ECONOMY

TRANSMISSION OF FINANCIAL CONTAGION IN THE BALTIC SEA REGION COUNTRIES DURING THE ENERGY CRISIS OF 2021—2022

Check for updates

A. M. Terekhov [1,2]
A. O. Ovcharov [1]

[1] Lobachevsky Nizhny Novgorod State University,
23 Gagarin Ave., Nizhny Novgorod, 603022, Russia
[2] Russian State University of Justice,
69 Novocheremushkinskaya St., Moscow, 117418, Russia

Received 02 February 2024
Accepted 22 October 2024
doi: 10.5922/2079-8555-2025-1-8

The global energy crisis of 2021—2022 significantly impacted the financial markets of many countries. The shock of price volatility in the oil and gas market triggered the transmission of crisis processes across various European countries, including those in the Baltic Sea region. This article analyses the effects of the energy crisis on these countries using the financial contagion methodology. The study aimed to estimate the financial contagion that spread through stock market channels in the Baltic Sea region during 2021—2022, as well as to systematize measures aimed at mitigating the consequences of the energy crisis and countering financial contagion. Using statistical analysis methods, the current state of the energy market in the Baltic region and its response to the conflict between Russia and Ukraine were examined. By reviewing a range of publications on the Baltic countries, evidence of financial contagion that emerged in different years under the influence of various shocks was identified. The financial contagion methodology was implemented by constructing DCC-GARCH models and estimating contagion effects using specialized test statistics. The calculations revealed that the energy crisis led to financial contagion in the markets of most Baltic Sea region countries. The study identified the causes of these countries' vulnerability to financial contagion and provided additional estimates of contagion from a sectoral perspective. This allowed for conclusions to be drawn regarding the resilience of individual economic sectors to the crisis. The varying degrees of exposure to financial contagion were explained by differences in dependence on external energy supplies and the nature of anti-crisis policies. The paper systematized a set of specific anti-crisis measures for households and businesses in the Baltic Sea region and outlined strategies for countering financial contagion.

Keywords:
Baltic Sea region, financial contagion, energy crisis, volatility, DCC-GARCH model, anti-crisis policy

To cite this article: Terekhov, A. M., Ovcharov, A. O. 2025, Transmission of financial contagion in the Baltic Sea region countries during the energy crisis of 2021—2022, *Baltic Region*, vol. 17, № 1, p. 141—161. doi: 10.5922/2079-8555-2025-1-8

Introduction

The European economy is frequently impacted by shocks of varying magnitude, nature and duration, with examples including the global financial and debt crises, Brexit and COVID-19. Having struggled to fully address the consequences of the COVID-19 pandemic, European countries are now confronted with new challenges, primarily stemming from heightened international political tensions. The military conflict between Russia and Ukraine was a global shock, leading to rising inflation, higher interest rates and increased volatility in financial, raw materials and food markets [1]. In turn, this provoked shocks in energy markets, leading to an energy crisis, which reached a global scale in 2022 [2].

The energy crisis began in 2021, when the global economy started to recover after the pandemic-induced sharp decline in aggregate demand. The rise in energy demand was a response to renewed economic growth and the recovery of commercial manufacturing. At the same time, growing natural gas and carbon quota prices contributed to higher energy rates across Europe [3; 4]. However, the outbreak of hostilities in February 2022 is still regarded as a turning point, with financial markets reacting with a significant surge in volatility in energy sector asset prices [5].

Crises are dynamic rather than static processes, with those in the energy sector being no exception. As they can potentially lead to transformations in intermarket relationships, the impact of an economic system crisis can be effectively examined through the lens of financial contagion theory and methods. This concept, which gained prominence in the 1990s through studies of Asian and Latin American financial crises, draws analogies with biological contagion and provides a key to understanding the mechanisms behind the transmission of various shocks from one entity to another, as well as the causes of crises unfolding. A system of statistical and econometric methods for detecting financial contagion enables the identification of shifts in economic relationships resulting from the negative impact of a particular shock.

This article applies financial contagion models to assess the impact of the 2021—2022 energy crisis on the economies of the Baltic Sea states. It provides an overview of studies on the dependence of these states on energy resources and their response to the energy shock. Additionally, the study briefly introduces the principles of financial contagion theory and presents the results of empirical findings on the characteristics of financial contagion in the Baltic Sea states. The main section of the article outlines the methodology and findings of the empirical study into contagion effects in the Baltic Sea states, both from a country-specific and industry perspective. Finally, the article systematises crisis management measures and analyses policies aimed at countering financial contagion.

Energy market of the Baltic Sea states: current status and response to the conflict between Russia and Ukraine

The current energy crisis began at the end of 2021, when the gas market was experiencing significant price volatility. This was due not only to the increase in consumption, but also to the introduction of new restrictive measures against the Russian economy. The fifth package of sanctions imposed a prohibition on the sale, provision, transfer, or export to Russia of goods and technologies essential for gas liquefaction. Restricting the use of Russian gas led to economic losses in European countries, as Russia had previously met two-thirds of their energy needs. At the same time, there was no viable substitute for traditional energy resources [6; 7]. The Baltic Sea states have endorsed the cessation of Russian energy commodities, with countries like Poland and Lithuania, in particular, having long pursued a cautious stance towards Russian energy supplies while developing new energy import infrastructure to diversify their sources [8].

The introduction of restrictions did not allow the Baltic Sea states to completely abandon Russian energy commodities, as in 2021 no viable alternatives existed to sufficiently diversify supplies and meet the required volume. As production capacity recovered from the COVID-19 pandemic, demand for energy sources increased, which in turn led to a rise in energy prices. Figure 1 illustrates the dynamics of the average values of the harmonised consumer price index for electricity and energy commodities in the Baltic Sea region. This indicator, employed in inflation assessment, aids traders in forecasting potential shifts in the currency market. The observed dynamics reflect the impact of the crisis induced by the conflict between Russia and Ukraine on the escalation of energy prices and the potential for systemic risk transmission through trade channels.

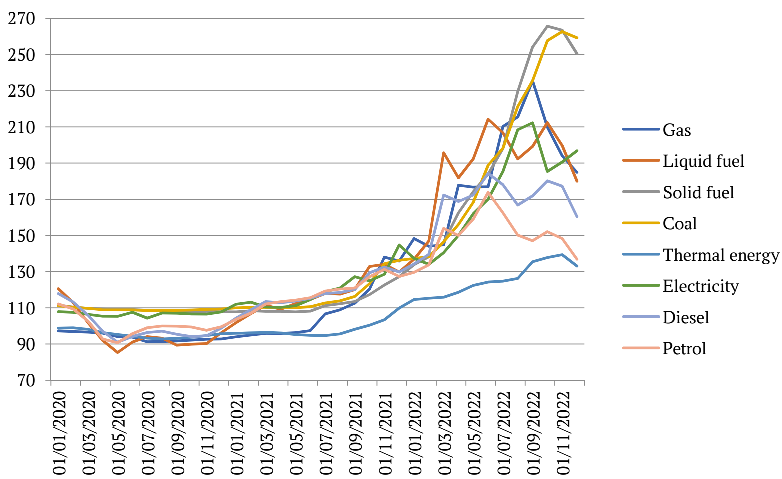

Fig. 1. Harmonised consumer price indices for electricity, heat and other energy commodities in the Baltic Sea states (excluding Russia) in 2020—2022, %

Computed according to Eurostat data[1].

