Explaining COVID-19 shock wave mechanism in the European service industry using convergence clubs analysis

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Abstract

The impact of COVID-19 on the economy and business is a major issue. We define convergence clubs as countries with the same impact of COVID-19 on service turnover by using a convergence algorithm for testing and clustering. We repeat the procedure in the hospitality and food industry, information and communication, transport, and storage. The impact of COVID-19 on each convergence club identified in the study varies empirically. The findings suggest that the impact of COVID-19 varies between countries and industries depending on the firm's agility, innovation, ownership, digital adoption, customer perception, pandemic status, and state financial assistance of companies.

Keywords COVID-19 · Service industry · Convergence · Turnover · European Union

JEL classification L8 · L88 · N70 · O14

1 Introduction

The study of the COVID-19 impact on economy and business is a topic under intense research. Research in this area is of great interest, with a active research community. Global and national service industries suffered a big blow (disruption in the supply chain) due to the COVID-19 shock wave. The impact is high on the service industry due to the lockdowns and disruptions in the supply chain. The extent of the loss varies across industries and within the service industry. The registered impact of COVID-19 on the service industry turnover points to a possible pattern,

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of convergence dynamics. Understanding the COVID-19 shock wave mechanism is essential to understanding why some economies and industries suffer significant damages. This study explains it for the service industry in selected European economies.

COVID-19 brought considerable scale disruption in 2019. Medical supplies are fighting disruption to avoid interrupting patient care (Lee and Lee 2020). The social service sector is struggling to provide its appropriate service (Belso-Martínez et al. 2020). Losses in national and international business have hardly hit companies. Inferior market liquidity in the market significantly reduced growth in revenue (Haleem et al. 2020). The service sector on a national and international level experienced tough losses in 2020 (on average 60% drop in Turnover), and challenges remain in the 2021 (Chakraborty and Maity 2020). The tourism sector is the one to take the hardest hit in the service industry (Skare et al. 2021; Gössling et al. 2020; Payne et al. 2021; Abraham et al. 2020).

Firms in the service industry are facing a difficult choice in the future. One of the challenges includes marketing in time of COVID-19 (Arora et al. 2020; Hoekstra and Leeflang 2020; Moliner-Velázquez et al. 2021). Some authors expect that COVID-19 recovery will be digital (Baig et al. 2020; Horgan et al. 2020; Lau 2020). This will require a change in the business model (Breier et al. 2021; Ritter and Pedersen 2020; Seetharaman 2020). A change in the business model is linked to a change in the corporate culture (Caligiuri et al. 2020; Kraus et al. 2020; Spicer 2020).

Firm innovativeness will play a crucial role in survival during the COVID-19 crisis (Ebersberger and Kuckertz 2021; Kabadayi et al. 2020; Lee and Lee 2020; Rashid and Ratten 2021). The central figures in all of this are artificial intelligence and automatization (Cain et al. 2019; Ivanov et al. 2019; Yang et al. 2020; Yu 2020; Zeng et al. 2020).

However, first we have to understand the COVID-19 shock wave mechanism to answer the following questions: Is the shock wave having the same impact on all economies? If not, why? Can we find a convergence pattern in the COVID-19 impact on the service industry? After measuring the aggregate effect of COVID-19 on service industry turnover, what about economic activities within the service industry? Are they all registering the same impact on the turnover? What are the factors behind the impact? No previous study has demonstrated convergence in the COVID-19 impact on the service industry across countries, as observed in the present study. This motivates the need for an alternative approach to estimate COVID-19 impact on the service industry in Europe. There is evidence to support the hypothesis that COVID-19's impact on the service industry in Europe follows a convergence pattern.

Specifically, we aim to investigate the impact using convergence analysis. To understand how industries, sectors and firms stand to COVID-19; we must measure its impact on them. Such empirical knowledge will avoid the 'schizophrenic' behavior of economic agents on the market (Phillips 1962), giving practitioners and policymakers quantitative knowledge to design efficient business and economic policy. In the case the impact is the same across industries, sectors, and firms, a generic business/economic policy can be applied. However, if this is not the case, and the

impact has a specific footprint across industries, sectors, and firms, to fight COVID-19 on the market, we need specifically designed business models and economic policies. The first step to it is to check for convergence in the COVID-19 impact. We do that for the service industry in Europe.

This study's secondary objective is to evaluate the impact of COVID-19 on particular economic activity within the service industry (level 1 classification). We explore the COVID-19 impact using (NACE Rev.2) statistical classification of economic activities in the European Community (Carré 2008). Sample selection in the study depends on the data availability. To monitor service industry performance in Europe, we use an index of turnovers in services (monthly data) from January 2015 to January 2021 for sixteen European economies. Nonlinear time-varying factor modeling is carried on separately for accommodation and food service, information and communication, transportation, and storage service sector. Here we specifically use the work of (Phillips and Sul 2007a, b, 2009; Du 2017; Sichera and Pizzuto 2019) as a base for work in this area.

The first part of the paper introduces convergence and convergence clubs in COVID-19 on the service industry. The second part provides the necessary background information for the reader, outlining the previous studies' findings on COVID-19 and the service industry. This is followed by Sect. 3, which describes data and methods used for the empirical analysis. The following section provides a quantitative analysis of the convergence and convergence clubs test results. The overall conclusions are discussed in the discussion section. The conclusion section summarizes findings and contributions made to COVID-19 literature on the service industry.

2 Literature review

We review the literature, listing the approaches proposed to study the COVID-19 impact on the service industry. COVID-19 has had a significant impact on our daily life, the business community, and even in international commerce, trade and movements (Haleem et al. 2020). Several studies included within the review suggest that the impact of COVID-19 on the service industry is significant and involves several aspects: from the business model to the corporate culture, risk management, organization type, customer perception, supply chains, innovation, ICT, and digitalization, artificial intelligence, and robotization. This work is novel in studying convergence and convergence clubs on COVID-19's impact on the service industry in Europe. This work is novel in using a nonlinear time-varying factor model on panel data to estimate whether the COVID-19 shock wave affects the service industry across European countries in a general pattern of differences arising.

