; Lamming, 1993). Global logistics is defined as the movement of goods and services across borders with integration to manufacturing industries to provide value addition to the customers (Lin, 2016). Exporting countries play a pivotal role in global trade; for example, China which is the hub of global economic activities for the last 2 decades and owns 60% of the world's GDP in terms of supply and demand, 65% of manufacturing activities, and 41% of exports to the rest of the world (Baldwin and Di Mauro, 2020). And this is the reason that disturbances in Chinese logistics have caused a remarkable impact on the manufacturers of the remaining world (UNCTAD Search, 2020).

Barua, (Barua, 2020), has discussed the likely impact of Chinese logistics disturbances on 13 industries of transitional goods globally, including automobile products, chemicals, machinery, instruments of precision, and information technology. He further explores that only a 2% decrease in Chinese exports due to logistics disruption resulted in a decrease of $ 4 billion in global trade in 34 countries of the world. The shutdown of operational activities by the world's largest companies like General Electric, Volkswagen, Nike, Airbus, and Toyota in exporting countries due to disruption in logistics activities has decreased the global trade among the countries (Author Anonymous, 2020). Besides this, logistics companies like DHL, FedEx, and UPS faced severe disturbances in national and international logistics of goods from exporting countries like China to the rest of the world (Tirschwell, 2020). Moreover, globally, the shipments of containers from 89 ports dropped by 60% since December 2019 and are expected to drop further (Knowler COVID-19, 2020). COVID-19 pandemic affected the logistics of raw material and finished goods, and the logistics of the service industries like tourism and travel industries are among those that were hit the most. WTO predicts a 20–30% decrease in tourism and travel compared to 2019, which will enormously affect the global revenues and the exporting countries like France, Italy, and the United Kingdom especially (Farrer Coronavirus, 2020; ICAO Economic, 2020).

Due to the abrupt rise in cases of COVID-19 in the United Kingdom, United States, Italy, China, and India, production and export of products and services to other countries dropped rapidly in the shape of lockdowns and quarantines. This decrease in production, manufacturing and global trade was mainly caused by disturbances in raw material logistics, finished goods, and services across the borders. According to the World Bank report, the world GDP decreased significantly during the lockdowns. The developed economies shrank by 7% in 2020 whereas; developing economies shrank by 2.5% during the same period. The global trade shrank by more than 13%, the highest after World War II. This reduction in global GDP is caused due to the local and international shutdown of production and manufacturing. Production and manufacturing have a strong relationship with the logistics of raw materials and products. The logistics activities have been severely impacted by operational risks and disruption risks many times in history. The disruption risks are rare but impacted the logistics activities with great magnitudes.

There exists a negative impact of communicable diseases on the logistics industry, and this negative impact leads to a decrease in global trade. The recent disturbance due to COVID-19 in these exporting countries has affected the transfer of raw material and finished goods from one region of the world to another. Recent reports indicate that the global trade of goods and services is getting slow due to the spread of the COVID-19 pandemic. The COVID-19 pandemic has threatened the global logistic industry because previous literature held logistic activities responsible for spreading communicable and infectious diseases such as the Ebola virus, HIV/AIDS, H1N1, MERS, SARS, and Swine flu across the world. This notion immediately affects the logistics industry soon after the outbreak of the COVID-19 pandemic. Hence we propose a hypothesis that:

H2: There is a positive and significant impact of the logistics industry on international trade.

Manufacturing Industry and Global Trade

The manufacturing industry is supposed to be the key element in global production as it helps enhance global trade and economic growth. Several studies have highlighted the role of the manufacturing industry on global trade and economic growth, such as Szirmai (Szirmai, 2012), Thirlwall (Thirlwall, 2006), Tregenna (Tregenna, 2009). Manufacturing includes all those activities associated with the movement of goods, innovation of products and services, planning and management of production, and dissemination of products and services (Martinelli, 1991). These studies suggest that the economic growth of developing and exporting countries mainly depends on the production infrastructure. In addition to it, industrialization is the crucial step towards production, manufacturing, and global trade. Rodrik (Rodrik, 2015) points out that the fast global trade and economic growth happened due to the massive transfer of manufacturing resources to the exporting countries. Industrial activities in developing and exporting countries expedite global trading channels. According to Szirmai (Szirmai, 2012), manufacturing is a vital element of international trade and economic growth, especially in developing and exporting countries. The shift of manufacturing infrastructure in developing countries in the shape of FDI automatically enhanced the production activities. This shift served as a bonus for exporting countries and expedited the international supply chain operations and overall economic growth. Production activities in the manufacturing industry are higher than in any other industry due to abundant resources and technological advancement.

