



## Research paper

## Are there bubbles in shipping freight during COVID-19?

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## ABSTRACT

This study examines the potential bubbles' shipping freight rates during the pandemic through the Generalized Supremum Augmented Dickey-Fuller test. The results explore multiple bubbles in the freight rates during corona disease (COVID-19). Moreover, the result finds that Baltic Dry Index is the most explosive and shows four bubbles, followed by Baltic Clean Tanker Index. The volatile behavior has been more frequent and pronounced since the second quarter of 2021, mainly instigated by the economic recovery. The results detect four bubbles in Baltic Dry Index caused by strong demand for raw materials and uncertainty restrictions. Furthermore, a single bubble in the Baltic Dirty Tanker Index is caused by the increasing oil price, growing demand for floating storage while burst due to new restrictions of the second wave, declining oil prices, and shortages of vessels. The need for oil products, logistical problems and the highest oil prices are the leading determinants of Baltic Clean Tanker index bubbles.

## 1. Introduction

A bubble is an important phenomenon that seriously affects financial and commodity markets (Khan & Köseoğlu, 2020). The bubble process is presented in several ways, and the price bubble is defined universally. According to Stiglitz (1990), a bubble arises when the market price surpasses the fundamental price. Similarly, a quick increase in price boosts demand and attracts investors, but a sudden drop discourages investors and reflects reduced demand (Case & Shiller, 2003). As a result, the quick rise followed by the decline indicates the presence of a bubble (Brunnermeier, 2016). Blanchard and Watson (1982, p. 945) defined a bubble as a process in which speculators purchase assets for more than their estimated underlying worth. As per the rational behaviour theory, asset prices reflect market knowledge, and bubbles are identified by the difference between predictable prices and actual values.

The main purpose of the study is to investigate whether there are bubbles in shipping freight rates, such as the Baltic Dry Bulk Index (BDI), Baltic Dirty Ship Index (BDTI), and Baltic Clean Tanker Index (BCTI), during the Coronavirus Disease (COVID-19) period. Similarly, to examine the difference in the behaviour of freight rates during the pandemic. The freight rates have shown sudden rise and fall during the pandemic and explosive behaviour. The presence of a bubble is

confirmed if the prices deviate from the fundamental values and burst vice versa (Stiglitz, 1990; Xie et al., 2022). Moreover, international trade is highly dependent on efficient transportation, and seaborne trade occupies a unique position in global trade (Khan et al., 2021a; Su et al., 2019; Tianming et al., 2021). Facts have proved that COVID-19 is the biggest crisis adversely affecting the global economy (Khurshid & Khan, 2021). The shipping industry is the main pillar of international trade and economy, and about 80% of the goods are transported through sea (Tianming et al., 2021), which has been severely affected by the pandemic (Khan et al., 2021b). Meanwhile, international sea trade slipped by -3.8% in 2020 due to weak economic growth, and port container traffic declined by -1.2% (UNCTAD, 2020). Furthermore, the pandemic has caused supply disruption, resulting in material shortages, port closures, and labor unavailability (Mańkowska., 2021). As a result, the shipping freight has witnessed successive upward trends and experienced explosive behaviour. Hence, studying the volatile behaviour of freight rates is extremely critical because of their direct and indirect influence on consumers and the overall economy.

The shipping industry endures the brunt of the pandemic due to the restricted economic and trade activities, coupled with the lowest need for raw materials and energy, which leads to the falling demand for shipping (Melas and Michail, 2021). It has caused great confusion in terms of severity and economic consequence, generating shortages of

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shipping and the highest freight rates. The COVID-19 triggers a financial crisis with wide-ranging implications for maritime transport, ports, shipping, and supply chains (Ho et al., 2021). The freight rates have witnessed the lowest level triggered by the complete lockdown in the first half of 2020 (Su et al., 2021; Xuan et al., 2021). Most European countries and the U.S. are under lockdown, with the least industrial productions obstructing the demand for shipping (March et al., 2021). However, the shipping industry has rebounded in the second half of 2020 due to the opening up of some Asian economies and the decrease in new cases. Meanwhile, the pandemic has pushed consumption, and e-commerce is the alternative purchasing source, increasing demand for shipping (Khurshid et al., 2023; Docherty et al., 2021). The most crucial factor is the stranded ships, which interrupt the supply chains and ultimately pressure the freight cost (Molaris et al., 2021). This unavailability of containers has resulted in the highest freight cost, especially from China to the U.S. and Europe.

Since the second quarter of 2020, China's exports to the U.S. and Europe have increased because the Chinese economy is accelerating its recovery. The shortage of ships and containers cannot meet the unexpected increase in demand which has affected trade flows (Michail et al., 2021). The rapid recovery of China's economy in 2020 sustains the smooth flow of international maritime trade. Moreover, trade flows are supported by containerized goods exported from China to the U.S. However, weak oil demand and OPEC production cut affected container demand in 2020, while the market gradually recovered and supply improved in 2021. The crude oil price hit a high level in 2021 due to economic recovery, and the prospect of the international energy market may increase demand for large crude oil carriers (Michail, 2020; Michail & Melas, 2022). The demand for raw materials drives the shipping industry in the second quarter of 2021, with freight costs at the highest level (Michail & Melas, 2020). The highest shipping cost has adversely affected commodity prices in the last quarter of 2021. Meanwhile, the freight cost bubble burst in October 2021, mainly caused by the stability of the supply chains, which may cause a decline in freight costs. Hence, the sudden ups and downs of major shipping freight such as BDI, BDTI, and BCTI during a pandemic are extremely paramount to be examined, and the policy implication can be useful input for the concerned stakeholders. The present highs in freight rates are mainly driven by the shock caused by the pandemic and unexpected increases in shipping demand (UNCTAD, 2020).

The discussion highlights the following research gap. The impact of COVID-19 on shipping freight rates is not fully understood, and there is a lack of research on the presence of a bubble in these markets during this period. The literature on bubbles in the shipping industry is limited, and there is a need for more studies on the topic. There is a gap in understanding the behaviour of shipping freight rates during a crisis. In conclusion, detecting a bubble during the pandemic is critical for policymakers because it influences financial and commodities markets. The shipping industry plays a crucial role in the global economy, and COVID-19 has severely impacted the shipping industry, causing supply disruption and leading to the highest freight rates. The sudden rise and fall in the shipping freight rates during the pandemic need to be examined as it directly and indirectly influences the economy. The COVID-19 has caused a financial crisis with wide-ranging implications for maritime transport, ports, shipping, and supply chains. The highest shipping cost has affected commodity prices, and shipping freight's sudden ups and downs during the pandemic must be examined for policy implications.