As illustrated in Figure 1, from February to March 2022, the rate of price growth surged for liquid fuels, gas, petrol and diesel. With a slight delay of

[1] HICP — monthly data (monthly rate of change), *Eurostat.eu*, URL: https://ec.europa.eu/eurostat/databrowser/view/prc_hicp_mmor/default/table?lang=en&category=prc.prc_hicp (accessed 03.02.2024).

approximately one month, sharp price increases followed for solid fuel, thermal energy, electricity and coal. Among the Baltic Sea states, Poland and Germany saw the least pronounced electricity price increases, while Estonia was the most affected, reaching a peak of 463.5 % in August 2022. The most noticeable gas price surges occurred in Lithuania, Latvia and Germany, while Sweden experienced the steepest increase in diesel fuel prices. Coal, similar to other solid fuels, exhibited the most significant price growth, albeit with a delayed onset, with Poland at the forefront (peaking at 386.4 % in October 2022), followed by Estonia and Lithuania.

Finland, Poland, Lithuania and Estonia demonstrate a high reliance (70—85 %) on Russian oil supplies, although this dependence is gradually declining. The Baltic Sea states are also among the European nations highly reliant on Russian gas, albeit with periodic fluctuations in the extent of this dependence [6]. Historically, the Baltic countries have sourced most of their natural gas via pipelines from the North Sea or Russia. Given that natural gas is more costly to store and transport than oil or coal, pricing in natural gas markets remains less predictable. Consequently, in recent years — particularly following the outbreak of hostilities in Ukraine — the construction of LNG terminals in Poland, Finland and Estonia has accelerated. However, these terminals do not yet provide volumes equivalent to those delivered via pipeline [9].

The Lithuanian energy market has unique characteristics. Given its limited fossil fuel reserves, this Baltic state relies heavily on oil and natural gas imports In the 1990s, most of Lithuania's electricity was generated by a single nuclear power plant, the Ignalina NPP. Until 2009, it met 77 % of the country's electricity needs. However, two NPP reactors were shut down in 2004 and 2009, with Lithuania turning from a net exporter to a net importer of electricity. Within a decade, the country has transitioned from a nuclear-centric energy approach to a national strategy prioritising renewable energy sources [10]. Nevertheless, the problem of energy dependence remains acute, as over 70 % of the country's electricity needs are currently satisfied by imports. At the same time, the importance of bio-energy in domestic energy supply is gradually increasing. Most of Lithuania's co-production power plants, district heating and residential buildings have switched from natural gas to biomass, due to the abundance of forests and arable land.[1] By 2030, Lithuania aims to reduce its electricity imports by half, fulfilling 70 % of its electricity demand through domestic renewable energy sources, including biomass, solar, wind and hydropower.

Methodology and methods

Specific methodological aspects of financial contagion research

The concept of financial contagion is interpreted in various ways in contemporary research. However, most academic economists define it as the trans-

[1] Energy system of Lithuania, *IEA50*, URL: https://www.iea.org/countries/lithuania (accessed 02.02.2024).

mission of shocks across countries, industries or economic sectors, potentially disrupting inter-market relationships. A narrower interpretation, frequently used in empirical studies, distinguishes financial contagion from 'calm' periods by defining it through extreme returns and heightened correlations between asset prices across different markets. The response to a shock can intensify interdependencies among countries or sectors, driven by shifts in national macroeconomic fundamentals or market dynamics. Notably, this phenomenon is often attributed to investors' 'herding mentality', where market participants mimic others, fuelling inflationary pressures and fostering the emergence of speculative 'financial bubbles' [13].

Complex and multifaceted, the financial contagion methodology comprises statistical and econometric methods and models designed to differentiate between crisis and 'calm' periods and to identify shifts in interrelationships. This enables the detection of the presence, direction and strength of financial contagion as it spreads through various channels, with the stock market regarded as the primary one. For instance, correlation analysis and the GARCH model have been employed to obtain evidence of financial contagion transmission from the US stock market to the Baltic Sea states (Estonia, Latvia and Lithuania) during the global financial crisis [14]. Yet, other possible channels, particularly the banking channel, should not be overlooked. For example, transaction data from the Danish payment system have been used to estimate contagion risk in the national deposit market [15]. Additionally, simulation modelling suggests that the unexpected collapse of a major bank presents a negligible risk of triggering financial contagion across the Danish monetary system.

In general, the Baltic Sea region — understood as the group of countries bordering the Baltic Sea — has received limited attention in financial contagion theory and methodology. Existing studies typically focus on either a specific country within the region or a broader selection of countries that includes Baltic Sea states. For example, in research examining the spread of financial contagion during the global financial crisis (GFC) and the euro area debt crisis across multiple stock markets, only one Baltic Sea state, Estonia, was included in the sample [16]. Cross-correlation analysis in that study found Estonia to exhibit very weak contagion effects, whereas countries from other macro-regions, such as Slovenia, Nigeria and Vietnam, demonstrated significantly stronger contagion effects.

Empirical studies on financial contagion most often examine the Baltic Sea region as consisting of Latvia, Lithuania and Estonia, focusing on their regional and global financial market integration. For instance, cointegration analysis and the Granger causality test have been employed to demonstrate long-run bidirectional causality between the stock indices of Vilnius, Riga and Tallinn, indicating regional market integration [17]. However, there are relatively few findings that specifically illustrate how Baltic markets respond to particular shocks or adverse events that trigger risk transfer and financial contagion. Table 1 presents selected examples from various international studies conducted over different years.

Table 1

Empirical findings on financial contagion in the three Baltic Sea states

Shock or event	Financial contagion detection method	Basic results
Political news from Russia	Multivariate generalisation of the GARCH — VARMA-AGARCH asymmetric model	The influence of political news on financial contagion in the Baltic Sea states is declining over time. The spread of the contagion depends on investors' interpretation of political news and bilateral trade between the Baltic Sea states and Russia [18]
GFC	Cointegration analysis, Granger, Dickey-Fuller, Johansen tests	Financial risks were transmitted more significantly to the markets of Latvia and Estonia, while Lithuania was affected to a lesser extent. During periods of economic shock, investors' interests and expectations tend to align with those of larger markets [19]
GFC	Adjusted correlation coefficients, GARCH model	A marked intensification of financial linkages between the United States (a crisis-affected country) and Estonia, Latvia and Lithuania (non-crisis-affected countries) was observed immediately after 15 September 2008, the onset of the crisis [14]
Lehman Brothers Bank collapse	DCC-GARCH model, tests	System-wide shocks originating in global financial centres impact Baltic markets, with Estonia and Lithuania experiencing the most pronounced effects of cross-border financial contagion transmission [20]
GFC and European debt crisis	FIAPARCH model	Latvia and Lithuania were vulnerable to contagion during the GFC (while Estonia was not) but remained unaffected during the debt crisis (when Estonia was). Investors should approach simultaneous investments in the Baltic region's emerging markets with caution [21]

Although initial groundwork has been established for studying financial contagion in the Baltic Sea states, further empirical research is needed to assess how these countries respond to various shocks, including energy shocks and to identify and explain the causes of potential financial contagion.

