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Analyzing the impact of container shipping service reliability on global supply chain pressure: An asymmetric approach

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A B S T R A C T

Delays in international trade negatively affect the global world economically, commercially, and politically. We aimed to empirically determine the asymmetrical effect of the delays experienced in the arrival of container shipping vessels to their destinations on the pressure on the global supply chain by using Global Schedule Reliability (GSR) and Global Supply Chain Pressure Index (GSCPI). The dataset covers the period between January 2017 and April 2023 and consists of 76 observations. The results show that the effect of delays on the supply chain is asymmetrical, while the increase in delays increases the pressure, the decrease in delays has no effect. This shows that the effects of delays on the supply chain are sticky and take a long time to clear from the system. In this direction, policies are recommended to minimize the effect of delays on international trade.

INTRODUCTION

Optimum functioning of the global supply chain is crucial for the global economy, as production and consumption activities are interconnected worldwide. A well-functioning supply chain ensures efficient transportation of goods. Thus, costs are reduced and delivery times are accelerated. In addition, production activities located in different parts of the world due to globalization are not interrupted due to a well-functioning supply chain. It also helps stabilize prices, reducing inflationary pressures. In addition, a predictable supply chain increases investor confidence and reduces risk from uncertainty. In this respect, there is a strong relationship between economic activities and the operational ability of the supply chain (Shahzad et al., 2023).

One of the most important actors in the global supply chain is maritime transport, because approximately 90% of the world's cargoes in quantity and 30% in value are transported by sea (Janic, 2022). In addition, maritime transport plays a triggering role in international trade due to the cost advantage arising from large volumes (Lun et al., 2023). Since ships are a very large means of transportation, the cost of transportation per unit is considerably lower and this makes trade with long distances possible (Tongzon, 2022). In addition, wide and almost unlimited waterways can be used as roads for sea transportation, allowing cargo to be transported without requiring huge infrastructure investments. When a country is strongly connected to the global maritime transport network, it gains competitive advantage in the international market. For these reasons, maritime transport is of great importance for international trade and economy, both globally and regionally (Durmuş, 2023).

Operational activities in maritime transport are generally carried out in three different ways: liner shipping, industrial shipping, and tramp shipping. Industrial shipping is about

the transportation of large industrial companies' own cargoes with their own ships. Liner and tramp shipping operators provide transportation services to shippers. While liner shipping is based on the execution of activities by calling at certain destinations on a certain route on certain dates, tramp shipping is based on the execution of point-to-point contract-based activities (Song, 2021). Therefore, the types of cargoes carried by both types of operational activities also differ. While products with high added value are generally transported with liner shipping, products with low added value are generally transported with tramp shipping (Koukaki and Tei, 2020). For this reason, it is of great importance for the supply chains that ships reach their destinations on time in liner shipping operations for several reasons. First, the on-time arrival of ships ensures minimizing inventory holding costs (Cariou et al., 2019). This increases satisfaction for both companies and customers. Second, when ships arrive on time, manufacturers and other businesses can make healthy production plans (Schuldt, 2011). Possible delays can cause inefficiency, cost increase, and job loss by disrupting production plans. Third, the timely arrival of ships minimizes disruptions in the global supply chain. Since many production stages are globally dependent on each other, disruption in any stage will spread to other stages ((Hoffer, 2015). Fourth, the timely arrival of ships generates a better and more trusting relationship between ship owners and customers (Plomaritou and Papadopoulos, 2018). This situation can have a positive impact on the whole society by reducing costs. Fifth, the timely arrival of the ship will facilitate the optimization of transport modes, as cargoes arriving by sea transport are transported inland by other modes (Verbraeck, 2016). In general, the timely arrival of ships has significant effects on the global supply chain.

