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Trade Heterogeneity in the EU: Insights from the Emergence of COVID-19 Using Time Series Clustering

Heterogeniczność handlu w UE – ustalenia dotyczące wpływu COVID-19 z wykorzystaniem metody grupowania szeregów czasowych

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ABSTRACT

Objective: The objective of the paper is to analyse segmentation of EU-27 countries based on quarterly growth rates of exports and imports by using time series clustering.

Research Design & Methods: We applied a time series clustering algorithm using TS nodes in SAS Enterprise Miner. To analyse the impact of the pandemic, we considered clusters based on export and import growth rates for two time periods, pre-emergence and post-COVID-19 emergence.

Findings: We find that grouping based on export and import growth rates vary for EU-27 countries. Also, clustering results change significantly for post-COVID-19 emergence compared to pre-COVID-19 emergence. Cyprus emerged as an exception based on export growth rates, while Malta came out as an outlier based on the segmentation of its import growth rates.

Implications/Recommendations: The impact and severity of COVID-19 has varied across EU countries, which have shown a varied impact in their trade patterns characterised by growth rates of exports and imports. The clustering analysis presented in the paper helps to explain similarities and differences in trade patterns of EU members during the COVID-19 pandemic to effectively implement and harmonise EU specific trade policies to member countries.
Contribution: The study contributes to the literature on EU trade by providing an approach to analysing EU-27 segments using time series clustering analysis. It also enhances the growing literature on the impact of the pandemic on international trade by separating clustering analysis for the COVID-19 period and investigating the drivers for the segmentation.

Article type: original article.

Keywords: COVID-19, international trade, European Union, exports, imports, time series, UNCTAD, clustering.

JEL Classification: F1, B23, C20.

STRESZCZENIE

Cel: Celem artykułu jest ocena wyników segmentacji krajów UE-27 opartej na kwartalnych stopach wzrostu eksportu oraz importu, dokonanej z użyciem metody grupowania szeregów czasowych.
Metodyka badań: Zastosowano algorytm grupowania szeregów czasowych z wykorzystaniem narzędzia TS Nodes programu SAS Enterprise Miner. Aby ocenić wpływ pandemii COVID-19, wzięto pod uwagę skupienia krajów wyodrębnione na podstawie stóp wzrostu eksportu i importu dla dwóch okresów: przed pandemią COVID-19 oraz w jej trakcie.
Wyniki badań: Ustalono, że skupienia krajów UE-27 wyodrębnione na podstawie stóp wzrostu eksportu oraz stóp wzrostu importu różnią się. Ponadto nastąpiła znacząca zmiana wyników grupowania krajów po pojawieniu się COVID-19 w porównaniu z wynikami dla okresu sprzed pandemii. W przypadku grupowania wykorzystującego stopy wzrostu eksportu krajem odstającym okazał się Cypr, a w przypadku segmentacji na podstawie stóp wzrostu importu – Malta.
Wnioski: Nasilenie i skutki pandemii COVID-19 różniły się w poszczególnych krajach UE, co znalazło odzwierciedlenie w ich zróżnicowanym wpływie na strukturę handlu poszczególnych krajów, ocenianym na podstawie stóp wzrostu eksportu oraz importu. Zaprezentowana w artykule analiza skupień pomaga wyjaśnić podobieństwa i różnice w strukturze handlu krajów członkowskich UE występujące podczas pandemii COVID-19, co może służyć skutecznemu wdrażaniu i harmonizowaniu szczegółowych polityk handlowych UE w krajach członkowskich.
Wkład w rozwój dyscypliny: Opracowanie stanowi wkład w badania z zakresu handlu UE dzięki wykorzystaniu do jego analizy metody grupowania szeregów czasowych w odniesieniu do krajów UE-27. Wzbogaca jednocześnie coraz popularniejszy nurt badań poświęconych wpływowi pandemii COVID-19 na handel międzynarodowy poprzez propozycję określenia ram czasowych dla analizy skupień w postaci okresu zdefiniowanego przez pandemię COVID-19 i zbadanie czynników wpływających na segmentację.

Typ artykułu: oryginalny artykuł naukowy.

Słowa kluczowe: COVID-19, handel międzynarodowy, Unia Europejska, eksport, import, szeregi czasowe, UNCTAD, grupowanie.

1. Introduction

The unparalleled outbreak of coronavirus disease 2019 (COVID-19) has presented one of the most consequential global challenges for humanity in this century. The pandemic has had enormous effects on public health, economics, politics and society (Cheng, Cao & Liao 2020). This has posed one of the most difficult challenges for the world's economies to maintain their growth and has consequently impacted international trade. The pandemic crisis coupled with the US–China trade war has demonstrated the vulnerability of economic interdependence. To prevent the spread of the COVID-19 pandemic, countries around the world have taken a variety of restrictive measures, which resulted in significant impact on the international trade in goods. In order to counter the economic challenges of COVID-19, governments have responded with large-scale fiscal and monetary interventions to support household and business income and to maintain financial stability (Gopinath 2020).

