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COVID-19 and the financial resilience of Finland's seaports

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Abstract

This research quantifies the impacts that COVID-19 had on the financial performance of Finnish seaports. The data comprises annual financial statement information from 18 seaports. The ports are different in terms of ownership, size, and main lines of business. Most ports' turnover dropped because of COVID-19, and their profitability declined. However, the ports were able to maintain their financial position quite well despite their declining turnovers. Statistically significant impacts of COVID-19 were observable regarding turnover growth, profitability, labor intensity and capital intensity. Surprisingly, ports with mainly import traffic had the least negative impacts on turnover growth.

Keywords: Port performance, Financial analysis, COVID-19, Finland

Introduction

Pandemic impacts on ports and port performance

COVID-19 pandemic hit the Finnish ports as it did all the ports around the world. On average, there was a drop of 7% in maritime traffic volumes measured by tonnes from 2019 to 2020, and a further drop of 2% between 2020 and 2021 according to the statistics the Finnish Transport and Communications Agency Traficom. COVID-19 hit the passenger traffic, while cargo traffic was less affected; see also Fig. 2. (www.traficom.fi). The pandemic started to have its effects in late 2019, and the World Health Organisation officially declared the global pandemic in January 2020. According to OECD (2022), because of the pandemic, international trade plunged in 2020 but recovered sharply in 2021. Whilst total trade flows have recovered to pre-pandemic levels, trade impacts across specific goods, services and trade partners were highly diverse, and created pressures on supply chains even after the pandemic was over.

Studies on the pandemic impact have been conducted recently. UNCTAD (2022) provided a global oversight on COVID-19 impacts and implications on maritime transport. Notteboom et al. (2021) identified the differences in adaptation mechanisms that the global shipping industry had during COVID-19. Prathvi et al. (2021) studied the impact of COVID-19 on the seaports of India. Chua et al. (2022) analysed impacts and solutions in response to the COVID-19 pandemic, developing and formulating strategies to strengthen maritime transports of COVID-19. Dramatic impacts were foreseen due

to COVID, although thorough and detailed impact analyses of COVID-19 on seaports' financial and economic performance are absent. Fedi et al. (2022) anticipated that the pandemic was a prologue for a deeper change and that in the future some ports will show more resilience than others. Monios and Wilmsmeier (2022) claimed that oligopolistic market structures were one reason for poor resilience of the container shipping industry. This could also apply to ports, too. The usual thinking behind resilience is that de-centralised and diversified systems are typically more resilient than their opposites. Multiple impacts on work force, local economies and more widely on global supply chains and consumption were summarised by Merk et al. (2022).

Impact of the pandemic on three Asian ports—Shenzhen, Hong Kong and Singapore—was studied by Gu et al. (2023). Their conclusion was that ports with better control of the pandemic had a better cargo throughput. Wang et al. (2022) analysed port traffic with the help of AIS (Automatic Identification System). The results showed, not surprisingly, significant increases in anchoring and berthing time for different types of vessels in Beibu Gulf in China. Cullinane and Haralambides (2021) reported the decline in container ports' throughput in 2020, like Rotterdam, Shanghai and Los Angeles. However, there were also volume increases, such as in Port Said, Tangier and Gioia Tauro. Xu et al. (2021) observed quite severe impacts on Chinese ports. In Finland, the loss in volumes particularly due to passenger restrictions were addressed by Hilmola (2022). Most of these studies are still observational because the phenomenon, i.e. the pandemic, is still recent and there is no established research tradition.

There are also studies that have addressed port performance in general. Laxe et al. (2021) studied the profitability of Spanish ports, and López-Bermúdezet al. (2019) studied the performance of Argentinian ports. Mlambo (2021) assessed and tested port performance with regards to trade performance, whereas Munim and Schramm (2018) investigated seaports of 91 countries to explain how improving the quality of port infrastructure contributed to better logistics performance, which ultimate is expected to contribute to seaborne trade and economic growth. Palthe et al. (2018) investigated transport costs and times along the transport chain in Europe and concluded that these are dominant factors for port competitiveness. In Finland, ports' financial performance was analysed by Leviäkangas et al. (2015) and Rönty et al. (2011). The conclusion was that seaports were a significant source of cash to their owners.

Finnish ports play an utmost important role for foreign trade and hence to national economy. More than 90% of exports and over 70% of the imports in terms of value is transported via sea, and hence through the ports. The performance and resilience of seaports is therefore a key question to Finland's national economy (Finnish Shipowners' Association 2023). Furthermore, the municipality -owned ports contribute significantly to local economy, and not only in terms of jobs and tax revenues. Port of Helsinki, for example, was, with its 12.3 million passengers the largest passenger port in the world.

A brief history of Finland's seaports

Finnish seaports have historically been municipality-owned entities. Between 2010 and 20215 a major restructuring of ports took place as most municipality-owned enterprises (MOE) were transformed into municipality-owned limited liability companies (MOC). There are also a few private seaports that still mainly serve as hubs for

large industrial facilities. These ports are either privately-owned limited companies (POC) or just parts of corporations' business units.

Before the restructuring, seaports had a good financial and economic performance record. This enabled MOEs to divert cash flow to their owners, i.e., the cities and municipalities, thus patching the public accounts (Leviäkangas et al. 2015; Rönty et al. 2011). However, financial transparency was limited when ports were a part of the municipality or city accounting system, either as an MOE or integrated in the municipality organization (Ojala 1991). There has been no extensive, thorough investigation into the ports' financial and economic performance since restructuring. Most Finland's seaports are small in international comparison, as shown in Fig. 1 (also inland waterway ports are visible), although the Port of Helsinki is the largest passenger port in Europe. The classification of port size in the World Port Source portal is their own (World Port Source 2022), and not followed in the subsequent analysis.

Before restructuring and corporatization, cities and municipalities were able to extract substantial cash flow from their ports (Leviäkangas et al. 2011, 2015). Additionally, port entities were not subjected to any corporate or other taxation, which made them even more capable of diverting cash to their owners.