Contemporary literature can be contributed in several ways. The study considers the detection of bubbles in BDI, BDTI, and BCTI during the pandemic. These shipping freights have experienced upward and downward movements, making ascertaining these trends and bubbles essential. The close correlation between transportation costs and global trade makes bubble behavior and its underlying factors important. In addition, the uncertainty caused by the pandemic has made international trade fragile, negatively impacting the shipping industry. Therefore, the instability of freight will affect the supply chain and commodity

prices. Therefore, evaluating market efficiency during a pandemic is critical to the global economy and investors. Similarly, based on our knowledge, this study examines the impact of COVID-19 on the explosive behavior of major shipping freights such as BDI, BDTI, and BCTI, which contributes to the existing literature. The econometric techniques of Supremum Augmented Dickey-Fuller (SADF) and Generalized Supremum Augmented Dickey-Fuller (GSADF) are suitable for exploring bubbles because the window size is flexible, the detection rate is higher, and the bubbles in the full sample and sub-samples can be identified. The results explore multiple bubbles in freight rates driven by the demand (supply) of goods and raw materials during COVID-19. The outcomes indicate that BDI has multiple bubbles caused by strong demand for raw materials and uncertainty restrictions. The findings offer useful information about the specific determining factors of the fluctuations and can be avoided in the future by overcoming the underlying factors. Moreover, the early warning enables the stakeholders to mitigate the effects of the potential bubbles. It helps to design mechanisms to identify and avoid negative influences on the international shipping market and economy. The international shipping industry has a contagion impact on the commodity market, energy market, and the overall economic outlook. As maritime trade is the main pillar of global trade, uncertainty in the shipping industry can significantly impact the economy. Thus, examining the explosiveness is valuable and can help lessen the risks of collapse in the shipping industry.

The remaining of this paper is outlined as follows: Section 2 describes the literature review. The present value model and methodology are explained in section 3. The data is described in section 4. The empirical analysis is outlined in section 5. While section 6 presents the conclusion.

## 2. Literature review

Kavussanos and Visvikis (2006) find that the global shipping industry experiences shipping freight volatility. Adland et al. (2006) discuss the asset bubbles in shipping to confirm whether the asset market value deviates from the basic values. They conclude that asset market values are closely related to basic values and detect no bubbles. Scarsi (2007) concludes that shipping freight experiences troughs, recoveries, peaks, and collapses triggered by geopolitical risk and financial instabilities. Cocconcetti and Medda (2016) analyze the BDI boom and bust and confirms bubbles in BDI driven by speculation. Chen et al. (2018) find BDI falls substantially during the financial crisis in 2008, and the bubble burst as a result of exogenous and endogenous factors. Su et al. (2019) examine the shipping freight bubbles and detect multiple bubbles. It shows that freight rates deviated from the fundamental values four times, caused by the strong demand for oil prices, dollar volatility, and the global financial crisis. Khan et al. (2020) use the GSADF method for bubble detection in precious metals and conclude that multiple bubbles.

Arifin (2020) reveals that COVID-19 significantly impacts the global shipping market, characterized by slumps in demand for goods, affecting the freight rate of the global containers. Michail and Melas (2020) conclude that COVID-19 directly impacts BDI and BDTI because of the demand contraction. Millefiori et al. (2021) report an unprecedented decline in maritime mobility as a result of the lockdown and imposition of containment measures. Khan et al. (2021a) evaluate the BDI response to oil price fluctuations in the context of geopolitical uncertainty. The results explore that BDI is highly vulnerable to price changes in the short run, which is more robust in the presence of geopolitical instability. Khan et al. (2021b) investigate the role of global economic uncertainty between oil prices and BDTI. They conclude that oil prices are the leading determinant of BDTI in the short term, while the higher global uncertainty makes the correlation between oil prices and BDTI more pronounced. Menhat et al. (2021) notice that COVID-19 has adversely affected the Malaysian maritime industry. Xu et al. (2021, pp. 1–19) evaluate the COVID-19 effects on transportation and logistics in China. The outcomes explore that the pandemic negatively impacts land freight

rates and is insignificant to ocean freight. Tianming et al. (2021) assess the COVID-19 impact on the maritime supply chains and conclude that the pandemic leads to strict lockdowns and squeezes economic activity and maritime transport and freight rate. Khan et al. (2021c); Khan et al. (2021d) employ the GSADF approach to detect the bubbles in oil and coal prices, and the results explore multiple bubbles.

The existing literature reveals a lack of studies about freight rate bubbles during the pandemic. In contrast, most studies before the pandemic confirmed that bubbles occurred due to geopolitical risk, oil prices, speculation, and financial crisis. On the other hand, the freight rate studies during the pandemic explain that the freight rate remains volatile because of the uncertainty caused by COVID-19 and the lowest economic activity and oil prices. However, the existing literature lacks specific studies that evaluate the explosive behaviour of shipping freight. Thus, we examine the bubble phenomenon of shipping freight during the pandemic and confirm multiple bubbles. Moreover, the studies about the freight bubbles before the pandemic concentrates exclusively on BDI while ignoring the other freight rates, such as BDTI and BCTI. Evaluating the entire shipping market is extremely critical for prediction and policymakers. Therefore, this study considers the major shipping freight rates such as the BDI, BDTI, and BCTI during the pandemic, representing different segments of the industry, and offers a comprehensive knowledge of the international shipping market and ocean trade. Similarly, some studies about freight rate fluctuation suggest no data testing and quantitative while more concentration on the qualitative, which can provide a precise and useful estimation of the actual behaviour. However, we use the daily data and an econometric technique to detect the explosive behaviour of the shipping freight and confirm the multiple bubble and origin and end coincides with specific events. The methods of SADF and GSADF are suitable for exploring bubbles because the window size is flexible, the detection rate is higher, and the bubbles in the full sample and sub-samples can be identified.