COVID-19 broke out in China in December 2019 but quickly spread throughout the world. All the G7 economies saw their first cases by the first week of February 2020 and by early March, all the G7 nations had entered an accelerating phase (*Mitigating…* 2020). Europe has been one of the worst hit COVID-19 regions, accounting for almost a third of global COVID19-related deaths as of January 2021 (https://www.worldometers.info/coronavirus, accessed: 31.01.2021). The European Union is responding to the outbreak of COVID-19 and its consequences by adopting a wide range of measures in numerous areas, including international trade. The pandemic resulted in direct trade restrictions across the globe, including trade within the EU (Bown 2020). According to the WTO (2020), by April 2020, 80 countries had introduced export prohibitions or restrictions as a result of the pandemic. Such measures can potentially create tensions between trading countries and fiercely disrupt international markets more generally.

The World Trade Organization has acknowledged that the COVID-19 pandemic unleashed unprecedented upheaval in the economy and international trade, as production and consumption have been reduced worldwide. In the second quarter of 2020, merchandise trade suffered its largest decline ever recorded over any period, falling by 14.3% compared to the previous period. The world's GDP is expected to have contracted by almost 5% in the first year of the pandemic. Particularly

hard hit, Europe experienced an unprecedented drop in its exports over this period. The volume of trade in goods for Europe is expected to fall by almost 9% in 2020, before rising – or so it has been forecast – in 2021. The drop in services was at least as severe, causing some sectors to collapse, such as air transport, its activity declining by around 80% between January 2020 and April 2020 (Hervé 2021).

The European Union is a unique economic and political union between 27 EU countries[1] that together cover much of the European continent. The EU is responsible for finalising trade policy and negotiating trade agreements for member countries, which allows the EU to carry more weight in international trade negotiations than individual members (*The EU in Brief* 2016). Despite having a single market thanks to the EU's economic union, the member countries still vary in terms of their integration with the EU as they joined the union at different stages. Also, member countries individually are at different growth trajectories with varying priorities. As a result, it is expected that EU countries will exhibit a variety of trade patterns. Trade among EU countries as a share of total trade in goods ranged from just over 37% for Ireland to 80% for Slovakia in 2019. Germany contributed to slightly less than one-fourth of total intra-EU exports to member countries in 2019, while 10 out of 27 member countries contributed less than 1% (*Intra-EU Trade…* 2021). In this context, it is important to analyse the trade patterns of EU countries in the recent pandemic period to identify similarities and differences in their export and import growth rates. Doing so will make it possible to effectively implement and harmonise EU specific trade policies to member countries.

The objective of this paper is to analyse the recent trends in exports and imports of EU-27 countries, including during the recent COVID-19 pandemic period and assess whether these countries were impacted similarly based on time series clustering analysis. We consider all 27 members of the EU and use exports and import volume quarterly growth data from 2014 to 2020. Data for the paper has been taken from the United Nations Conference on Trade and Development (UNCTAD). First, we use clustering analysis to partition the EU countries into homogeneous groups or clusters in order to assess how export and import growth rates have been distant across EU countries. Second, we try to identify the characteristics of EU countries that explain the formation of these clusters. For the clustering analysis, we consider two samples – 2014Q1 to 2019Q4, and 2020Q1 to 2020Q3 – to understand the dynamics of these clusters over time and also to identify the impact of COVID-19 on their formation.

Previewing our main results, we find three clusters of EU countries for exports and imports for the two samples. Considering quarterly export growth rates for time period 2014Q1 to 2019Q4, Bulgaria, Estonia, Finland, Greece, Ireland, Lithuania,

[1] Following the UK's exit in January 2020, there are 27 member countries in the EU.

Malta, the Netherlands and Sweden form one cluster, while Denmark, Hungary, Italy, Latvia, Portugal and Spain form the second. The rest of the 12 countries make up the largest cluster. When the analysis period is shortened to 2020Q1 to 2020Q3, in order to assess the impact of COVID-19 on export data, the groups change significantly: Estonia, Finland, Lithuania, Luxembourg and Slovakia form the second cluster, while Cyprus is the only country in the third cluster. The other 21 countries are in the first cluster.

For import growth rates for a larger sample, the first cluster contains: Austria, Croatia, Cyprus, Czechia, Germany, Poland, Romania, Slovakia and Spain. Denmark, Finland, Greece, Hungary, Luxembourg, Malta and Portugal are part of the third cluster while the remaining 11 countries make up the largest cluster. As with exports, there is a significant change in the cluster when the analysis period is shortened to 2020. Denmark, Estonia and Luxembourg form the second cluster, and Malta is the only country in the third cluster. The remaining 23 countries comprise the first cluster.

Clusters obtained for the pandemic period (2020) indicate that patterns in the fall of exports and imports of the EU-27 countries were similar, resulting in most countries being grouped together in one cluster. Cyprus, Estonia, Finland, Lithuania, Luxembourg and Slovakia were not part of the majority cluster during the COVID-19 period for export growth rates, while Malta, Denmark, Estonia and Luxembourg were outliers during the COVID-19 period for import growth rate segmentation. The results are preliminary as they can change with more data availability in future. Also, we have not considered social and demographic factors of EU-27 countries for the segmentation, which could enhance the clustering results.