The restructuring meant that former municipality -administered port entities were transformed into limited liability companies. The number of legal entities recognized by official statistics grew from 40 to 52 between 2014 and 2015 (Table 1), partly because some port entities were split into several limited companies. The restructuring made the ports, now stand-alone legal entities, independent from the direct municipality control, but in most cases municipalities remained as shareholders. With shareholding, the legislation applied to ports was also changed so that standard corporate law took force. The ramifications of this change have not been formally analyzed.

The number of personnel somewhat decreased since not all the former municipality civil servants were transferred to port companies. Interestingly enough, however, salaries increased drastically, and in fact doubled after the restructuring was completed in 2015. Between 2014 and 2015, the average annual salary per staff person increased

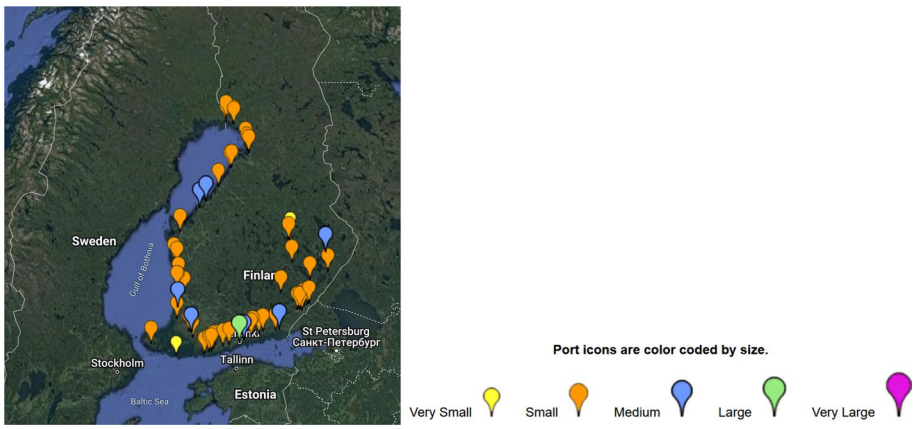

Fig. 1 Finnish ports (both sea and inland waterways); source: World Port Source (note: the size categorization is changed later for this paper)

Table 1 Ports' key figures 2013–2020 (source: national accounts www.statfin.fi)

Data from national accounts for 2013–2020 (TOL 2008[a], 52,221 Ports, legal units)								
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
			R				**P**	
Number of legal units	44	40	52	52	52	50	59	75
Turnover €1000	244 763	244 442	249 954	263 056	278 064	291 495	276 704	254 227
Staff person-years	779	666	681	704	680	678	589	624
Sum of salaries €1000	17 094	16 916	33 684	33 713	34 287	34 353	31 053	32 968

[a] TOL 2008 is the national industry classification, following the standards of the International Standard Classification of All Economic Activities (ISIC) according to United Nations

R = sector restructuring completed, P = first year of pandemic effects

from 25.4 to 49.5 kEUR. The turnover of ports in turn remained quite stable showing that after restructuring and corporatization the business remained as before.

Objectives and scope

The objective of this paper is to provide an answer to one main research question*: How did COVID-19 affect the financial performance of Finnish seaport companies*? The research question emerges from the need to capture more precisely the impact of COVID-19. The impacts have been well recognized and acknowledged in general sense and worldwide, but not so often explicitly assessed in terms of unambiguous financial ratios. What also remains an unresolved question is if there were any observable differences in resilience between different types of ports against the pandemic shock. Therefore, the analysis is also about financial resilience. An intuitive assumption would be that larger port utilities would be more resilient against most shocks and that ports with diversified businesses would be less exposed. The results of this analysis will show that this is not necessarily the case.

When considering resilience, the standard definition of ISO standard 22,031:2019 (ISO 2019) is the basis adopted for this research. The ISO standard defines practices and processes on how to ensure business continuity in crises and shocks, to maintain business operations continuity at an acceptable level right after the shock, and to recover rapidly to a normal level. Financial ratios are one way to operationalise resilience of businesses. Resilience research on transport systems and more in-depth definitions can be found e.g., in Leviäkangas and Michaelides (2014), and Leviäkangas et al. (2013). While resiliency theory stems from medicine and psychology, there is not yet a solid theoretical foundation in engineering or economics. There are multiple definitions for resiliency. One of the most straightforward definitions states that "*resilience means stable trajectory of healthy functioning after a highly adverse event*" (Southwick et al. 2014). This definition clearly corresponds to the principles of business continuity.

The structure of this paper is as follows:

- Sections" Introduction" and "Data and Methodology" set the background and motivation for this research
- Section "Descriptive analysis" describes the data incorporated and methods applied

- Section "Statistical analysis on pandemic impact" provides descriptive statistics and observations on financial performance of the port companies
- Section "Conclusion and discussion" provides a detailed statistical analysis and testing of hypotheses that financial ratios weakened because of the pandemic
- Section 6 concludes the research and discusses the results and their implications.

The contribution of this paper is first and foremost observational. As there is a widely accepted perception that the pandemic had serious impacts on transport, including the maritime mode and on supply chains in general, the Finnish seaports' case shows that the pandemic was survived with surprisingly tolerable consequences in terms of financial impacts. This should be a lesson to port owners, as well as to transport policy and strategy decisionmakers, be they at political or corporate level: radical reactions and turns may easily be exaggerated and counterproductive. More precisely, our contributions are as follows:

- The results imply, or at least lets us hypothesise, that even serious crises can be survived with lesser pain than perhaps feared, provided that the fundamentals of the society and economy are in order. For example, the Finnish shipping lines can by and large be confident that at least the ports are functioning during the crises of the kind witnessed.
- Financial statements offer an unbiased snapshot of the real financial impacts of the pandemic; therefore, it should be noted that unambiguous measurements of the impacts of the pandemic (and similar crises) can be done reliably, provided the data is there. Without reliable data, the picture may be blurred and there is more room for negative opportunism, i.e., attempt to exploit such crises in the future.
- Finally, the contribution is to ports' business development. The results are somewhat surprising when it comes to how well different types of ports survived and were able to recover from the pandemic impacts. There are implications specific to how port owners should review their strategies and business processes.