Study design and empirical basis

The study consisted of the following stages.

In the first stage, the countries comprising the Baltic region were identified. To achieve this, we applied the narrow approach outlined in [22]. Consequently, our selection included nine countries, excluding Belarus, Iceland and Norway, which are considered part of the region under the broad approach.

The study focused on the stock channel of financial contagion transmission. Consequently, the empirical basis comprised data on shares, stock indices and marketplace trading in energy resources. To account for the specific characteristics of European oil and gas trade, statistics from European marketplace trading were utilised. The data forming the empirical foundation for subsequent computations included:

— Prices of ICE Dutch TTF Natural Gas Futures (TFMBMc1 — Netherlands)[1] and Brent Crude Oil Futures (LCOU4) — UK (London Intercontinental Exchange (ICE Futures Europe);[2]

— basic and sector indices of the Baltic Sea states;

— share quotation of large companies domiciled in the Baltic Sea states.

The frequency of information disclosure was daily, covering the period from 2 January 2021 to 31 December 2022, with over 20,000 observations analysed. Selected observations were transformed into logarithmic series of returns and analysed for stationarity, using the Augmented Dickey-Fuller (ADF) test.

The second stage involved a graphical analysis of volatility dynamics in the oil and gas market, enabling the identification of the onset of the energy crisis and the initiation of the financial contagion process. The standard deviation of the indicators was used as a measure of their volatility.

At the third stage, transmitter-receiver variable pairs were tested for ARCH effects to determine the suitability of the DCC-GARCH model, considering the available data structure for estimating financial contagion transmission from the transmitter to the receiver. The testing was conducted using pre-constructed paired linear regression models.

The fourth stage included analysing DCC-GARCH models constructed for multiple transmitter-receiver bundles. This analysis utilised logarithmic returns of gas and oil prices as potential contagion transmitters, alongside logarithmic returns of stock indices from individual Baltic Sea states as potential contagion receivers. Given the complexity of the mathematical formulation of the technique under consideration, it is not discussed in this article. The original DCC-GARCH model is presented in [23], while its application in Russian studies can be found in [24; 25].

At the fifth stage, the average values of the previously computed series of dynamic conditional correlations were evaluated and the hypothesis about the presence or absence of contagion was tested. Contagion was considered to occur if the average values of dynamic conditional correlations exceeded those observed during the crisis period ($\overline{DCC}_{kriz}$), as opposed to the stable one ($\overline{DCC}_{stab}$):

$$H_0: \overline{DCC}_{kriz} > \overline{DCC}_{stab}, \tag{1}$$

$$H_1: \overline{DCC}_{kriz} < \overline{DCC}_{stab}, \tag{2}$$

[1] Past data — ICE Dutch TTF Natural Gas Futures, *Investing.com*, URL: https://ru.investing.com/commodities/ice-dutch-ttf-gas-c1-futures-historical-data (accessed 24.07.2024).
[2] Past data — Brent Oil Futures, *Investing.com*, URL: https://www.investing.com/commodities/brent-oil-historical-data (accessed 02.02.2024).

Two-sample t-test assuming different variances, the Wilcoxon — Mann — Whitney u-test for differences in median values and the Kolmogorov — Smirnov z-test were employed to confirm the fact of contagion by evaluating series of dynamic conditional correlations.

Results and discussion

Estimates of oil and gas market volatility as a predictor of financial contagion in the Baltic Sea states

Figure 2 shows the volatility dynamics of oi and gas as potential sources of financial contagion. The onset of the crisis period was marked by heightened volatility in energy prices. Notably, a substantial increase in natural gas price volatility was observed from mid-September 2021, driven by a combination of the following factors:

— high demand for gas in Europe due to a cold winter and greater reliance on gas for heating (attempts to reduce coal usage);

— international geopolitical tensions leading to reduced gas supplies from Russia to Europe;

— insufficient liquefied natural gas production in the United States due to natural disasters and maintenance issues;

— rising consumption of liquefied natural gas in Asia driven by economic growth and a shift away from coal in various sectors;

— speculation in financial markets.

The rise in oil price volatility was observed later, beginning on 26 November 2021. The factors contributing to this volatility included:

— investor concerns over the spread of the Omicron COVID-19 variant, which could lead to renewed quarantine measures and reduced oil demand;

— a sharp rise in the United States' crude oil inventories, resulting in lower demand for oil;

— the refusal to extend the OPEC+ oil production cut agreement, in place since early 2021, which contributed to market uncertainty;

— the strengthening of the United States dollar

It is important to note that while oil and gas are alternative energy sources, they are not interchangeable. Consequently, a sharp decline in gas supply does not immediately impact the oil market, as confirmed by our observations. The gap between the onset of heightened volatility in the two markets exceeds six weeks. As gas storage and transportation costs exceed those of oil — especially in European countries, including the Baltic Sea states, as evidenced by studies [9] — natural gas markets are inherently less liquid and more volatile.

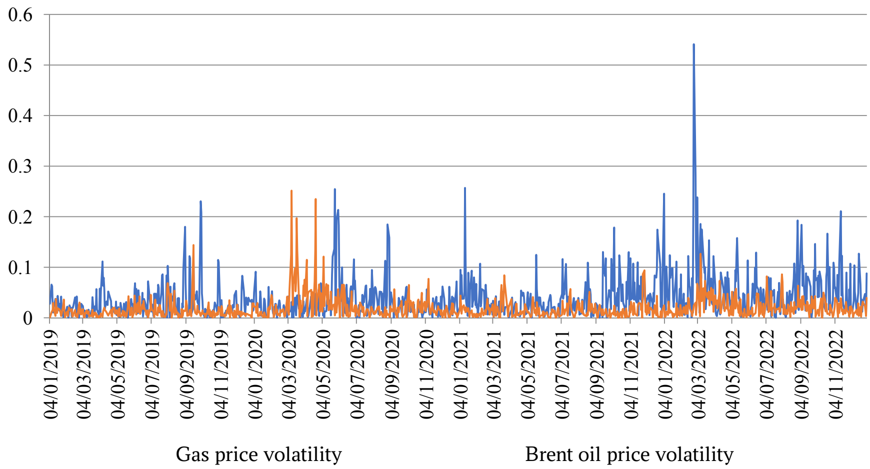

Fig. 2. Dynamics of natural gas and Brent crude oil price volatility

Compiled according to the European marketplace trading statistics.[1]

The pre-crisis period encompassed several months in 2021, during which energy price volatility remained relatively stable, whereas the crisis period was defined as the interval when price standard deviations were at least twice as high as normal. Table 2 presents detailed characteristics of the selected periods, relevant to the potential transmission of financial contagion.

