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SPATIAL IMPACT OF COVID-19 IN TURKEY

Impact of COVID-19 pandemic on exports: new evidence from selected European Union countries and Turkey

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Abstract

The COVID-19 pandemic, a new type of coronavirus that the world faced, broke out at the end of 2019 causing numerous impacts on all countries. Particularly the European Union (EU) countries were notably affected by COVID-19 pandemic lockdowns and stringency policies. Furthermore, although Turkey was successful in combating many areas of the COVID-19 pandemic compared to the EU countries, its international trade was affected. This paper empirically investigates the impact of the COVID-19 pandemic on selected EU countries (Bulgaria, Estonia, France, Germany, Greece, Latvia, Lithuania, Luxembourg, Poland, Romania, Slovakia, Slovenia, Spain, Czechia) and Turkey's exports with monthly panel data analyses over the March 2020–December 2021 period. The findings suggest that the COVID-19 pandemic had negative impacts on exports in the EU and Turkey. For example, a 1% increase in COVID-19 stringency reduced exports by 0.102%, and a 1% increase in total COVID-19 cases caused a decline in exports of 1.620%. Furthermore, the Dumitrescu–Hurlin panel causality test results show a two-way causality relationship between COVID-19 cases and export levels. In addition, unidirectional causality linkage exists from the COVID-19 stringency index. Therefore, causality test results confirm an impact of the COVID-19 pandemic on exports during the stringency measures and lockdowns.

Keywords COVID-19 pandemic · Exports · International trade · EU · Turkey

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1 Introduction

Globalization has increased the interdependence of countries with the integration of world economies since the 1980s. In 1980 global export of goods and services was 2 trillion dollars; it increased to approximately 18 trillion dollars in 2020 (UNCTAD 2022). In addition, the integration of the world is not limited to the economy alone. The process of social and political globalization has also significantly increased. The Social Globalization Index increased from 41 to 64, and the Political Globalization Index increased from 42 to 62 over the period 1980–2019 (Gygli et al. 2019)

After World War II, several economic, political, and technological developments emerged restructured the global system. Notably, globalization created comprehensive agenda in reshaping the new international order. Bretton Woods institutions such as International Monetary Fund (IMF), World Bank (WB), and World Trade Organization (WTO) have overtaken crucial missions to liberalize the world economy since the 1970s (Albertoni and Wise 2021). From this phase of globalization, the integration and interdependence of the world economy have sharply increased, and barriers removed to flow freely of trade, investment, and people. As Fig. 1 represents, the export and import share has risen by 13 to 25.7 percentage points from the 1970s. The interconnection of the world also covers social and political dimensions. Social globalization means interpersonal flow, whereas political globalization represents integrating a country's world political system (Farzanegan et al. 2021; Gygli et al. 2019). Therefore, all sub-combinations of globalization affect all spheres of the world. Along with globalization, improvement has been achieved in various macroeconomics indicators in national economies; however, the crises experienced in the historical process show that economic fragility is higher in countries, where the degree of globalization is high.

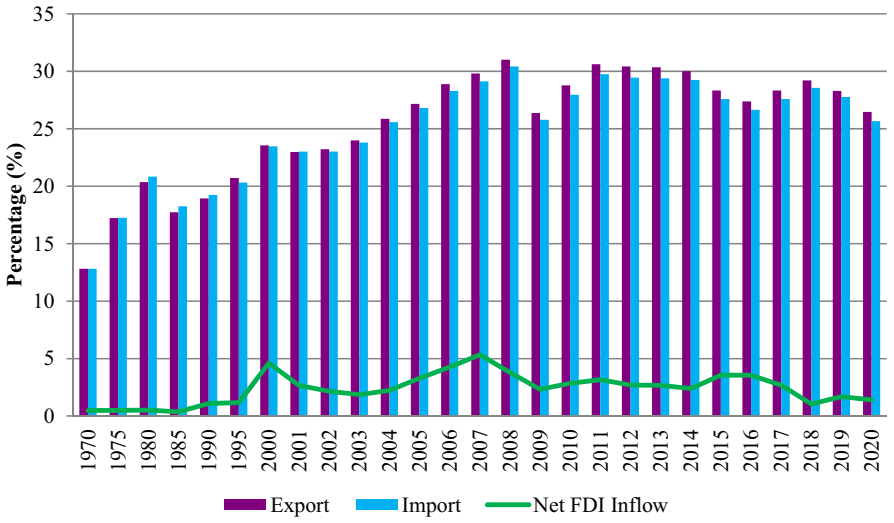


Fig. 1 General view of the world trade and net inflow of foreign direct investment (FDI) (%). Source: World Bank 2022

After the 2008 global financial crisis, the rising protectionism tendency led to a slowdown in globalization. About 10 years after the crisis, the world economy has faced a new crisis. The new type of coronavirus (hereafter COVID-19), which broke out in China at the end of December 2019, has seriously affected the world. Initially, most people labeled that COVID-19 is a regional issue rather than global (Gruszczynski 2020). However, it is denominated as a pandemic by the World Health Organization (WHO) at the beginning of 2020 (Che et al. 2020).

According to the World Health Organization, as of March 1, 2022, 434.154 million cases of COVID-19 were confirmed, and approximately 6 million cumulative deaths were recorded globally. It continues to spread chaotically across the world. Policymakers around the world immediately have imposed string restrictions on people's mobility, international travel, and economic activity to protect their citizens from the adverse impact of COVID-19. Notably, the restriction of cross-border economic activities has seriously affected the global economy (Vo and Tran 2021). These string measures have caused severe disruptions for the global economy. The world output shrank by 3.1%. Whereas the gross domestic product of developed countries contracted by 4.5%, the output of Emerging Market and Developing Economies decreased by 2% in 2020 (IMF 2022). Indeed, this is one of the worst economic turbulence since World War II (Zhao et al. 2021). However, the impact of COVID-19 on international trade has been more significant. The export and import volume declined by 9.4% and 9%, respectively, in 2020 (IMF 2021). The impact of COVID-19 on countries' exports differ because of differences in countries in terms of tradable products, the duration of the restrictions, the responses to COVID-19, and the recovery of the global economy. Nevertheless, export has a crucial role for developing countries to sustain their competitive position in the global economy.

It is evident that the COVID-19 crisis has created significant adverse influences on global trade in the short-run. With all its dimensions, the globalization and unexpected shocks in the capitalism cause deep and comprehensive results in a short span of time. When considering together with the 2008 global financial crisis, the COVID-19 crisis has distinctly revealed that globalization rendered defenseless the world vulnerable in many ways in the twenty-first century. Therefore, it is crucial to bring out the long-term impact of such crises. Most of the preceding empirical studies mainly address the impact of COVID-19 on international trade among countries. However, this study examines the long-term influence of COVID-19 on exports through the panel ARDL method by considering different COVID-19 indicators.

Hence, this paper contributes to the existing literature in various aspects. First of all, to the best knowledge, this is the seminal study to analyze the long-term impact of the COVID-19 crisis on selected EU countries and Turkey's export volume using aggregate export data. Second, this study elaborates on the nexus between COVID-19 and exports volume by accounting for the cross-sectional dependency, slope heterogeneity, and a more reliable framework using the Panel ARDL (Autoregressive Distributed Lag) developed by Pesaran et al. (1999), Pesaran and Shin (1999), and Pesaran et al. (2001).

The rest of the paper is organized as follows: Sect. 2 explains the general overview of COVID-19 and international trade; Sect. 3 provides relevant literature, including the impact of COVID-19 on foreign trade. Section 4 describes the data

and empirical methodology. Section 5 shows the estimation findings, and Sect. 6 provides the conclusions and key policy recommendations.

2 The general overview of the COVID-19 and international trade in EU and Turkey

The spread of COVID-19 undoubtedly hits all countries in a short time. It spreads to whole world through trade, people mobility, trade, cross-border investment (Iwuoha and Jude-Iwuoha 2020).