Accommodation and food service activities suffered a significant hit from the COVID-19 shock wave. As a result of the pandemic, there will be long-term and short-term effects on global tourism. With the ideas, strategies, and collaboration of stakeholders, tourists' safety and security are in focus Ulak (2020). The study of (Harms et al. 2021) finds that causal and effectuation components relevant to the gastronomy industry are incredibly high. Means, contingency, and control

orientation are elements of all configurations associated with a high degree of business model innovation. Innovative gastronomy entrepreneurs should include them in their strategic orientation in the present crisis. Indonesian tourism industry revenue registered a robust decline with a clear negative expectation trend of employees in the hospitality sector (Riadil 2020). One of the first studies to examine the impact of the COVID-19 pandemic on the travel and tourism industry is (Skare et al. 2021). Based on panel structural vector auto-regression (PSVAR) on data from 1995 to 2019 in 185 countries and dynamic system modeling, the authors estimate the impact of the pandemic crisis on the tourism industry worldwide. Operational and investment in the travel tourism sector should be protected, and capacity strengthened in the next 2 years. The study shows (Rutynskyi and Kushniruk 2020) that the introduction of COVID-19 quarantine significantly reduces the number of tourists in Ukraine. Many generational cohorts differ significantly on perceived travel risk, both internationally and domestically (Abraham et al. 2020). COVID-19 may have a profound impact on tourist behavior. Due to their personal and cultural background, individuals are likely to experience different emotions. Tourists have become more selective, but now they choose destinations with which they will stay longer on their trips, (Wen et al. 2020) Research of (Aburumman 2020) found travel-related industries, like tourism and airlines, were significantly affected by the pandemic.

Flexibility and change in the corporate culture give the firm an edge in adapting to the COVID-19 shock wave. Study of (Kraus et al. 2020) is the first report of an empirical analysis of the long-term effects of the COVID-19 pandemic on family businesses in five European countries. They discuss the impact of the current crisis on business models and operational technologies in the context of innovation and digitization. Finally, it should be noted these changes were not premeditated but resulted from the crisis. Research of (Spicer 2020) shows that with significant changes in the environment (COVID-19), firms' behavior must change to adapt to this reality. Sull and Sull (2020) study the topics that experienced the most significant bumps in sentiment scores during COVID-19 in the top 50 companies and the most significant decline in sentiment in the bottom 50 companies. For example, in the top 50 companies, employees talked about transparent leaders 43% more positively in the early months of the pandemic than in the previous year, while employees in the bottom 50 companies talked about this issue 17% more negatively during COVID-19.

Changes in the actual business model in firms is another way of fighting the negative impact of COVID-19. When a coronavirus crisis occurs in an organization, managers must deal with short- and long-term consequences. Before making any significant changes to the business model, managers have to consider how the crisis will affect the firm's current performance measures (Ritter and Pedersen 2020). Organizations must search for digital substitutes or service delivery methods that require little or no contact as the Covid-19 crisis intensifies. The opportunities presented to design improved existing products, rethink product and service delivery, seek strategic partners in the new ecosystem, and develop new market approaches (Seetharaman 2020). In the first wave of COVID, authors investigate how formal and informal effects combine with business-model innovation (Harms et al. 2021). In their study, (Morgan et al. 2020) analyzed the bright and dark side of pivoting in

response to exogenous shocks like the COVID 19 pandemic. They propose that arbitrage opportunities justify pivoting for new start-ups, while innovative opportunities should be at the center of existing companies' pivotal agenda.

Pandemic crisis abruptly changed micro and macro business environment affecting firms' innovation capabilities (Lee and Lee 2020), agility and organization (Duc et al. 2020) business strategy (Al-Omouh et al. 2020; Kabadayi et al. 2020; Pantano et al. 2020) and technological adaptation (López-Cabarcos et al. 2020; Yang et al. 2020). Innovation management should strive for continuity and involvement of innovative start-ups. These flexible and energetic actors can help accelerate the innovation process (Ebersberger and Kuckertz 2021). After learning how to optimize in response to the current customer needs, companies are looking to meet future needs (Cromwell and Kotelly 2021; Xuefang et al. 2020). There are vital signs that many small businesses will be most affected by the Covid 19 crisis, including their ability and ability to support research and development, innovation. The results of (Rahimzhan and Irani 2020) point out that innovation has a significant impact on tourists' "returning" intentions to travel to tourist destinations due to the tendencies of tourism activities as a result of the the Covid 19 crisis. Data from study (Arora et al. 2020) suggests that about 20% of U.S. consumers have switched to a retail brand, and over half intend to keep their purchase decisions. Firms focus on the immediate cost cuts, but they do not care about how much time, energy, or resources are used in operational processes (Hoekstra and Leeftang 2020). More outsourcing has been pursued in some companies, which has led to dependence on foreign manufacturers (including those mentioned above), lower stock prices, and a high dependence on China in the U.S. (groceries).

As research (Baig et al. 2020) has shown, they have discovered five fundamental principles that apply to scaling and sustaining digital technologies regardless of their origins. Digital environments and technologies enable us to identify better treatment needs, including preventive, self-control, and curative solutions. Services can be improved to serve the quality better, accessibility, efficiency, and equity of the health system (Horgan et al. 2020). COVID-19 could be a platform for robotics that can be rapidly deployed and used by front-line and back-office experts and critical partners (Cain et al. 2019; Ivanov et al. 2019; Yang et al. 2020; Yu 2020; Zeng et al. 2020).