The rest of the paper is structured as follows. Section 2 reviews the literature to discuss previous related work, gaps in the literature and our contribution to this body of work. Section 3 presents the data and methodology while Section 4 analyses the results. Section 5 concludes the paper, describing limitations of the research and providing future scope of analysis.

2. Literature Review

A good deal of research has been done on EU trade since the EU was formed as a trading bloc. H. Badinger and F. Breuss (2004) used a static and dynamic panel approach to estimate the determinants of the growth of intra-EU trade from 1960 to 2000. The results suggest that income growth was a driving force, accounting for approximately two-thirds of total growth. From 1960 to 2000, intra-EU trade grew by an impressive 1,200 per cent in real terms (6.7 per cent per annum), compared with a more moderate 730 per cent growth in the trade EU countries managed with the rest of the world. In the past two decades, economic integration of EU countries has further consolidated through numerous economic integration agreements

(EIA). A substantial share of trade between the EU and the rest of the world is currently covered by EIAs, and ongoing negotiations will further grow this share. Not counting intra-EU trade, 70% of all imports to the EU-27 in 2013 and 27% of all EU-27 exports were influenced by EIAs (Soete & Van Hove 2017).

The EU is arguably the biggest trading power in the world and it engages in an unrivalled, extremely dense network of preferential trade agreements (Zimmermann 2019). The EU currently has about 100 trade agreements in place or in the process of being updated or negotiated (*The EU Position…* 2021). Trade agreements are not only a means to reducing tariffs, but also to get partners to recognise EU quality and safety standards, and to respect products with a protected designation of origin. These trade agreements are also expected to enhance trade volume of member countries. S. Baier and J. Bergstrand (2005) show, based on empirical evidence, the quantitative effects of FTAs on trade flows using the standard cross-section gravity equation for US trade data. Despite Brexit, the EU will continue to be a major trading bloc globally. The strength of the EU as a trading power, its core strategic outlook and its negotiating behaviour will change only marginally (Zimmermann 2019). Out of 27 EU countries, 19 use the euro as the official currency and are collectively known as Euro area. All EU Member States, except Denmark, are required to adopt the euro and join the Euro area, once they are ready to fulfil the economic and legal conditions, as agreed in agreed in the Maastricht Treaty in 1992 (*Countries…* 2021). According to P. R. Lane (2006), the most important gains from the single currency would be the reorganisation and unification of financial markets across the Euro area.

Trade is closely linked to the economy and hence any external shock to the economy will have its subsequent impact on trade or vice-versa. The COVID-19 pandemic has presented an unprecedented challenge to the world. It follows on the heels of the global financial crisis of 2008–09, although the causes and fallout are obviously completely different. G. Alessandria, J.P. Kaboski and V. Midrigan (2010) examined the decline in trade during the 2008–09 crisis. They found that in response to a global productivity shock, a calibrated model shows a larger decline in output, and an even larger decline in international trade, relative to a more standard model without inventories.

With its enormous toll on the economy, COVID-19 has given rise to attempts to analyse its implications for the economy as well as international trade. K. Hayakawa and H. Mukunoki (2021) analyse monthly trade date for exports to 34 countries in 2019 and 2020 using a gravity model and find that COVID-19 has had significant negative effects on both exporting and importing countries. The lockdown measures, social distancing and workforce impacts due to illness and deaths have decreased the scale of production, thereby reducing the supply of exports. On the import side, the effect of COVID-19 is reflected in decreased aggregate demand by

the importing country. The degree of supply shock and demand shock differ across industries. The shocks will be smaller for providers of essential products than of non-essential ones. C. Li and X. Lin (2021) analyse the impact of COVID-19 on trade using a global general equilibrium model for 26 countries with a trade-cost and trade-imbalance structure. Their study identifies three main channels by which the pandemic can impact trade: reduced supply capacity due to the impact on labour and production; reduced foreign demand; and the increased cost of trade during the pandemic.

R. Baldwin and B. Weder di Mauro (*Mitigating…* 2020) indicate that global supply chains have been impacted since the inception of the pandemic. They analyse the impact of COVID-19 on G7 countries and China, which account for almost two-third of global GDP. They categorise the economic shocks resulting from the pandemic in three categories: medical shock resulting from people who are infected by COVID-19 and therefore not contributing to GDP; economic shock resulting from containment measures; and expectation shock. G. Gopinath (2020) analyses the effects of the pandemic from both the demand and supply sides. Business disruptions and prevention measures from the governments have lowered production, creating shocks to supply. Meanwhile, customers and businesses are reluctant to spend money, resulting in demand shocks. Using time series analysis, J. B. Sobieralski (2020) analyses uncertainty shocks resulting from the pandemic and their effects on airline employment. Employment has been affected to a greater extent at the major airlines than at low-cost airlines. The worst hit employees are those dealing with flight operations, while management employees have been less affected. Recovery in airline employment following the pandemic shocks is forecast to take between 4 and 6 years.

This paper contributes to the literature on EU trade by providing an approach to analysing patterns in EU trade by time series clustering analysis. At the same time, it also enhances growing literature on the impact of COVID-19 on international trade by separating clustering analysis for the COVID-19 period and investigating the drivers of segmentation.