The theoretical underpinnings include number of aspects, such as managerial decision making under crises. Sayegh et al. (2004) emphasized emotions, intuition and tacit knowledge as having an important role in managerial decisions under crises, in addition to traditional rationality. Since the pandemic crisis was the first of its kind in terms of scale and magnitude, and since there was little experience on how to deal with it and what would be its ultimate impacts, it is quite certain that many decisions were made also on non-rational basis, simply because there was no past data to learn from. Similar thoughts have been presented by Agor (1986), Barr (1998), and Ford (1985), just to name a limited few. The role of mental habits and emotions have for long been identified as factors affecting humans' perception of induction and causality, and thereby their decisions—tracing all the way back to the philosophers of ancient Greece and time of Enlightment. This paper attempts to reduce the probability of emotional reactions by eliciting unambiguous observed data set for future rational decision making, when the next crises are met.

Data and methodology

Data sources

The primary data sources of analysis are drawn from legal documentation, as the registered financial statements are based on corporate regulation. This makes the research approach strictly empirical and observational. The pandemic effect analysis is based on key ratios derived from the annual financial statements of the seaport companies. These ratios provide a demonstrable picture of financial performance in terms of profitability, liquidity, and other financial attributes. The data was acquired from the Finnish Patent and Registration Agency *PRH* (www.prh.fi) using their online service portal, after receiving permissions to access the databases. The data from the database is available for free for research purposes but cannot be shared with third parties.

Port features were collected from the public statistics of Finnish Port Association (www.finnishports.fi) and Finnish Transport Infrastructure Agency (www.vayla.fi).

Financial statements and ratios

The statements were aggregated and standardized in accordance with Table 2. This means that basically no adjustments were made on the statements. The calculated ratios were based on as robust income statement and balance sheet lines as possible. Since the accounting principles and financial information presentation guidelines (e.g., financial statements) of Finnish limited companies are standardized, the comparability is ensured. Although some statements were available already from 2011, only the data from 2015 onwards was used, since it can be said that it was the time point when the current seaport architecture was in place and the data is available on a comparable basis.

The financial ratios calculated for the analysis were divided into profitability, liquidity, solidity and productivity. Only one ratio per category was selected except for productivity where both labor and capital productivity were analyzed. The ratios were also selected so that there was no bias when using financial statement variables for ratio calculus. The categories and ratio formulas are shown in Table 3. The calculated averages are arithmetic and un-weighed (e.g. by firm size). All calculated ratios are based on division calculus, so the differences between port companies are explicit and comparable.

Table 2 Port companies' income statement and balance sheet format used in the analysis

Income statement	Balance sheet	
Turnover	Assets	
+Other income	Fixed assets	
−Materials & services	Current assets	
−Salaries & personnel	Liabilities	
−Depreciations	Equity	
−Other expenses	Debt	Long-term debt
=Operating margin		Short-term debt
+financing gains & dividends		
−Interest payments & financing expenses		
=Profit before taxes		
−Taxes		
=Profit (after taxes)		

Table 3 Financial key figures used in the analysis

Profitability	
Profit/turnover (%)	**Profit margin**
Liquidity	
Current assets/short-term debt	Current assets to short-term debt ratio
Solidity	
Equity/debt	Equity-to-debt ratio
Productivity	
Salaries/turnover (%)	Labor intensity (inverse of labor productivity)
Fixed assets/turnover	Capital intensity (inverse of capital productivity)

Table 4 Data on sample seaports for 2019–2020 (Statfin 2022)

	International goods traffic, million tonnes		**TEU, units**		**Passengers in international traffic[a], million**		**International cruise passengers[b], million**	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Hanko	4.9	4.8	63 764	74 180				
HaminaKotka	14.9	14.2	669 533	622 521				
Helsinki	14.2	13.2	526 196	501 310	12.8	4.7	0.6	0.0
Inkoo	2.0	2.1						
Kalajoki (Rahja)	0.5	0.4	4 530	214				
Kaskinen	1.1	1.2						
Kemi	1.6	1.4	19 100	13 161				
Kokkola	6.0	6.2	15 128	12 665				
Naantali	5.7	6.1			0.2	0.1		
Oulu	2.4	1.8	35 712	28 353				
Pietarsaari	1.3	1.1	1 638	2 141				
Pori	3.2	2.9	944	809				
Raahe	4.7	4.7	492	145				
Rauma	5.7	4.8	261 152	217 932				
Tolkkinen	0.1	0.2						
Turku	2.0	2.4	3 351	3 350	2.6	0.8	0.1	0.0
Uusikaupunki	2.5	2.1	1 578	1 447				
Vaasa	0.9	0.8	140	84	0.2	0.1		

[a] Ports with over 2,000 passengers in international traffic per year

[b] Ports with over 20,000 cruise passengers in international traffic visiting the port per year

Port data

The port data included altogether 18 seaports. The ports and their respective recent data are shown in Table 4 (recent data) and 5 (port type and characteristics). Ports are classified according to ownership, size, primary line-of-business (LOB), specialization, freight flow direction, and main type of freight. Most of the ports were members of the Finnish Port Association. Only the data on legal entities was available, but these ports comprise the majority of all the ports in the country. Only a few ports that belonged to large industrial entities (for example, ports in Tornio and Sköldvik) were missing from the data set, so the data coverage can be considered very good: more than 80% of the goods volumes (in tonnes) and passenger volumes are covered by the sample. The sample excluded

the Aland islands, which served 14%19% of international passengers travelling through Finnish ports (in 2019–2021) (Table 5).