This economic growth and international supply chain operations have been lucrative enough to catch the world's business community's eyes and fulfil the demands of customers across the world. However, the operational and disruption risks in history have many times drowned the dreams of stakeholders. Operational risks and disturbances are usually manageable, and their impact is most of the time measurable and predictable on the manufacturing industry and global trade. On the other hand, disruptions and disturbances caused due to natural disasters and communicable diseases like the Ebola virus, Swine flu, MERS, SARS, and COVID-19 have unpredictable and immeasurable impacts on manufacturing and international trade. Pre COVID-19 analysis of world trade predicts that the global production networks (GPN) were the major portion of world trade that increased industrialization and increased the less developed nations' productivity. Countries like China, India, and Korea have become leaders in the export industry due to GPNs (Vidya et al., 2020). Hence due to competitive advantage in production, manufacturing, distribution, China, Korea, and Japan became the hub of global supply chains. Certain countries among exporting countries, like China and others, are believed to be a hub of industrial goods with a specialization in information and communication technology (Baldwin and Tomiura, 2020).

Dasgupta and Singh (Dasgupta and Singh, 2006) conducted a cross-sectional study for 48 developing nations from 1990 to 2000 and posit that manufacturing still acts as a vital economic growth element. Increased share of manufacturing remarkably contributed to economic growth as compared to the agriculture and services industry. A significant association was established connecting the industrialization level and per capita income in emerging economies. The contribution of manufacturing to GDP and job creation increased due to higher per capita income in emerging economies. The real GDP growth rates on economic development lie in the growth rate of manufacturing (Fagerberg and Verspagen, 1999). Banjoko et al. (2012) posit that the experiences of developed economies and developing economies like India, China, Malaysia, Singapore, and North Korea regarding the manufacturing industry's role exposed a positive relationship between the manufacturing industry and economic development. Similarly, the study of Portugal-Perez and Wilson (Portugal-Perez and Wilson, 2012) revealed that trade improvement not only positively impacted the imports but also increases exports along with the improved provision of inputs related to production and enhanced contribution in international and territorial value chains.

Due to the logistics services' interruptions globally, the production of goods in these countries specialized for production decreased significantly. Hence the negative blow on global logistics disturbed global production, leading to a negative effect on global trade. This disruption in logistics, manufacturing and global trade leads to demand contractions internationally (Baldwin and Freeman, 2020). As per the theory, logistics, manufacturing, and global trade disturbances direct economic fundamentals shifting (Krugman, 1997). Hence, we propose a hypothesis that:

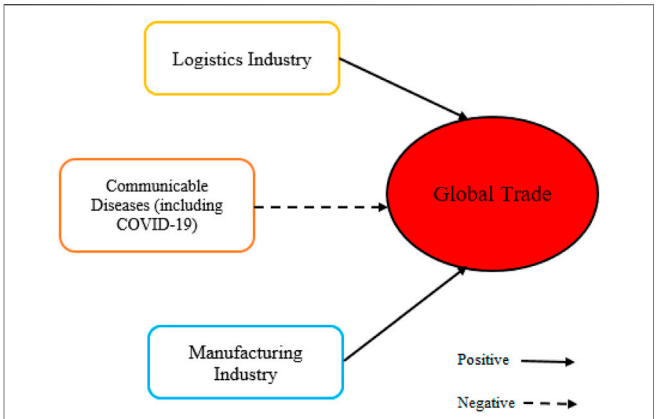

FIGURE 2 | Conceptual framework.