Table 2

Results of identifying pre-crisis and crisis periods in the study markets

Indicator	Contagion transmitter	
	Gas	Oil
Onset of the volatility stabilisation period (calm period)	11.02.2021	31.03.2021
Onset of increased volatility period (crisis period)	16.09.2021	26.11.2021
End of the examined increased volatility period	30.12.2022	30.12.2022
Average volatility during the calm period	0.017	0.013
Average volatility during the crisis period	0.043	0.029

Overall, natural gas exhibited greater price volatility than oil throughout the study period, in both stable and crisis intervals. During the crisis period, gas price volatility rose more sharply than oil price volatility, with growth rates of 252.9 % and 169.2 %, respectively. This suggests that the gas crisis was the principal catalyst of the global energy crisis and the ensuing financial contagion processes.

[1] Past data — ICE Dutch TTF Natural Gas Futures, *Investing.com*, URL: https://ru.investing.com/commodities/ice-dutch-ttf-gas-c1-futures-historical-data (accessed 24.07.2024) ; Past data — Brent Oil Futures, *Investing.com*, URL: https://www.investing.com/commodities/brent-oil-historical-data (accessed 02.02.2024).

Estimates of financial contagion in the Baltic Sea states

The results of the ADF test-based analysis do not reject the hypothesis of stationarity for the examined variables at a confidence level of 95—99 % (0.00 < p-value < 0.05).

Testing for ARCH effects indicated that the hypothesis of ARCH process presence could not be discarded for all paired bundles of the type 'gas → Baltic Sea state' and 'oil → Baltic Sea state'. Accordingly, DCC-GARCH models were constructed for all paired bundles in the selection. Dynamic conditional correlations (DCCs) derived from the simulations were employed to assess contagion transmission. Average DCC values (calculated as the arithmetic mean of the DCC series) and median values were computed separately for stable and crisis periods. The hypotheses were then tested using the t-test, u-test and z-test. The critical value of the Student's t-test statistic for DCC pairs was $t_{crit} = 1.98$. The significance of the u-test and z-test statistical criteria was assessed at a confidence level of 95 % (p-value < 0.05). Contagion was confirmed when all three test statistics failed to reject the hypothesis of contagion (Table 3).

Table 3

Results of detecting financial contagion in the Baltic Sea states from the oil and gas market during the 2021—2022 energy crisis (tested at a 5 % significance level)

Country	DCC (pre-crisis period)		DCC (crisis period)		t-test, t_{calc}	u-test, p-value	z-test, p-value	Presence of contagion
	Average	Median value	Average	Median value				
Contagion source: gas market								
Germany	−0.050	−0.038	−0.170	−0.171	18.50	0.000	0.000	+
Denmark	−0.201	−0.023	−0.026	−0.023	−14.51	0.000	0.000	–
Latvia	0.046	0.055	−0.046	−0.046	8.53	0.000	0.000	+
Lithuania	0.080	0.103	−0.106	0.182	15.03	0.000	0.000	+
Poland	0.019	0.025	0.003	0.005	0.64	0.210	0.001	–
Finland	−0.089	−0.089	−0.186	−0.183	32.98	0.000	0.000	+
Sweden	−0.199	−0.126	−0.133	−0.134	−2.64	0.949	0.000	–
Estonia	0.055	0.068	−0.154	−0.140	13.22	0.000	0.000	+
Russia	0.106	0.109	−0.109	−0.098	19.58	0.000	0.000	+
Contagion source: oil market								
Germany	0.154	0.159	0.139	0.149	−0.62	0.923	0.000	–
Denmark	−0.158	−0.240	−0.083	−0.078	2.98	0.000	0.000	+
Latvia	0.140	0.143	−0.007	−0.002	−9.24	0.000	0.000	–
Lithuania	0.134	0.131	0.007	0.020	−12.30	0.000	0.000	–
Poland	0.378	0.381	0.122	0.141	−13.72	0.000	0.000	–
Finland	0.240	0.264	0.081	0.084	−6.45	0.000	0.000	–
Sweden	0.152	0.148	0.093	0.078	−3.28	0.002	0.000	–
Estonia	0.093	0.050	0.085	0.095	−0.25	0.339	0.116	–
Russia	0.371	0.368	0.051	0.049	−31.74	0.000	0.000	–

Thus, during the energy crisis, financial contagion was observed in seven Baltic Sea states — Germany, Lithuania, Latvia, Finland, Estonia, Russia and Denmark. Contagion from gas was detected in the first six states, while Denmark experienced contagion from oil.

As noted earlier, the primary driver of financial contagion in the states under consideration was the post-pandemic economic recovery, which spurred increased demand for energy commodities. However, escalating geopolitical tensions and the tightening of sanctions against Russia, particularly in the energy sector, hindered the ability to meet these demands. For instance, Germany had long been highly dependent on Russian natural gas, with Russia supplying 65.4 % of its total imports in 2021 (55,443.3 million m^3). By 2022, this share had more than halved to as little as 29.6 % (25,941.1 million m^3),[1] necessitating urgent supply substitutions, reliance on alternative markets and an increased intake of more expensive LNG amid a resource shortage. Given Germany's role as Europe's industrial hub, with 59 % of its natural gas consumption allocated to industrial enterprises, the drastic transformation of its energy market triggered financial contagion across various national industries. Given Germany's role as Europe's industrial hub, with 59 % of its natural gas consumption accounted for by industrial enterprises, the drastic transformation of its energy market triggered financial contagion across various national industries.

Countries with lower dependence on natural gas have also proven to be vulnerable to financial contagion. In Finland, for example, natural gas accounted for 5.3 % of power generation and 10.9 % of heat generation in 2021. Yet, the country experienced financial contagion due to its reliance on Russian oil imports. Additionally, the decline in peat production as a fuel source for heat generation further contributed to contagion.

The susceptibility of Latvia, Lithuania and Estonia to financial contagion may stem from various factors, including increased electricity generation from thermal power plants using natural gas and reduced generation from renewable energy sources (RES). Moreover, these countries have withdrawn from the BRELL power grid system. Lithuania, in particular, faces challenges such as insufficient power grid capacity and a low share of electricity generation from cost-effective renewable sources — solar, wind and hydropower — meeting only 20 % of its energy needs. Consequently, the country lacks the capacity to generate a sufficient amount of electricity [26].