Transportation and accommodation are two of the most widely impacted sharing economy segments due to COVID-19 restrictions (Batoool et al. 2020). Since the Covid-19 incident, there have been more average daily tasks posted on the platform economy daily. Since this has developed into an extraordinary circumstance, the gig economy cannot keep up because of the current uncertainty (Umar et al. 2020). The results show the importance of essential categories for rethinking the workplace after COVID-19 and for the whole process of change in the workplace (de Lucas Ancillo et al. 2020). The service industry also suffers impacts from global foreign exchange markets volatility and uncertainty (Fasanya et al. 2020). This study searches to determine the connectedness and spillover effects of COVID-19 currency pairs around the world.

A review of the literature undertaken found that empirical evidence of COVID-19 on the service industry is still lacking (data availability, proper methods). The empirical link using the nonlinear time-varying factor model on panel data has not

been previously investigated in the literature. Previous research showed pandemic crises bring considerable changes in business micro and macro environment. However, the empirical assessment of the impact (COVID-19 shock wave) on Turnover, employment, profitability, supply and demand is still missing. We are primarily interested in capturing the empirical link between COVID-19 and service industry turnover. We need this information to provide an empirical metric to the literature to understand the true extent of the pandemic's impact on the service industry. There appears to be no factual information on this subject in the literature. This study estimates the empirical link between COVID-19 and the service industry (using NACE Rev.2 statistical classification of economic activities in the European community). Specifically, we investigate the impact of COVID-19 on Turnover for selected economic activities in the service industry: accommodation and food service, information and communication, transportation, and storage.

3 Data and methods

To study the impact of COVID-19 on accommodation and food service, information, communication, transportation, and storage in Europe, this study uses monthly data from January 2015 to January 2021 for sixteen European economies. Sample selection was limited by the data availability (monthly recurrence). We use the service turnover index (2015=100), which includes the seller invoices' various charges. Service turnover index is set to (2015=100) since cOnvergence testing procedure we use in this study demands data to be indexed to the starting data point of the series (first data in the series). Other costs are considered in the calculation of rebates and deductions and special charges the customer is liable. VAT or similar taxes are not part of business expense turnover). For details on Turnover's index, see Eurostat and Office for Official Publications of the European Communities (2006). Turnover is a significant short-term indicator for all services because there are only a few other distribution indicators. The turnover index measures the development of the service market, so we use it to assess the impact of COVID-19 on the service sector in Europe (Fig. 1).

Figure 1 show the impact of COVID-19 on the service industry (total) in Europe. We can see the biggest drop (index points) in turnover is registered in Turkey (− 40), Estonia (− 34), Italy (− 21), Hungary (− 20), Greece (− 18), Spain (− 17), Belgium (− 11), Austria (− 9), Croatia (− 9), Cyprus (− 6), France (− 4). Other countries in the sample registered a decline in the turnover index but lower compared to above countries.

The impact of COVID-19 differs across service industry. Portugal registered a drop in index turnover for transportation and storage industry of (− 47) index points, Albania (− 60), Malta (− 53), Romania (− 37), Turkey (− 57). Cyprus (− 39). In accommodation and food service industry (as expected) the drop was significant. In Turkey, index turnover drops by (− 135) index points, Albania (− 89), Poland (− 82), Romania (− 95), Croatia (− 79), Malta (− 85), Norway (− 90), Spain (− 77), Cyprus (− 89).

Source: Eurostat (online data code STS_SETU_M)

Fig. 1 Index of turnover in European service industry. Source: Eurostat (online data code STS_SETU_M)

Information and communication service industry show resilience to the COVID-19 impact with biggest drop in index turnover (index points) for Spain (− 19), Latvia (− 16), Lithuania (− 13), Malta (− 11), Slovakia (− 11), UK (− 11), Slovenia (− 11).

The primary data source we use in this study is Eurostat short-term business statistics 2021 Eurostat (2021) for available 16 countries. We have data for Germany for the accommodation and food service activities only.

To evaluate COVID-19 impact on the service industry in Europe, we follow the convergence hypothesis (Johnson and Papageorgiou 2020). Our primary hypothesis is convergence in Turnover in the service industry (ac- accommodation

and food service, information and communication, transportation and storage) in Europe. Turnovers are affected across countries, as the turnover movements of each country have a ripple effect. Several factors can allow for this transmission of COVID-19 shock wave: disruption in the supply chain, lockdowns, falling demand, change in the service industry—online/web shopping, institutional framework, the share of tourism in the gross domestic product (GDP), business sector competitiveness and digitalization level and spatial patterns in service industry turnover determinants (Apergis and Payne 2012). Looking at Eurostat's data (2021), we can observe that the impact of COVID-19 on the accommodation and food service activities in Europe was tremendous (Fig. 2). As Fig. 2 shows, in April 2020, sixteen European economies registered a catastrophic fall in the Turnover in services (accommodation and food). The highest fall in Turnover was in Spain, Croatia, and United Kingdom. Some resilience to the COVID-19 shock wave in April 2020 is shown in the Turnover of the service industry in Denmark, Slovakia, Sweden, and Turkey. High correlation and apparent convergence in service industry turnover for selected European economies are visible in Fig. 2. Service industries in the selected countries in Europe move together, displaying potential convergence patterns. However, as we can see in Fig. 1, there is no single convergence pattern in Turnover for the selected European service industries. Instead, several convergence paths and potential convergence clubs

Source: Eurostat (online data code STS_SETU_M)

Fig. 2 Turnover in accommodation and food services – monthly data (January 2015=100). Source: Eurostat (online data code STS_SETU_M)

are noticeable. Data and correlation in service industry turnover January 2015 to January 2021 for selected European economies (Table 1) support convergence testing on COVID-19 impact on Turnover.