One of the biggest global problems of the twenty-first century, COVID-19, has taken the whole world under its influence in a short period. However, the impact of COVID-19 on economies is different. Table 1 reports that the USA is the most affected country, followed by India, Brazil, France, the UK, and Russia as of 3rd March 2022. Furthermore, the WHO's regional data indicates that Europe is the hardest-hit region by the spread of COVID-19, killing 1.879.356 people total. This is approximately 32% of the whole world. Especially Germany, France, UK,

Table 1 COVID-19 statistics (as of 3rd March 2022)

Countries	Cumulative Confirmed Cases	Cumulative Confirmed Deaths
World	437.333.859	5.960.972
USA	78.307.631	943.293
India	42.938.599	514.246
Brazil	28.787.620	649.333
France	22.112.589	135.471
UK	18.985.572	161.630
Russia	16.592.824	353.230
Germany	15.053.624	123.238
Turkey	14.148.450	94.648
Italy	12.829.972	155.000
Spain	11.036.085	99.883
Argentina	8.904.176	126.257
Iran	7.060.741	137.064
Netherlands	6.398.114	21.570
Colombia	6.064.583	138.767
Poland	5.694.767	111.864
Indonesia	5.630.096	149.036
Mexico	5.508.629	318.149
Japan	5.067	23.860
Ukraine	4.489.022	106.239
South Africa	3.674.042	99.412

Source: WHO 2022

Italy, and Spain are the most affected countries in Europe. On the other hand, Turkey has one of the highest COVID-19 cases in Europe. 14.148.450 COVID-19 cases and 94.648 deaths have occurred from the beginning of the pandemic to the present in Turkey.

Mainly, to prevent the transmission of the negative impact of COVID-19 in its first phase, many European countries have conducted stringent domestic and international measures, such as restrictions on people's mobility, closing cross-border, lockdown in school, work, etc (Post et al. 2021).

In general, the first lockdown policies have been implemented since the end of January 2020 in some countries in the world. As mentioned before, closure of the border, schools, workplaces, stay-at-home implementation, and restrictions on internal and international travel after the quick spread of COVID-19 fear has been operated by policy-makers as reflected by a sharp jump in the stringency index Fig. 2 in Europe and Turkey. The stringency measures started to ease in May 2020, and until the second wave, it continued in the normal path. However, at the end of 2020 (or at the beginning of 2021), the restrictions have been reinforced in Europe and Turkey with the second wave. All these measures incurred significant obstacles for Europe's and Turkey's exports. The Eurostat (2022) statistics show that Europe's and Turkey's exports dropped significantly, both in volume and the month-on-month growth rate in March and April 2020, as they implemented rigid lockdown policies. The EU-27's exports of goods decreased to 247 billion Euros from 260 billion in March 2020 and 173.7 billion euros in April 2020. Similarly, total exports of goods in Turkey decreased from 6 billion Euros to 4 billion Euros in April 2020. Thus, in this case, the COVID-19 potentially causes high risks for lockdown and hence a sharp decline in international trade.

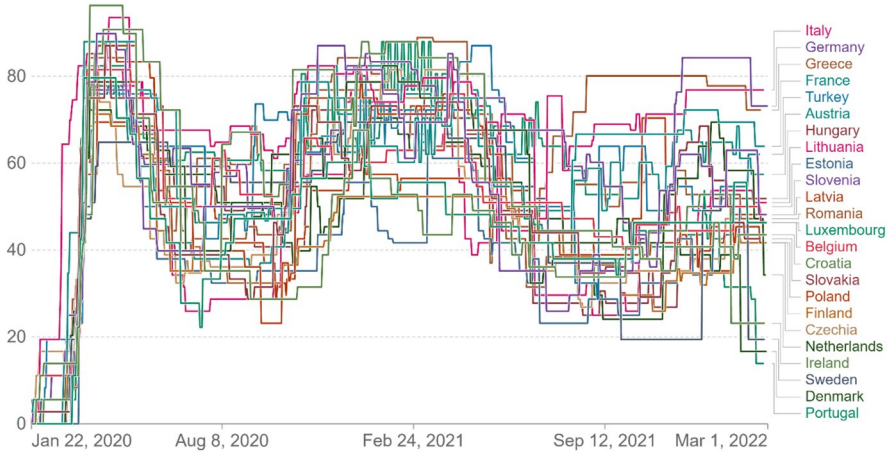


Fig. 2 COVID-19 stringency index of EU and Turkey. Source: Hale et al. (2021); Our world in Data (2022)

3 Literature review

The studies examining the impact of COVID-19 on international trade are pretty limited. At the beginning of COVID-19, countries immediately and seriously began to impose rigid restrictions. Many governments banned individuals' mobility and restricted international economic activities to severe adverse outcomes of COVID-19. The restrictions affected mostly export and import. However, some international organizations emphasize the global effect caused by the COVID-19, the clear evidence is also essential to reveal how countries' export and import are affected by the COVID-19.

Ugurlu and Jindřichovská (2022), tried to discover the impact of COVID-19 on international trade using the ARDL method for Visegrad Four (V4) countries using the monthly data from 2010M1 to 2021M4. They found that while the COVID-19 affected trade relations of these countries, its impacts vary among countries. Jindřichovská and Uğurlu (2021) have dissected the trade impact of COVID-19 between EU-15 countries and China for the period 2018:1 to 2020:5 (for China's export) and 2018:1 to 2020:7 (for EU-15's export). They explored that although the COVID-19 pandemic decreased trade volume between China and EU-15, China has high-level flexibility to produce healthcare and medical goods in terms of mitigating the inverse impact of the pandemic. Zhao et al. (2021), examined the impact of various implications of the COVID-19 on China's export and its trading partners using the Fixed and Random effect method over the period 2019M1–2020M8. They concluded that the COVID-19 is negatively associated with China's export, but China's export is affected positively depending on partner countries' COVID-19 situations. Che et al. (2020), explored the impact of COVID-19 on China's export for the period from 2019M1 to 2020M5. Their findings suggest that China's exports to high-risk countries tend to shrink more than low-risk countries. Similarly, Ben-xi and Zhang (2020) analyzed the effect of COVID-19 on exports of the agricultural sector in China using the firm-level data. The study's empirical findings represent that, although COVID-19 negatively affects some exports of the goods, exports in the various sectors have been stable, even arising in many of them thanks to increasing the demand for agricultural products. For example, the export of grain and oil rose. However, exports of horticultural products are negatively affected by the pandemic.

Espitia et al. (2022), observed that negative impact of COVID-19 on trade varied among the sectors in the disaggregated panel data set of 28 countries over the period from onset of the pandemic to 2020M6. The paper also provides that when countries become a part of the global value chain, they are exposed to more vulnerability in international trade. Farzanegan et al. (2021), examined the relationship between globalization and COVID-19 fatality in the panel data set of more than 150 countries. The results indicate a positive relationship between globalization and COVID-19 fatality. Namely, a higher degree of globalization causes to exposure more COVID-19 fatality.

Hayakawa and Imai (2022), analyzed the COVID-19-medical equipment nexus in 35 exporter countries and 250 partners. The estimated results pointed

out that COVID-19 has a negative impact on medical product export. However, a decline in export is tighter when economic, political, and geographical relations are stronger among the partners. In addition, demographic factors are crucial factors in the import of personal protective goods. Likewise, Bickley et al. (2021) analyzed the linkages between globalization and COVID-19 responses for 185 countries over the 2020M1–2020M10 periods; they reported that more globalized countries are positively associated with COVID-19 string restrictions. In contrast, high institutional capacity, such as government effectiveness, plays a role in tempering the travel restrictions through political and economic integration. Guan et al. (2020) discussed a potential effect of the COVID-19 controls on global value chains. They indicated that the negative impact of COVID-19 rules measures depends on longitude rather than its rigidity. Bontempi and Coccia (2021) studied the relationship between international trade and COVID-19 over the period of 2020M3–2021M2 in the provinces of Italy. They found out that when considered together with economic growth, environmental, and demographic factors, trade openness is more responsible in spreading COVID-19 cases.

Arenas et al. (2022) employed the Philippines' data to investigate the linkage between lockdown policies and international trade from 2019M1 to 2020M12 using an event-study methodology. The results provided evidence that international stringency measures reduce the Philippines' export and import volume instead of internal restrictions. Hayakawa and Mukunoki's (2021) analysis tried to explore the relationship between COVID-19 and international trade by employing the gravity technique with monthly data from M1–M8 in 2019 and 2020 for 34 countries who export to 173 countries. Their findings offer broad conclusions regarding the impact of COVID-19 on international trade. First, COVID-19 dramatically negatively affected exporters' and importers' foreign trade. Second, the negative international trade impact of COVID-19 on importers has begun to mitigate from July 2020. Finally, it is observed that the effects of COVID-19 vary across the sectors. For example, while COVID-19 harms durable goods, it positively affects medical products.