As is known, the pressure on the global supply chain ultimately increases the costs and reduces the purchasing power of the people by triggering inflation due to the reasons mentioned above (e.g., Liu and Nguyen, 2023; Ye et al., 2023; Kim et al., 2023). In addition, as the transportation costs increase, the need for foreign exchange of the state increases as transport charges are generally paid in foreign currency (Branch and Robarts, 2014), while their competitive advantages decrease (Porter, 1990). For this reason, we aimed to empirically reveal the possible differences in the effect of timely arrival of container ships on the pressure of the supply chain for companies and policy makers. Thus, proactive strategies can be developed by following the global container schedule reliability as the causality analysis determines the direction of information flow. Since the variables were produced relatively recently, no empirical study with a similar approach could be found in the literature. As a result of the asymmetric causality test we applied by considering the distributions of the variables, schedule reliability affects global supply chain pressure significantly and asymmetrically. We found only significant causality from decreases in reliability to increases in supply chain pressure. This shows that the decrease in the timely arrival of the ships increased the pressure, but the increase did not have any decreasing effect on the pressure. When ships start to delay, this causes congestion and pressure in the supply chain. Even if the ships start to arrive on time, this negative effect continues for a long time. In other words, the decline in reliability has a sticky effect on supply chain pressure.

In the second part of the study, the relevant literature is evaluated and a conceptual framework is formed. In the third part, the dataset and method used in the study are introduced. The empirical findings are presented in the last part.

Literature Review

The narrative approach was preferred while reviewing the literature. The fact that there are many studies from various fields in our research topic makes it difficult to conduct an in-depth systematic review on a specific relationship between specific variables. The narrative approach is based on making a general assessment of a topic by conducting a reasonable comparison. Thus, the studies are summarized by referring to the theory related to the research area and a framework is drawn for our own research question (Clark et al., 2021). While reviewing the literature, the keywords "GSCPI", "container schedule reliability", and “freight rate determinants” were searched in web of science (WOS). In addition, the same keywords were searched in the google scholar, and it was aimed to reach other studies that were not listed in the WOS, because studies from every index are listed in the scholar.

When studies on GSCPI are reviewed in the literature, it is seen that they are generally associated with environmental, climatic, economic, and financial issues. Some of these studies have been compiled to draw a general theoretical framework for our study. There are several studies examining the GSCPI variable in environmental and regional terms in the literature. In the study by Qin et al. (2023a), GSCPI was used as a dependent variable and other variables affecting it were investigated. The southern oscillation (SOI), which represents changes in air pressure differences in a certain region, and the geopolitical risk index (GPR), which represents global geopolitical risks, are modeled as independent variables with the wavelet-based quantile regression approach. The results obtained showed that both variables affect the GSCPI variable in different time dimensions. Extreme climatic conditions and increasing geopolitical risks increase the pressure on supply chains. In addition, as the increased GSCPI value directly affects

transportation activities, it can also affect CO_2 emissions. This situation was investigated by Tiwari et al. (2023) and they found that disruptions in the supply chain significantly increase gas emissions in the short and long term.

GSCPI was also associated with several macroeconomic financial indicators as it is also representative of global risk and can affect the level of the risk appetite of investors. In a study examining the relationship between gold prices and GSCPI using the wavelet approach, Li et al. (2023) determined that the GSCPI variable affects gold prices in the short, medium, and long term, while the gold price affects the GSCPI variable in the short and medium term. In this case, they stated that gold both played a predictive role in the GSCPI index and remained a safe haven by maintaining its hedging feature against increasing pressures. The same issue was investigated by Qin et al. (2023b) with causality analysis. The results obtained showed that the GSCPI variable had both positive and negative effects on the gold price. They indicated that increasing supply chain pressures may increase the tendency to view gold as a safe haven. In a study using the GSCPI variable as a proxy variable for global supply chain uncertainty (GSCU), the relationship between GSCU and precious metals was investigated by Su et al. (2023). In the research conducted with wavelet-based quantile regression analysis, it was determined that the interactions differed in the short, medium and long term. In addition, the effect of the GSCPI variable on alternative investment instruments has also been the subject of research. The relationship between GSCPI and bitcoin markets was analyzed by Qin et al. (2023c), and they determined that the GSCPI variable affects bitcoin markets positively and negatively, although it changes over time.