H3: There is a positive and significant impact of the manufacturing industry on global trade.

DATA AND METHODOLOGY

This study uses a fixed effect panel estimation technique to measure the energy efficiency, renewable energy consumption, foreign direct investment, Logistics industry's effect, Communicable diseases (including COVID-19), and manufacturing industry on global trade in top exporting countries naming China, United States, Germany, Netherlands, Japan, France, Korea, Italy and United Kingdom. The data has been extracted from the World Development Indicators and Statista 2020 for 13 years ranging from 2007-to 2020. **Figure 2** shows the conceptual framework of this study. Following is the equation for testing hypotheses:

$$Trade_{it} = \beta_0 + \beta_1 LI_{it} + \beta_2 MI_{it} - \beta_3 CD_{it} + \varepsilon_{it} \quad (1)$$

LI is the logistic industry, MI is the manufacturing industry, and CD is communicable diseases (Including COVID-19), $\beta_{1\text{\textdiamond}2\text{\textdiamond}3}$ depicts the coefficients that are to be determined, ε_{it} and depicts the error term; whereas i is for the country, and t is for time. The dependent variable, global trade, is measured through trade as a percentage of GDP taken from the World Development Indicator (WDI). Additionally, the independent variable, logistics industry, has been measured through the Logistics Performance Index, taken from Statista, which comprises of six further constructs: 1) Capability to trace and track consignments, 2) Proficiency and excellence of logistics services 3) Affluence of assembling competitively priced shipments 4) Proficiency of levies approval process 5) Frequency with which shipments reach consignee within scheduled or expected time 6) Quality of trade and transport-related infrastructure. Simultaneously, data for the manufacturing industry has also been extracted from the WDI, which comprises four further constructs. 1) Industry: Industry value added (% of GDP) 2) Agriculture: Agriculture value added (% of GDP) 3) Manufacturing: Manufacturing

TABLE 1 | Data sources.

Variable	Variable presentation	Period	Source
Proficiency and quality of logistics services	LPI 1	2007–2020	Statista (2021)
The effectiveness of the taxes approval process	LPI 2	2007–2020	Statista (2021)
The affluence of assembling competitively priced shipments	LPI 3	2007–2020	Statista (2021)
Ability to trace and track consignments	LPI 4	2007–2020	Statist (2021)
The frequency with which shipments reach consignee within the scheduled or expected time	LPI 5	2007–2020	Statist (2021)
Quality of trade and transport-related infrastructure	LPI 6	2007–2020	Statista (2021)
Service: Service value added (% of GDP)	SER	2007–2020	WDI (2021)
Trade: Trade (% of GDP)	TR	2007–2020	WDI (2021)
Industry: Industry value added (% of GDP)	IND	2007–2020	WDI (2021)
Agriculture: Agriculture value added (% of GDP)	AGR	2007–2020	WDI (2021)
Manufacturing: Manufacturing value added (%of GDP)	MAN	2007–2020	WDI (2021)
Fossil Fuel (% of total consumption)	FF	2007–2020	WDI (2021)
Energy efficiency	EFF	2007–2020	WDI (2021)
Renewable energy consumption	REC	2007–2020	WDI (2021)
Foreign direct investment inflows	FDI	2007–2020	WDI (2021)
Communicable diseases	CD	2007–2020	WDI (2021)

TABLE 2 | Descriptive statistics.

Variable	Obs	Mean	Std.Dev	Min	Max
Trade (% of GDP)	117	4.081	0.49	3.198	5.066
Communicable diseases	117	1.815	0.382	1.105	2.565
Manufacturing Value added (% of GDP)	117	2.764	0.419	2.18	3.478
Service Value added (% of GDP)	117	4.167	0.146	3.758	4.369
Agriculture Value Added (% of GDP)	117	0.452	0.723	-0.57	2.327
Fossil Fuel (% of total consumption)	117	4.385	0.186	3.834	4.552
Industry Value added (% of GDP)	117	3.195	0.302	2.827	3.85
LPI 1: Competence and quality of logistics services	117	1.374	0.061	1.215	1.589
LPI 2: Efficiency of the customs clearance process	117	1.353	0.06	1.221	1.461
LPI 3: ease of arranging competitively priced shipments	117	1.283	0.049	1.166	1.472
LPI 4: Ability to track and trace consignments	117	1.291	0.079	1.095	1.417
LPI 5: Frequency with which shipments reach consignee within the scheduled or expected time	117	1.425	0.045	1.303	1.537
LPI 6: Quality of trade and transport-related infrastructure	117	1.382	0.065	1.163	1.491