3. Data and Methodology

The paper considers all 27 countries of the EU for the analysis. We use quarterly data on volume growth rates of merchandise exports and imports of EU-27 countries from 2014 quarter 1 (Q1) to 2020 quarter 3 (Q3). The data have been collected from UNCTAD and the title of the source table is "Volume growth rates of merchandise exports and imports, quarterly" (UNCTAD, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=99, accessed: January 2021). The quarterly growth rate is measured year-on-year. We use data from 2014 due to reflect the addition of Croatia, the last member to join the EU – in 2013. In order to

understand the impact of COVID-19, we also perform clustering analysis for two time periods. The first analysis is for a longer period, including all quarters from 2014Q1 to 2019Q4 (24 quarters); and for the second, we shorten the analysis period to the most recent 3 quarters (2020Q1 to 2020Q3) in order to capture COVID-19's impact. While the major impact of COVID-19 in the EU started in 2020Q2, many countries in the union imposed lockdowns in March 2020 to restrict the pandemic and hence the usual economic activities, including trade, were impacted in 2020Q1[2].

We use clustering to understand the trends in exports and imports of EU countries and to identify groups with similar trends. Clustering is widely used in data science to group sets of objects such that more similar objects are grouped together. This produces a set of clusters which contain all the objects from the data set. Time series data analysis has become increasingly popular thanks to the availability of historical data. The analysis in this paper is performed using TS nodes in SAS Enterprise Miner, an industry leading software platform for data analytics. Aggregated time series data has been used in many fields to discover trends and similarity behaviour. These help data scientists extract valuable information from complex and time series datasets. Time series segmentation is done through a time series clustering analysis using agglomerative and K-means techniques. We look at how different pockets in the region are performing, which helped us group similarly performing countries. Similarity analysis is performed to compare time series and to find the series that exhibit similar characteristics over time. We fix the appropriate number of clusters in the data after employing the hierarchical clustering process and the elbow method. With three as the optimal number, we do K-means clustering to arrive at the clusters.

S. Schubert and T. Lee (2011) detail the advantages of using TS nodes in SAS for time series data. Clustering through TS nodes produces output that identifies clusters of time series with related trends while enabling researchers to detect similar patterns in historical time series data. K. Nakkeeran, S. Gala and G. Chakraborty (2012) use clustering approach with TS nodes for a retail store's time series data in order to obtain business insights. TS nodes in SAS generate similarity analysis using hierarchical cluster dendrograms and cluster constellation plots. Clustering through similarity analysis can be used to compare time series data and to find time series that show similar characteristics.

[2] We also attempted to restrict the second analysis to only two quarters, 2020Q2–2020Q3, and to expand the first analysis data to 2014Q1 to 2020Q1. The results for the first analysis change slightly in three clusters for exports and imports as shown in the appendix. However, time series clustering for the second analysis could not be performed due to the insufficient number of quarters.

4. Results and Discussion

4.1. General Remarks

In this section, we present the segmentation results of EU-27 countries based on export and import growth rates. The results of clustering analysis are presented in two stages: first, based on export growth rates for both time periods, then the import growth rates.

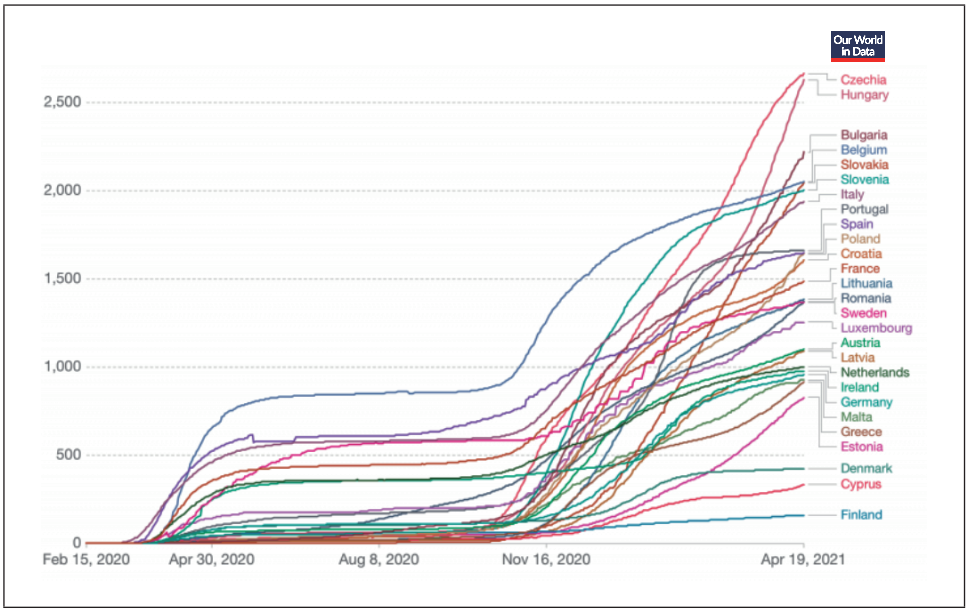

Fig. 1. Confirmed Cumulated COVID-19-related Deaths per one Million Inhabitants of EU-27 Countries

Source: (Damiani 2021).