Khan et al. (2021) analyzed the impact of COVID-19 on global macroeconomic variables by employing the descriptive analysis method and concluded that COVID-19 has significantly negative effects on all macroeconomics indicators. Liu et al. (2021) examined the effect of COVID-19 lockdown measures and deaths on China's export in 2020 using the gravity-like method. They carried out that China's export significantly declined due to the COVID-19 lockdown measures and COVID-19 deaths in China's trade partner. In addition, China's export is positively affected when COVID-19 deaths arise among the main trading partners. In conducting input–output data, Simola (2021) investigated the nexus between COVID-19 and global value chains (GVCs) in Europen Union. The empirical estimations postulated that COVID-19 hits seriously overall international trade and GVCs, except for transport equipment. In policy inference taking from findings, it is estimated that COVID-19 will not cause radical transformation in GVCs, but it can lead to some trends reshaping GVCs improvements. Li and Lin (2021) expounded that The COVID-19 significantly exaggerates trade cost and damages world trade.

Choi et al. (2022) used data from different countries to test any relationship among COVID-19 and main macroeconomic indicators, including investment,

economic growth, household consumption, export, production, government spending, tax revenue, and export in tourism by employing the GTAP model. Their empirical evidence approved that although COVID-19 has increased investments, it has reduced economic growth, production, exports, and household consumption. In addition, export of the tourism sector is negatively affected by COVID-19. Furthermore, government expenditures arose for combating with COVID-19.

Jaffur et al. (2021) investigated the pandemic's influence on Mauritius' trade level and its 11 trade partners from January 2020 and June 2020 by utilizing the Bayesian structural time series approach. The scrutinized implies that COVID-19 generally negatively influences Mauritius' export level. However, it heavily affects France, Germany, Italy, Spain, The UK, The USA, and South Africa as a significant trading partners. Zainuddin et al. (2022) researched the nexus between COVID-19 and Malaysia's bilateral trade, considering the effect on different product categories for the period between January 2018 and December 2020. They employed the gravity model to observe this relationships. Their results revealed that an increase in COVID-19 cases leads to a rise in the export of capital and consumption products among Malaysia and its trading partners. Barbero et al. (2021) scrutinized the effect of COVID-19 on trade based on the state-of-the-art gravity technique and the data of 68 countries over the period of January 2019–October 2020. The empirical findings indicate different aspects. First, the countries members of a regional trade agreement are exposed to more negative impacts. Second, government intervention exaggerates the harm of COVID-19 on trade flow. Finally, the negative influences of the pandemic are felt sharply by the countries that have the same income level.

Varona and Gonzales (2021) used the ARDL method to check the links between COVID-19 and economic activity with the daily data covering the period 06/03/2020 to 07/06/2020 in Peru; the result shows that an increase of 1% in COVID-19 shock, the economy shrinks by 15% and 24% in the short-run and long-run, respectively. Wang and Mo (2022) used a fixed-effects model to examine the relationship between international trade and pandemics with the monthly data for China, Germany, Japan, Australia, Canada, Italy, United States, United Kingdom, and India spanning the period 2011 and 2020. Their empirical findings indicate that COVID-19 negatively affects imports rather than export in many countries. Besides, COVID-19 deaths are more effective than COVID-19 infections on a contraction of international trade, and government policy against fighting COVID-19 is harmful.

4 Data and econometric methodology

4.1 Data

This study aims to analyze the impact of COVID-19 on selected European Union (EU) countries (Bulgaria, Estonia, France, Germany, Greece, Latvia, Lithuania, Luxembourg, Poland, Romania, Slovakia, Slovenia, Spain, Czechia) and Turkey's exports by employing panel ARDL method over the time span of March 2020–December 2021. The countries as samples and time for this analysis are

chosen based on data availability. Table 2 shows the variables, describing their units as well as sources.

To examine the impact of COVID-19 on exports for selected countries, we followed the Zhao et al. (2021)' study for constructing an empirical model. Therefore, we use the model specification as follows:

$(\mathrm{EXP}_{it}) = f\left(\mathrm{EXC}_{it}, \mathrm{CPI}_{it}, \mathrm{STRN}_{it}, \mathrm{TCovid}_{it}\right)$,

The logarithmic form of our model is as follows:

$$\mathrm{LnEXP}_{it} = \beta_0 + \beta_1 \mathrm{lnEXC}_{it} + \beta_2 \mathrm{lnCPI}_{it} + \beta_3 \mathrm{lnSTRN}_{it} + \beta_4 \mathrm{lnTCovid}_{it} + u_{it} \quad (1)$$

where the t and i denote time dimension and number of country-section, respectively. The coefficients of β_1, β_2, β_3, and β_4, are the long-run elasticities of exports with respect to exchange rate, inflation, COVID-19 stringency index and total COVID-19 cases, respectively. Moreover, u_{it} represents the is error term in the model. The expected signs of the long-run parameters of Eq. (1) are displayed in Table 3.

Source: Authors' compilation

4.2 Econometric methodology

4.2.1 Cross-sectional dependency (CD)

In econometric literature, the first step of analysis is to check the presence of cross-sectional dependency among the variables. If there is a cross-sectional dependency between variables, using the second generation panel unit root tests are reliable in regression estimation. To determine the existence of cross-sectional dependency, we employ Breusch-Pagan (1980) LM and Pesaran (2004) CD tests.

The Pesaran (2004) CD test statistic can be written as below:

$$\mathrm{CD} = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(\hat{\rho}_{ij} - 1\right) \sim N(0,1) \quad (2)$$

Both LM and the CD tests estimate the null hypothesis of no cross-sectional dependency between cross sections (Murshed and Dao 2020). Along with the CD test, it is necessary to test the possible presence of slope homogeneity; if it is overlooked, the coefficients of variables could be biased. Therefore, we employ Pesaran and Yamagata (2008) test to determine slope homogeneity under the null hypothesis of the presence of slope homogeneity against the alternative hypothesis of slope heterogeneity.

4.2.2 Panel unit root test

The classical panel unit root tests ignore the cross-sectional dependency among variables (Rauf et al. 2018; Saud et al. 2019). Therefore, we perform the Hadri and Kurozumi (2012) panel unit root test one of the second generation panel unit root tests. The Hadri and Kurozumi (2012) panel unit root test is an adjusted version of the KPSS test, which has been adopted to panel data. This test is robust to

Table 2 Definition of variables

Notation	Variable	Description	Source
LnEXP	Exports, million currency units	Sum of all transactions of goods and services from residents of a country to non-residents	The Global Economy (2022)
LnEXC	Exchange rate, USD	The amount of local currency units that can be exchanged for one USD	The Global Economy (2022)
LnCPI	Consumer price index (CPI)	It measures the changes in the cost of a basket of goods and services	The Global Economy (2022)
LnSTRN	COVID stringency index	The index ranges from 0 to 100. An increase in the index means that government adopts the highest strict lockdown policies	The Global Economy (2022)
LnTCovid	Total COVID cases	The number of total COVID cases per million (at the end of the month)	The Global Economy (2022)

Source: Authors' compilation

Table 3 The expected signs of the elasticity parameters

Variables	Expected Sign	Theoretical Explanation
Exchange rate (EXC)	+/–	It is expected to be negative in the short-run and positive in the long-run if the Marshall–Lerner condition has occurred
Consumer price index (CPI)	–	Since the inflation rate increases, national goods and services become more costly than foreign goods and services. Thus increase in CPI affects exports demand negatively
COVID stringency index (STRN)	–	As restrictive measures are adopted to prevent COVID-19 cases and deaths, economic activities slow down, and exports decrease
Total COVID cases (TCovid)	–	The rise in COVID-19 cases and deaths leads to the closure of workplaces. General economic activities and export levels are affected adversely by lockdown policies

the cross-sectional dependency, and can be applied in case of both $T<N$ and $T>N$ (Anoruo and Elike 2015). There are two test statistics, ZA_spac, and ZA_la, in Hadri and Kurozumi (2012) test.