value added (%of GDP) 4) Fossil Fuel (% of total consumption). Moreover, the communicable diseases (CD) measured inactive cases are also extracted from WDI. **Table 1** contains the details of all the variables and their sources.

ANALYSIS AND RESULTS

The analysis starts with descriptive statistics measuring mean, median, Std. Dev, Min, and Max in **Table 2**. The values of min and max rule out any suspected existence of outliers in the data. The sample mean of trade is 4.081 shows that, on average, sample countries have 4% of GDP attributable to trade. The minimum and maximum values also appear to be not far from the mean, eliminating any risk of an outlier in the data. Communicable diseases have a mean value of 1.815 and a standard deviation value of 0.382. Manufacturing and Service value-added have the mean values of 2.764 and 4.167, respectively, which show the average percentage of a given country's GDP attributable to manufacturing and services value-added. It is also evident that the standard deviations for all of these measures are also very minor.

Table 3 shows the correlation matrix among independent variables and the dependent variable. The correlation coefficient between trade and communicable diseases is (-0.1161), which confirms the negative relationship. At the same time, constructs for the logistics industry are found to be having positive relationships with trade, which depicts the positive link between them.

Table 4 contains the regression output of fixed and random effect models. The Hausman test's probability value confirms that the fixed effect is appropriate for analyzing the effect of the manufacturing industry, logistics, and communicable diseases on global supply chains as it is evident that fixed effects regressions are very useful when the data falls into groups such as countries, industries, companies, etc. Since our data fall into such categories, there might be unobservable factors correlated with the variables used in our model, which will result in omitted variable bias. Since we believe that these unobservable variables are time-invariant, the use of fixed effects regression will remove this omitted variable bias.

TABLE 3 | Correlational matrix.

Variables	Trade	Communicable Diseases	Service	Industry	Manufacturing	Fossil fuel	Agriculture	LPI 1	LPI 2	LPI 3	LPI 4	LPI 5	LPI 6
Trade	1	–	–	–	–	–	–	–	–	–	–	–	–
Communicable diseases	−0.1161*	1	–	–	–	–	–	–	–	–	–	–	–
Service	−0.2171*	−0.1368*	1	–	–	–	–	–	–	–	–	–	–
Industry	−0.0603	−0.0627*	−0.8894	1	–	–	–	–	–	–	–	–	–
Manufacturing	−0.051	−0.0283*	−0.8276	0.972**	1	–	–	–	–	–	–	–	–
Fossil Fuel	0.0167	0.1162**	−0.1826	0.3495**	0.3142***	1	–	–	–	–	–	–	–
Agriculture	0.0136*	−0.297	−0.7772	0.6657*	0.5999	−0.0776*	1	–	–	–	–	–	–
LPI 1	0.2188*	0.1768	0.636**	−0.5206	−0.4756	0.0943*	−0.7681	1	–	–	–	–	–
LPI 2	0.2384**	0.1982	0.6386*	−0.5386	−0.49	0.0351**	−0.7648	0.9565*	1	–	–	–	–
LPI 3	0.35***	−0.0232	0.2975	−0.2966	−0.2894	0.1116*	−0.4052	0.6423	0.603**	1	–	–	–
LPI 4	0.0307	0.2001	0.7533*	−0.6523	−0.6199	−0.0091	−0.832**	0.8533	0.8556*	0.4768	1	–	–
LPI 5	0.2366**	0.1537	0.6612*	−0.6029	−0.5545	−0.0407	−0.8098	0.9182*	0.9279	0.5671*	0.8572	1	–
LPI 6	0.0968*	0.1128	0.6483	−0.4999	−0.4308	−0.0035	−0.6893*	0.8979*	0.9268	0.5222	0.8047	0.8594**	1