EU-27 countries have been severely impacted by COVID-19 and accounted for close to one-third of global COVID-19 related deaths. In order to compare the intensity of COVID-19's impact, deaths per million is a better measure as it takes into account the population of the country. As of April 2021, Czechia and Hungary were the most severely impacted countries of the EU in terms of COVID-19 deaths per million, while Denmark, Cyprus and Finland were the least impacted as shown in Figure 1. Of the EU-27 countries, only Finland, Cyprus and Denmark have COVID-19 related deaths per million less than the global average of 510 (https://www.worldometers.info/coronavirus/, accessed: April 2021).

4.2. EU-27 Clustering Based on Export Growth Rates

We analyse the segmentation of EU-27 countries based on export growth rates for 24 quarters in the time period 2014Q1–2019Q4. We also consider a shorter period of 3 quarters (2020Q1–2020Q3) to analyse the impact of the pandemic on the earlier segmentation of EU-27 countries.

Table 1. EU-27 Exports Clusters (2014Q1–2019Q4)

EU-27 Exports Clusters		
Cluster 1	Cluster 2	Cluster 3
Austria, Belgium, Croatia, Cyprus, Czechia, France, Germany, Luxembourg, Poland, Romania, Slovakia, Slovenia	Bulgaria, Estonia, Finland, Greece, Ireland, Lithuania, Malta, Netherlands, Sweden	Denmark, Hungary, Italy, Latvia, Portugal, Spain

Source: the authors.

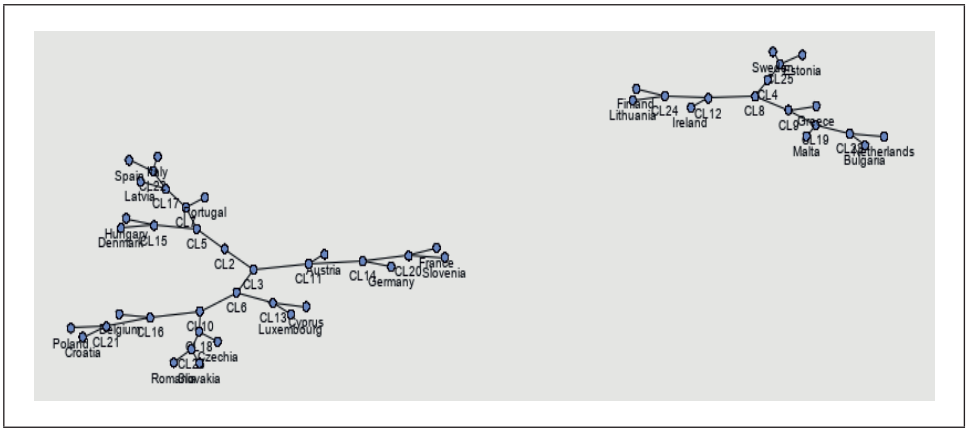

Fig. 2. Cluster Constellation Plot for EU-27 Exports (2014Q1–2019Q4)
Source: the authors.

Based on the clustering results for EU-27 export growth rates for the period 2014–2019 (shown in Table 1), we obtain 3 clusters. Cluster 1 contains 12 countries, while clusters 2 and 3 contain nine and six countries, respectively. The average of the quarterly export growth rates for the period 2014–2019 was 5.3% for the countries in cluster 1, 3.5% for the countries in cluster 2 and 2.6% for those in cluster 3.

A cluster constellation plot (Fig. 2) provides a more visually intuitive illustration of similar time series clusters. The constellation plot contains an array of points

(in this case, all EU-27 countries) that are arranged in connecting clusters and similar groupings. Each country is represented by a point in the plot and the cluster number denotes cluster identification.

Table 2. EU-27 Exports Clusters (2020Q1–2020Q3)

EU-27 Exports Clusters		
Cluster 1	Cluster 2	Cluster 3
Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden	Estonia, Finland, Lithuania, Luxembourg, Slovakia	Cyprus

Source: the authors.

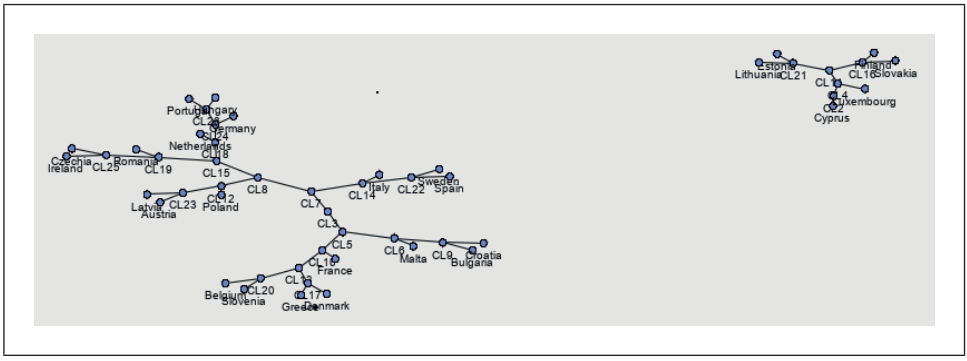

Fig. 3. Cluster Constellation Plot for EU-27 Exports (2020Q1–2020Q3)
Source: the authors.