In terms of the components GSCPI contains, there are also direct effects on the inflation of the countries, as the increased GSCPI variable also means increased transportation costs. In the research conducted by Liu and Nguyen (2023), the effect of the GSCPI variable on the United States's inflation was examined. The results show that increasing pressure raises input costs and triggers inflation by increasing society's higher price expectations. A similar study was conducted by Ye et al. (2023) for developed and developing countries using panel data. They found that an increase of 1 standard deviation in the GSCPI variable increased the inflation of developed countries more than that of emerging ones. In a similar study conducted for Sub-Saharan African countries and using panel data, it was revealed by Andriantomanga et al. (2023) that changes in the GSCPI variable significantly affected inflation in African countries. They suggested that central banks could implement proactive monetary policies to control the increase in inflation by following developments in the supply chain. The effect of the GSCPI variable on inflation is not limited to price increases, and it is also pass-through to other areas. It was revealed by Kim et al. (2023) that increases in the GSCPI variable not only increase inflation but also cause decreases in employment and production activities. Due to increasing risk and uncertainty, companies naturally reduce their production and demand for labor. In a microscale study by Hupka (2022), the effect of the global supply chain pressure index on the leverage ratios of firms was investigated. The author determined that the increase in pressures in the supply chain decreased total debt ratios and was decisive in company policies.

The movement of the GSCPI variable naturally occurs under the influence of some factors. However, we couldn't encounter a study in the literature that directly analyzes this and is suitable for scope of our work. Because of this situation, we aimed to compile some studies on the components that make up the GSCPI variable and to generate a framework about the factors that may affect it. While forming the GSCPI index, maritime and air transportation costs, and the Purchasing Managers' Index (PMI) surveys of the major economies in the world are used. Maritime transportation costs are represented by Baltic Dry Index (BDI), which measures the market in which dry bulk cargoes are transported, and Harpex Index, which measures the market in which container cargoes are transported (New York FED, 2023). The PMI survey, on the other hand, shows the health of the general economy and provides information about macroeconomic conditions such as GDP, inflation, exports and labor (S&P Global, 2023).

When we consider the issue in terms of freight rates that make up the GSCPI variable, freights are basically formed by the balance between supply and demand. Shift on either side causes the equilibrium freight point to be higher or lower (Karakitsos and Varnavides, 2014). Therefore, any factor that affects supply and demand in maritime transportation will also affect the GSCPI. When we look at the literature, there are numerous studies, and it is not possible to mention all of them. In addition, since this study is not a study focusing on freights, we only considered it appropriate to summarize the factors affecting the freights they determined in their findings. While scanning these studies, the word "freight" was used as a keyword in various combinations in the databases mentioned above.

Factors affecting freights are divided into microeconomic and macroeconomic. Since each ship can be considered as a separate business in terms of microeconomics, the costs may vary depending on the condition of the ship and the business. The microeconomic factors discovered in the literature can be listed as age of the ship (Alizadeh and Talley, 2011), size of the ship (Kavussanos, 2003), speed of the ship (Beenstock and Vergottis, 1989; Magirou et al., 2015), characteristics of buyers

and sellers (Adland et al., 2016), open registries (Wilmsmeier and Martinez-Zarzoso, 2010), and bunker price (Shen and Chou, 2015; Yin et al., 2017). On the other hand, the macroeconomic and some other factors discovered in the literature can be listed as oil price (Shi et al., 2022), fleet size (Xu et al., 2011), industrial production (Strandenes, 1984), connectivity to transportation network (Wilmsmeier and Hoffmann, 2008), exchange rates (Chi, 2016), commodity prices (Bandyopadhyay and Rajib, 2023), inflation (Michail et al., 2022), GDP (Başer and Açık, 2019), port efficiency (Lei and Bachmann, 2020), port closures (Lewis et al., 2006), market sentiment (Bai et al., 2021), weather conditions (Açık and Başer, 2018), and pandemics (Xu et al., 2022). Any factor that affects freight will naturally be reflected in the GSCPI value, but modeling all these factors is relatively difficult.