The impact on transportation and storage activities for the selected countries (data not presented due to editorial space) was significant and negative but not as large as accommodation and food services. The most significant decline in the transportation and storage service turnover was in Croatia, Spain, Portugal, Latvia, and the UK. Information and communication service activities on 2020/04 register positive trends (increase in Turnover) despite the COVID-19 effects. The only exception (with a negative trend and drop in Turnover) are Spain and Portugal, which is exciting data to observe.

Before convergence testing, we use Hodrick and Prescott (1997) to pre-filter the data to isolate the trend component we use to run the log t regression test

$$\min_{\{g_t\}_{t=1}^T} \left\{ \sum_{t=1}^T (y_t - g_t)^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\} \quad (1)$$

Following a recommendation from Hamilton (2018).

To test for the convergence in Turnover for the service industry in the selected European countries for the COVID-19 impact, this study follows Phillips and Sul (2007a, b, 2009; Du 2017; Sichera and Pizzuto 2019). Model for series (Turnover) decomposition takes the form

$$X_{it} = \left(\frac{g_{it} + a_{it}}{\mu_t} \mu_t \right) = b_{it} \mu_t \quad (2)$$

g_{it} =systematic factor, transitory component a_{it} , b_{it} as a systematic idiosyncratic component, X_{it} is the turnover index in service (2015=100, panel data), μ_t is a common growth component.

To check for the convergence in the turnover index in the service industry from January 2015 to January 2021, we must test for the transitory component

Table 1 List of countries in the sample 2015/01 to 2021/01

Country	
Bulgaria	Czechia
Croatia	Denmark
France	Finland
Germany	Latvia
Luxembourg	Portugal
Romania	Slovenia
Slovakia	Sweden
Turkey	U.K.

Source: Eurostat (2021)

$$h_{it} = \frac{X_{it}}{N^{-1} \sum_{i=1}^N X_{it}} = \frac{b_{it}}{N^{-1} \sum_{i=1}^N b_{it}} \quad (3)$$

and b_{it}

$$b_{it} = b_i + \frac{\sigma_i \xi_{it}}{L(t)t^\alpha} \quad (4)$$

Test assumptions follow b_{it} as time-invariant, i.i.d. ξ_{it} , random variables across i , N (0,1) and weakly dependent over t .

Slowly varying increasing function $L(t)$ and index turnover convergence rate α (Sichera and Pizzuto 2019). The null hypothesis of convergence in the service industry turnover (H_0 =COVID-19 impact on the service industry does not differ across countries) is tested using (Phillips and Sul 2007a, b, 2009)

$$H_t = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2 \rightarrow 0 \text{ as } t \rightarrow \infty \quad (5)$$

With H_{it} as cross-sectional variation and h_{it} being a relative transition component. First, we test the whole sample for the convergence in service turnover (COVID-19 shock wave is the same across all service industries in selected countries) using Eq. (5). If the null hypothesis (H_0) of convergence in service turnover holds, the impact of COVID-19 is the same across all service industries in the sample.

Rejection of (H_0) means there is no convergence in service turnover across countries. Thus, the impact of COVID-19 on the service industry varies for different service industries. We expect (H_0) to be rejected for the sample, implying (what we expect) COVID-19 impact on service industry turnover differs significantly across the industries in the sample. After rejecting (H_0), we apply the log t regression model (test).

$$\log \frac{H_1}{H_t} = -2\log(\log t) = \alpha + \beta \log t + u_t, \text{ for } t = [rT], [rT] + 1, \dots, T \quad (6)$$

To identify service industries with similar COVID-19 impact on the turnover index. Testing for convergence among different service industries for COVID-19 impact allowed us to identify service industries with similar impact (club convergence). Using Eq. (6) (log t regression test) helps us to identify service sectors having the exact impact of COVID-19 on turnover index and group them in different clubs (convergence clubs). Each club (group) is formed according to the log t regression test on service turnover index results, grouping service industries with the similar impact of COVID-19 on index turnover in convergence clubs (clustering algorithm).

Clustering algorithm test for the convergence across service industries on pre-filtered service turnover index data grouping industries according to β (speed of convergence in turnover index) $\frac{H_1}{H_t}$ (cross-sectional variance ratio)

$$H_t = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2 \quad (7)$$

Sichera and Pizzuto (2019).

We apply a one-sided t test (robust) to test for the convergence in the turnover index for the sample with the rule of thumb $t_{\hat{\beta}} \leq -1.65$ (H_0 rejected at the 5% level).

The clustering algorithm is applied for club clustering (service industry convergent clubs) if the null hypothesis for sample convergence in the service turnover index is rejected. Using the clustering algorithm and procedure allows us to group service industries (by countries) with convergence dynamics in the service turnover index. According to the clustering procedure, countries with similar convergence dynamics in the service turnover index (reflecting the COVID-19 impact) will be grouped.

Following the clustering algorithm procedure described above, we start by applying the log t test on the whole sample. We test for convergence in the whole sample first, sixteen European economies, from January 2015 to January 2021. In the case the null hypothesis of convergence for the whole sample is rejected, we proceed using a clustering algorithm to find club convergence (countries with a similar impact of COVID-19 on service turnover index). We repeat the procedure across three different service sector activities: accommodation and food service, information and communication, transportation, and storage.

To take account for differences in characteristics of the service industry in each European country and share of the service industry in the economy we calculate relative transitional path for each country. Variation in log t parameters transition to steady state includes determinants driving convergence (service sector characteristics and service share in the economy).

4 Results

These results suggest that the COVID-19 impact differs across countries and service sectors, and background factors (determinants).

First, we present the results of convergence testing for the accommodation and food service activities. In the case of the equal impact of COVID-19 on the accommodation and foodservice industry in the selected European countries, the null hypothesis of convergence should hold. In other words, if the COVID-19 impact does not vary across selected countries, the convergence hypothesis will be accepted.