Port size was categorised so that the five largest ports in terms of turnover in 2019 were classed as large (L), the following six as medium size (M), and the remaining seven as small (S). The classification was done so that three groups with approximately similar size were formed in order to support descriptive analysis. The type of business focus (passenger, freight, or combined) was determined based on volume figures in 2019. Multipurpose vs. single-purpose variable refers to whether the port was mainly serving one or a few industrial entities (e.g., a steel or paper manufacturing plant), or whether port traffic consisted of a mix of cargo and/or passenger flows. Some ports were more oriented towards exporting or importing, while the traffic of other's was more balanced. Finally, also the freight type was assessed, if it was mainly bulk or unitized cargo in

Table 5 Port types and characteristics

Port company[a]	Ownership: Public, Private	Size[b]: Large, Medium, Small	Primary LOB[c]: Passenger, Freight, Both	Specialisation[d]: Multipurpose, Single-purpose	Freight direction[c]: Export, Import, Both	Freight main type: Bulk[e], Unitised (trailer, container), Both
Hamina-Kotka	Public	Large	Freight	Multi	Export	Both
Hanko	Public	Large	Freight	Multi	Both	Unitized
Helsinki	Public	Large	Both	Multi	Both	Unitized
Inkoo	Private	Large	Freight	Single	Both	Bulk
Kalajoki	Public	Small	Freight	Multi	Export	Bulk
Kaskinen	Public	Small	Freight	Single	Both	Bulk
Kemi	Public	Medium	Freight	Single	Export	Bulk
Kokkola	Public	Large	Freight	Multi	Export	Both
Naantali	Public	Medium	Both	Multi	Import	Both
Oulu	Public	Medium	Freight	Single	Both	Both
Pietarsaari	Public	Small	Freight	Single	Export	Bulk
Pori	Public	Medium	Freight	Multi	Both	Bulk
Raahe	Public	Medium	Freight	Single	Import	Bulk
Rauma	Public	Medium	Freight	Multi	Export	Both
Tolkkinen	Private	Small	Freight	Multi	Both	Bulk
Turku	Public	Large	Both	Multi	Both	Unitized
Uusi-kaupunki	Public	Small	Freight	Multi	Both	Both
Vaasa	Public	Small	Both	Multi	Import	Bulk

[a] Port location usually also indicates the company name (e.g. 'Port of Hanko Ltd.')

The Port of Tolkkinen is located in the City of Porvoo

The Port of Vaasa is part of the Swedish port group Kvarkenhamnar AB, yet 50% is owned by the city of Vaasa. Kvarkenhamnar in turn is owned by Swedish municipalities/cities

The Port in Inkoo is owned and operated by Inkoo Shipping Ltd

The Port of Raahe is an adjunct to steel manufacturer SSAB Ltd. operated port

[b] Ports with a turnover of more than 12 MEUR in 2019 are considered as large (L), ports with a turnover of less than 5 MEUR as small (S); in between belong the medium-sized (M) ports

[c] Based on Finnish Transport Agency (2018). Ports with less than 1/3 of their freight volumes in the export or import category were considered as mainly import or export ports, respectively

[d] Based on ports' annual reports from 2019

[e] Bulk also includes project deliveries, break-bulk, or other non-unitized cargo

containers and/or trailers. Bulk cargo included also break-bulk, project deliveries, and other non-unitized cargo. These variables are controlled only in the descriptive analysis since the sample size is too small to do it with statistical methods.

Most of the ports, especially those that are municipality -owned, are traditional landlord ports that lease the land area for port operators and own the port basic infrastructure: berths, roads, rails, water, electricity. The revenues of the port companies comprise cargo fees, vessel fees, treatments of waste, and other service fees. Hence the revenue streams are very much tied to the volume of vessel traffic.

Statistical testing of the pandemic effect

Statistical testing is done by using paired t-tests that are typically used to measure effect significance before and after treatment, intervention or some other factor that may be causing a change. In this case, the effect was the pandemic. Test statistic t is calculated as

$$t = \frac{\bar{x}_d - \mu_0}{S_d/\sqrt{n}}$$

where $\bar{x}_d$ is the average of differences between pairs, i.e., the difference between financial ratios before (2016–2018 average trend) and after (2019–2021 average trend), μ_0 is the expected difference under $H_0 = 0$, i.e., the null hypothesis is that there is no difference between the ratios before and after; alternative hypothesis is $H_1 =$ ratios are weaker after the pandemic break, S_d is the standard deviation of the differences of the pairs, n is the number of pairs, i.e., the number of companies.

The application of t-test assumes normally distributed variables (the pair differences before and after). The normality assumption is tested by the Shapiro–Wilk test with significance level $\alpha = 0.1$ for type I error, i.e. there is more than 10% risk that normality assumption is incorrectly rejected. Thus, when the calculated P-value exceeds the set $\alpha = 0.1$, the normality assumption can be accepted. Shapiro–Wilk test was considered appropriate because it is less conservative than o some other tests (e.g. Kolmogorov–Smirnov) and applicable also to small sample sizes (Riffenburgh 2006; King and Eckersley 2019). However, like any hypothesis test, Shapiro–Wilk is also not 100% reliable. Therefore, histograms were also visually checked for tested distribution. A free online statistical software package was used for testing (Statistics Kingdom).

The tested hypothesis for t-test was one-sided with the following null and alternative hypotheses:

$H_0 =$ there is no difference between the ratios compared before and after the pandemic break.

$H_1 =$ the ratios are weaker after the pandemic.

Although the descriptive analysis is already quite revealing and evident regarding some ratios, such as turnovers, there are other ratios where the case is not that clear unless statistically tested.