The test statistics can be calculated as shown follows (Hadri and Kurozumi 2012):

$$y_{it} = z_t^{'}\delta_i + f_t\gamma_i + \varepsilon_{it}, \varepsilon_{it} = \varnothing_{i1}\varepsilon_{it-1} + \cdots + \varnothing_{ip}\varepsilon_{it-1} + v_{it} \tag{3}$$

In Eq. (3), z_t is deterministic trend for $i=1,\ldots\ldots\ldots,N$ and $t=1,\ldots\ldots\ldots,T$; $z_t^{'}\delta_i$ and f_t denote the individual effect and unobserved common factor, respectively. The null hypothesis of the Hadri and Kurozumi test represents that the series do not contain unit root and the alternative hypothesis is that the series have unit root processes.

The main hypotheses of the Hadri and Kurozumi test are as below (Hadri and Kurozumi 2012):

$$H_0 : \varnothing_i(1) \neq 0 \,(\text{series are stationary})$$

$$H_1 : \varnothing_i(1) = 0 \,(\text{series are not stationary})$$

4.2.3 Panel cointegration

In several studies, the Pedroni (1999) residual-based cointegration method is utilized to validate the existence of cointegration. However, under the cross-sectional dependency, this technique can be unreliable. Therefore, the Westerlund (2007) panel cointegration test-one of the second generation panel cointegration tests (Murshed et al. 2021) is used to analyze the long-run cointegrating association between export and the regressors in the panel sample.

Westerlund (2007) bootstrap panel cointegration test has some advantages over other cointegration tests. For example, the short-run and long-run dynamics can differ (Sabir and Gorus 2019). It is also robust to cross-sectional dependency between variables. In this test, there are four test statistics (G_t, G_α, P_t, and P_α) to check the presence of the cointegration. G_t and G_α represent the group statistics, whereas P_t and P_α denote the panel statistics (Behera and Dash 2017).

Based on an error correction, Westerlund (2007) bootstrap panel cointegration model can be depicted as follows (Murshed et al. 2021):

$$\Delta y_{it} = \delta_t^{'} d_t + \alpha_i\left(y_{i,t-1} - \beta_i^{'} x_{i,t-1}\right) + \sum_{j=1}^{p_i} \alpha_{ij}\Delta y_{i,t-j} + \sum_{-q_i}^{p_i} \gamma_{ij}\Delta x_{i,t-j} + e_{it} \tag{4}$$

Furthermore, the test statistics of the Westerlund (2007) panel cointegration can be specified as follows (Adebayo et al. 2021):

$$G_t = \frac{1}{N}\sum_{i-1}^{N} \frac{\alpha_i'}{SE(\alpha_i')} \tag{5}$$

$$G_{\alpha} = \frac{1}{N}\sum_{i-1}^{N}\frac{T\alpha_i'}{\alpha_i'(1)} \tag{6}$$

$$P_t = \frac{\alpha'}{SE(\alpha')} \tag{7}$$

$$P_{\alpha} = T \tag{8}$$

As mentioned before, in Eq. (5) and Eq. (6) G_t and G_{α} indicate the group means statistics, while P_t and P_{α} indicate panel statistics in Eq. (7) and Eq. (8) (Adebayo et al. 2021; Charfeddine and Kahia 2019).

4.2.4 The panel ARDL approach

Then another step is to find out the long-run relationships between variables accounting for the results of preliminary tests. The Hadri and Kurozumi panel unit root test results confirmed that all variables are stationary at first differences. This means that all variables in the model EXP, EXC, CPI, STRN, and TCovid are integrated at first differences. In this framework, to estimate the long-term associations among the variables, we utilize the panel ARDL method, which can be applied in the presence of the same or different levels of stationarity in series. Namely, as a dynamic method, the panel ARDL is consistent irrespective of whether the variables are stationary at different levels. The Panel ARDL method is proposed by Pesaran et al. (1999), Pesaran and Shin (1999), and Pesaran et al. (2001) with two different estimators-Pooled Mean Group (PMG) and Mean Group (MG). In addition, Hausman's test results determine to decide between PMG and MG estimators as the most suitable method to seize.

Adoption from Eq. (1), we capture the panel ARDL regression as follows:

$$\begin{aligned}\Delta\ln\mathrm{EXP}_{it} = {} & \alpha_i + \sum\nolimits_{j=1}^{p-1}\beta_{ij}\Delta\mathrm{LnEXP}_{i,t-j} + \sum\nolimits_{j=0}^{l-1}\gamma_{ij}\Delta\mathrm{LnEXC}_{i,t-j} + \sum_{j=0}^{q-1}\delta_{ij}\Delta\mathrm{LnCPI} \\ & + \sum_{j=0}^{k-1}\varnothing_{ij}\Delta\mathrm{LnSTRN}_{i,t-j} + \sum_{j=0}^{\propto-1}\varnothing_{ij}\Delta\mathrm{LnTCovid}_{i,t-j} + \theta_1\mathrm{LnEXP}_{i,t-1} + \theta_2\mathrm{LnEXC}_{i,t-1} \\ & + \theta_3\mathrm{LnCPI}_{i,t-1} + \theta_4\mathrm{LnSTRN}_{i,t-1} + \theta_5\mathrm{LnTCovid}_{i,t-1} + \varepsilon_{1,it}\end{aligned} \tag{9}$$

The regression model in Eq. (9) can be rewritten in the Error Correction form, which can show the long-run and short-run estimates:

$$\Delta \ln EXP_{it} = \alpha_i + \sum_{k=1}^{p} \beta_{i,j} \Delta \ln EXP_{i,t-j} + \sum_{k=0}^{l} \gamma_{i,j} \Delta LnEXC_{i,t-j} + \sum_{k=0}^{q} \delta_{i,j} \Delta LnCPI_{i,t-j} + \sum_{k=0}^{k} \varnothing_{i,j} \Delta LnSTRN_{i,t-j} + \sum_{k=0}^{\infty} \varnothing_{i,j} \Delta LnTCovid_{i,t-j} + \vartheta_{ij} ECM_{t-i} + \varepsilon_{it} \quad (10)$$

In Eq. (10), the parameters placed on the differences represent the short-run relationships, ϑ_{ij} is the speed of adjustment coefficient shows how variables converge to equilibrium (Tenaw and Beyene 2021). If ϑ_{ij} is statistically significant and negative, it means a long-run relationship among variables.

4.2.5 Causality test

It is essential to determine how causal linkages exist among endogeneous and exogenous variables are associated with validating short-run and long-run relationships between variables. Thus, we apply the Dumitrescu–Hurlin (2012) panel causality test to reveal the causal relationship in the model. The Wbar statistics and Zbar statistics are used to estimate the Dumitrescu–Hurlin panel causality (Saud et al. 2019; Kongbuamai et al. 2020).

The Dumitrescu and Hurlin (2012) panel causality is tested through an equation specified as:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} i = 1, 2, 3, \ldots, N; t = 1, 2, 3, \ldots, T \quad (11)$$

The Dumitrescu–Hurlin panel causality test is employed under the null hypothesis of no causality among the variables against the alternative hypothesis of the presence of causality among the variables.