4.1 Impact of COVID-19 on accommodation and food service activities

Since the t statistics (Turnover) value is smaller than test statistics $t_{\hat{\beta}} \leq -1.65$, the null hypothesis of convergence in service turnover index is rejected at the 5% level for the whole sample. Despite the global COVID-19 impact on the service industry, we find no evidence to support the hypothesis of convergence in Turnover for

Table 2 Log (*t*) convergence test results in service turnover

Variable	Coeff	Standard error	<i>T</i> -stat
Turnover			
Log (<i>t</i>)	− 3.805	0.093	− 40.794*

Source: Own Research

*Reject the null hypothesis of competitiveness convergence at the 5% level

Source: Own Research

Fig. 3 Clustering analysis and convergence clubs in service turnover from January 2015 to January 2021. Source: Own Research

accommodation and food service activities for the observed countries. COVID-19 impact on accommodation and food service activities differs significantly across the countries in the sample.

After rejecting the competitiveness convergence hypothesis for the whole sample (all countries), we identify convergence clubs (set of countries converging in COVID-19 impact on service industry). Following initial convergence clubs (set up from the 17 countries), we test for possible club merging to obtain the final convergence club structure for Turnover. The club merging test result shows that Club 3 and Club 4 can be merged to form a new club (Club 3), including countries both from Club 3 and Club 4.

Using the convergence test modeling, we identify six convergence clubs from the sample of 17 countries using the service turnover index as the COVID-19 impact indicator. Table 2 list the identified convergence clubs and countries clustered according to the log (*t*) test results.

Figure 3 list the identified convergence clubs and countries clustered according to the log (*t*) test results.

Figure 3 shows us accommodation and food services industries (across countries) grouped according to the COVID-19 impact on the turnover index. Countries were grouped according to the convergence test results, where countries within a group share the same dynamics to the steady state in service turnover (log *t* close to 1). We see six different clubs (grouped by COVID-19 impact on Turnover) and Turkey's divergent country. The distinct key to COVID-19 impact on service turnover

in the accommodation and service activities is the tourism GDP. The important factor behind the impact of COVID-19 on the accommodation and service industry in selected countries is the tourism GDP (contribution of travel and tourism to GDP as a share of GDP). This is visible from the tourism GDP share, the latest World travel and tourism council data gateway (2021). Data is as follows: Slovakia (6.4%), Romania (5.3%), Finland (8.7%), Latvia (8.4%), Czechia (7.8%), Denmark (8.2%), Sweden (9.7%), Bulgaria (11.6%), Luxembourg (9.1%), Slovenia (12.3%), France (9.6%), Portugal (19.8%), Croatia (25.1%), Spain (14.6%), Germany (8.6%), UK (10.9%), Turkey (11.3%). Countries are grouped in convergence clubs, each club showing a group of countries with similar (convergence) impact of COVID-19 on the service turnover index. Countries in each of the clubs identified in the study share the same impact of COVID-19 on service turnover (convergence in the COVID-19 impact).

Convergence Club 1 (Slovakia, Romania) shows the group of countries converging in service turnover index, sharing similar (converging) COVID-19 impact on these countries' service industries. Put simply, Slovakia and Romania share the same effect (impact) of COVID-19 on the service industry, in this case, accommodation and food service activities. At the end of 2020, the service turnover index was – 6 index points in Slovakia and – 84 in Romania compared to December 2019. We follow the same notation for all clubs.

Convergence Club 2 (Finland, Latvia, Czechia) is the next cluster of countries with the same convergence dynamics in service turnover in COVID-19. The accommodation and food service sector in these countries was affected to the same extent by COVID-19, identified by the clustering algorithm. In December 2020, the service turnover index was – 51.2 index points in Finland, – 79.8 (Latvia), – 78.2 (Czechia) compared to December 2019.

The biggest convergence club is Club 3 with Denmark, Sweden, Bulgaria, Luxembourg, and Slovenia. These countries register a convergence in the service turnover index (after the impact of COVID-19). Denmark registered a decline in service turnover of – 48.8 index points from December 2020 to December 2019, Sweden (– 50.2), Bulgaria (– 62.4), Luxembourg (– 49.5), Slovenia (– 104.4). Convergence Club 4 (France, Portugal) register a fall in the service turnover index of – 68.2 index points (France) and – 51.3 (Portugal) at the end of 2020. Both countries show convergence in service turnover index after the impact of COVID-19 (the null hypothesis of convergence in service turnover is not rejected, see Table 3).

Convergence Club 5 with Croatia and Spain shows two countries depending on the tourism GDP and sharing club convergence in service turnover. In December 2020, Croatia registered – 38.9 index points fall in the service turnover index and Spain – 58.7 to December 2019. It is crucial to notice here, two countries heavily depending on tourism registered significant but not the highest fall in service turnover in the sample. Still, Country and Spain are among the economies with the highest GDP drop in 2020 in Europe. Service turnover resilience to COVID-19 impact is influenced by the share of the tourism GDP in the economy (Croatia, Spain, Portugal) and the flexibility, agility of the tourism service to adapt to COVID-19 condition (Portugal). Other exogenous conditions, such as COVID-19 crisis management, also play an essential role.

Table 3 Convergence club classification (service turnover)

Initial classification $\hat{\beta}$ (S.E. of $\hat{\beta}$)	Tests of club merging $\hat{\beta}$ (S.E. of $\hat{\beta}$)	Final classification $\hat{\beta}$ (S.E. of $\hat{\beta}$)
Club 1 [2] 3.357 (1.431)	Club 1+2 - 3.6614* (0.0293)	Club 1 [2] 3.537 1.431)
Club 2 [3] 0.745 (0.309)	Club 2+3 - 0.1911 (0.1894)	Club 2 [8] - 0.191 (0.189)
Club 3 [5] 0.323 (0.105)	Club 3+4 0.8317* (0.1347)	Club 3 [3] 2.05 (1.125)
Club 4 [2] 2.05 (1.125)	Club 4+5 - 1.7014* (0.1103)	Club 4 [2] 3.418 (0.878)
Club 5 [2] 3.418 (0.878)	Club 5+6 - 1.4312* (0.1986)	Club 5 [2] 1.523 (0.484)
Club 6 [2] 1.523 (0.484)		Club 6+group 7 - 4.084* (0.1154)
		Divergent [1] Turkey

Source: Own Research

*Reject the null hypothesis of service turnover convergence at the 5% level. The numbers in brackets stand for the number of countries in a group

Germany and U.K. share the convergence Club 6, with Germany – 81.7 index points drop in the service turnover index and UK – 40.9 compared to December 2019. Both countries (the null hypothesis of convergence are not rejected) show convergence in service turnover in COVID-19.