Possible increases in GSCPI indicate that disruptions in the supply chain have increased, transportation costs have increased, and expectations for the future have become negative. Disruptions in the supply chain can negatively affect national and international trade, as they generate problems in the supply of raw materials and the delivery of final products. In addition, increases in transportation costs may discourage more entrepreneurs from participating in business activities (Reyes and Sawyer, 2016), increase costs, cause inflation (Carrière-Swallow et al., 2023), and thus reduce the welfare of society (Sexton, 2016). Finally, negative expectations can lead to a sticky process and the formation of chronic inflationary markets. In this respect, it is important to identify and analyze the factors that cause such events, represented by the changes in the GSPCI, to take proactive measures. In the literature, the focus has been mostly on the factors that GSCPI affects rather than the factors that affect GSCPI. These factors consisted of issues such as gas emission, inflation, employment, gold price, investment instruments, and cryptocurrencies. However, in order to understand such interactions, it is necessary to go to the source and examine the main factors affecting GSCPI. Since maritime transportation accounts for approximately 80% of global trade by volume (Song, 2021), the impact of the performance of this transportation mode on the supply chain is inevitable. However, there is a lack of empirical studies on the seaside of GSCPI in the literature. Ship delays, which significantly affect the supply, especially in maritime transport, are likely to have an impact on freight and therefore on GSCPI. When the proportion of fleet available for maritime transport decreases due to the shortage of supply, freights and thus supply chain pressure increase. In this respect, we demonstrated our contribution by analyzing the effect of GSR on GSCPI asymmetrically, considering the distributions of the variables.

MATERIALS AND METHODS

Our dataset covers the period between January 2017 and April 2023 and consists of 76 observations. The Global Schedule Reliability (GSR) variable is a reliability index compiled from statistics on whether container ships arrive at their destination on time. It is simply obtained by the ratio of the number of on time voyages to the total number of voyages and corresponds to a percentage. For example, if 15 out of 100 voyages arrive late in the relevant month, the reliability index is calculated as 85, showing that 85% of that month's voyages were made on time. During the calculation process, ships arriving 1 day after their estimated time of arrival (ETA) were also considered to have arrived on time. The index is published monthly by Sea Intelligence (2023). In the chart presented in Figure 1, the change in schedule reliability over time can be observed. The index, which followed a stable course and was around 75 until the start of the pandemic period, then fell to 30 with a rapid decline. The factors that cause this can be counted as the imbalance of supply and demand due to the pandemic, the closure of the Suez Canal, hurricanes, and port congestion.

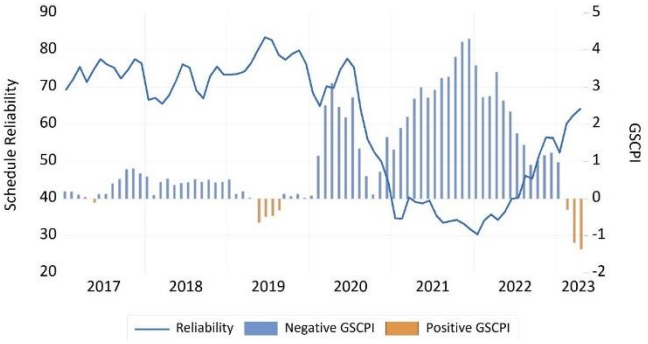

Figure 1. Global supply chain pressure vs service reliability

The Global Supply Chain Pressure Index (GSCPI) variable was proposed by Benigno et al. (2022) and published by the Federal Reserve Bank of New York to monitor the healthy functioning of the global supply chain by integrating transportation costs and some global production indicators (New York FED, 2023). The developed index consists of normalized values and can be interpreted in 3 different situations. First, the fact that the index is around 0 is interpreted as the normal functioning of the global supply chain. Second, a negative index indicates a very well-functioning supply chain without any significant pressure. Third, a positive index indicates that the supply chain is under pressure. In general, the index value is expected to be negative. However, it cannot be deduced that the supply chain works well in every negative situation, because in cases of economic recession, the index can take negative values because demand also narrows (Transport Geography, 2023). For instance, the negative values experienced since 2023 are

due to this situation rather than the perfection of the supply chain.