### 3. Methodology

The SADF approach proposed by Phillips et al. (2011) is applied to identify the price bubble. The right-hand unit root test subject to forward recursive regression is suitable for measuring the repeated behavior of the unit root relative to explosives. The periodic downfall of prices and the bursting of the anticipated price bubble are measured by the SADF test. The right-hand SADF process suggested by Phillips et al. (2011) is formulated as below:

$$\Delta M_t = \theta + \delta M_{t-1} + \sum_{j=0}^l \theta_j \Delta M_{t-1-j} + \varepsilon_t, \varepsilon_t \sim NID(0, \sigma^2) \tag{1}$$

where  $M_t$  is freight cost and  $l$  is the number of lags. The basic location of the sequence is regularly 0; therefore, at the endpoint of each sample, change from  $q_0$  to  $q_1$ . The ADF statistic for a case that estimates from 0 to  $q_2$  is illustrated by  $ADF_0^{q_2}$ . The SADF statistic is as follows:

$$SADF_{q_0} = \sup_{q_2 \in (q_0, 1)} \{ADF_{q_2}\} \tag{2}$$

In the case of a single bubble, SADF is adequate, while freight cost has multiple bubbles, which is inappropriate. Nevertheless, Phillips et al. (2012, 2013) spot some weaknesses of the SADF technique for proving numerous bubbles. It is particularly evident in long sample periods or rapidly changing markets where more than one episode of exuberance is suspected. To overcome this weakness and deal with multiple breaks of exuberance and collapse, the GSADF test introduces flexible window widths in the implementation (Phillips et al., 2012; 2013). GSADF test flexible window continues a description of this problem (Phillips et al., 2012; 2013). It usually focuses on a set of sample systems for ADF testing. The structure balances the end of the regression  $q_0$  to 1 and increase the sample by adjusting the initial and end-stage of the recursion in the variable window length to the useable range.

The “GSADF employed to estimate the multiple bubbles (Phillips et al., 2011, 2012). The method suggested by Phillips et al. (2011), compared to other approaches of recursive formulas, achieves acceptably for structural breaks and is particularly effective as a real-time bubble finding algorithm (Homm & Breitung, 2012). Similarly, the method is appropriate for any frequency data and is measured by a formal statistical valuation of bubble presence, while other approaches are subject to the subjective judgment of the deviations from the fundamental prices. Hence, the method is suitable for real-time bubble recognition. Similarly, the procedure used to determine the dates of bubbles through a recursive procedure against critical values for the standard right-tailed ADF statistic. Furthermore, the tests allow a periodic test for possible non-stationary behavior of a time series against mildly explosive alternatives. The GSADF test also has the advantage of detecting bubbles even under a condition of potential misspecification of the market fundamental process. Instead of establishing the beginning point of the sample, the GSADF test extends the sequence by changing both the beginning and the ending points over a feasible range of flexible windows.”

Especially, the GSADF permits  $q_1$  altering from 0 to  $q_2 - q_0$ . The precise detection of multiple bubbles is due to greater windows and better data sub-samples. Phillips et al. (2012, 2013) describe the GSADF statistic to be the largest ADF statistic within a rational domain of  $q_1$  and  $q_2$ ; this statistic as  $SADF(q_0)$  follows:

$$SADF_{q_0} = \sup_{q_2 \in (q_0, 1), q_1 \in (0, q_2 - q_0)} \{ADF_{q_1}^{q_2}\} \tag{3}$$

the limit of the GSADF test is illustrated in Equation (6) while continuing the random walk and the null hypothesis in the regression model and represented as follows:

$$\sup_{q_2 \in (q_0, 1), q_1 \in (0, q_2 - q_0)} \left\{ \frac{\frac{1}{2} q_w [w(q_2)^2 - w(q_1)^2 - q_w] - \int_{q_1}^{q_2} w(q) d_q [w(q_2) - w(q_1)]}{q_w^{1/2} \{q_w\} \int_{q_1}^{q_2} w(q)^2 d_q - \left[ \int_{p_1}^{p_2} w(q)^2 d_q \right]^2} \right\}^{1/2} \tag{4}$$

where  $q_w = q_2 - q_1$ .

The procedure develops with the standard Wiener method with systematic and random attributes and leads to sampling with a constrained point. It is accepted that there is  $n_1, n_1, \dots, n_N$  a stated break between them with an equal break. The significant value of GSADF statistics surpasses the right-tail critical value of SADF statistics. The asymptotic critical value is decided through numerical simulation, and the bootstrap program is a method of finite sample distribution. This technique includes a data labeling strategy, so changing the main reason for the explosion of freight cost characteristics is unreasonable.

### 4. Data

The daily data of the major shipping freight rates from September 2019 to December 2021 are used to examine bubbles during the pandemic. The periods are described with frequent rapid fluctuations in the shipping freights. The pandemic has squeezed the global maritime trade due to falling demand for goods, severely impacting the international shipping industry. Moreover, COVID-19 has disrupted the global economy, cut production activity and consumption and affected demand, supply and logistics (UNCTAD, 2020). The freight rate movements are expressed by BDI, BDTI, and BCTI, which the Baltic Exchange in London publishes. Thus, the average shipping price for dry bulk material is called BDI, which can express the economic outlook. Likewise, BDTI is the average global shipping cost of oil on the 12 international routes. However, BCTI measures tankers prices that ship the cleaned cargo of the oil product like petrol, diesel, and heating oil.

The trends of the shipping freights are shown in Fig. 1. It shows that the shipping industry is devastated in the first stage of the pandemic

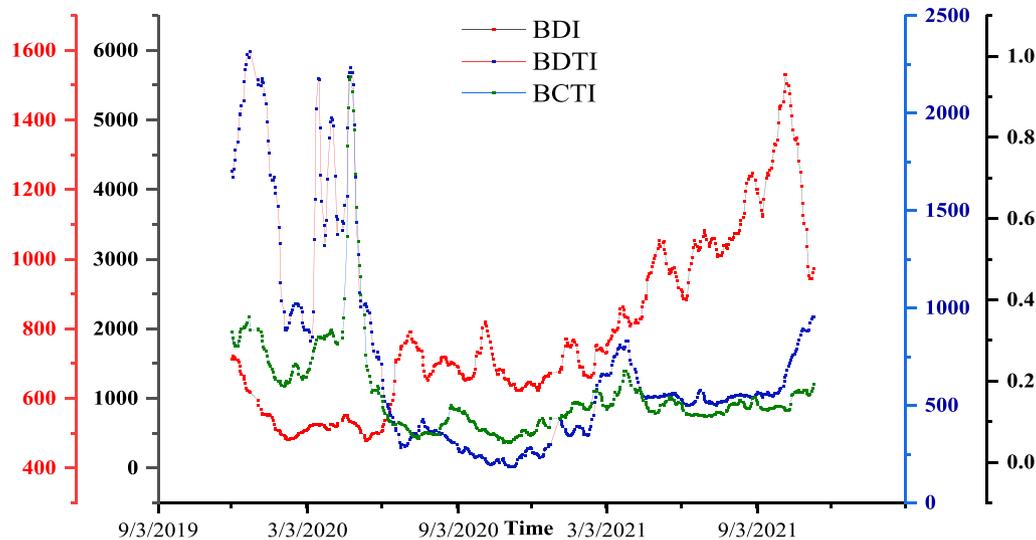


Fig. 1. Trends of shipping freight.