The only exception is Turkey, exhibiting divergence behavior in the service turnover index. COVID-19 impact on Turkey's accommodation and food service sector diverges completely from to rest of the countries in our sample.

From December 2020 to December 2019 service turnover index in Turkey decreased by – 47.5 index points.

The following section presents the results of convergence testing in the information and communication sector.

4.2 Information and communication activities

Convergence analysis of the COVID-19 effect on the information and communication sector in Europe shows quite exciting results. Part of the losses in the accommodation and food services sector was compensated by increased online sales (webshops) and web marketing. For example, in Croatia, internet sales revenues during 2020 increased by an average of 40%, compared to average annual growth rates of 3% in the previous years.

First, we test for convergence in the whole sample using log (t) regression (see Table 4).

Since the t value is $t_{\beta} \hat{\leq} -1.65$ reject the null hypothesis of service turnover convergence in the whole sample. Therefore, as expected, COVID-19 impact on the information and communication sector varies across countries.

Using the convergence test modeling, we identify four convergence clubs from the sample using the service turnover index as the COVID-19 impact indicator. Table 5 list the identified convergence clubs and countries clustered according to the log (t) test results.

The club merging test result shows that Club 3 and Club 4 can be merged to form a new club (Club 3), including countries both from Club 3 and Club 4.

Following the convergence modeling procedure described in section three, we identify four convergence clubs as in Fig. 4.

Convergence Club 1, with countries sharing the similar impact of COVID-19 on the information and communication service sector, consists of Bulgaria, Croatia, Luxembourg, and Romania. In these countries, the dynamics in the service turnover in the ICT industry converge in COVID-19. Bulgaria's service turnover index

Table 4 Log (t) convergence test results in service turnover

Variable	Coeff	Standard error	T -stat
Turnover			
Log (t)	– 2.931	0.018	– 162.686*

Source: Own Research

*Reject the null hypothesis of competitiveness convergence at the 5% level

Table 5 Convergence club classification (service turnover)

Initial classification $\hat{\beta}$ (S.E. of $\hat{\beta}$)	Tests of club merging $\hat{\beta}$ (S.E. of $\hat{\beta}$)		Final classification $\hat{\beta}$ (S.E. of $\hat{\beta}$)	
Club 1 [4]	0.296 (0.065)	Club 1 + 2 – 2.770* (0.0204)	Club 1 [4]	0.296 (0.065)
Club 2 [3]	1.138 (0.091)	Club 2 + 3 – 0.6911 (0.1254)	Club 2 [7]	0.068 (0.076)
Club 3 [5]	2.824 (1.655)	Club 3 + 4 – 1.7897* (0.0575)	Club 3 [2]	2.824 (1.655)
Club 4 [2]	2.824 (1.655)	Club 4 + group 5 – 3.1058* (0.0245)	Divergent [3]	Turkey, Latvia, Denmark

Source: Own Research

*Reject the null hypothesis of service turnover convergence at the 5% level. The numbers in brackets stand for the number of countries in a group

Source: Own Research

Fig. 4 Clustering analysis and convergence clubs in service turnover from January 2015 to January 2021. Source: Own Research

increased by 4.40 index points from December 2020 to December 2019. For the same period, the service turnover index in Croatia increased by 15.9 index points. A significant increase in the service turnover index was registered in Luxembourg (93.8 index points) and 23.5 in Romania.

Convergence Club 2 lists countries with convergence in the service turnover index—COVID-19 impact. Using the clustering algorithm procedure, we identify Czechia, Sweden, Slovenia, and the U.K. as members of the club. These countries share the same convergence path in the service turnover index. From December 2020 to December 2019, service turnover in Czechia declined by – 4.30 index points, in Sweden increased by +5.60 index points, Slovenia – 6.40 and UK – 19.80. Thus, COVID-19 impact on the service turnover index follows the same relative transition path.

The third convergence club (Club 3) includes France, Slovakia, and Finland. COVID-19 impact on service turnover in these countries follows the same relative transition path. Service turnover index at the end of 2020 relative to the end of 2019 increased by 12.30 index points in France, decreased by – 12.50 index points in Slovakia with + 5.90 index points in Finland.

Last convergence club (Club 4), sharing the same relative transitional path (convergence) in-service Turnover identifies Portugal and Spain as club candidates. Service turnover in 2020 relative to 2019 increased by 8.10 index points in Portugal and decreased by – 7.50 index points in Spain.

The clustering algorithm isolates a divergent group with Turkey, Latvia, and Denmark with different COVID-19 impact on service turnover to other countries in the sample. In Turkey, the service turnover index from December 2020 to December 2019 increased by 86.40 index points, decreased by – 8.50 in Latvia, and increased by 3.30 index points in Denmark. The relative transition path concerning the panel average and club's specific path following COVID-19 regimes show divergent behavior.

Bellow, we apply the same clustering procedure to the transportation and storage sector.

4.3 Transportation and storage activities

The convergence test results in service turnover index 2015=100 for the whole sample for the transportation and storage sector reject the null hypothesis of convergence at a 5% level (Table 6).