Descriptive analysis

Turnover decline, but resilience in profitability

The average annual growth rate trajectory for the ports before the covid outbreak was about 8% from 2016 to 2018. When WHO officially declared the pandemic in early

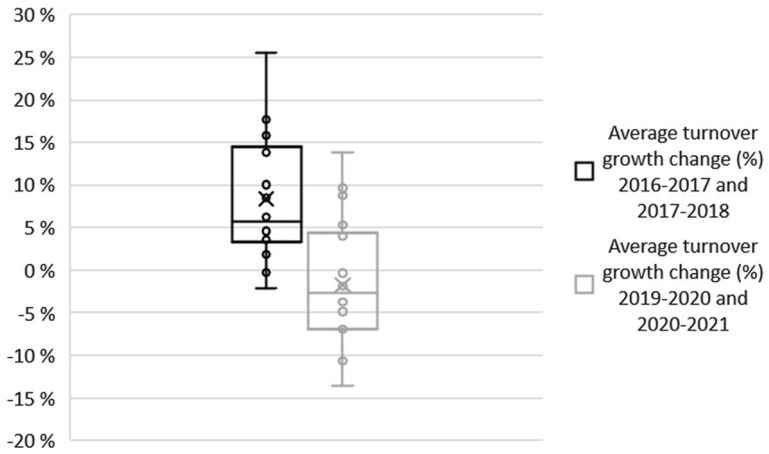

Fig. 2 Average annual turnover growth changes before and after the pandemic

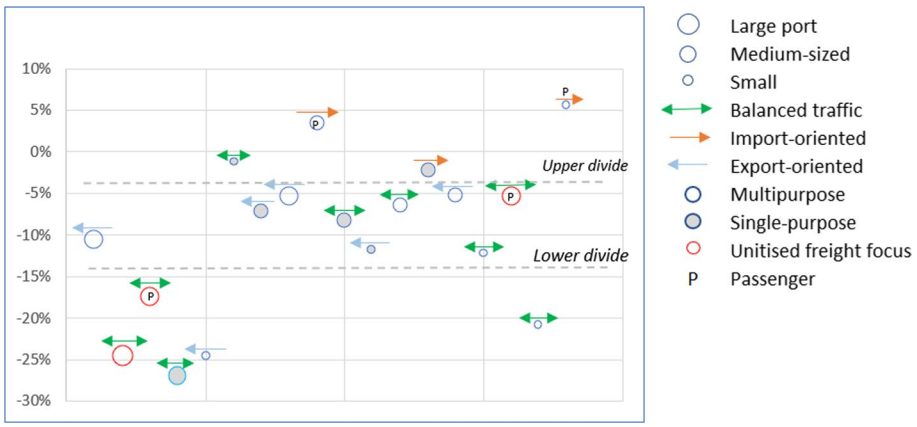

Fig. 3 Turnover growth change in different types of ports

2019, much of the traffic started facing multiple difficulties, and the turnovers rapidly declined. Figure 2 shows the analyzed 18 ports' growth rate changes before and after the pandemic. After-pandemic growth rate declined to -10% from the pre-pandemic rate of 8%. However, some ports were able to keep their positive turnover trajectory despite the obvious drop, but that was the case with respect to only a few.

The turnover change is visualized in Fig. 3, which shows how turnovers changed for different types of ports (size, type of traffic, specialization). To help identify the clusters of different types of ports, two divide lines are drawn. The upper line shows the ports with the least turnover decline and the lower one the ports that were hit the severest. One would have expected that the ports which, in particular, carried passengers would have been among those suffering the most as travel restrictions and other restrictive recommendations took force. However, only the largest passenger port—Helsinki—seemed to experience a severe turnover decline. The other ports' passenger volumes were more modest to begin with, yet surely significant in terms of their business; however, the Port of Turku, for instance, survived the plunge of passenger numbers surprisingly well.

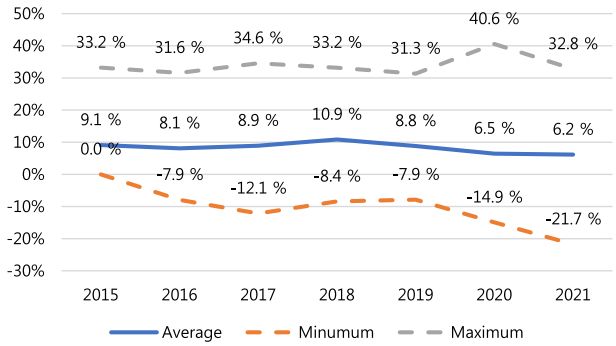

Fig. 4 Profitability (profit/turnover) of the port companies for 2015–2021

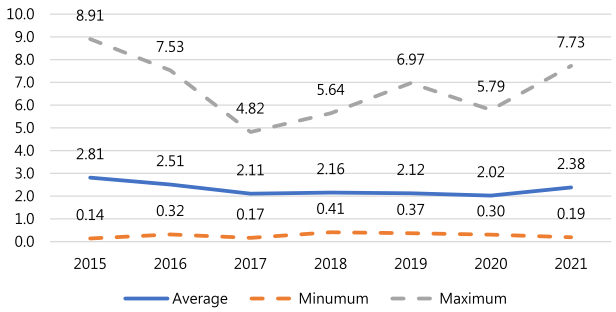

Fig. 5 Port companies' liquidity position (current assets/short-term debt) for 2015–2021

Another interesting observation is that import-focused ports seem to have had more resilience against the pandemic shock. Figure 3 visualizes how—above the 'upper divide' (upper dashed horizontal line)—three out of the four ports are import-oriented, and no other import-focused ports are below the upper divide. Between the upper and lower divides, ports had only slightly negative turnover growth, or the growth rate was even positive for some ports.

Surprisingly, ports with more balanced traffic were not performing any better than export-oriented ports. An intuitive expectation would be that balanced traffic brings diversification of risk and hence dampens the impacts. However, observations indicate the opposite. Single-purpose export ports were not the most resilient, but not the worst either. Only one small export port was below the 'lower divide' that marks a − 25% negative average turnover change for 2019–2020 and 2020–2021. Most of the export-oriented ports belong to the group between the upper and lower divides.

Profitability measurement revealed equally interesting facts. Despite the drops in turnovers, the profitability of the ports seemed much less affected. Figure 5 shows the annual profit margins (profit per turnover) for 2015–2021. The average profit margin ranged between 8 and 10% before the pandemic and dropped after 2019. However, the drop was not as severe as one would have expected—only a few percentage points to about 6% and yet staying on the positive side on average. The gap between the minimum and maximum profit margin figures widened, though, and more cases of profitability problems were observed.