Regarding the causes of the gas crisis in Latvia and the resulting financial contagion, it is important to note that the country was wholly reliant on Russian gas supplies between 2015 and 2020. In contrast, Lithuania's dependence, though

[1] Imports of natural gas by partner country, *Eurostat.eu*, URL: https://ec.europa.eu/eurostat/databrowser/view/nrg_ti_gas__custom_12445435/default/table?lang=en (accessed 02.02.2024).

fluctuating, generally declined, with Russian gas accounting for 41.8 % of its supply in 2020.[1] A combination of factors — including restricted access to Russian energy commodities, adverse climatic conditions and increased natural gas and electricity consumption following the COVID-19 pandemic — contributed to financial contagion [6].

The contagion in the Russian stock market driven by gas supply issues is attributed to the country's substantial loss of its European sales market, estimated at 77.1 % of total exports as of 2020. The decline in export revenues impacted various sectors of the Russian economy, while factors such as restrictions on Russian gas supplies, the seizure of Russian energy assets abroad and the sabotage of the Nord Stream pipeline further contributed to increased uncertainty in the Russian stock market, heightening its vulnerability to financial contagion.

Poland's resilience to contagion related to natural gas supply issues arises from the fact that 64.8 % of its gas needs are met through LNG imports. The country operates an LNG terminal in Świnoujście, which fulfils its gas demand, reducing reliance on regional European gas market conditions. Pipeline gas demands are met via the Baltic Pipe, while overall energy consumption remains dominated by solid fossil fuels, particularly bituminous coal.

In Sweden, RES account for 67.4 % of electricity generation and 72.6 % of heat generation, while nuclear power contributes 30.8 % and 27.4 %, respectively. As of 2021, gas comprises only 0.2 % of electricity generation and 0.6 % of heat generation, with oil comprising 0.2 % and 1.3 %.[2] Sweden remains energy-independent from external hydrocarbon supplies, rendering it resistant to financial contagion from energy market disruptions.

For the countries under consideration, financial contagion may also ensue from the speculative policies of the United States, the primary geopolitical partner in terms of LNG supply, which accounted for 44 % of demand in 2022 and 48 % in 2023.[3] By the first half of 2022, the United States had become the world's largest LNG supplier, with the EU and the UK receiving 71 % of its exports.[4]

The financial contagion in Denmark can be explained by several factors. The Danish economy relies on imported crude oil to meet its energy needs. Fluctuations in oil prices and a decrease in global oil supply led to a rise in oil prices

[1] Natural gas import dependency by country of origin, *Eurostat.eu*, URL: https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_IDOGAS/default/table (accessed 02.02.2024).
[2] Complete energy balances, *Db.nomics.world*, URL: https://db.nomics.world/Eurostat/nrg_bal_c?tab=list (accessed 12.10.2024).
[3] Filimonova, I. V., Provornaia, I. V., Nemov, V. Iu., Kartashevich, A. A. 2023, LNG global market: Structural peculiarities and development forecast, *Neftegaz.ru*, URL: https://magazine.neftegaz.ru/articles/rynok/769892-mirovoy-rynok-spg-strukturnye-osobennosti-i-prognoz-razvitiya/?ysclid=m0yrqqc23m393718163 (accessed 12.10.2024).
[4] Armstrong M., 2022, LNG in Europe: Ready or Not?, *Statista.com*, URL: https/www.statista.com/chart/27837/european-lng-import-terminals/ (accessed 12.10.2024).

within the country, which affected its economy. No contagion linked to the gas market was detected, likely owing to Denmark's domestic gas extraction from the North Sea, which helps mitigate possible shortages. Additionally, the country operates the Energinet gas transmission system and partially offsets shortfalls to European countries through the Baltic pipe, benefiting from this arrangement. However, higher energy prices have significantly impacted the competitiveness of Danish goods, as their production is energy-intensive. This, in turn, led to a decline in foreign exchange earnings from exports. Furthermore, the ban on insuring Russian oil cargo shipments and providing corresponding services, announced in the summer of 2022, also had an impact. The share of Russian oil imports to Denmark decreased by more than threefold as a result, plummeting to 7.8 % in 2022.[1] The sanctions imposed on Russian sea carriers led to a decline in revenues for Danish contractors, who control approximately 60 % of all Russian oil shipments by sea.

The absence of oil market-driven contagion in other countries is primarily due to the resource's availability, the development of supply channels and the capacity for rapid diversification, preventing any deficits.

Estimates of sectoral financial contagion

The results obtained for financial contagion at the country level, it is reasonable to infer that it propagated within the economies of the affected countries. The parallel with biological infection is evident — just as a virus initiates a replicative cycle upon entering the human body, in economic systems, this cycle manifests not within cells but through the transmission of shocks from one market, industry or sector to another.

For the seven affected countries, additional contagion estimates were obtained along the 'oil and gas market → industries or sectors of the national economy' pathway. The calculations incorporated various stock indices from Russia, Germany, Denmark and Finland, as well as share prices of companies in Estonia, Latvia and Lithuania within specific sectors. Stock prices were considered a potential transmission channel due to the absence of industry indices for these countries, as they are not computed or published for the relatively small number of publicly traded companies.

The estimation followed a similar approach. Testing for ARCH effects indicated that the hypothesis of ARCH processes could not be rejected for all pairs of analysed variables. Table 4 displays the final results obtained for industry-level financial contagion.

[1] Imports of oil and petroleum products by partner country, *Eurostat.eu*, URL: https://ec.europa.eu/eurostat/databrowser/view/NRG_TI_OIL__custom_12261734/default/table?lang=en (accessed 03.02.2024).

Table 4

Results of detecting financial contagion from the oil and gas market across selected industries and sectors of the Baltic Sea states during the 2021—2022 energy crisis (tested at a 5 % significance level)