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results show that communicable diseases' coefficient is negative (-0.108) and is significant at 10%, which to some extent shows that communicable diseases may have some adverse effect on trade. Similar findings are reported by Singh et al., (Singh et al., 2020), that confirm how the deadly COVID-19 affected the lives and the economy of millions of people around the globe. They further proved it with a simulation model in their study of how demand and supply were affected severely due to lockdowns and caused shortages due to suspended logistic and manufacturing activities in the food supply chain network. Similarly, the study of Barua (Barua, 2020) also predicts the negative effect of the COVID-19 pandemic on global trade, and it further explains that this dilemma can introduce many new ways of global trade and investment.

Besides this, the coefficients of agriculture value-added, which is (0.334), and manufacturing value-added, which is (0.775), are significant at 1%, confirming that the manufacturing industry has a greater impact on the global supply chains. One unit change in Agriculture value-added and manufacturing value-added will increase the trade by 33.4 and 77.5%, respectively. At the same time, the coefficient of Fossil fuel is also found to be significant at 10% with a coefficient (0.318). Therefore, these findings authenticate that agriculture value-added and manufacturing value-added can play an important role in enhancing trade and economic conditions, which will improve the supply chain globally. In addition to it, the significant and positive coefficient of fossil fuels also validates that the manufacturing industry of a country as a whole can contribute significantly to expanding trade, and this expansion of trade will further contribute to global trade. These findings are consistent with Deshmukh and Haleem (Deshmukh and Haleem, 2020), whose findings confirm that manufacturing industries have been hit severely across the globe due to this COVID-19 pandemic, especially in Europe, the United States, China and India. They suggested that the disruptions caused by COVID-19 can be viewed as an opportunity to enhance improved manufacturing facilities to cope with the new markets internationally. A study conducted by Katuria and Raj (Katuria and Raj, 2009) at the regional level revealed that the more industrialized areas flourish more rapidly than other regions. In association with Katuria and Raj (Katuria and Raj, 2009), research of Chakravarty and Mitra (Banjoko et al., 2012) also explored that manufacturing is a vital and most important factor of overall economic expansion.

At the same time, the logistics industry is also found to have a significant impact on global supply chains as it is evident from the results that three of its constructs are significant at 1 and 10%. The LPI 3 is significant at 1% with a coefficient of (0.973) whereas, LPI 1 and LPI 6 are significant at 10% with a coefficient of (0.131) and (0.517), respectively. According to the findings, the ease of arranging competitively priced shipments (LPI 3) is the most significant variable that implies that slight ease in these shipments will improve the trade dramatically up to 97%. Overall it can be viewed that the logistics industry can play a significant role in supply chain operations internationally by improving its ease of arranging competitively priced shipments and the quality of logistics and infrastructure related to trade.

TABLE 4 | Regression analysis.

Variables	Fixed effect	Random effect
Communicable diseases	−0.108*	−0.414***
	(0.0645)	(0.0722)
Service Value added (% of GDP)	−2.301	−7.762
	(0.551)	(0.499)
Industry Value added (% of GDP)	−1.133	−6.268
	(0.289)	(0.496)
Manufacturing Value added (% of GDP)	0.775***	2.193**
	(0.215)	(0.262)
Agriculture Value Added (% of GDP)	0.334***	0.177***
	(0.106)	(0.0675)
Fossil Fuel (% of total consumption)	0.318*	0.620***
	(0.262)	(0.136)
LPI 1: Competence and quality of logistics services	0.131*	1.198**
	(0.209)	(0.569)
LPI 2: Efficiency of the customs clearance process	−0.0555	-0.729
	(0.316)	(0.840)
LPI 3: ease of arranging competitively priced shipments	0.973***	2.002*
	(0.447)	(1.208)
LPI 4: Ability to track and trace consignments	−0.457	0.638
	(0.567)	(1.456)
LPI 5: Frequency with which shipments reach consignee within the scheduled or expected time	−0.0530	−0.681
	(0.375)	(1.016)
LPI 6: Quality of trade and transport-related infrastructure	0.517*	3.350**
	(0.549)	(1.361)
Constant	14.21***	39.21***
	(2.852)	(3.012)
Observations	117	117
Number of Countries	9	9
Hausman	Prob (0.001)	

Standard errors in parentheses.
***p < *0.01*, **p < *0.05*, *p < *0.1*.