While only one port out of 18 registered a steep decline, i.e., a negative profit margin in 2018, in 2020 the number had increased to seven ports, recovering to three cases in

2021. Therefore, the profitability of the ports appears to have been largely unaffected and hence resilient, and the bounce-back was ostensibly rapid. On the other hand, some ports continued to struggle with profitability in 2021. This is shown in Fig. 4: the worst-case profit margins sunk below − 20%.

Liquidity and solidity

Liquidity was measured as a ratio of current assets to short-term debt. The ratio is close to the more traditional current ratio but is a simplified version of it. The ratio indicates how large a share of short-term debt liabilities is covered by cash or liquid assets. High ratios signal better liquidity position. The ex-ante assumption is that the pandemic weakened the port companies' liquidity.

Figure 5, observing the ratios for 2015–2021, clearly shows that the pandemic had very little impact, if any, on the ports' liquidity position. The ratios have remained stable on average, and there is no clear discontinuity over time. Some ports did in fact strengthen their liquidity. The likely explanation is that owners infused some extra capital due to pandemic crisis. This assumption is supported by the statistics on solidity.

Solidity was measured by the equity to debt ratio. This ratio simply indicates to what extent the capital base of rests on owners' equity and debt investors' lending. When the ratio has a value of 1, the equity equals the debt, and the company is financed 50% by debt and 50% by equity. When the ratio exceeds 1, the port company is mainly equity -financed.

In Fig. 6, no observable change in solidity is visible when looking at the average ratios across the data set. However, there were some cases where solidity was radically increased. It is difficult to speculate why this took place, excluding the prospective capital infusions from shareholders as a precaution against the pandemic crisis. It is not entirely implausible either, that the solidity increase may have been due to an overly protective reaction of the shareholders.

Productivity

Productivity was measured by both labor intensity and capital intensity. Labor intensity was indicated by salaries and personnel costs divided by turnover. The inverse of labor intensity is labor productivity that signals how much turnover is generated by work input. The higher (lower) the labor intensity, the lower (higher) is labor

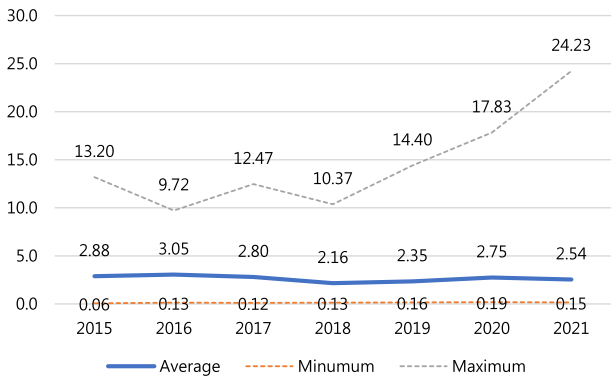

Fig. 6 Solidity of port companies for 2015–2021

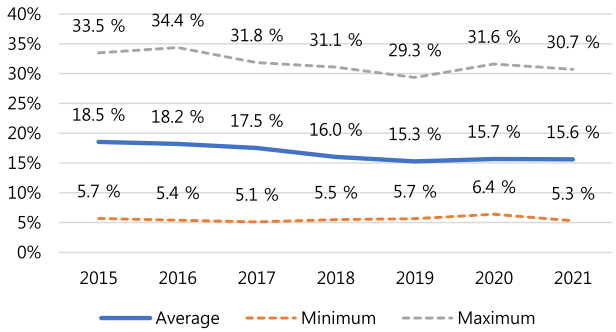

Fig. 7 Labor intensity for 2015–2021

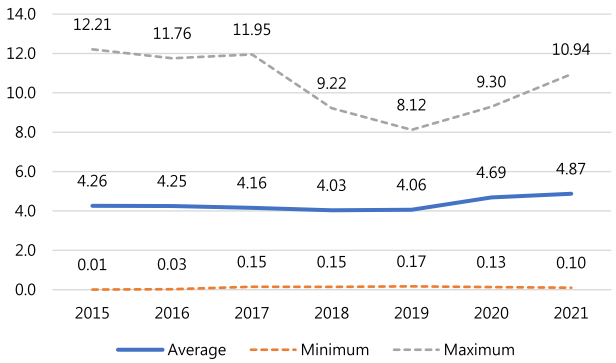

Fig. 8 Capital intensity (fixed assets / turnover) for 2015–2021

productivity. Some of the ports were extremely labor intensive. The minimum and maximum values varied between 5% and more than 30%.

In Fig. 7, there is no visible pandemic shock effect; nevertheless, the turnovers (i.e., the denominator) dropped due to the pandemic. Therefore, there are grounds to assume that the workforce was not radically adjusted since the share of labor costs rose in relation to turnover in 2020, by 2.3% units. However, there were no significant labor intensity changes due to COVID. There were cases where the changes were clear, but these were trends over time rather than clear changes before and after 2019.

Capital productivity was measured the same way as labor productivity, but inversely. Capital intensity (inverse of capital productivity) is equal to fixed assets over turnover. The ratio indicates the magnitude of fixed asset capital (machines, buildings, infrastructure) needed to generate the turnover. Low capital intensity means a better return on capital and better capital productivity. Higher ratios mean that large amounts of capital are tied into fixed assets.

In Fig. 8, the data shows that there may have been a slight increase in capital intensity because of COVID. However, this is a direct consequence of declined turnovers, as it is unlikely that port companies would have had time to react to the pandemic situation by selling some fixed assets. Therefore, the existing assets remain in the numerator of this ratio while the denominator decreases. However, before COVID there was a trend of gradually improving capital productivity.