Industry or sector	DCC (pre-crisis period)		DCC (crisis period)		t-test, t_{calc}	u-test, p-value	z-test, p-value	Presence of contagion
	Average	Median value	Average	Median value				
Germany								
Automotive engineering	0.124	0.122	−0.204	−0.191	43.87	0.000	0.000	+
Banking sector	0.072	0.075	−0.253	−0.259	30.77	0.000	0.000	+
Chemical industry	0.149	0.152	−0.195	−0.172	24.56	0.000	0.000	+
Mass-media	0.163	0.170	−0.192	−0.181	32.11	0.000	0.000	+
Techniques	0.060	0.064	−0.114	−0.103	24.29	0.000	0.000	+
Insurance	−0.065	−0.069	−0.167	−0.155	10.80	0.000	0.000	+
Transport and logistics	−0.014	−0.015	−0.194	−0.180	21.48	0.000	0.000	+
Industry	0.130	0.151	−0.217	−0.211	20.39	0.000	0.000	+
Health service	0.084	0.080	−0.150	−0.115	24.89	0.000	0.000	+
Retail trade	−0.043	−0.042	−0.204	−0.204	16.61	0.000	0.000	+
Software	0.045	0.043	−0.166	−0.168	20.27	0.000	0.000	+
Telecommunications	0.057	0.070	−0.089	−0.065	12.66	0.000	0.000	+
Utility services	0.038	0.032	−0.190	−0.191	27.54	0.000	0.000	+
Financial services	0.047	0.056	−0.201	−0.206	29.14	0.000	0.000	+
Consumer sector	−0.031	−0.031	−0.208	−0.199	37.72	0.000	0.000	+
Latvia								
Techniques	−0.192	−0.124	−0.214	−0.183	0.068	0.259	0.000	–
Food-processing industry	0.164	0.199	−0.125	−0.116	23.37	0.000	0.000	+
Utility services	0.196	0.197	0.092	−0.089	29.36	0.000	0.000	+
Health service	−0.089	−0.083	0.034	0.034	−6.56	0.000	0.000	–
Consumer sector	−0.170	−0.188	−0.063	−0.055	−6.28	0.000	0.000	–
Transport	−0.022	−0.023	−0.040	−0.038	1.35	0.000	0.000	–
Lithuania								
Telecommunication services	0.130	0.111	−0.080	−0.074	10.25	0.000	0.000	–
Banking sector	−0.032	−0.032	−0.117	−0.117	5.99	0.000	0.000	+
Real estate	0.153	0.153	−0.037	−0.031	9.75	0.000	0.000	+
Tourism	0.174	0.157	−0.146	−0.141	22.89	0.000	0.000	+
Oil and gas sector	−0.058	−0.077	−0.072	−0.075	0.87	0.816	0.000	+
Construction	0.013	−0.032	−0.262	−0.216	10.84	0.000	0.000	+
Utility services	−0.171	−0.171	−0.093	−0.090	−9.64	0.000	0.000	–
Food-processing industry	0.130	0.128	0.168	0.099	−1.30	0.568	0.011	–
Energy sector	0.150	0.173	−0.169	−0.166	17.64	0.000	0.000	+
Textile industry	−0.037	−0.041	0.022	0.013	−1.98	0.000	0.000	–
Finland								
Telecommunications	0.029	0.032	−0.081	−0.048	9.25	0.000	0.000	+
Direct materials	−0.052	−0.040	−0.180	−0.178	9.08	0.000	0.000	+
Health service	−0.135	−0.108	−0.077	−0.075	−2.67	0.088	0.000	–

The end of Table 4

Industry or sector	DCC (pre-crisis period)		DCC (crisis period)		t-test, t_{calc}	u-test, p-value	z-test, p-value	Presence of contagion
	Average	Median value	Average	Median value				
Industry	−0.180	−0.107	−0.215	−0.225	1.66	0.000	0.000	–
Finance	0.064	0.075	−0.105	−0.083	10.06	0.000	0.000	+
Techniques	−0.026	−0.026	−0.126	−0.130	8.18	0.000	0.000	+
Oil and gas sector	0.053	0.054	−0.023	−0.012	12.40	0.000	0.000	+
Utility services	0.008	0.014	−0.114	−0.123	6.48	0.000	0.000	+
Estonia								
Food-processing industry	−0.161	−0.164	0.008	0.006	−27.93	0.000	0.000	–
Textile industry	−0.056	−0.065	−0.137	−0.129	9.13	0.000	0.000	+
Real estate	0.061	0.071	−0.091	−0.069	13.62	0.000	0.000	+
Finance	−0.009	−0.006	0.113	0.113	−9.71	0.000	0.000	–
Electrical equipment	0.038	0.034	−0.156	−0.151	17.45	0.000	0.000	+
Banking sector	0.019	0.048	−0.151	−0.152	13.23	0.000	0.000	+
Construction	0.036	0.029	−0.217	−0.200	18.56	0.000	0.000	+
Retail trade	−0.015	−0.015	−0.180	−0.177	14.26	0.000	0.000	+
Transport	0.090	0.105	−0.161	−0.161	27.43	0.000	0.000	+
Russia								
Metallurgy	−0.043	−0.056	−0.199	−0.208	10.61	0.000	0.000	+
Oil and gas sector	0.146	0.117	−0.119	−0.113	32.50	0.000	0.000	+
Energy	−0.036	−0.100	−0.130	−0.132	7.35	0.000	0.000	+
Telecommunications	−0.053	−0.051	−0.129	−0.138	8.04	0.000	0.000	+
Consumer sector	0.020	−0.023	−0.173	−0.159	11.92	0.000	0.000	+
Chemistry and petroleum chemistry	−0.048	−0.020	−0.157	−0.157	8.59	0.000	0.000	+
Finance	0.053	0.081	−0.149	−0.132	5.52	0.000	0.000	+
Transport	0.023	0.024	−0.174	−0.188	25.29	0.000	0.000	+
Denmark								
Software	−0.040	−0.039	0.083	0.084	24.86	0.000	0.000	+
Consumer goods	0.023	0.026	0.104	0.128	5.88	0.000	0.000	+
Health service	−0.182	−0.182	0.045	0.040	26.13	0.000	0.000	+
Real estate	0.001	0.012	0.028	0.026	2.93	0.016	0.000	+
Banking sector	0.183	0.191	0.098	0.123	−5.16	0.000	0.000	–
Techniques	−0.040	−0.039	0.083	0.083	24.67	0.000	0.000	+
Chemical industry	0.078	0.075	0.081	0.082	0.93	0.129	0.000	–
Oil and gas sector	−0.013	−0.003	0.124	0.137	13.93	0.000	0.000	+
Financial services	−0.107	−0.018	−0.020	−0.033	5.25	0.006	0.000	+

As shown in Table 4, financial contagion during the energy crisis impacted multiple economic sectors across all countries. The oil and gas industry and the energy sectors were the most exposed, which is consistent with the causes and consequences of the crisis. However, certain sectors demonstrated greater resilience than others. For instance, the immunity of some Latvian sectors, particularly healthcare and technology, can be attributed to their relatively low reliance on external energy supplies and strong support from the state. Denmark's banking system, recognised as one of the most stable globally, and Lithuania's telecommunications sector, sustained by steady demand from households and businesses, also exhibited resistance to financial contagion. Nevertheless, overall sectoral vulnerability to energy shocks remained high, underscoring the necessity of developing crisis mitigation strategies and implementing policies to counteract financial contagion.

The sectoral stock markets of Estonia, Latvia and Lithuania remain in an early stage of development, consisting of only a limited number of companies whose share prices do not provide a comprehensive representation of sectoral stock market dynamics. Consequently, estimates of contagion at the sectoral level remain inherently incomplete.

Anti-crisis policy and counteraction to financial contagion

Anti-crisis policies in the Baltic Sea states included governmental responses to the energy shock of 2021—2022, which significantly impacted households and multiple economic sectors. Various measures were implemented to mitigate the effects of rising energy prices, including subsidies and compensations, increased budgetary allocations, tariff freezes, tax reductions and the provision of loans and bank guarantees. Table 5 presents a summary of these policies for the selected countries (excluding Russia), along with examples of specific measures.