When the course of the index is analyzed in Figure 1, it is seen that it followed a normal course until the start of the pandemic, which moves around the 0 value. However, with the onset of the pandemic, it rose to very high levels. Factors such as factory closures, restriction of worker mobility, supply and demand imbalances, and online shopping trend exploding due to lockdown in the pandemic have increased disruptions in the supply chain. The index has started to decline since the second half of 2022. The main reasons for this can be shown as softening customer demand, decrease in real wages due to inflation, tightening monetary policies, and falling container freight rates (OECD, 2023). The index also successfully represents other important macro events in the period covered. For example, Hurricanes Maria and Harvey in 2017 caused delays and port congestions by disrupting the voyages of ships. Subsequently, this has increased the pressure on the global supply chain. Similarly, the blockage of the Suez Canal by a ship in March 2021 increased the pressure on the supply chain, causing increased voyage times and costs. The historical tightness of supply in the Los Angeles/Long Beach areas was another factor that increased the pressure. Finally, Russia's war against Ukraine in February 2022 disrupted the global optimization of container transportation and put pressure on the supply chain (Transport Geography, 2023).

Although the correlation between raw data in general seems to be significant with -0.74 (t= -9.59, p=0.00), raw data contain unit root, and means and variances of the variables change over time. The correlation between the differentiated series was insignificant with-0.02 (t= -0.25, p=0.79). In other words, there is no linear instantaneous relationship between the series.

The descriptive statistics values presented in Table 1 provide information about the movements and distribution characteristics of the variables in the period under consideration. The service reliability index took a relatively low value of 60% on average in the period under consideration. The highest reliability level was 83%, while the lowest level was 30%. The GSCPI variable, on the other hand, does not show much variation because it is related to how much standard deviation is deviated from the mean. The highest positive deviation was 4.30 while the highest negative deviation was 1.36.

When the variability of the variables was examined, the ratios of the standard deviation to the mean were calculated as 117% for GSCPI and 27.7% for GSR variable. In other words, while the supply chain pressure was highly variable, the confidence index followed a relatively stable course. Considering the distribution characteristics of the variables, the normality hypothesis is rejected at the 5% level for both variables. In other words, the series do not have normal distribution properties and contain asymmetrical structures. This is also supported by the fact that the skewness values are different from 0.

Table 1. Descriptive Statistics

	GSCPI	GSR
Mean	1.127985	60.80803
Median	0.596636	67.48200
Maximum	4.307350	83.47160
Minimum	-1.364702	30.41170
Std. Dev.	1.322246	16.90202
Skewness	0.638617	-0.538236
Kurtosis	2.477378	1.720295
Jarque-Bera	6.030796	8.855379
Probability	0.049026	0.011942
Observations	76	76

Source: Sea-Intelligence (2023); New York FED (2023)

To reveal the asymmetric structure in the variables more accurately, we presented the Quantile-Quantile Plots of both variables in Figure 2. These plots compare the distributions of the variables against the normal distribution. This means that the further away from the theoretical 45-degree straight line, the further away from the normal distribution. As can be seen, especially the tail values are located far from the normal distribution line. The distributions of both variables are S-shaped, and this is more evident in the GSR variable. These findings on the distributions of the variables show that using methods that consider asymmetry rather than linear analysis methods can provide more valid results.