Statistical analysis on pandemic impact

The following data series were tested:

- Turnover change before and after the pandemic start; these were annual changes averaged for 2016–2017 and 2017–2018 (before), and 2019–2020 and 2020–2021 (after); $H_1 =$ Before > After), i.e., turnover decline
- Profit margin (profit/turnover) before and after the pandemic; these were averages for 2017–2018 (before) and 2020–2021 (after); $H_1 =$ Before > After, i.e., profit margins decline
- Liquidity position (current assets/short-term debt); average of annual ratios for 2017–2018 (before) and 2020–2021 (after); $H_1 =$ Before > After, i.e., liquidity positions weaken
- Solidity (equity/debt); average of annual ratios for 2017–2018 (before) and 2020–2021 (after); $H_1 =$ Before > After, i.e., solidity declines
- Labor intensity (labor productivity); average of annual ratios 2017–2018 (before) and 2020–2021 (after); $H_1 =$ Before < After, i.e., labor productivity declines
- Capital intensity (capital productivity); average of annual ratios 2017–2018 (before) and 2020–2021 (after); $H_1 =$ Before < After, i.e., capital productivity declines

The procedure of averaging the 'before' and 'after' ratios evens out annual fluctuations and gives a more reliable picture as to whether sustainable changes actually took place. The results of testing for statistical significance testing are shown in Table 6. Two tests were run: two-sided t-tests for mean values before and after the pandemic outbreak, and the Shapiro–Wilk test to test for normality of the data, so that the t-test could be regarded as valid.

The statistical tests are relatively straightforward in terms of interpretation. First, the change in turnovers is both visible in descriptive statistics (Figs. 2 and 3) as well as from statistical calculus. Paired t-test shows statistical significance of more than 90% (p-value less than 0.1) for turnover growth, profit margin and capital intensity. This significance level was considered appropriate since the sample size was quite limited, and the data in itself—the financial ratios—are always subjected to some manipulation, for instance through depreciation.

The turnovers declined significantly, and the difference in before-after values is more than 10% units. Profit margins and labor intensity changed, and there was some significance in the t-test statistics (< 0.1). So, profit margins declined and so did labor intensity, the latter meaning that in fact labor productivity increased. Capital intensity increased after the pandemic shock. For liquidity and solidity significant differences before and after were not detected and H_0 (before = after) was accepted.

The test results can be regarded valid, as the assumption of normality holds in all measured cases. Visual checking of the histograms was also made. However, the data was limited to 18 observations and there are several technical statistical parameters that can be considered for a more refined analysis.

Table 6 Data from the sample seaport companies: changes before-after in turnover growth, profit margin, liquidity position, solidity, and labor and capital intensity (productivity)

	Turnover growth change		Profit margin		Liquidity		Solidity		Labor intensity		Capital intensity	
Port no	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
1	3,6%	− 7.0%	12.7%	14.1%	0.44	1.18	0.42	0.62	11.0%	13.2%	3.50	3.63
2	13.8%	− 0.6%	18.4%	4.3%	1.92	3.71	0.45	0.57	10.9%	13.2%	2.73	3.46
3	3.8%	− 3.6%	11.5%	− 18.3%	3.36	4.31	1.56	1.91	9.6%	8.5%	4.51	5.21
4	25.5%	− 1.4%	9.9%	11.7%	1.82	2.24	2.54	4.32	29.8%	29.4%	0.54	0.74
5	17.6%	− 6.9%	− 2.0%	− 6.3%	4.01	0.51	6.60	1.62	9.9%	9.2%	4.94	6.30
6	10.0%	8.7%	8.3%	8.7%	1.74	0.69	0.95	1.61	6.6%	8.0%	0.58	0.73
7	2.3%	− 4.9%	17.4%	− 1.5%	2.80	2.79	9.17	5.38	28.7%	26.2%	5.54	9.74
8	5.1%	− 0.3%	7.3%	3.9%	1.44	0.78	5.60	2.85	11.8%	7.9%	4.45	5.34
9	6.2%	9.6%	11.0%	13.6%	0.84	1.37	0.26	0.28	19.1%	17.8%	2.39	2.45
10	− 2.2%	− 0.4%	2.2%	− 2.7%	0.78	0.72	1.55	1.73	15.9%	10.7%	5.66	6.76
11	15.8%	4.0%	0.0%	13.8%	0.58	0.79	0.12	0.20	22.0%	14.3%	7.88	9.63
12	4.6%	− 1.9%	− 1.1%	0.0%	4.07	2.53	4.07	2.53	26.9%	30.8%	10.59	7.83
13	16.0%	13.8%	14.8%	17.3%	5.23	2.27	0.29	0.36	5.3%	5.8%	1.71	3.45
14	3.6%	− 1.6%	7.1%	− 0.6%	1.64	1.60	1.36	1.02	16.9%	10.1%	6.96	8.81
15	8.4%	− 3.8%	33.3%	36.7%	0.36	0.25	0.21	0.23	na	na	3.73	2.95
16	1.8%	− 3.6%	5.0%	2.7%	2.38	5.02	0.42	0.48	19.8%	18.2%	3.03	2.77
17	14.0%	− 6.9%	32.5%	20.1%	3.33	6.76	8.23	21.03	9.9%	13.4%	4.86	6.12
18	− 0.3%	5.3%	− 10.3%	− 3.8%	1.63	2.16	0.85	0.90	31.1%	29.2%	0.15	0.12
t-test statistics	$t(17) = -4.075$ $p < 0.01$		$t(17) = -1.493$ $p = 0.08$		$t(17) = 0.181$ $p = 0.57$		$t(17) = 0.197$ $p = 0.58$		$t(16) = -1.389$ $p = 0.91$		$t(17) = 2.060$ $p = 0.03$	
Hypothesis conclusion	H_1 is accepted (Before > After)		H_1 is accepted (Before > After)		H_1 is rejected (Before ≤ After)		H_1 is rejected (Before ≤ After)		H_1 is rejected (Before ≥ After)		H_1 is accepted (Before < After)	
Shapiro–Wilk	$P = 0.386 > 0.1$		$P = 0.158 > 0.1$		$P = 0.489 > 0.1$		$P = 0.489 > 0.1$		$P = 0.674 > 0.1$		$P = 0.178 > 0.1$	
Normality	Accepted		Accepted		Accepted		Accepted		Accepted		Accepted	

Conclusion and discussion

The pandemic shock on Finnish ports was visible and detectable from the financial accounts of the port companies. However, despite the clear drops in turnovers, the ports steered through the pandemic surprisingly well. For example, liquidity or solidity of the companies hardly changed, although some expected decline occurred with regards to profit margins. In essence, not even the shareholders of the port companies seemed to have suffered considerably, at least as measured by profitability. However, this study did not analyze in detail how shareholder wealth was affected.