Table 5

Anti-crisis measures taken in the Baltic Sea states during the energy crisis

State	Anti-crisis measures	
	Households	Business
Germany	Increased social benefits, coverage of heating costs, one-time payments to vulnerable populations, rental subsidies	Capping energy price increases, granting subsidies to energy and trading companies, providing substantial financial aid to the Uniper energy company and implementing a revised gas auction format
Denmark	Covering electricity bills, providing subsidies for the prompt replacement of individual gas heating systems, increasing the tax-free portion of heating bills	Temporary reduction of electricity tariffs and state-backed loans for energy companies
Latvia	Housing allowances, compensation for housing and utility bills, social payments	Compensation for propane-butane gas and diesel fuel expenditure exceeding the threshold level
Lithuania	Compensation for rising electricity and gas expenditure, increased discounts for solar energy consumers	Additional investments in the electric power sector, support for business initiatives to implement solar, wind and electric batteries, tax incentives
Poland	Freezing electricity and gas prices, subsidising the purchase of coal for heating	Reduction of VAT rates on energy resources, compensation payments to gas companies, tightening of monetary policy

The end of Table 5

State	Anti-crisis measures	
	Households	Business
Finland	Subsidies and tax deductions for utility and transportation costs	Grants to agricultural enterprises, bank guarantees for housing and utilities companies, reduction of VAT rates for passenger transportation services, compensation of expenses to fishing companies
Sweden	Compensation for rising electricity costs and an increase in housing allowances for families with children	Setting an upper limit on electricity prices, reducing fuel taxes, providing bank guarantees to housing and utility companies
Estonia	Subsidies for low-income families to cover utility costs, ceiling on electricity and gas tariffs	Reduction of electricity payments and investment grants for energy security in industry

Compiled according to materials from [28—31].

Obviously, these measures required large-scale administrative oversight, legal regulation and financial backing, with the German government shouldering the greatest cost. For instance, a €65 billion package was announced in September 2022 to support a Europe-wide cap on energy company profits, reduce electricity prices and subsidise the electricity grid in an attempt to curb price increases. The programme also included lump-sum payments of €300 for pensioners and €200 for university students, along with increased rental subsidies, child allowances and other social benefits. Similar initiatives, albeit with significantly smaller budgets, were launched in other countries. The government of Lithuania introduced compensation measures for electricity and gas consumers affected by rapidly rising prices. The maximum electricity price compensation was set at €0.285/kWh, while gas price compensation reached €0.99/m^3. The 2022 budget allocated €973 million for this purpose, with approximately €570 million allocated to households. Additionally, Lithuania actively promoted a transition to solar energy, increasing the budget for solar customer incentives from €5 million to €35 million in 2022, more than doubling the number of participants. Consequently, total monthly solar power consumption capacity rose from 261.8 MW in January 2022 to 572.3 MW by December 2022 [28].

Countering financial contagion should be adapted to the specific channels through which it is transmitted. If contagion spreads through trade, policies may include import restrictions or outright bans. In the case of cross-border lending, measures could involve financial leverage restrictions and stringent bank capital requirements. As this study examines financial contagion spread through the stock market, managing portfolio investments becomes a central concern. Capital flow controls, government or central bank purchases of portfolio assets, asset guarantees and financial market stabilisation mechanisms — such as repo transactions or secured lending to market participants — have been highlighted as effective countermeasures [32]. These strategies are equally relevant for the Baltic Sea states affected by financial contagion, which should, as a priority, maintain a balanced international portfolio investment strategy, diversify their assets and closely monitor macroeconomic linkages. Additionally, implementing investor protection mechanisms can mitigate financial losses in the event of contagion.

Driven by the energy crisis, European measures to counter financial contagion became part of the energy market reform initiated in September 2022. This reform aimed to mitigate risks for consumers, industry and investors, which continually arise in various markets due to the heightened volatility in energy prices [33]. Early results of the European anti-crisis policy can already be seen in the diversification of energy supplies. In the first half of 2022, imports of liquefied natural gas from outside the Russian Federation (i. e. the United States, Canada and Norway) increased by 19 billion m^3 year-on-year. Cooperation with Azerbaijan was expanded, particularly concerning the Southern Gas Corridor and a Trilateral Memorandum of Understanding was signed with Egypt and Israel on gas exports. Additionally, energy dialogue with Algeria was resumed and cooperation with major producers in the Persian Gulf continued. The EU also established a platform for joint gas purchases, enabling member countries to maximise their collective purchasing power. The goal of this voluntary coordination mechanism is to secure more favourable prices, enhance transparency and support member states that need assistance in gas procurement due to a lack of financial resources.

Overall, the anti-crisis measures taken by the countries contributed to the stabilisation of energy prices and a reduction in their volatility. In the context of global instability, these measures proved effective in responding to the crisis, including in countries where no contagion was recorded. The shocks of a global nature and the strong interconnectedness of EU economies, along with policies based on common principles, necessitated the adoption of these national-level measures. They not only helped counteract financial contagion but also precluded it in individual countries, thereby having a preventive effect.

Conclusion

The energy crisis of 2021—2022 posed a significant challenge to the economies of the Baltic Sea states. Our study revealed instances of financial contagion from both a country-specific and industry perspective. Dependence on Russian energy imports and underdeveloped domestic energy infrastructure left many Baltic Sea states vulnerable to the energy shock, primarily originating from the gas market. However, government interventions helped mitigate the crisis effects and shielded the financial system from systemic contagion. The crisis highlighted the critical need for energy resource diversification and the development of renewable energy sources, enabling the Baltic Sea states to build greater resilience against future global energy market shocks.

Other approaches, notably the Diebold-Yilmaz methodology for constructing VAR models, can be employed to explore the processes of financial contagion. This methodology helps capture the dynamics of temporal relationships and estimate how changes in one market may influence other markets [34]. Its application would enable the identification of countries and industries where contagion is detected 'first' or 'late'. Such insights are valuable for developing anti-crisis policies and implementing preventive measures against financial contagion.

This study, conducted at the Lobachevsky State University of Nizhny Novgorod, Russia, was funded by a grant from the Russian Science Foundation № 24-28-00124, https://rscf.ru/project/24-28-00124

References

1. El Khoury, R., Nasrallah, N., Hussainey, K., Assaf, R. 2023, Spillover analysis across FinTech, ESG, and renewable energy indices before and during the Russia—Ukraine war: International evidence, *Journal of International Financial Management & Accounting*, vol. 34, № 2, p. 279—317, https://doi.org/10.1111/jifm.12179

2. Kamal, M. R., Ahmed, S., Hasan, M. M. 2023, The impact of the Russia—Ukraine crisis on the stock market: Evidence from Australia, *Pacific-Basin Finance Journal*, vol. 79, p. 102036, https://doi.org/10.1016/j.pacfin.2023.102036

3. Zakeri, B., Paulavets, K., Barreto-Gomez, L., Echeverri, L. G., Pachauri, S., Boza-Kiss, B., Zimm, C., Rogelj, J., Creutzig, F., Ürge-Vorsatz, D., Victor, D. G., Bazilian, M. D., Fritz, S., Gielen, D., McCollum, D. L., Srivastava, L., Hunt, J. D., Pouya, S. 2022, Pandemic, war, and global energy transitions, *Energies*, vol. 15, p. 6114, https://doi.org/10.3390/en15176114