because of the sudden lockdowns and social restrictions. This situation gets worse with the border closure and mobility restrictions. The economic growth slowed, and the demand for raw materials fell because of the shutting of the manufacturing industries, reflected in the diminishing demand for the shipping industry. Moreover, empty containers and ships are stranded in different countries, disrupting the supply chain. As a result, the shipping demand slumps in the first half of 2020, and cargo ships have fewer port calls. The oil prices collapsed in mid-March 2020, which contracted the global maritime trade, and the major freight rates witnessed their lowest level. BDI is severely inflicted in the first quarter of 2020, mainly caused by the global trade collapse because it is the dry bulk material cost of shipping. While the worldwide demand for raw materials is at the lowest level, and BDI remains at the low level.

Similarly, BDTI is also affected because the pandemic has collapsed the oil demand and prices decline to the lowest level in history, which is detrimental for the BDTI and BCTI in the first quarter of 2020. However, BDTI and BCTI rebound in the second quarter of 2020 as the oil-related product has recovered, shown in the rising trends of the shipping freight rates. Meanwhile, BDI remains at a low level, mainly explaining that global demand for raw materials is still stagnant due to uncertainty followed by the rapid spread of the virus. However, the fear of the second wave in August 2020 resulted in the decline of both BDTI and BCTI, followed by a decrease in energy prices. Meanwhile, BDI shows a mild upward trend which can explain that some Asian countries have resumed their economic activities due to a receding number of new cases. This has increased demand for the goods and has led to shipping demand in late 2020. However, the shipping industry endures the pandemic till the first quarter of 2021, and the situation will turn around in the second quarter of 2021. Therefore, BDI moves upward rapidly as the economies resume economic activities, increasing the demand for raw materials, increasing the shipping demand, and putting pressure on the freight rates. Moreover, the stranded ships and containers have adversely put pressure on the shipping cost because of the unavailability of the containers. As a result, the shortage has exacerbated the shipping cost and has shown a historically high level. However, the shipping freights started declining in November 2021 due to the stability in the supply chains, which may help reduce the commodity's cost.

The explanation of the shipping freights is illustrated in Table 1. The difference between the maximum and minimum values indicates that BDI has the highest volatility during the pandemic, which is confirmed by the standard deviation. It explores the highest standard deviation followed by BDTI. Moreover, positive skewed values are detected for all the freight rates. The kurtosis values are greater than 3, which explores

Table 1

Summary statistics.

	BDI	BDTI	BCTI
Mean	1930.356	702.187	559.386
Maximum	5650.000	1597.000	2190.000
Minimum	393.000	403.000	309.000
Std. Dev.	1230.857	295.174	254.426
Skewness	0.932	1.529	3.461
Kurtosis	3.171	4.438	19.255
Jarque-Bera	70.957***	231.320***	6321.496***

Note: \*\*\* represents the significance level at 1%.

that series are leptokurtic distributed. Similarly, the non-normality distribution is detected through the Jarque Bera test.

### 5. Empirical results

The study employs different unit root tests like Augmented Dickey and Fuller (1981) test, Phillips-Perron (1989) test, and Kwiatkowski, Phillips, Schmidt, and Shin (1992) test to explore the stationarity. Table 2 exhibits the outcomes of unit root tests. It shows stationarity at the first difference. Moreover, the outcomes confirm that variables follow the random walk process.

The explosiveness of the shipping freight rates are examined through the SADF and GSADF. It identifies bubbles when BSADF statistics exceed than the critical values and ends when the statistic drops below the critical value (Khurshid et al., 2023; Su et al., 2020). The findings are highlighted in Table 3. The outcomes mention that shipping freights have bubbles as the test statistics exceed than the critical values. The result reveals explosive behaviour in shipping freights and underlines detecting the bubbles.

Table 2

Unit root test.

	ADF	PP	KPSS
BDI	-1.360	-1.238	2.211***
BDTI	-2.308	-2.332	1.062 ***
BCTI	-3.438	-3.142	0.700***
$\Delta$ BDI	-7.675**	-9.318***	0.087
$\Delta$ BDTI	-11.652***	-8.172***	0.143
$\Delta$ BCTI	-9.262***	-7.938***	0.038

Note: \*\*\* shows the significance level at 1%.

**Table 3**  
SADF and GSADF.

		BDI	BDTI	BCTI
SADF		4.491***	2.664***	6.692***
SADF critical values	90%	0.822	1.144	1.334
	95%	1.152	1.727	1.489
	99%	1.456	2.194	1.612
GSADF		8.009***	8.243***	7.369***
GSADF critical values	90%	2.064	1.704	1.353
	95%	2.252	1.744	1.572
	99%	2.478	1.776	1.748

Note: \*\*\* shows significance at the 1% level.

Fig. 2 exhibits the multiple bubbles in BDI. The first bubble starts on 6/12/2020 as the strong steel demand has pushed the freight rate. Meanwhile, the Chinese iron ore has increased by 32% due to higher economic stimulus efforts, while concern remains for the iron supply from Brazil. Moreover, BDI rebounds as a result of a sharp rise in demand for steelmaking ingredients. The rising shipping of iron ore from Brazil and coal from the U.S. to India has decreased the number of ships and caused a massive change in freight rates. The iron ore flow from Australia and Brazil contributes to the rising freight. Similarly, interest rates have gradually risen, and operators have become more active, positively impacting freight costs. As China increases its purchases of goods, such as coal and iron ore, the cost of transporting commodities is soaring (Michail and Melas, 2021). However, the momentum breaks on 7/20/2020, and BDI decreases, which may be explained by the uncertainty and restrictions caused by the second wave of the pandemic. Moreover, strategic investments such as the new building, ordering, and repairing are affected due to widespread uncertainty in 2020. It shows that new buildings and repairs have been postponed while ordering contracts down by 53% in July 2020 (Ho et al., 2021). Similarly, the merger agreement between Hyundai Heavy Industries and Daewoo Shipbuilding and Marine Engineering may cause an unbalanced trade and competition environment and reduce competition in the shipbuilding industry.