Table 4 Descriptive statistics

	LnEXP	LnEXC	LnCPI	LnSTRN	LnTCovid
Mean	9.600	0.507	5.265	3.952	4.278
Median	9.147	− 0.122	4.756	3.970	4.684
Maximum	12.939	3.222	8.952	4.477	5.400
Minimum	7.147	− 0.197	4.569	2.995	1.763
Std. Dev	1.644	1.030	1.097	0.292	0.888
Skewness	0.421	1.341	2.557	-0.349	-0.852
Kurtosis	2.021	3.543	8.656	2.541	2.505
Jarque–Bera	21.401	96.221	746.305	8.957	40.465
Probability	0.000	0.000	0.000	0.011	0.000
Observations	308	308	308	308	308

Source: Authors' compilation

Table 5 Multicollinearity (correlation matrix) results

	LnEXP	LnEXC	LnCPI	LnSTRN	LnTCovid
LnEXP	1.000	0.526	– 0.159	0.196	0.052
LnEXC	0.526	1.000	0.179	0.026	0.011
LnCPI	– 0.159	0.179	1.000	– 0.097	– 0.105
LnSTRN	0.196	0.026	– 0.097	1.000	– 0.228
LnTCovid	0.052	0.011	– 0.105	– 0.228	1.000

Source: Authors' compilation

Table 6 Cross-sectional dependency test results for each series and slope homogeneity test results

Tests	lnEXP	lnEXC	lnCPI	LnSTRN	LnTCovid
	Test Statistics				
$CDLM_1$	1194***	1262***	1181***	1289***	1390***
LM_{adj}	205.9***	219.2***	204.1***	228.5***	244.7***
$CDLM_2$	39.602***	36.545***	42.551***	26.674***	43.919***
Homogeneity Test	Test Statistics				
Ä	3.687***	6.113***	4.096***	1.738***	8.916***
$Ä_{adj}$	3.967***	6.578***	4.407***	1.870***	9.595***

***Denotes statistical significance level at 1%

Source: Authors' compilation

5 Estimation results

In the empirical analysis to reveal the effects of COVID-19 on exports, the descriptive statistics showing the data's characteristics are examined in the first stage. The descriptive statistics are reported in Table 4.

According to Table 4, we observe the highest volatility in exports and the lowest in the COVID-19 stringency index. All variable also is positive in the minimum and maximum range, except for the exchange rate variable, which does not have a normal distribution. Furthermore, according to the skewness indicator, the COVID-19 frequency index and the total COVID-19 cases are negative, whereas other variables are positive. From the point of the kurtosis, all variables are positive.

Table 5 reports the correlation matrix of all the variables. If the coefficient among two regressors is higher than 0.85%, there will be a multicollinearity problem (Jahanger 2022). According to the results from Table 5, the correlation coefficient is lower than 0.85, representing our regression model is free from multicollinearity. The findings from cross-sectional dependency tests for Eq. (2) and slope homogeneity are provided in Table 6.

As shown in Table 6, all cross-sectional dependency tests reject the null hypothesis of no cross-sectional dependence at 1%. Hence it means that mutual dependence

Table 7 Hadri and Kurozumi unit root test results

Variables	Level		First Difference		Order of integration
	ZA_spac	ZA_la	ZA_spac	ZA_la	
LnEXP	3.804 [0.000]	4.565 [0.000]	0.967 [0.166]	1.094 [0.136]	I(1)
LnEXC	4.204 [0.000]	5.642 [0.000]	-3.097 [0.998]	-3.167 [0.992]	I(1)
LnCPI	1.435 [0.075]	1.939 [0.026]	-1.906 [0.971]	1.271 [0.898]	I(1)
LnSTRN	3.707 [0.000]	8.978 [0.000]	-0.229 [0.590]	-0.342 [0.634]	I(1)
LnTCovid	1.855 [0.031]	1.466 [0.071]	0.490 [0.311]	1.142 [0.126]	I(1)

Source: Authors' compilation

exists across the countries. In addition, $\ddot{\Delta}$ and $\ddot{\Delta}_{adj}$ tests confirm the slope heterogeneity in the model. After determining the presence of the cross-sectional dependency and slope heterogeneity, we utilize the Hadri and Kurozumi (2012) panel unit root test as a second generation panel unit root. The Hadri and Kurozumi (2012) unit root test findings are postulated in Table 7.

The displayed Hadri and Kurozumi unit root test findings in Table 7 validate that all variables are stationary at first differences. Existing the same stationary level [I(1)] among variables requires using the dynamic panel ARDL to explore short-run and long-run linkage (Adeel-Farooq et al. 2021). The panel ARDL estimation technique offers some supremacies to reveal the dynamic relationship between variables. For example, it allows employing the ARDL method, where all variables are stationary at a level or difference or mixed level (Azam et al. 2021b). Namely, the panel ARDL method is fit to establish the model when series are cointegrated at I(0) or I(1) or mixed order of integration of not more than I(1) (Salisu and Isah 2017; Ali et al. 2020). Hence, the first differences in stationary results of series justify employing the panel ARDL.

While the cross-sectional dependence of the series is essential in selecting the unit root test to be applied, the state of the cross-sectional dependence of residuals is critical for determining the cointegration test to be used. According to the results displayed in Table 8, the null hypothesis that residuals are not interrelated has been

Table 8 Cross-sectional dependency test results for the model

Tests	Constant	Constant + Trend
$CDLM_1$	825.4***	798.5***
LM_{adj}	112.2***	101.9***
$CDLM_2$	27.58***	27.68***

***Denotes statistical significance level at 1%

Source: Authors' compilation

Table 9 Westerlund (2007) bootstrap panel cointegration test results

	Robust test statistics	Probability
G_t	− 3.673	0.000
G_α	− 6.496	0.785
P_t	− 10.688	0.000
P_α	− 9.163	0.002

The robust *p* value are for based on 400 bootstrap replications

Source: Authors' compilation

rejected at a 1% significance level. Hence, it represents that our model consists of the cross-sectional dependence, and it is required to employ the second-generation cointegration test. Therefore, the Westerlund (2007) cointegration test is applied as a second generation cointegration analysis. We test the null hypothesis of no cointegration against cointegration among variables. The results from Westerlund (2007) cointegration tests are reported in Table 9.

The test statistics at a 1% significance level imply that there is a long-run cointegrating relationship among the variables. Thus, in line with the presence of the cointegration, it can be concluded that the dependent variable, export volume has a long-run association with consumer price index, exchange rate, total COVID-19 cases, and COVID-19 stringency index. Upon determining the credible evidence of a cointegrating relationship between variables for our primary model, Eq. (9), we estimate the long-run parameters of the variables for Eq. (9).

Behera and Mishra (2020), Benli (2020), Azam et al. (2021a), and Azam et al. (2021b), utilize the panel ARDL method, where there exists cross-sectional dependency between series. Therefore, in line with these studies, we employ the panel ARDL technique to estimate long-run elasticities in the presence of cross-sectional

Table 10 Results of PMG

Variables	Coefficient	*t* statistics	Probability
Long-run			
LnEXC	− 0.051	− 2.172	0.0310
LnCPI	− 0.014	− 4.525	0.0000
LnSTRN	− 0.102	− 3.741	0.0002
LnTCovid	− 1.620	− 2.678	0.0080
ECM_{t-1}	− 0.841	− 8.780	0.0000
Short-run			
Δ LnEXC	− 0.078	− 0.339	0.7349
Δ LnCPI	0.012	1.517	0.1306
Δ LnSTRN	− 0.054	− 2.077	0.0390
Δ LnTCovid	− 0.434	3.527	0.0005
Constant	10.859	7.7101	0.0000
Hausman Test	0.65		0.936

Source: Authors' compilation

dependency. The outcomes of the Hausman test justify taking into account the PMG estimator. The estimation outcomes of the PMG and MG are compared with the Hausman test statistic to decide the most appropriate estimator. Hausman test results justify taking into account the PMG estimator.

In the context of Eqs. (9) and (10), the short-run and long-run elasticities from the PMG, are documented in Table 10. We divide the PMG results into two periods. As a result, it is obtained that while in the short-run, COVID-19 stringency measures and total COVID-19 cases are negatively associated with exports in selected countries, in the long-run, all variables, exchange rate, consumer price index, COVID-19 stringency index, and COVID-19 cases have a negative impact on exports. Besides, the findings demonstrate that the COVID-19 stringency index and the COVID-19 cases are the most influential factors negatively affecting these countries' exports. A rise of 1% in the COVID-19 stringency index and COVID-19 cases account for a reduction in the exports by 0.102% and 1.620%, respectively. As approved by several studies in the empirical literature, the restrictive policies adopted to reduce the impacts caused by the COVID-19 pandemic negatively affect exports in EU countries and Turkey.