To analyse the impact of COVID-19, we shorten the analysis period to 2020Q1 to 2020Q3. The clustering results (as shown in Table 2) change significantly for this period. Cluster 1 has 21 countries, cluster 2 has five countries, and cluster 3 contains only Cyprus. For cluster 1, the average quarterly export growth rate is –7.9%, –8.7% for cluster 2, and, surprisingly, 6.2% for cluster 3.

The cluster constellation plot in Figure 3 shows two distinct large clusters (1 and 2) and Cyprus making up the third cluster. Cyprus is closer to cluster 2 than to cluster 1. Cyprus' trade is mainly oriented towards the EU, and comprises 145% of GDP in 2019 (World Bank Data, https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=CY, accessed: April 2021). In 2018, the main destinations for

Cyprus' exports were the European Union and Libya; while imports came chiefly from Greece, Germany and Italy (https://www.nordeatrade.com/en/explore-new-market/cyprus/trade-profile, accessed: April 2021).

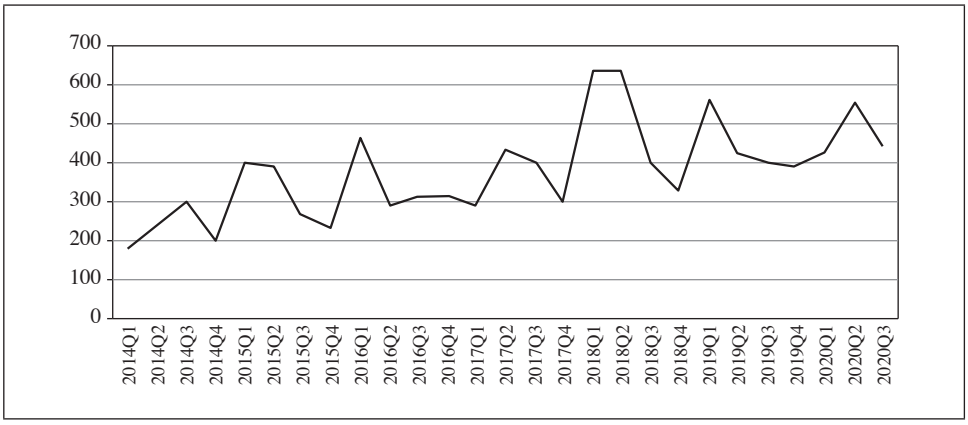

Fig. 4. Export Volume of Cyprus (2005 = 100)

Source: quarterly, volume growth rates of merchandise exports, UNCTAD, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=99 (accessed: January 2021).

As Figure 4 shows, Cyprus' export volumes were higher in 2018, dropped in 2019Q2 and rose again in 2020Q1 and 2020Q2. The quarterly average growth of exports (year-on-year) for Cyprus are 31.2% and 10.9% for 2020Q2 and 2020Q3, respectively, leading to a positive average growth rate of 6.2% for the period 2020Q1 to 2020Q3.

4.3. EU-27 Clustering Based on Import Growth Rates

We analyse the segmentation of EU-27 countries based on import growth rates for 24 quarters in the time period 2014Q1–2019Q4. Similar to clustering analysis for exports, we shorten the period to 3 quarters (2020Q1–2020Q3) of import growth rates in order to analyse the impact of the recent pandemic on the segmentation of EU-27 countries.

Based on the clustering results for EU-27 import growth rates for the period 2014–2019 (as shown in Table 3), we obtain 3 clusters. Cluster 1 contains 9 countries, while clusters 2 and 3 have 11 and 7 countries, respectively. The average quarterly import growth rate was 6.3% for the cluster 1 countries, 3.4% for cluster 2, and 2.4% for cluster 3. The cluster constellation plot (Fig. 5) depicts the clustering results showing that clusters 2 and 3 are closer to each other than cluster 1.

Table 3. EU-27 Imports Clusters (2014Q1–2019Q4)

EU-27 Imports Clusters		
Cluster 1	Cluster 2	Cluster 3
Austria, Croatia, Cyprus, Czechia, Germany, Poland, Romania, Slovakia, Spain	Belgium, Bulgaria, Estonia, France, Ireland, Italy, Latvia, Lithuania, Netherlands, Slovenia, Sweden	Denmark, Finland, Greece, Hungary, Luxembourg, Malta, Portugal

Source: the authors.

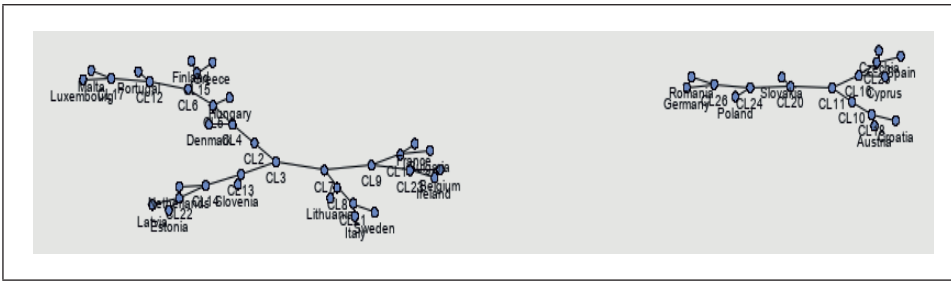

Fig. 5. Cluster Constellation Plot for EU-27 Imports (2014Q1–2019Q4)
Source: the authors.