TABLE 5 | GMM test for robustness.

Variables	One Step difference GMM	One step System GMM
Communicable diseases	−0.107*	−0.332**
Service Value added (% of GDP)	−4.312	−8.642
Industry Value added (% of GDP)	−3.521	−4.237
Manufacturing Value added (% of GDP)	0.632**	0.892**
Agriculture Value Added (% of GDP)	0.258**	0.198***
Fossil Fuel (% of total consumption)	0.315*	0.627**
LPI 1: Competence and quality of logistics services	0.582	0.365*
LPI 2: Efficiency of the customs clearance process	0.014*	0.008**
LPI 3: ease of arranging competitively priced shipments	0.751	0.993*
LPI 4: Ability to track and trace consignments	−0.342	−0.235
LPI 5: Frequency with which shipments reach consignee within the scheduled or expected time	0.032*	0.013*
LPI 6: Quality of trade and transport-related infrastructure	0.461**	0.237**
Renewable energy consumption	0.548*	0.319**
Energy efficiency	0.332**	0.271***
Foreign direct investment	0.712***	0.642***
Constant	21.37***	33.27***
Number of instruments	17	17
AR (2)	0.1894	0.3967
Hansen	0.0922	0.1375

***p < *0.01*, **p < *0.05*, *p < *0.1*.

Besides these, we also employed the GMM test for robustness and included renewable energy consumption, energy efficiency and foreign direct investment as control variables (see **Table 5**).

The results of the GMM test shows that Communicable disease is negative and significant at a 10% level, which means one per cent change in communicable disease will reduce trade by -0.107%. At the same time, the coefficient of Manufacturing Value added, Agriculture Value Added, and Fossil Fuel is also found to be positive and significant at a 5 per cent level of significance. Additionally, all three control variables are also found to be positive and significant at 5 and 1% respectively which ensures the robustness of our results through GMM.

Szirmai and Verspagen (Szirmai, 2012) have examined the association between the share of service and manufacturing sectors to GDP and development of GDP to per capita income by utilizing panel data for both developed as well as developing nations for three different periods ranging from 1950 to 1970, 1970–1990, and 1990–2005. They realized that manufacturing serves as a backbone of economic growth for low and middle-income nations due to the abundance of human capital in those nations. While aiming at the middle-income economies, Su and Yao (Su et al., 2017) conducted a study and used three methodologies for the long run, i.e., Granger causality tests, cross-sectional regression, and panel regression, to assess the role of the manufacturing sector as a driver of growth for the services sector. Further, Ivanove (Ivanov, 2020b) study substantiates that the timing of the opening and closing of the facilities at various levels might become a major cause that determines the epidemic eruption impact on the supply chain rather than an upstream interruption duration or speed of epidemic spread. The results showed that the manufacturing industry serves as an engine of growth for the services sector. Hence these findings led the researchers to determine that manufacturing serves as a vital element for the growth and flourishing of economies. Besides this, they also concluded that the deindustrialization of premature nature negatively impacts economic growth.