Thanks to globalization, after the 1980s, national economies have become more sensitive to international developments (Frieden 2008). Especially after the collapse of the Bretton Woods system, the effect of the floating exchange rate system on international trade became more evident (Sugiharti et al. 2020). In this context, the exchange rate is one of the critical determinants of export. Theoretically, the impact of the exchange rate depreciation on foreign trade occurs through the price and quantity (production) effect. The price effect arises due to the exchange rate depreciation, as domestic goods and services become cheaper than foreign goods. On the other hand, the quantity (production) effect refers to adapting production capacity to price changes. Hence, the increase in demand for domestic goods, which have become cheaper, encourages the rise in production volume and exports (Sek and Har 2014). Nevertheless, the price effect on foreign trade is negative in the short-run. Since it takes a particular time for the decision units to adapt to this, the positive effect of the exchange rate depreciation on exports takes place in the medium and long term (Doussoulin 2021). Thus, since our analysis period covers the short-run, the negative sign of the consumer price index is the expected outcome. Besides, the global supply chain was disrupted during the COVID-19. Therefore, many countries could not respond effectively to global demand despite the exchange rate depreciation.

In addition to the exchange rate, the inflation rate is another essential factor determining export volumes. Theoretically, there is an inverse relationship between the inflation rate and exports that increases the price of domestic goods and services in the international market (Sahoo and Sethi 2018). The negative sign of the consumer price index (CPI) parameter means that a higher price of the goods and services could account for a lower export level. Therefore, as expected, high inflation may negatively affect exports by weakening competitiveness in selected EU countries and Turkey in the long-run.

Many governments impose restrictive policies to control the spread of COVID-19. Measures such as the closure of schools and workplaces, restriction of the movement of individuals, goods, and services have led to a slowdown in global

economic activities (Hayakawa and Mukunoki 2020). The COVID-19 stringency index is calculated to express the composite measure of the restrictive measures taken by policy-makers against the COVID-19. An increase in stringency index represents an increase in the degree of restrictive measures. In the initial stages of the pandemic, stringent restrictive measures were put in place, especially in most EU countries (Meunier 2020; Warren et al. 2021). These restrictive measures are felt chiefly in international trade. For example, in April 2020, approximately 80 countries implemented export restrictions on health products (Jean 2020). In our model, the negative and statistically significant coefficient of the stringency index shows that stringent lockdown measures have a negative impact on export volumes. In line with our results, we can argue that lockdown measures to prevent the adverse impact of COVID-19 harms export in EU countries and Turkey. Furthermore, the negative sign of the elasticity parameter of total COVID-19 cases is consistent with the indication of the stringency index, because stringent measures are closely related to COVID-19 cases. When countries are exposed to COVID-19 cases, public authorities tend to carry out lockdown precautions. Thus, the findings based on the effects of COVID-19 show that the tightening measures taken to mitigate the hitches of COVID-19 have a significant contractionary impact on exports. Our empirical findings in terms of the trade impacts of COVID-19 are in line with Che et al. (2020), Hayakawa and Imai (2021), Zhao et al. (2021), Hayakawa and Mukunoki (2021), Liu et al. (2021), and Ugurlu and Jindřichovská (2022).

After determining the sign of coefficients, another stage is crucial to carry out causal relationships between variables. Therefore, the Dumitrescu–Hurlin panel causality test is applied to determine the possible causal relationship. Table 11 presents the findings from the Dumitrescu–Hurlin panel causality test.

The Dumitrescu–Hurlin panel causality findings exhibit significant inferences for EU countries and Turkey policymakers. Thus, the results indicate a two-way causality relationship between COVID-19 cases and exports level. Otherwise, unidirectional causality linkage exists from the COVID-19 stringency index, exchange rate, and consumer price index to exports level (Fig. 3). The causality

Table 11 Outcomes of the Dumitrescu–Hurlin panel causality

Variables	*W* stat	*Z* bar stat	Probability
LnEXP ≠ LnSTRN	0.638	− 1.038	0.299
LnSTRN ≠ LnEXP	0.212	− 1.947	0.051
LnEXP ≠ LnTCovid	9.474	17.820	0.000
LnTCovid ≠ LnEXP	10.158	19.278	0.000
LnEXP ≠ LnEXC	1.643	1.1067	0.268
LnEXC ≠ LnEXP	2.058	1.991	0.046
LnEXP ≠ LnCPI	1.086	− 0.082	0.933
LnCPI ≠ LnEXP	4.073	6.292	0.001

The lag length is chosen as one according to the AIC criteria

Source: Authors' compilation

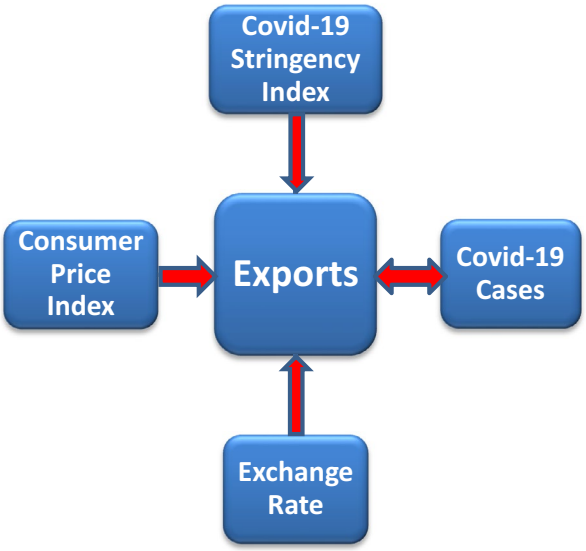


Fig. 3 Graphical view of the causality relationships. Source: Authors' drawing

test results confirm the impact of the COVID-19 pandemic on exports during the stringency measures and lockdowns. Namely, it is evident that results are consistent with our panel ARDL estimations which indicate the negative impact of COVID-19 on exports for selected EU countries and Turkey.

Hence, it can be put forward that the COVID-19 pandemic is a substantial determinant of contraction in exports. Meanwhile, inflation and exchange rate have a significant adverse impact on EU countries and Turkey's exports. Based on panel ARDL and causality test findings, it can be a favorable choice for concerned policy-makers to comprehensively consider the damaging effects of lockdown policies on economic activities.

6 Conclusions and policy recommendations

The world has been experiencing an influential turbulence. The COVID-19 pandemic as a global crisis has affected all spheres of society. Our paper aims to determine the impact of the COVID-19 pandemic on selected EU countries' and Turkey's exports. Previous studies generally focus on the nexus between COVID-19 and bilateral trade for short-run dynamics. This study employs the panel ARDL estimation technique to explore the long-run relationship between COVID-19 and exports using monthly data covering the March 2020–December 2021 period. The estimation results show that the overall COVID-19 pandemic negatively affects the exports in the selected EU countries and Turkey. Significantly, total COVID-19 cases have a strong negative impact on exports. We found that the total COVID-19 cases caused a decrease by 1.620% in exports, and also, the COVID-19 stringency index led to a

decline in exports by 0.102% during the pandemic. In addition, exchange rate and inflation are also negatively associated with exports level.

Furthermore, to clarify the causal relationship between the COVID-19 pandemic and exports, we use the Dumitrescu–Hurlin panel causality method. The causality findings indicate bidirectional relationships among total COVID cases and exports level. In addition, it is concluded that a one-way causal relationship runs from the COVID-19 stringency index, consumer price index, and exchange rate to exports.

Our empirical findings offer the following policy recommendations:

1. The COVID-19 pandemic, which is one of the great crises that the global system is exposed to, created tremendous effects in a short time all over the world. Thanks to globalization, the high-level interdependence of countries has led to the contraction of global trade and supply chains. Adopting the restrictive measures to prevent the increase in COVID-19 cases and deaths has entailed significant effects on global trade. Thus, decision-makers should prioritize policy attention; they should strengthen their supply chain in the face of unexpected turmoil, such as COVID-19.
2. The COVID-19 stringency index is negatively associated with export volume, representing string lockdown causes a decrease in export volume. The COVID-19 pandemic showed that the world heavily depends on globalization. Particularly in the EU, the citizens had serious challenges obtaining the main personal protective equipment, masks, and other primary cleaning products. Therefore, the EU governments adopted string measures to control COVID-19. These stringency policies cause the contraction in international trade. Hence, the negative impacts of the COVID-19 pandemic, which runs from rigid lockdown, can be more destructive if the COVID-19 pandemic continues for a long time (Che et al. 2020). The government of EU countries and Turkey may prepare themselves for international fluctuation. Developing regional cooperation can be the ideal option to overcome the contraction in export and the supply chain's vulnerability.
3. Especially in EU countries, it is evident that supply chains are very fragile. The weakness of the common policy-making against COVID-19 has brought up various debates in terms of political economy. If the developed countries of the EU insist on prioritizing their interests, it is difficult for the EU to develop common policies. Therefore, all members of the EU must prioritize mutual benefit rather than self-interest. In addition, EU countries should reduce their high dependence on other markets for various products in terms of export sustainability.
4. From the perspective of Turkey, the contractionary effect of COVID-19 on exports is undoubtedly very important. Moreover, the high dependency on intermediate goods and raw materials has a substantial negative impact on export in the face of the global contraction. In this framework, it is necessary to structurally reduce the dependence on imports in the Turkish economy. Besides, Turkey's export destination mainly consists of European Union countries. Due to the long-standing lockdown in Europe, Turkey's exports can be at high risk. Accordingly, policy-makers should develop to diversify the export regions.