Table 4. EU-27 Imports Clusters (2020Q1–2020Q3)

EU-27 Imports Clusters		
Cluster 1	Cluster 2	Cluster 3
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden	Denmark, Estonia, Luxembourg	Malta

Source: the authors.

The clustering results (as shown in Table 4) change significantly for the shorter period (2020Q1–2020Q3). Cluster 1 has 23 countries, cluster 2 has three countries while cluster 3 contains only Malta. For cluster 1, the average quarterly import growth rate is –6.8%, for cluster 2, –9%, and for Malta (cluster 3) it is significantly lower, at –18%. The cluster constellation plot in Figure 6 suggests two distinct large clusters and a third cluster containing only Malta, which is closer to cluster 2 than cluster 1.

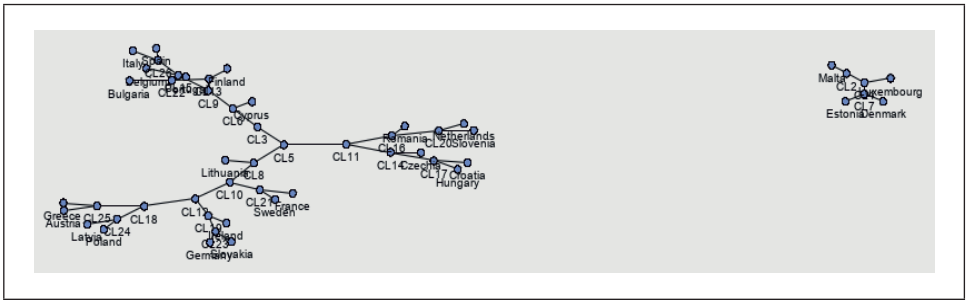

Fig. 6. Cluster Constellation Plot for EU-27 Imports (2020Q1–2020Q3)
Source: the authors.

The COVID-19 pandemic is having an acute impact on critical sectors of Malta's economy, including tourism and external trade. The country's economy relies heavily on foreign trade, principally in Europe. International trade represents 269% of GDP (World Bank Data, https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=MT, accessed: April 2021), one of the highest rates in the world. Malta's main trading partners are Germany (13.4%), Italy (7.7%), and France (7.3%); while its imports come mainly from the UK (18.5%), Italy (16.9%) and Germany (6.6%) (https://www.nordeatrade.com/se/explore-new-market/malta/trade-profile, accessed: April 2021).

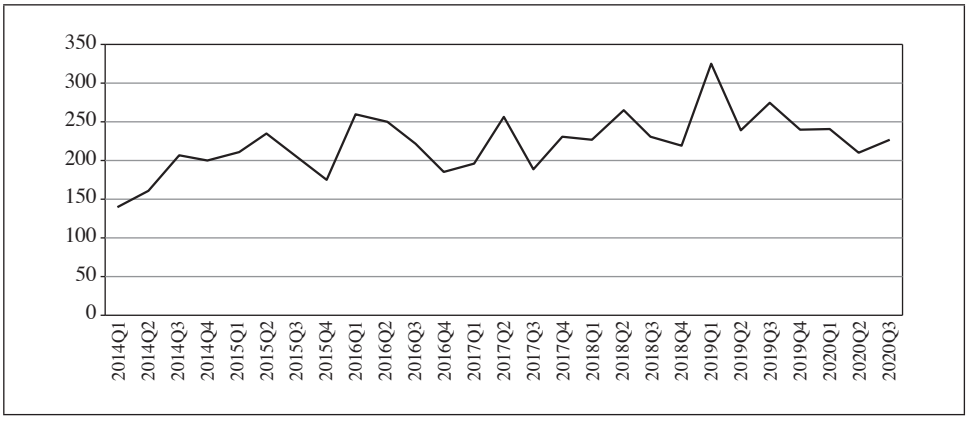

Fig. 7. Import Volume of Malta (2005 = 100)
Source: quarterly, volume growth rates of merchandise imports, UNCTAD, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=99 (accessed: 10.01.2021).

Malta's growing trade relations with the UK for imports were significantly impacted by the UK's exit from the EU in 2020. Also, Malta's import volumes were

significantly higher than average in 2019Q1 (Fig. 7), resulting in a sharp 26% year--on-year decline in its quarterly import volume.

From the clustering analysis, it can be inferred that the pandemic took a severe toll on the export and import volumes of most of the EU-27 countries in 2020. The export and import growth rate patterns for these countries are similar, resulting in most countries being grouped together in a single cluster. For the basis export growth rates, 21 countries were grouped together in one cluster, while for the basis import growth rates, 23 countries were grouped in the same cluster. Cyprus emerged as an outlier for clustering based on export growth rates for the COVID-19 period, showing positive growth in exports on a quarterly basis (year-on-year). Meanwhile, Malta emerged as an outlier for clustering based on imports during the same period, undergoing a much more pronounced drop in import volume on a quarterly basis than other countries.