Since the t value is $t_{\beta} \leq -1.65$ we reject the null hypothesis of service turnover convergence for the sample. Thus, COVID-19 impact on transportation and storage sector varies across European economies.

The clustering algorithm isolates five convergence clubs and one divergent group.

For all five identified convergence clubs, the null hypothesis of service turnover holds (Table 7).

The club merging test result show clubs can not be merged to form a new club with the final club classification listed in Fig. 5.

Convergence club 1 (Club 1) includes Sweden, Luxembourg, and Bulgaria. For this group of countries, we see similar transitional behavior in service turnover in the time of COVID-19. Sweden registered a decline in service turnover index (2020/2019) of – 16 index points, Luxembourg Bulgaria – 31.6, and Bulgaria with + 1.9 index points.

Table 6 – Log (t) convergence test results in service turnover

Variable	Coeff	Standard error	T-stat
Turnover			
Log (t)	– 3.508	0.014	– 255.286*

Source: Own Research

*Reject the null hypothesis of competitiveness convergence at the 5% level

Table 7 Convergence club classification (service turnover)

Initial classifica- tion $\hat{\beta}$ (S.E. of $\hat{\beta}$)	Tests of club merging $\hat{\beta}$ (S.E. of $\hat{\beta}$)		Final classifica- tion $\hat{\beta}$ (S.E. of $\hat{\beta}$)
Club 1 1.773 [3] (0.169)	Club 1 + 2 – 1.8039* (0.1385)		Club 1 1.773 [2] (0.169)
Club 2 0.076 [3] (0.171)	Club 2 + 3 – 1.3179* (0.1973)		Club 2 0.076 [8] (0.171)
Club 3 2.3466 [2] (1.5359)	Club 3 + 4 – 1.3358* (0.1955)		Club 3 2.347 [3] (1.536)
Club 4 – 0.5728 [2] (0.529)	Club 4 + 5 – 1.5094* (0.4875)		Club 4 – 0.576 [2] (0.529)
Club 5 0.4845 [2] (1.2426)	Club 5 + Group 6 – 3.9560* (0.0015)		Club 5 0.485 [2] (1.243)
			Diver- gent [3] Roma- nia, Tur- key, Croa- tia

Source: Own Research

*Reject the null hypothesis of service turnover convergence at the 5% level. The numbers in brackets stand for the number of countries in a group

Source: Own Research

Fig. 5 Clustering analysis and convergence clubs in service turnover from January 2015 to January 2021. Source: Own Research

The second convergence club (Club 2), with countries sharing similar transition paths in service turnover in COVID-19, lists Denmark, Slovakia, and France as club members. In 2020 relative to 2019, service turnover in transportation and storage falls by -3.4 index points in Denmark, $+4.4$ in Slovakia, -9.7 in France. Denmark and Slovakia show strong convergence while France shows weak convergence in the group.

Czechia and Spain form the next convergence group (Club 3). Countries follow a similar transition path in service turnover close to one. Both countries register convergence in time of COVID-19, implying a similar effect of a pandemic to the transportation and storage sectors in these countries. In Czechia, due to the pandemic crisis, service turnover dropped by -1.5 index points, with Spain reaching -12.3 index points at the end of 2020.

Convergence club 4 (Club 4) with Latvia and Finland display strong convergence in service turnover dynamics. Both countries register a similar transition path (COVID-19 impact) on the service turnover index. In Latvia index dropped -2.9 index points (end of 2020), with Finland registering -22 index points in the same period.

The final convergence group (Club 5) clusters together Portugal and the UK Club 5 exhibits weak convergence with Portugal showing a more considerable drop-in service turnover (-31.3 index points). With a significant transportation sector registering significant (lower to Portugal) drop-in service turnover index (-12.1 index points) at the end of 2020.

The clustering algorithm forms a divergent group with three countries (Romania, Turkey, and Croatia) not sharing a similar relative transition path to other countries in the sample. The impact of COVID-19 on service turnover in the transportation and storage sector in these countries differs from other countries in the sample. In Romania, the service turnover index increased by 23 index points from December 2020 to December 2019. During the same time, Croatia registered a fall of -13.4 index points and Turkey an increase of 40.3 index points.

Empirical results provide evidence COVID-19 impact varies across countries but also service sectors. Identified convergence clubs prove it. Study- in the isolated clubs, we can identify the factors of influence and explain why COVID-19 impact is different across the accommodation and food service sector, information and communication sector, and transportation and storage. These findings demonstrate the importance of understanding the nature and mechanism behind the COVID-19 shock to the service industry.

5 Discussion

The findings indicate that COVID-19 impact is significantly different on a country and industry (sector) level. Economies and service sector losses from COVID-19 follow different transitional paths implying different transition patterns to COVID-19 shock. Using clustering algorithm, countries are grouped in convergence clubs as clubs' members having similar transition path in service turnover during COVID-19.

Using service turnover index for accommodation and food service, information and communication, and transportation and storage activities can observe the COVID-19 impact in different service industries. Our empirical findings show the impact is different for each industry. For the accommodation and food service industry, we identify six convergence clubs. More convergence clubs identified means the COVID-19 impact differs considerably in the accommodation and food service industry (Skare et al. 2021). These results are in line with previous findings showing COVID-19 has a significant impact on tourist preference change. Safety and security for tourist are now on top of the list (Abraham et al. 2020; Ulak, 2020) Changes in business model innovation in tourism industry is now crucial for the tourism business to stay competitive (Harms et al., 2021).

Tourism expectations change also plays a crucial role in the industry flexibility to COVID-19 (Riadil 2020), as empirical data in this study also support.

Convergence testing in this study supports the above findings of COVID-19 impact on the tourism service sector. Countries promptly addressing travel safety and security, tourist preferences change, destination attraction (Arora et al. 2020), effective border crossing, and quarantine policy will provide better control for the COVID-19 shock wave. If this was not the case, as our findings show, the COVID-19 shock wave would have the same effect across countries in the tourism service industry.