The second bubble originated on 1/07/2021 when BDI jumped 11%, driven by the Chinese coal demand. Moreover, before the lunar year holidays, steel stock is replenished by steel mills and traders, showing a promising market trend. Meanwhile, the cold spell and off-season have

increased China's energy demand, which may push the freight rate. The rising demand of China for Brazil's iron ore causes an increase in the cost of shipments. Similarly, the higher demand for coal from Indonesia may explain the rising shipping freight. Demand for raw materials has fallen, and concerns about steel supply to the world's largest producer have diminished. Similarly, the third bubble occurs on 4/21/2021 and bursts on 5/13/2021. As the global prices of wheat, corn, and soybeans rise, BDI has soared. Moreover, BDI jumps as increasing iron ore shipment from Brazil and freight costs record the biggest daily jump since February 2017. The cargo volumes from the world's top suppliers of iron ore increase, and shipments recover from Australia and Brazil. Similarly, China's rebar and hot-rolled coil futures have closed higher due to stricter capacity and output control concerns. Furthermore, the considerable congestion in specific ports, crew problems, and difficult situations in India reduce fleet efficiency. The iron ore benchmark rises due to failed dialogue between China and Australia. However, the bubble burst on 5/13/2021 because of the slowdown of the demand in China for rebar and iron ore because of the monsoon rains and scorching temperatures in the north. The container segment of the shipping industry experience reducing demand for containerized goods, and companies adopt strategies to manage supply capacity. The reduced capacity triggers severe problems as carrier delays of two to three weeks, piling up the containers at ports. However, the situation exacerbates due to the limited window at ports caused by the labor shortages, which may reflect in the freight rates. The last bubble starts on 8/18/2021 and bursts on 10/20/2021. During the period, BDI has risen to the highest level in 13 years, encouraged by robust demand. It is argued that global shipping constraints, port congestion in China, and an overall rebound in commodities demand explain the recent spike in BDI. Thus, the strong demand with weather-related shipping constraints in many corridors has driven the freight cost to the highest level (Michail and Melas, 2021). However, the bubble burst on 10/20/2021 when BDI marked its lowest level in the last week of October 2021. It is mainly caused by the increasing iron ore stockpiles in China, which have slowed demand for large vessels and appear in the decline of BDI. Moreover, China's coal supply is improving after the government has taken measures to increase production and coal use, resulting in the recent decrease in seaborne freight.

Fig. 3 exhibits a single bubble in BDTI which starts on 2/15/2021

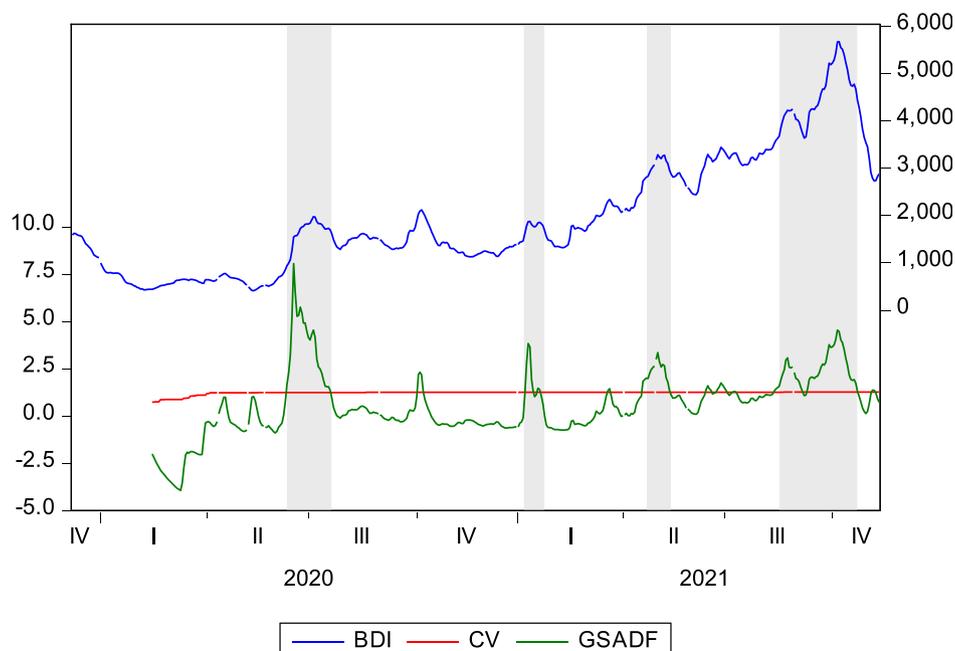


Fig. 2. GSADF test of BDI.

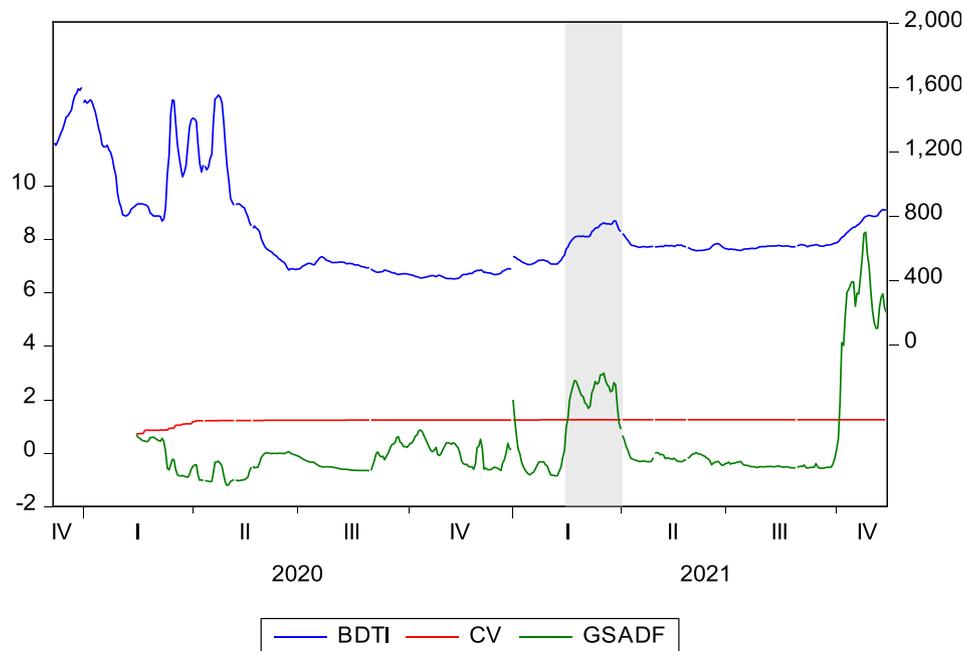


Fig. 3. GSADF test of BDTI.