5. Conclusion

The COVID-19 pandemic carries heavy threats to the global economy, including international trade. To maintain stable and coordinated trade relations among countries, it will be important to avoid conflicts or disorders which could have a visible impact on the current state of international trade. The EU is a major force in international trade and has an important role to play in defending multilateral consistency, while also promoting flexibility. The rate at which the EU bounces back from the COVID-19 crisis in trade terms will depend on several factors: whether oil prices recover, the speed at which supply chains recover, and the extent to which global demand resumes.

Using time series clustering, we have analysed recent trends in the growth of exports and imports among EU countries. Most of the countries grouped together in a single cluster for the COVID-19 period, indicating that the patterns in exports and imports were similar in most countries. This could have been driven by harmonised EU policies on international trade. Countries like Cyprus and Malta, which each formed separate clusters, were unique in their export and import volume data, respectively, resulting in their demonstrating slightly different patterns.

This study contributes to the literature on international trade and COVID-19 by providing an initial analysis of trade patterns for EU countries after the pandemic. However, there are also limitations to the study. First, limited data points after COVID-19 have been covered, and patterns could change as data become more available. Second, the clustering analysis could be improved by using other dimensions of EU countries including social and demographic factors. Lastly, for the clustering algorithm we used an SAS Enterprise Miner tool, which costs money. However, the approach and methodology could easily be replicated using free software like R.

Appendix

EU-27 Time Series Clustering Based on 2014Q1–2020Q1 Data

A.1. Clusters Based on Export Growth Rates

Table A.1. EU-27 Export Clusters (2014Q1–2020Q1)

EU-27 Export Clusters		
Cluster 1	Cluster 2	Cluster 3
Belgium, Croatia, Cyprus, Czechia, Denmark, Hungary, Poland, Portugal, Romania, Slovenia, Spain	Austria, Finland, France, Germany, Italy, Luxembourg, Slovakia	Bulgaria, Estonia, Greece, Ireland, Latvia, Lithuania, Malta, Netherlands, Sweden

Source: the authors.

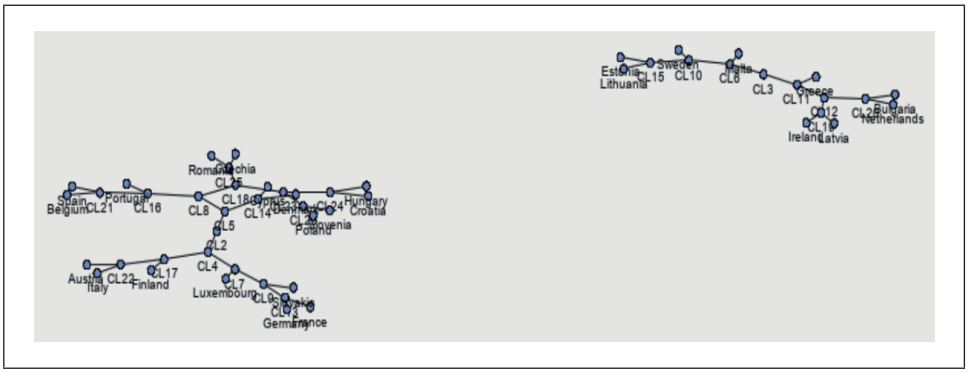

Fig. A.1. Cluster Constellation Plot for EU-27 Exports (2014Q1–2020Q1)

Source: the authors.

A.2. Clusters Based on Import Growth Rates

Table A.2. EU-27 Import Clusters (2014Q1–2020Q1)

EU-27 Import Clusters		
Cluster 1	Cluster 2	Cluster 3
Bulgaria, Croatia, Cyprus, Czechia, Denmark, Germany, Hungary, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain	Austria, Belgium, Estonia, Finland, Greece, Italy, Malta, Sweden	France, Luxembourg

Source: the authors.

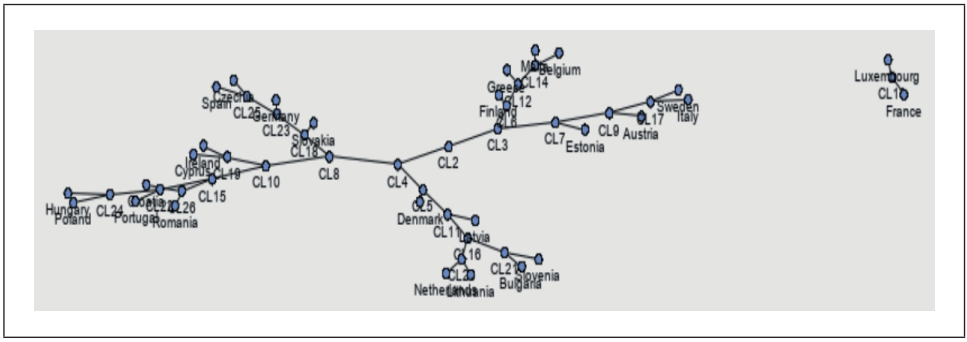

Fig. A.2. Cluster Constellation Plot for EU-27 Imports (2014Q1–2020Q1)
Source: the authors.

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