CONCLUSION, POLICY IMPLICATIONS, LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Supply chain complexities grew as the world became interconnected. This global environment offered abundant new opportunities for supply chain diversification and optimization but at the same time exposed the supply chain network to disruptions of higher complexity, uncertainty, and magnitude (Golan et al., 2020). Recently the novel COVID-19 affected all spheres of life, and it has equally affected the supply chain globally. This study attempts to analyze the relationship among energy efficiency, renewable energy consumption, foreign direct investment, energy consumption, global trade, logistics and manufacturing industries during the COVID-19 pandemic in top exporting countries using a fixed-effect panel estimation technique. This study's data has been extracted from the World Development Indicators and Statista 2021 for 13years ranging from 2007to 2020. The results validate the estimated view that high-risk diseases significantly and negatively influence supply chain operations internationally. Simultaneously, manufacturing and logistic industries are also significantly positively influencing global trade operations. Additionally, the utilization of renewable energy resources, efficient electricity use at minimum cost and accommodating the FDI also has significant consideration among developing exporting countries. These factors were also significantly associated with the global output and global sustainability issues during the COVID-19 pandemic.

Practical Implications

These results implicate that improving the manufacturing and logistic industries and coping with the risk of pandemic diseases can prosper the overall international trade and logistics. By paying attention to the affluence of assembling competitively priced shipments, the proficiency of the customs approval process, quality of logistics services, and infrastructure related to trade can significantly expand the export from the logistics industry. Also, enhancing industrial and agricultural value-added healthier consequences might be attained in global supply chain operations from the manufacturing industry.

In addition to it, the supply chain officials should need to address the supply chain disruptions, and these disruptions due to communicable diseases need to be prioritized as it disturbs the supply chains with high and unpredictable magnitudes. Strategic thinkers of supply chains should consider capacity building regarding the storage and transportation of materials for a longer time to fulfil unpredictable situations like communicable diseases outbreak. Sustainability is one of the major issues of this era. Hence the utilization of efficient, renewable and low-price energy resources should be considered to enhance the global output and economic growth of the nations. Managing the foreign direct investment in exporting countries is also a challenging job to address before and during the pandemic. The exporting countries should address only those FDI projects that use sustainable business operations only. Moreover, managers of supply chain management should adopt the recently proposed model of Dmitry Ivanov (Ivanov, 2020b), which introduces the concept of a viable supply chain by integrating resilience and sustainability. The viable supply chain model provides multi-dimensional supply chain structures that help to maintain supply-demand needs and adaptive methods among the transitional structural designs.

Besides this, communicable diseases, especially COVID-19, have brought de-globalization for a certain but meaningful period. As globalization has brought the production shift in one region of the world that leads to the dependency of one entire region to another and in our case, only a few countries contain the major share of the international market. So countries should learn the lesson from this pandemic and increase their domestic production so that they can be able to handle the supply-demand needs of at least their population under challenging times.

Most importantly, the enhancement of technology in logistics and manufacturing is the dire need of time, especially after the

COVID-19 pandemic on global trade. As this virus attacks humans and keeps them away from working in most industries, robotic and other automated machinery in manufacturing and logistics activities should be enhanced to meet the production and logistics needs of at least the life-saving and other necessities of life across the world.

Limitations and Future Research Directions

This study like others has certain limitations. Firstly, this study uses only communicable diseases, especially the COVID-19 pandemic and tried to discuss their impact on the logistics and manufacturing industry that impacted the global trade. Future research can be conducted to adopt some other natural disruptions like floods, earthquakes, and human catastrophes to understand their impact on logistics, manufacturing, and global trade. Secondly, many other areas of the supply chain besides logistics and manufacturing have also been severely affected due to COVID-19 such as lean and agile production, forecasting of material and finished products, and inbound logistics. In future research, tools of future forecasting, SCM sustainability, and technological aspects should be considered to mitigate the impact of such disruptions in global supply chains. Thirdly, literature has been called plenty of time for conceptual and empirical-based research in context to COVID-19. There is a dire need to understand the flexibility, more resilient, and hybrid decision SCM models to overcome the impact of such disruptions in the future. More, importantly this research is quantitative; future research can consider qualitative and mixed-method research to provide further deep understanding. The sample size and target countries of this study are limited hence; future research can consider further counties especially developing countries to measure the impact of COVID-19 on logistics, manufacturing, and national output.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

Conceptualization SK, DG and SH writing—original draft MT, SK, MAK and MRK writing—review, and editing SH, SK, DG and MT methodology MAK, and MRK project administration SK, MT and DG.

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