We can account for the difference in COVID-19 impact on the service industry by comparing accommodation and food services to the information and communication service industry. Our convergence analysis isolates four convergence clubs in the industry. The implication of this is that COVID-19 impact on the industry is more equally distributed across countries. This finding is expected since COVID-19 increased online web sales and internet revenues (Kraus et al. 2020). Firms' agility and business model adaption in the ICT industry is higher than the tourism service industry (Spicer 2020), (Umar et al. 2020). A quick change in the actual business model mirrors a change in the club's convergence which we evidence in this study (Duc et al. 2020; Pantano et al. 2020; Ritter and Pedersen 2020).

The innovative environment on a micro and macro level, government support to digital infrastructure, competitive higher education system, a significant share of the GDP created through the internet, and online sales facilitate the economic capacity to fight COVID-19's adverse effects on the ICT industry. This corroborates with our findings isolating four convergence clubs clustered upon transition path in service turnover index in time of COVID-19.

Transportation and storage service sectors experience significant COVID-19 impact on service turnover. Our findings show that COVID-19 impact on the transportation and storage industry differs across European countries, supporting findings in (Batoool et al. 2020). The results obtained here may have implications for understanding why COVID-19 shock effects differ across the transportation and storage service sector with five identified convergence clubs. Having five identified convergence clubs show COVID-19 impact on the relative transition path in the service turnover index significantly differs across European economies due to travel restrictions (Murano et al. 2021). This effect is particularly significant in the air transport industry (Suau-Sanchez et al. 2020). Particularly vulnerable to COVID-19 impact

is the public sector, with an unprecedented decline in service turnover (Liu et al. 2020).

Future directions are related to applying the logistic distribution model (Logit, Tobit) for the identification of main factors behind the convergence (relative transition path) in convergence clubs. We suggest that future studies examine service turnover convergence determinants to understand why the COVID-19 impact on the service industries differs across European economies. This work can be used as a reference for future studies on COVID-19 impact on the service industry. Further study is needed to uncover the details of the convergence clubs—what drives convergence clubs (main determinants). The present study aimed to test the following hypotheses: (1) COVID-19 impact on the service industry differs across countries and service industry sectors; (2) there is convergence in impact on the service turnover (existence of the convergence clubs).

The findings' practical implications are for policymakers to understand the mechanism behind the COVID-19 shock wave on the service industry. Such quantitative knowledge will give them information essential to designing efficient policy sets to fight COVID-19's adverse effects. The results obtained here may have managerial implications for understanding how COVID-19 impacts the service industry on a micro-level. An implication of this is managers can learn firm's agility, business model change, innovation, digitalization, corporate culture, business environment are tools they can rely on to alleviate losses due to COVID-19.

Data availability for the service industry on a monthly level is one limitation of this study. The available data is limited, and no previous study has focused on convergence in COVID-19 impact on the service industry. Despite this limitation, this study's findings are significant because they allow separate analysis of the COVID-19 impact on country and sector level. This work is novel in describing COVID-19 impact on the service industry in Europe. This research is hoping to contribute to understanding how COVID-19 affects industries (dynamic of the shock, pattern, transition, convergence).

6 Conclusion

In conclusion, we have shown COVID-19's impact on the service industry in Europe and the nature of shocks, its dynamic properties. The effect of COVID-19 on the service industry in Europe differs across countries and industries. We use convergence testing to prove the effect is not equal for all countries and industries in the sample. If the convergence hypothesis holds for convergence clubs (country groups), it is evidence that COVID-19 impact on the service industry (and sectors) is affected by endogenous determinants. This study is the first to check for the convergence in COVID-19 impact on the service industry turnover in Europe.

Using testing and clustering convergence algorithm, we identify convergence clubs as a group of countries having the same effect as COVID-19 on the service turnover. The same effect is investigated across countries and different service industry sectors: accommodation and food services, information and communication, transportation, and storage services. Empirical evidence shows COVID-19

impact is different for each convergence club we identify in the study. Also, the COVID-19 effect is different for a specific sector. Information and communication services registered losses (in some countries Turnover even increased) relatively lower to the effect on other two sectors. The information and communication sector was the 'less hit' sector by COVID-19. Transportation and storage services suffered a sizeable negative impact of COVID-19. Public transportation was particularly exposed to COVID-19 adverse effects. However, the effect of COVID-19 on transportation and storage services is in extent lower to the one in accommodation and food services.

We find strong convergence in index turnover during 2020 pandemic times. The COVID-19 impact on the service industry was different for western European economies compared to central and eastern European (ex-socialist) economies. The pandemic impact is also different across service industries public transportation and storage, food and accommodation, information and communication. The ICT sector show more resilience to the COVID-19 impact since supply chains for internet sales proved more robust to traditional supply chains. Policymakers and practitioners in the service industry must focus on building economy and firms' innovation, agility, flexibility, set up back-up suppliers net and assure liquidity and financing conditions needed in crisis management.

The tourism service industry is the one that suffered the biggest hit. Still, the effect is not equally distributed over countries in the sample. Spain and Croatia registered the most significant decline in the service turnover for the accommodation and service industry. The fact that COVID-19 impact on service turnover is not following a unique pattern is empirical evidence that factors like business model, a firm's agility, innovation management, corporate culture, ownership (family firms), digital adoption, consumer perception and preference, epidemic measures, state financial COVID-19 support play a crucial role in mitigating pandemic adverse effects. Future studies are needed to explore the individual role of factors above in COVID-19 impact on the service industry. This study can serve future researchers to use the convergence clubs identified here. Looking at the group of countries (clusters we find here) having a similar COVID-19 impact on services can help identify the pattern and determinants and compare them to other convergence clubs.

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Declarations

Conflict of interest Authors declare they do not have any competing financial, professional, or personal interests from other parties.

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