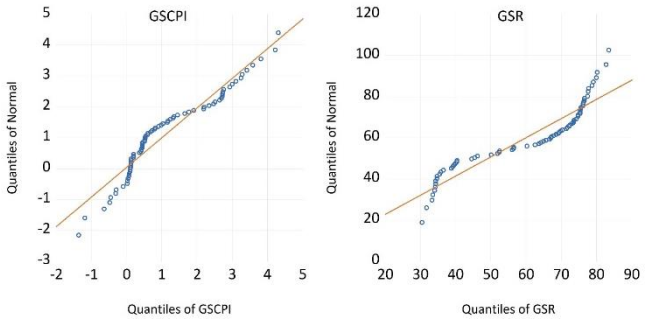

Figure 2. Quantile – quantile plot of the variables

Considering the asymmetric structure of the variables, we preferred to use asymmetric causality analysis in our study. In addition, the method we have chosen makes it possible to analyze the fact that the reactions of the players in the market may differ according to the market conditions because the players may be heterogeneous. Also, the information in the market may be spreading asymmetrically (Erdogan et al., 2022). The method was developed by Hatemi-J (2012) and makes it possible to test the relationships between the positive and negative shocks of the variables in 4 different combinations, i.e. (i) from positive to positive, (ii) from

positive to negative, (iii) from negative to negative, (iv) from negative to positive. The philosophy of the method is the same as the linear Granger (1969) causality analysis, only it uses the values of the shocks instead of the past values of the variables.

Since the Toda and Yamamoto (1995) process is followed in this method, the series does not have to be stationary. However, it is necessary to determine the maximum integration degrees of the series using unit root tests (Umar and Dahalan, 2016). If one or both of the series contains unit root, the maximum integration value is set to 1, while if neither of the series contains unit root, it is set to 0. Another advantage of determining the maximum degree of integration in the analyze process and adding it to the unrestricted VAR model is to overcome the long-term loss of information, because when the difference-taking process is applied to the series, it causes loss of information in the long run (Alola and Uzuner, 2021).

RESULTS

Augmented Dickey-Fuller (ADF) (1981) and Philips-Perron (PP) (1988) tests were applied to the series to determine the maximum degree of integration used in the asymmetric causality test, and the results are presented in Table 2. The ADF test assumes error terms to be independent and have constant variance. The PP test is an improved version of and is robust to autocorrelation and heteroscedasticity in the series (Enders, 2004). When the Q-stat (Ljung and Box, 1978) values of the series were examined up to 32 lags, there was a high rate of autocorrelation in both series. Therefore, in addition to the ADF test, the PP test was also applied. The null hypotheses of the tests indicate the existence of a unit root. In the results obtained, both tests revealed the same findings. While both variables contain a unit root at the level, they become stationary when their first difference is taken. For this reason, the maximum degree of integration was determined as 1 in the asymmetric causality test. In addition, econometrically, the unit root in the series shows that the mean and variances change over time. Such series are difficult to predict and carry the shocks to which they are subjected.

While applying the asymmetric causality test, the GAUSS software code was used. 1 was set as the maximum integration degree and 6 was set as the maximum number of lags in the model. AICc, which is the improved version of AIC for small samples, was preferred for the selection of the most appropriate lag value. The number of bootstrap simulations used to calculate critical values was determined to be 1000. The asymmetric causality test was tested in both directions, from GSR to GSCPI and from GSCPI to GSR. The null hypothesis of the test indicates noncausality between the variables. According to the results presented in Table 3, the null of the noncausality hypothesis was rejected in only 1 of the relationships analyzed in 8 different combinations. Since the data are not normally distributed, the null hypothesis of non-causality is rejected at the 5% confidence level when the MWALD test statistic is analyzed according to the bootstrap critical values. In this relationship, negative shocks in service reliability were identified as the cause of positive shocks in pressure in the global supply chain. However, an inverse relationship could not be determined. In addition, no significant relationship was found from the pressures in the supply chain to the reliability variable.