and ends on 4/09/2021. During the period, the impact on shipping is mixed, as some countries have not formulated policies to deal with COVID-19. Moreover, some countries impose varying quarantine periods, resulting in delays in sailing and re-routing. In the first quarter of 2021, BDTI rises because of the increasing oil price, reflecting the growing demand for floating storage (Molaris et al., 2021). The contango state of the oil market makes storing oil for future profitable sales. This has reduced the availability of vessels for transport because the traders have chartered tankers to store low-cost oil, creating shortages of ships which exert pressure on the freight rate. However, this upward trend moves in the opposite direction on 4/09/2021 as the new restrictions are imposed in several countries, resulting in higher uncertainty. Moreover, the economic outlook for the rest of the year is

downgraded, and energy demand may decline. Meanwhile, the oil price has shown a downward trend due to the new pandemic restrictions in the major oil-consuming countries such as Japan, Korea, India, and China. As BDTI reflects the shipping cost, the oil has been declining, creating less demand for shipping containers. Moreover, the freight rates decline sharply because of the huge number of vessels locked in floating storage and unable to return to active trade flow (UNCTAD, 2020).

Fig. 4 reveals the multiple bubbles in BCTI. The bubble starts on 4/15/2020 and ends on 5/1/2020. In the pre-pandemic period, the container shipping industry segment is struggling because of the excessive supply and lower demand reflected in low container freight rates. However, the sector experienced major setbacks due to production shutdowns and trade losses during the pandemic (Molaris et al., 2021).

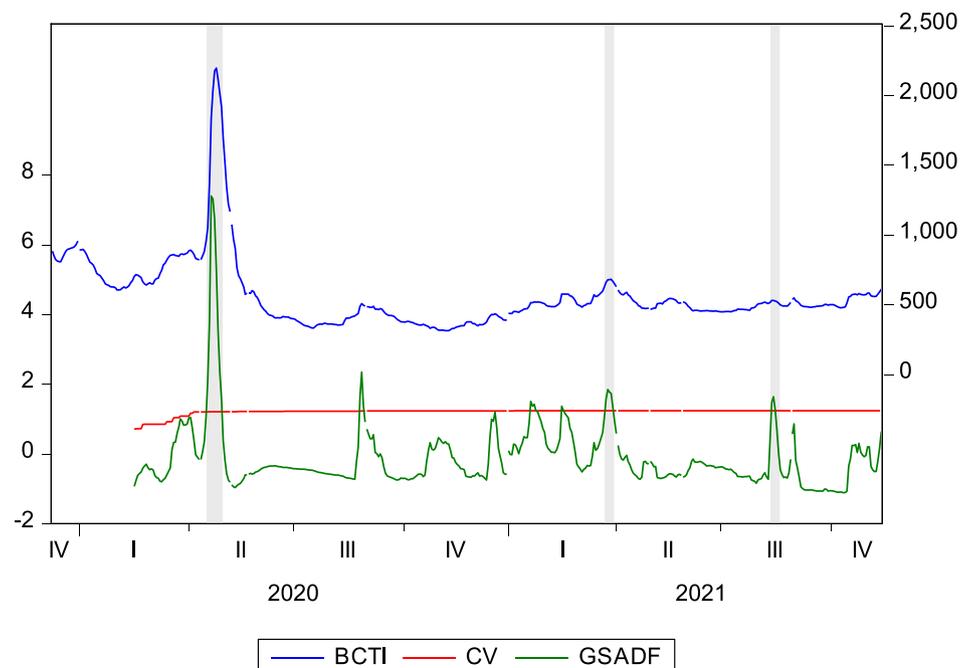


Fig. 4. GSADF test of BCTI.

BCTI reached the highest level when the demand for oil-related products increased because of the recovery in Asian countries. The outlook remains mixed, as activities are slow and steady back to normal. China is the first country to come out of the crisis, but demand is still uncertain. The shipment of Australian and Brazilian iron ore is trending below average. Meanwhile, the energy price declines because of lower economic activity and uncertainty reflected in the low BCTI. The second bubble starts on 3/19/2021 and bursts on 04/01/2021. Maritime trade is estimated to increase by 4.3% in 2021, and the outlook remains positive in the midterm, subject to rising uncertainties with expected lower growth in the world economy. During the period, the freight rates increased due to the closure of the Suez Canal delayed the trade flows for Europe and increased restrictions on the ship and port capacity. The re-routed voyages increase the distance and freight cost. Also, container shipping experience many logistical problems and inefficiencies that intimidate the recovery of supply chains. The average delays are at the highest level, increasing demurrage and detention fees and reflected in freight rates (Waters, 2021). The last bubble occurs from 11/08/2021 to 18/08/2021. The crude oil prices reached the highest level in over two years in August 2021, coupled with the removing the supply from the OPEC + members. Moreover, the ease of U.S. sanctions on Iran may cause a shift in production locations, increasing demand for tankers. In a nutshell, the study examines the shipping industry while assuming the major freight indicators such as BDI, BDTI, and BCTI during COVID-19. The analysis explores multiple bubbles during the pandemic. However, BDI is shown to be the most explosive, followed by BCTI. Likewise, the volatile behavior has been more frequent and pronounced since the second quarter of 2021, mainly caused by the economic recovery. Meanwhile, the supply is not keeping pace with demand, disrupting the supply chains and keeping freight rates volatile. Similarly, the contango phenomenon and the stranded ships and containers resulted in the highest freight rates.