Solidity increased radically with some port companies, and the interesting question is why? While on average there was not a discernible solidity change, there were individual companies that multiplied their equity capital. This may have been a precautionary step of the owners preparing for an extended period of downturn and wanting to make sure that the port company survived the crisis. Whether this was a hasty decision or not, remains for the company owners to consider but the capital injections were substantial in some cases.

The drop in turnover was explained largely by the increase in capital intensity (i.e., decrease of capital productivity) since it is obvious that fixed assets cannot be adjusted overnight, not even within couple of years. Therefore, the capital productivity decline is a result of lost turnover and losses in transport volumes. Labor productivity decreased after the pandemic shock, implying that the port companies did not significantly adjust their labor force due to declines in turnover. The implicit assumption is that the workforce was one of the stakeholders that was spared the worst possible effects of the pandemic. This may be a consequence of the ports' ownership: most ports were owned by a municipality or city that was the single shareholder, and this shareholder could well have other priorities than maximising its wealth.

Productivity ratios can be affected by many factors that are not directly observable form the financial statements, and this must be kept in mind when interpreting the results. However, while labor contracts should affect all the ports in a quite similar manner, corporate finance strategies, for example, remain in most cases confidential and cannot be easily observed from the outside.

It is surprising that import-oriented ports survived the pandemic shock without any greater difficulty, whereas there were no other port type characteristics that could be identified as being predominantly present or absent in well- or poor-performing port companies. One prospective explanation is that Finland was able to keep the economy going quite undisturbed allowing the overall demand for goods and products to stay stable. Societal resilience may therefore provide one plausible explanation. Overall business and public service continuity are of course crucial to keep the wheels of the economy rolling.

Very different results were obtained by Xu et al (2021), where the impacts on 14 Chinese ports seemed to have been more severe, particularly regarding imports. The poorer performance of ports with balanced traffic is contrary to one's intuition: diversification should bring resilience rather than vulnerability. Whatever the underlying explaining factors are, they are worth further research.

Finland is often claimed to have too many seaports, with limited economic scale and strength. Looking at how the ports were able to withstand the pandemic shock and

recover from it, it is easier to note strength and resilience rather than vulnerability and weakness, at least in the light of annual financial statement data. It would therefore be worthwhile to consider whether the obvious diversified national port architecture is in fact to be endorsed rather than criticized. However, it should also be noted that quite many of the smaller ports are specialized, so conclusions should not be made hastily. Nevertheless, Tapaninen (2015) analyzed the Finnish seaport network and concluded that different cargo groups are served in four or five different alternative ports. This brings flexibility and resilience. Also, societal overall resilience may be one factor to be considered; perhaps not as an independent attribute, but rather as a foundation on which also the ports and maritime ecosystems operate.

An international comparison between ports should be done following the lines of this research. That would reveal if for example port size or types have something in common in terms of resilience and vulnerability. Unambiguous empirical data, such as reported financial ratios based on generally accepted accounting principles would strengthen such comparative analysis. Also, after so much port privatization, it would be interesting to see how ownership seems to have affected ports' resilience to economic shocks and how the shock effects were distributed across various stakeholders: owners, employees, suppliers and creditors, for example.

It should be kept in mind that port companies are just one actor and stakeholder group in maritime logistics business ecosystem. Therefore, looking at the situation of port companies alone does not necessarily provide a complete picture. There are other actors, as well, such as stevedores, forwarders, warehousing, port services, shipping lines and logistics companies. Shippers, particularly large industrial actors, have a strong bargaining power against seaport companies, but so do labor unions that work in seaports. These balances of power may at least partly explain the dampened pandemic impacts on seaport companies—these companies had to be kept in business and in operation to serve the needs of industry and community.

Finally, we can conclude that the impacts of the pandemic on Finland's seaport companies offer us some valuable lessons. The first being that even severe crises and exceptional situations can be met and handled without greater fuss and keep the operations continuing. The scenes painted by media at the time of the crisis were much bleaker than what was the reality—when looking back at the financial key ratios and witnessing the actual financial impacts. The second lesson was that many presumptions regarding the strengths and weaknesses of the ports were unjustified in the light of the actual financial impacts—resilience and business continuity was observed with smaller ports, import ports, and even some passenger ports. These were able to deliver decent, even unaffected, financial results despite the adversities caused by the pandemic, and they were able to recover very quickly back to business.

"Our greatest glory is not in never failing, but in rising every time we fall" (Confucius).

Abbreviations

$\bar{x}_d$	The average of differences between compared data unit pairs
μ_0	The expected difference under the null hypothesis
H_0	The null hypothesis
H_1	The alternative hypothesis
n	The number of pairs compared
P	The Shapiro–Wilk test significance value

p The significance of the paired t-test statistic value
S_d The standard deviation of the differences of the compared data unit pairs
t The paired t-test statistic

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Author contributions
PL designed and led the research work, analysed, and interpreted the data. PL wrote most parts of the paper. LO collected research data and wrote some of the background concerning Finnish ports, as well as reviewed the paper. SMP contributed to the introduction section and reviewed the paper. VP edited and reviewed the paper, made data and reference checks, and participated in statistical analysis. All authors approved the final manuscript.

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Availability of data and materials
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Declarations

Competing interests
There are no competing interests of any sort.

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