Table 2. Unit root test results

Test	Variable	Level		First Difference		Conclusion
		Intercept	Intercept & Trend	Intercept	Intercept & Trend	
ADF	GSR	-1.42	-1.41	-6.30***	-6.30***	I (1)
	GSCPI	-1.86	-1.48	-6.11***	-6.22***	I (1)
PP	GSR	-1.04	-0.86	-6.21***	-6.19***	I (1)
	GSCPI	-1.38	-0.33	-5.99***	-6.08***	I (1)

Notes: (1) CVs for ADF and PP are -3.52 for ***1%, -2.90 for **5%, -2.58 for *10% at intercept; -4.08 for ***1%, -3.47 for **5%, -3.16 for *10% at trend and intercept. (2) Schwarz Information Criteria was used in the selection of lag length in ADF. (3) Barlett kernel spectral estimation and Newey-West Bandwidth methods were used in PP.

Table 3. Asymmetric causality test results

	GSR^+ to $GSCPI^+$	GSR^+ to $GSCPI^-$	GSR^- to $GSCPI^-$	GSR^- to $GSCPI^+$	$GSCPI^+$ to GSR^+	$GSCPI^+$ to GSR^-	$GSCPI^-$ to GSR^-	$GSCPI^-$ to GSR^+
Optimal Lag	1	1	1	1	1	1	1	1
Additional Lag	1	1	1	1	1	1	1	1
Test Stat	1.52	0.21	1.74	7.76	0.20	0.06	0.01	1.60
Asymp. P Value	0.21	0.64	0.18	0.00*	0.65	0.79	0.89	0.20
CV 10%	2.99	2.70	2.98	2.85	2.85	2.60	2.99	2.96
CV 5%	4.79	4.21	4.86	4.18	3.96	3.87	4.58	3.97
CV 1%	9.75	9.79	11.18	7.80	6.86	8.75	9.38	7.65

Note: *Null of noncausality was rejected.

DISCUSSION AND CONCLUSION

Container transport vehicles mostly perform their activities in accordance with a certain schedule. The ports they will call at, the times they will arrive, and the routes they will follow are determined in advance. However, due to some circumstances, there may be delays in their arrival. Adverse weather conditions, storms, and rough seas can make it difficult for ships to navigate and cause changes in routes, contributing to ship delays. Congestion at their port of call can delay loading and unloading activities, delaying their arrival at the next port. In addition, strikes at ports can delay operations. In addition, delays may occur as it becomes difficult to perform port operations and sail on certain routes in geopolitically risky areas. Finally, rare global events such as the blocking of the Suez Canal can also cause ships to arrive late at their destination (Janic, 2022). Whatever the reason, these delays have great effects on the global economy.

In our research, we aimed to determine the effect of the late arrival of ships of companies engaged in container transportation to their destinations on the pressure in the global supply chain. The effects of delays in maritime transport will be much greater than in other modes of transport, as approximately 90% of the world's manufactured goods in quantity are transported by container shipping (Song, 2021). The possible consequences of late arrival of ships are: (i) freight rates will increase as the supply of ships in the market is restricted, (ii) goods will be in short supply and prices will increase due to longer delivery times in international trade, (iii) inventory costs will increase due to longer holding times, and this will be reflected in prices of the goods, (iv) production processes will be disrupted because the production of goods is carried out in different countries due to the global integration of supply chain, (v) production and consumption activities will slow down as the confidence in transportation modes will decrease and uncertainty will increase, (vi) because the optimization of other transportation modes will deteriorate due to delayed ships, costs of them will also increase. In addition, since the delayed ships will increase their speed in order to reach the schedule on time, the emission rates they release will increase and thus the environmental cost will increase (Song, 2021). All these developments will be reflected in the country's economies as inflation and economic slowdown, as researched in the literature (Andriantomanga et al., 2023; Liu and Nguyen, 2023; Ye et al., 2023). In addition, as this situation increases uncertainty, investors can follow the developments in the global supply chain and switch to safe haven (Li et al., 2023; Qin et al., 2023b; Su et al., 2023) and alternative (Qin et al., 2023c) investment instruments, which contribute to the economic slowdown by causing a decrease in the demand for goods and services.