5. Overall, it is clear that the COVID-19 pandemic is a global phenomenon rather than a regional issue. Thus, global cooperation is critical for the future of globalization and international stability.

One of the most important limitations of our study is the lack of monthly aggregate data for all countries. For a comprehensive analysis, monthly sectoral data is needed to reveal clear evidence at the micro-level.

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Declarations

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References

Adebayo TS, Ramzan M, Iqbal HA, Awosusi AA, Akinsola GD (2021) The environmental sustainability effects of financial development and urbanization in Latin American countries. Environ Sci Pollut Res 28(41):57983–57996. https://doi.org/10.1007/s11356-021-14580-4

Adeel-Farooq RM, Raji JO, Adeleye BN (2021) Economic growth and methane emission: testing the EKC hypothesis in ASEAN economies. Manag Environ Quality 32(2):277–289. https://doi.org/10.1108/MEQ-07-2020-0149

Albertoni N, Wise C (2021) International trade norms in the age of Covid-19 nationalism on the rise? Fudan J Huma Soc Sci 14:41–66. https://doi.org/10.1007/s40647-020-00288-1

Ali MU, Gong Z, Ali MU, Wu X, Yao C (2020) Fossil energy consumption, economic development, inward FDI impact on CO2 emissions in Pakistan: testing EKC hypothesis through ARDL model. Int J Fin Econ 26:3210–3221. https://doi.org/10.1002/ijfe.1958

Anoruo E, Elike U (2015) Human capital-economic growth nexus in Africa: heteregeneous panel causality approach. Int J Econ Financ Issues 5(4):1017–1023

Arenas GC, Majune S, Montfaucon AF (2022) The impacts of lockdown policies on international trade in the Philippines. World Bank Policy Research Working Paper 9911.

Azam A, Rafiq M, Shafique M, Ateeq M, Yuan J (2021a) Investigating the impact of renewable electricity consumption on sustainable economic development: a panel ARDL approach. Int J Green Energy 18(11):1185–1192. https://doi.org/10.1080/15435075.2021.1897825

Azam A, Rafiq M, Shafique M, Yuan J (2021b) Renewable electricity generation and economic growth nexus in developing countries: an ARDL approach. Econ Res-Ekonomska Istraživanja 34(1):2423–2446. https://doi.org/10.1080/1331677X.2020.1865180

Barbero J, de Lucio JJ, Rodríguez-Crespo E (2021) Effects of COVID-19 on trade flows: measuring their impact through government policy responses. PLoS ONE 16(10):e0258356. https://doi.org/10.1371/journal.pone.0258356

Behera SR, Dash DP (2017) The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. Renew Sustain Energy Rev 70:96–106. https://doi.org/10.1016/j.rser.2016.11.201

Behera J, Mishra AK (2020) Renewable and non-renewable energy consumption and economic growth in G7 countries: evidence from panel autoregressive distributed lag (P-ARDL) model. IEEP 17:241–258. https://doi.org/10.1007/s10368-019-00446-1

Benli M (2020) The effect of external debt on long run economic growth in developing economies: evidence from heterogeneous panel data models with cross sectional dependency. Theoret Appl Econ 27(3):127–138

Ben-xi L, Zhang YY (2020) Impact of the COVID-19 pandemic on agricultural exports. J Integr Agric 19(12):2937–2945. https://doi.org/10.1016/S2095-3119(20)63430-X
Bickley SJ, Chan HF, Skali A, Stadelmann D, Torgler B (2021) How does globalization affect Covid-19 responses? Glob Health 17:57. https://doi.org/10.1186/s12992-021-00677-5
Bontempi E, Coccia M (2021) International trade as critical parameter of Covid-19 spread that outclasses demographic, economic, environmental, and pollution factors. Environ Res 201:111514. https://doi.org/10.1016/j.envres.2021.111514
Breusch TS, Pagan AR (1980) The Lagrange multiplier test and its applications to model specification in econometrics. Rev Econ Stud 47(1):239–253
Charfeddine L, Kahia M (2019) Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis. Renewable Energy 139:198–213. https://doi.org/10.1016/j.renene.2019.01.010
Che Y, Liu W, Zhang Y, Zhao L (2020) China's exports during the global Covid-19 pandemic. Front Econ China 15(4):541–574. https://doi.org/10.3868/s060-011-020-0023-7
Choi Y, Kim HJ, Lee Y (2022) Economic consequences of the Covid-19 pandemic: will it be a barrier to achieving sustainability? Sustainability 14:1629. https://doi.org/10.3390/su14031629
Doussoulin JP (2021) Policy responses to COVID-19 and the Marshall-Lerner condition: lessons from the crisis in Argentina. SSRN. https://doi.org/10.2139/ssrn.3958450
Dumitrescu EI, Hurlin C (2012) Testing for Granger non-causality in heterogeneous panels. Econ Model 29(4):1450–1460
Espitia A, Mattoo A, Rocha N, Ruta M, Winkler D (2022) Pandemic trade: Covid-19, remote work and global value chains. The World Economy 45(2):561–589. https://doi.org/10.1111/twec.13117
Eurostat (2022) https://ec.europa.eu/eurostat/data/database. Accessed 1 Mar 2022
Farzanegan MR, Feizi M, Gholipour HF (2021) Globalization and the outbreak of COVID-19: an empirical analysis. J Risk Finan Manag. https://doi.org/10.3390/jrfm14030105
Frieden J (2008) Globalization and exchange rate policy. In: Zedillo E (ed) The future of globalization: explorations in light of recent turbulence. Routledge, London & New York, pp 344–357
Gruszczynski L (2020) The Covid-19 pandemic and international trade: temporary turbulence or paradigm shift? Eur J Risk Regul 11:337–342. https://doi.org/10.1017/err.2020.29
Guan D, Wang D, Hallegatte S, Davis SJ, Huo J, Li S, Bai Y, Lei T, Xue Q, Coffman DM, Cheng D, Chen P, Liang X, Xu B, Lu X, Wang S, Hubacek K, Gong P (2020) Global supply-chain effects of Covid-19 control measures. Nat Hum Behav 4(6):577–587. https://doi.org/10.1038/s41562-020-0896-8
Gygli S, Haelg F, Potrafke N, Sturm JE (2019) The KOF globalisation index-revisited. Rev Int Org 14:543–574. https://doi.org/10.1007/s11558-019-09344-2
Hadri K, Kurozumi E (2012) A simple panel stationarity test in the presence of serial correlation and a common factor. Econ Lett 115:31–34. https://doi.org/10.1016/j.econlet.2011.11.036
Hale T, Angrist N, Goldszmidt R, Kira B, Petherick A, Phillips T, Webster S, Cameron-Blake E, Hallas L, Majumdar S, Tatlow H (2021) A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nat Hum Behav 5:529–538. https://doi.org/10.1038/s41562-021-01079-8
Hayakawa K, Imai K (2022) Who sends me face masks? Evidence for the impacts of COVID-19 on international trade in medical goods. World Econ 45(2):365–385. https://doi.org/10.1111/twec.13179
Hayakawa K, Mukunoki H (2020) Impacts of lockdown policies on international trade. Institute of Developing Economies (IDE) Discussion Paper No. 798.
Hayakawa K, Mukunoki H (2021) The impact of Covid-19 on international trade: evidence from the first shock. J Jpn Int Econ 60:101135. https://doi.org/10.1016/j.jjie.2021.101135
IMF (2021) International Monetary Fund. World economic outlook: managing divergent recoveries. Washington, DC
IMF (2022) International Monetary Fund. World Economic Outlook Update: Rising Caseloads, a Disrupted Recovery, and Higher Inflation. Washington, DC
Iwuoha JC, Jude-Iwuoha AU (2020) Covid-19: Challenge to SDG and globalization. Electron Res J Soc Sci Humanit 2(3):103–115
Jaffur ZK, Seetanah B, Tandrayen-Ragoobur V, Fauzel S, Teeroovengadum V (2021) The impact of COVID-19 outbreak on the Mauritian export trade: a disaggregated analysis. Int Trade Politics Develop. https://doi.org/10.1108/ITPD-06-2021-0007
Jahanger A (2022) Impact of globalization on CO2 emissions based on EKC hypothesis in developing world: the moderating role of human capital. Environ Sci Pollut Res 29:20731–20751. https://doi.org/10.1007/s11356-021-17062-9