## 6. Conclusion

The study examines the shipping freight rate during the pandemic for potential bubbles. The freight rate comprises BDI, BDTI and BCTI, which covers the transportation costs of the dry bulk raw material, oil shipments, and oil product cargo. In contrast, GSADF is employed for the econometric analysis, which performs better than traditional approaches to detecting bubbles. The results explore multiple bubbles in the freight rates during COVID-19. Moreover, the results show that BDI is the most explosive, followed by BCTI. However, the volatile behavior has been more frequent and pronounced since the second quarter of 2021, mainly caused by the economic recovery and disruption of the supply chains. Meanwhile, the supply is not keeping pace with demand, disrupting the supply chains and keeping freight rates volatile. Similarly, the contango phenomenon and the stranded ships and containers resulted in the highest freight rates. Similarly, the outcomes indicate that BDI has four bubbles caused by strong demand for raw materials and uncertainty caused by the pandemic. Furthermore, the results detect a single bubble in BDTI caused by the increasing oil price, reflecting growing demand for floating storage while bursting due to new restrictions of the second wave, declining oil prices, and shortages of the vessels locked by the floating storage. Also, BCTI experiences multiple bubbles triggered by the strong demand for oil products, the closure of the Suez Canal, logistical problems, and the highest oil prices. Detecting freight bubbles during normal periods can assist businesses in planning production schedules, adjusting inventory levels, and optimizing supply chains. Moreover, bubbles can reveal changes in demand for various

types of shipping services or routes. By monitoring these trends, businesses may optimize logistics operations to decrease costs and enhance efficiency. Furthermore, it may influence pricing strategy, allowing companies to modify prices to maximize revenue and profitability. On the other hand, supply chains can be interrupted during a crisis, and demand for certain products can increase rapidly. Businesses may get insights into changing demand patterns and adapt their supply chains by identifying bubbles. Similarly, freight bubbles can cause price volatility during a crisis when demand is high and supply is limited. Businesses can anticipate price rises and take measures to mitigate their impact by monitoring freight costs or exploring alternative shipping options. Similarly, monitoring freight bubbles and taking actions to sustain operations and minimize interruptions may help businesses get insights into important shipping routes and ports.

We can offer several policy recommendations for policymakers. The results conclude multiple bubbles in the shipping freight during the pandemic are driven by specific factors. The findings provide valuable information about the specific determining characteristics of the fluctuations and can be avoided in the future by overcoming the underlying factors. Moreover, the early warning enables the stakeholders to mitigate the effects of the potential bubbles. It helps to design mechanisms to detect and avoid adverse effects on the international shipping market and economy. The international shipping industry has a contagion impact on the commodity market, energy market, and the overall economic outlook. As maritime trade is the main pillar of global trade, uncertainty in the shipping industry can significantly impact the economy. Therefore, the analysis of the explosiveness is a useful contribution and can help to minimize the risks of collapse in the shipping industry. Also, the outcomes help to formulate measures before and after the bubbles. The study is more useful considering COVID-19 because the economic and political crisis usually leads to bubble bursts which can have adverse consequences for the various segments. Therefore, identifying bubbles in shipping freight at the right time allows regulators and policymakers to take preemptive actions. The recent fluctuation in shipping freight due to the COVID-19 has attracted great attention to the study of the international shipping market. This study can be extended while examining the COVID-19 impact on shipping freights in oil price fluctuations. It will evaluate the correlation in the energy market context, as oil prices can be a major contributor to shipping freight volatility. Moreover, the impact of COVID-19 on shipping freight can be examined in the wavelet quantile while taking oil price as a control variable.

## CRedit authorship contribution statement

**Khalid Khan:** Conceptualization, Methodology, Software, Data curation, Writing – original draft. **Adnan Khurshid:** Visualization, Investigation, Writing – review & editing. **Sinem Derindere Köseoğlu:** Visualization, Investigation, Writing – review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

Appendix

A. Bubble behaviour of shipping freight during 2001–2019

The data period is expanded to cover the normal crisis and understand the dynamic behaviour of the indexes. The new sample period is from 2001:01 to 2019:10, which includes the normal crisis. The findings explore that only BDI has bubble behaviour as the test statistics exceed than the critical values (See Table A).

**Table A**  
SADF and GSADF

		BDI	BDTI	BCTI
SADF		3.987 ***	-0.991	-0.982
SADF critical values	90%	1.347	1.190	1.115
	95%	1.152	1.497	1.272
	99%	1.816	1.867	1.608
GSADF		3.999***	-0.011	-0.308
GSADF critical values	90%	1.198	2.000	1.968
	95%	2.255	2.246	2.146
	99%	2.398	2.681	2.681

Panel 1 of Figure A exhibits the bubbles in BDI. The first bubble is detected around 2003–2004, while the second bubble is detected in 2007–2008. The first bubble coincides with the energy crisis in 2004, which significantly contributed to the bubble phenomenon. Similarly, the second bubble coincides with the global financial crisis in 2008. However, the result shows that BDTI and BCTI have no bubbles. (See Panel 2–3). Therefore, it is concluded that shipping freight is more volatile during the pandemic than during other crises.