When we examined the data we used in the research, their distributions were not normal and they may contain asymmetrical relations, considering the tail effects. As a result of the asymmetric causality test that we applied, we were able to detect a significant result for only 1 of the 4 possible outcomes. Negative shocks in the schedule reliability variable are the cause of positive shocks in the GSCPI variable. In other words, as the rate of ships arriving at their destinations late increases, the pressure on the global supply chain also increases. In addition, the optimum delay for relationships was determined to be 1, which can be interpreted as the delays of ships in the current month affect the supply chain pressure in the next month. However, we could not detect any significant results from the increase in the rate of ships arriving on time to the decrease in pressure. This situation can be explained by several different reasons. First, market players may place more emphasis on negative news than positive news, which can also be supported by the negative bias in behavioral economics (MacFadyen, 2015). Second, negative news may also negatively impact future expectations, causing supply chain pressure to remain sticky. Third, shipowners may be trying to compensate for losses caused by ship delays by keeping freight rates higher for a longer period. Fourth, input prices, which have risen due to pressure from delayed shipping, may not fall afterwards. For the remaining 2 combinations, i.e., positive to positive and negative to negative, it is a reasonable result that no significant result can be obtained. The increase in the rate of on-time arrivals does not increase the pressure on the global supply chain, on the contrary, it can be expected to reduce it (although we cannot support this situation statistically). Similarly, as the rate of ships arriving on time decreases, the pressure on the supply chain does not decrease, but rather increases (we were able to support this statistically). Insignificant results meet our theoretical expectations. From the perspective of the components of GSCPI, the decrease in ships arriving on time may lead to a decrease in the number of available ships in the market, resulting in an increase in freight rates due to the shortage of supply side. In addition, there may be cost increases due to the optimization problems, as disruptions occur in intermodal transport modes due to delayed ships. In general, the increase in supply-demand imbalance increases the pressure on the global supply chain.

Based on these results, some suggestions can be made for policy makers to prevent ship delays. First, investments in facilitating the transfer of containers between ports can be increased and thus an alternative route can be offered to the container in case of any setback or congestion. Second, even if relatively small ports cannot be invested in, hub ports can

be developed to handle a large amount of cargo traffic by optimizing their location and equipment reserve. Third, the cargo operation capacity can be increased by increasing the stock of mobile and floating equipment and positioning it in the optimum position, providing rapid dispatch to the needed area. Thus, the need for fixed investments that require high costs can be reduced. Of course, improvements made only on the port side are not enough to eliminate the negative effects of the pressure on the supply chain. Some suggestions can also be offered to line operators against the pressure in the supply chain. First, by strengthening the communication channels with the ports and the shippers, it can be ensured that the congestion at the port does not increase due to delays. Second, increasing container inventories can enable faster circulation. Third, in case of congestion, relations with alternative ports can be developed and cooperation in relevant alternative regions can be increased. Fourth, they can prepare risk management plans and thus be agile in ship planning and emergency actions in case of any congestion.

On the other hand, it could theoretically be expected that the pressure on the increasing supply chain would significantly affect the late arrival of ships as more ships could be delayed due to increased pressure. However, our empirical findings did not provide any significant evidence regarding this relationship. The biggest limitation of the study is related to data availability. The GSCPI variable can be obtained much earlier than the GSR variable. However, the scope of the research remained relatively narrow since the values of the GSR variable dated before January 2017 could not be reached. Particularly, including the effects of the Chinese boom effect in the process until the 2008 global economic crisis and thereafter the effects of oversupply in the maritime industry can bring important findings to the literature. In addition, it can be examined in which periods the pressure of reliability on the supply chain is significant with time-varying approaches. Also, models and simulations can be made on major events that significantly disrupt the global supply chain and their possible consequences can be investigated.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

The author declares that formal consent is not required for this type of study.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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