Jean S (2020) How the COVID-19 pandemic is reshaping the trade landscape and what to do about it. Intereconomics 55(3):135–139. https://doi.org/10.1007/s10272-020-0890-4
Jindřichovská I, Uğurlu E (2021) E.U. and China trends in trade in challenging times. J Risk Finan Manag 14:71. https://doi.org/10.3390/jrfm14020071
Khan A, Khan N, Shafiq M (2021) The economic impact of Covid-19 from a global perspective. Contemp Econ 15(1):64–75. https://doi.org/10.5709/ce.1897-9254.436
Kongbuamai N, Bui Q, Yousaf HMAU, Liu Y (2020) The impact of tourism and natural resources on the ecological footprint: a case study of ASEAN countries. Environ Sci Pollut Res 27:19251–19264. https://doi.org/10.1007/s11356-020-08582-x
Li C, Lin X (2021) Covid-19 and trade: simulated asymmetric loss. J Asian Econ 75:101327. https://doi.org/10.1016/j.asieco.2021.101327
Liu X, Ornelas E, Shi H (2021) The trade impact of the Covid-19 pandemic. CESifo Working Paper, No. 9109, Center for Economic Studies and Ifo Institute (CESifo), Munich.
Meunier T (2020) Full lockdown policies in Western Europe countries have no evident impacts on the COVID-19 epidemic. MedRxiv. https://doi.org/10.1101/2020.04.24.20078717
Murshed M, Dao NTT (2020) Revisiting the CO2 emission-induced EKC hypothesis in South Asia: the role of export quality improvement. GeoJournal. https://doi.org/10.1007/s10708-020-10270-9
Murshed M, Ali SR, Banerjee S (2021) Consumption of liquefied petroleum gas and the EKC hypothesis in South Asia: evidence from cross-sectionally dependent heterogeneous panel data with structural breaks. Energy Ecol Environ 6(4):353–377. https://doi.org/10.1007/s40974-020-00185-z
Our World in Data (2022) Covid-19 stringency index https://ourworldindata.org/grapher/covid-stringency-index, Accessed 1 Mar 2022
Pedroni P (1999) Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bull Econ Stat 61(S1):653–670
Pesaran MH (2004) General diagnostic tests for cross section dependence in panels. CESifo Working Paper Series No. 1229; IZA Discussion Paper No. 1240.
Pesaran MH, Shin Y (1999) An autoregressive distributed lag modelling approach to cointegration analysis. In: Steinar Strøm (Ed) Econometrics and economic theory in the 20th century: The Ragnar Frisch centennial symposium (pp. pp. 371 - 413). Cambridge: Cambridge University Press.
Pesaran MH, Yamagata T (2008) Testing slope homogeneity in large panels. J Econometr 142(1):50–93
Pesaran MH, Shin Y, Smith RP (1999) Pooled mean group estimation of dynamic heterogeneous panels. J Am Stat Assoc 94(446):621–634
Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. J Appl Economet 16(3):289–326
Post RAJ, Regis M, Zhan Z, Heuvel ERVD (2021) How did governmental interventions affect the spread of Covid-19 in European countries? BMC Public Health 21:411. https://doi.org/10.1186/s12889-021-10257-2
Rauf A, Liu X, Amin W, Ozturk I, Rehman OU, Hafeez M (2018) Testing EKC hypothesis with energy and sustainable development challenges: a fresh evidence from belt and road initiative economies. Environ Sci Pollut Res 25:32066–32080. https://doi.org/10.1007/s11356-018-3052-5
Sabir S, Gorus MS (2019) The impact of globalization on ecological footprint: empirical evidence from the South Asian countries. Environ Sci Pollut Res 26:33387–33398. https://doi.org/10.1007/s11356-019-06458-3
Sahoo M, Sethi N (2018) The dynamic relationship between export, import and inflation: empirical evidence from India. Indian Econ J 66(3–4):294–311. https://doi.org/10.1177/0019466220935552
Salisu AA, Isah KO (2017) Revisiting the oil price and stock market nexus: a nonlinear Panel ARDL approach. Econ Model 66:258–271. https://doi.org/10.1016/j.econmod.2017.07.010
Saud S, Chen S, Haseeb A (2019) Impact of financial development and economic growth on environmental quality: an empirical analysis from Belt and Road Initiative (BRI) countries. Environ Sci Pollut Res 26(3):2253–2269. https://doi.org/10.1007/s11356-018-3688-1
Sek SK, Har WM (2014) Testing for Marshall-Lerner condition: bilateral trades between Malaysia and trading partners. J Adv Manag Sci 2(1):23–28. https://doi.org/10.12720/joams.2.1.23-28
Simola H (2021) The impact of Covid-19 on global value chains. Bank of Finland Institute for Emerging Economies (BOFIT), Policy Brief.
Sugiharti L, Esquivias MA, Setyorani B (2020) The impact of exchange rate volatility on Indonesia's top exports to the five main export markets. Heliyon 6(1):e03141. https://doi.org/10.1016/j.heliyon.2019.e03141

Tenaw D, Beyene AD (2021) Environmental sustainability and economic development in sub-Saharan Africa: a modified EKC hypothesis. Renew Sustain Energy Rev 143:110897. https://doi.org/10.1016/j.rser.2021.110897
The Global Economy (2022). https://www.theglobaleconomy.com/. Accessed 1 Mar 2022
Ugurlu E, Jindřichovská I (2022) Effect of Covid-19 on international trade among the Visegrad countries. J Risk Finan Manag 15(2):41. https://doi.org/10.3390/jrfm15020041
UNCTAD (2022) Statistics, https://unctad.org/statistics. Accessed 22 Jan 2022
Varona L, Gonzales JR (2021) Dynamics of the impact of COVID-19 on the economic activity of Peru. PLoS ONE 16(1):e0244920. https://doi.org/10.1371/journal.pone.0244920
Vo TD, Tran MD (2021) The impact of covid-19 pandemic on the global trade. Int J Soc Sci Econ Invent 7(1):1–7. https://doi.org/10.23958/ijssei/vol07-i01/261
Wang R, Mo Y (2022) The impact of COVID-19 on global import and export trade. Rev Bus 42(1):19–40
Warren GW, Lofstedt R, Wardman JK (2021) COVID-19: the winter lockdown strategy in five European nations. J Risk Res 24(3–4):267–293. https://doi.org/10.1080/13669877.2021.1891802
Westerlund J (2007) Panel cointegration tests of the Fisher effect. J Appl Economet 23:193–233. https://doi.org/10.1002/jae.967
WHO (2022) Coronavirus (Covid-19) dashboard, https://covid19.who.int/ Accessed 3 Mar 2022
World Bank (2022) World Development Indicator, https://data.worldbank.org. Accessed 22 Jan 2022
Zainuddin MRKV, Khairuddin NA, Hamidi HNA (2022) Impact of COVID-19 on Malaysia's bilateral export: testing for heterogeneous effects in the product category. Asian Econ Lett. https://doi.org/10.46556/001c.25386
Zhao Y, Zhang H, Ding Y, Tang S (2021) Implications of Covid-19 pandemic on China's exports. Emerg Mark Financ Trade 57(6):1716–1726. https://doi.org/10.1080/1540496X.2021.1877653

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