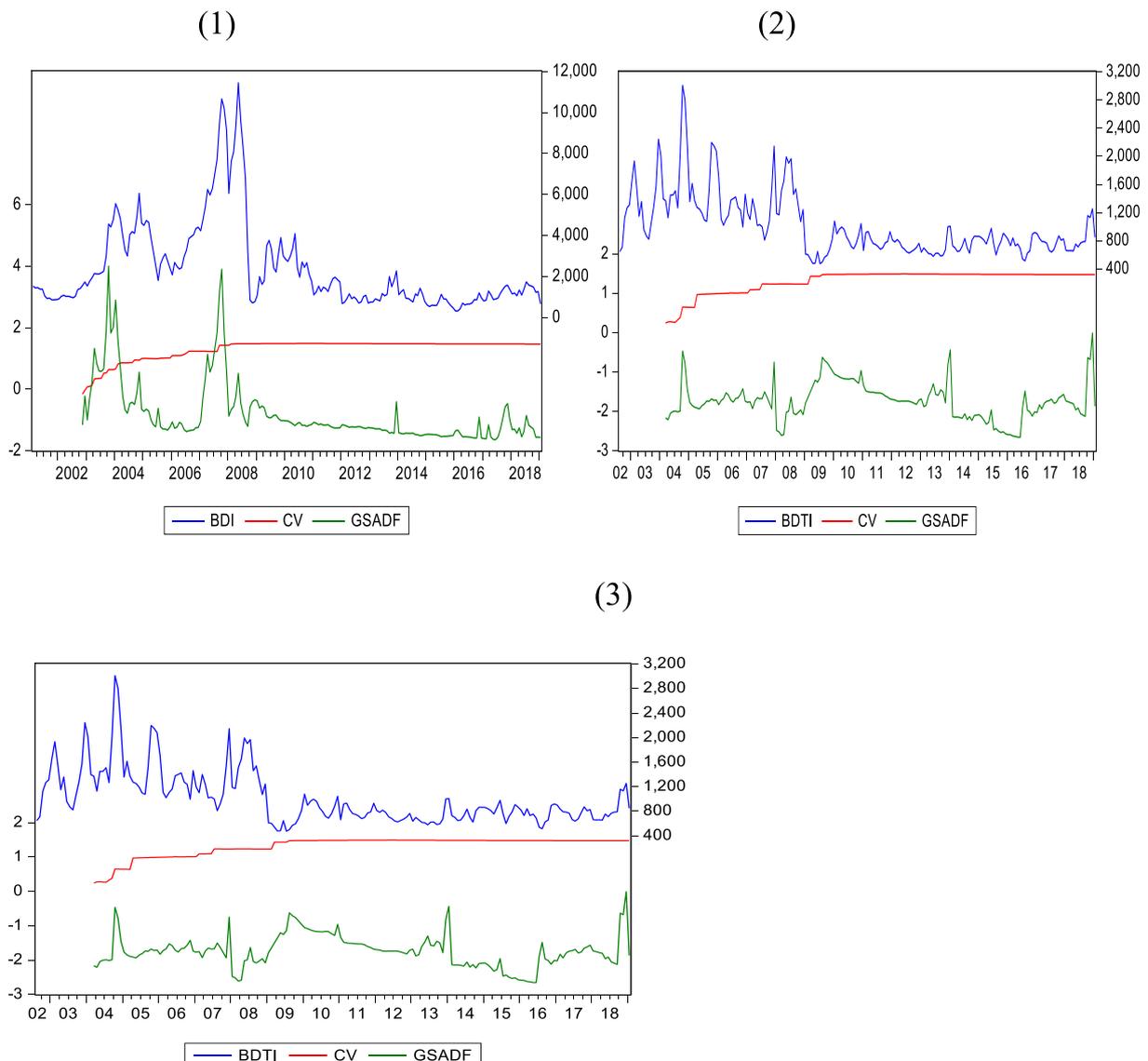


Fig. A. GSADF test of BDI, BDTI and BCTI

### B. Impact of oil price shipping freight during 2001–2022

We use the wavelet analysis to examine the impact of oil price (OP) on the BDI. The OP significantly impacts the BDI, as it affects the cost of operating and maintaining dry bulk ships. The cost of operating ships increases due to high OP, leading to a decline in the BDI. Conversely, the cost of operating ships decreases due to low OP, leading to increased BDI. During the financial crisis in 2008, OP dropped sharply, which led to a surge in the BDI. However, during COVID-19, global demand for oil and shipping fall dramatically, leading to a decline in both the BDI and OP. (See Figure B, panel 1). Similarly, BDTI is closely related to the OP as most shipping freight is used for transporting oil and petroleum products. The demand for crude oil drives the demand for shipping, and a fluctuation in the OP directly impacts the BDTI. The BDTI saw a sudden rise in value during the 2008 financial crisis caused by the highest OP. However, with the global economic slowdown, the oil demand decreased, leading to a fall in the BDTI. The sharp drop in OP in 2014 due to oversupply and weak demand caused shipping costs to fall and the BDTI to decline. However, as the global economy recovered, OP began to rise again, leading to an increase in shipping costs and a corresponding rise in the BDTI. (See Figure B, panel 2). BCTI is significantly impacted by the OP, as it reflects the demand for clean petroleum products, such as gasoline and diesel. Historically, during high OP, such as in 2008, the BCTI has significantly increased. Similarly, in 2011, when OP rose to over \$100 per barrel, the BCTI also increased. On the other hand, when oil prices decrease, the BCTI also experiences a decline. The same scenario repeated in 2014 when OP dropped due to increased production and weakened demand. (See Figure B, panel 3).

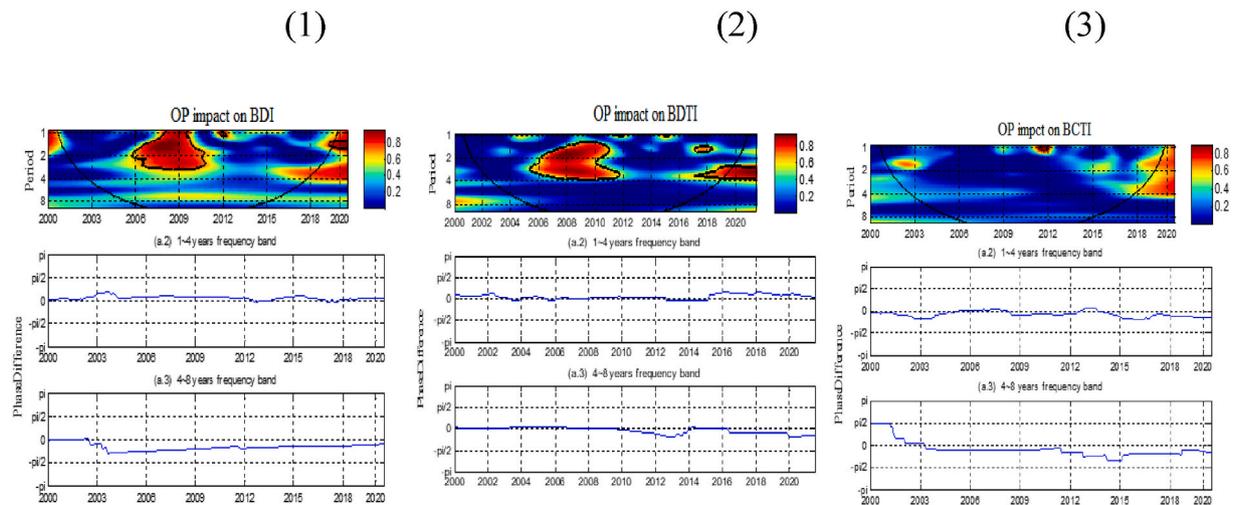


Fig. B. OP impact on BDI BDTI and BCTI

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