4. Kayani, U. N., Hassan, M. K., Moussa, F., Hossain, G. F. 2023, Oil in crisis: What can we learn, *The Journal of Economic Asymmetries*, vol. 28, e00339, https://doi.org/10.1016/j.egyr.2023.06.039

5. Kola-Bezka, M. 2023, One size fits all? Prospects for developing a common strategy supporting European Union households in times of energy crisis, *Energy Reports*, vol. 10, p. 319—332, https://doi.org/10.1016/j.egyr.2023.06.039

6. Martínez-García, M., Ramos-Carvajal, C., Cámara, Á. 2023, Consequences of the energy measures derived from the war in Ukraine on the level of prices of EU countries, *Resources Policy*, vol. 86, 104114, https://doi.org/10.1016/j.resourpol.2023.104114

7. Gritz, A., Wolff, G. 2024, Gas and energy security in Germany and central and Eastern Europe, *Energy Policy*, vol. 184, p. 113885, https://doi.org/10.1016/j.enpol.2023.113885

8. Mišík, M., Nosko, A. 2023, Each one for themselves: Exploring the energy security paradox of the European Union, *Energy Research & Social Science*, vol. 99, 103074, https://doi.org/10.1016/j.erss.2023.103074

9. Zakeri, B., Staffell, I., Dodds, P. E., Grubb, M., Ekins, P., Jääskeläinen, J., Cross, S., Helin, K., Gissey, G. C. 2023, The role of natural gas in setting electricity prices in Europe, *Energy Reports*, vol. 10, p. 2778—2792, https://doi.org/10.1016/j.egyr.2023.09.069

10. Sattich, T., Morgan, R., Moe, E. 2022, Searching for energy independence, finding renewables? Energy security perceptions and renewable energy policy in Lithuania, *Political Geogr.*, vol. 96, 102656, https://doi.org/10.1016/j.polgeo.2022.102656

11. Sivonen, M. H., Kivimaa, P. 2024, Politics in the energy-security nexus: an epistemic governance approach to the zero-carbon energy transition in Finland, Estonia, and Norway, *Environmental Sociology*, vol. 10, № 1, p. 55—72, https://doi.org/10.1080/23251042.2023.2251873

12. Liobikienė, G., Liobikas, J., Miceikienė, A. 2024, How the attitudes and perception of war in Ukraine and environmental aspects have influenced selection of green electricity in Lithuania, *Journal of Cleaner Production*, vol. 434, 140057, https://doi.org/10.1016/j.jclepro.2023.140057

13. Lakos, G., Szendrei, T. 2017, Explanations of Asset Price Bubbles, *Financial and Economic Review*, vol. 16, № 4, p. 122—150, http://doi.org/10.25201/FER.16.4.122150

14. Kuusk, A., Paas, T., Viikmaa, K. 2011, Financial contagion of the 2008 crisis: Is there any evidence of financial contagion from the US to the Baltic states, *Eastern Journal of European Studies*, vol. 2, № 2, p. 61—76.

15. Amundsen, E., Arnt, H. 2005, Contagion risk in the Danish Interbank market, *Danmarks Nationalbank Working Papers*, vol. 29, p. 1—26, URL: http://hdl.handle.net/10419/82331 (accessed 03.02.2024).

16. Mohti, W., Dionísio, A., Vieira, I. 2019, Ferreira, P. Financial contagion analysis in frontier markets: Evidence from the US subprime and the Eurozone debt crises, *Physica A: Statistical Mechanics and its Applications*, vol. 525, p. 1388—1398, https://doi.org/10.1016/j.physa.2019.03.094

17. Masood, O., Bellalah, M., Chaudhary, S., Mansour, W., Teulon, F. 2010, Cointegration of Baltic stock markets in the financial Tsunami: Empirical evidence, *International Journal of Business*, vol. 15, № 1, p. 119—132.

18. Soultanaeva, A. 2008, Impact of political news on the Baltic state stock markets, *Umea Economic Studies*, vol. 735, p. 1—21.

19. Dubinskas, P., Stunguriene, S. 2010, Alterations in the financial markets of the Baltic countries and Russia in the period of economic downturn, *Technological and Economic Development of Economy*, vol. 16, № 3, p. 502—515, https://doi.org/10.3846/tede.2010.31

20. Deltuvaitė, V. 2016, Cross-border contagion risk transmission through stock markets channel: The case of the baltic countries, *Financial Environment and Business Development*, vol. 4, p. 43—54, https://doi.org/10.1007/978-3-319-39919-5_4

21. Alexakis, P. D., Kenourgios, D., Dimitriou, D. 2016, On emerging stock market contagion: The Baltic region, *Research in International Business and Finance*, vol. 36, p. 312—321, https://doi.org/10.1016/j.ribaf.2015.09.035

22. Klemeshev, A. P., Korneevets, V. S., Palmowski, T., Studzieniecki, T., Fedorov, G. M. 2017, Approaches to the definition of the Baltic Sea region, *Baltic Reg*ion, vol. 9, № 4, p. 7—28, https://doi.org/10.5922/2079-8555-2017-4-1

23. Engle, R. 2002, Dynamic Conditional Correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models, *Journal of Business & Economic Statistics*, vol. 20, № 3, p. 339—350, https://doi.org/10.1198/073500102288618487

24. Asaturov, K., Teplova, T., 2014, Volatility spillover and contagion effects on stock markets: Global and Local Leaders Determination (Part 2), *Vestnik Moskovskogo universiteta. Seriya 6: Ekonomika*, vol. 6, p. 3—34, https://doi.org/10.38050/01300105201461

25. Pivnitckaya, N. A., Teplova, T. 2021, DCC-GARCH-model for identifying long-term and short-term effects of financial contagion in response to the credit rating updates, *Economics and Mathematical Methods,* vol. 57, № 1, p. 113—123, https://doi.org/10.31857/S042473880014080-7

26. Liobikienė, G., Matiiuk, Y., Krikštolaitis, R. 2023, The concern about main crises such as the COVID-19 pandemic, the war in Ukraine, and climate change's impact on energy-saving behavior, *Energy Policy*, vol. 180, 113678, https://doi.org/10.1016/j.enpol.2023.113678

27. Johnson, S., Rachel, L., Wolfram, C. 2023, Design and implementation of the price cap on Russian oil exports, *Journal of Comparative Economics*, vol. 51, № 4, p. 1244—1252, https://doi.org/10.1016/j.jce.2023.06.001

28. Sgaravatti, G. S., Tagliapietra, Trasi, C., Zachmann, G. 2021, National fiscal policy responses to the energy crisis, *Bruegel Datasets*, URL: https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices (accessed 02.09.2024).

29. Sperber, E., Frey, U., Bertsch, V. 2024, Turn down your thermostats — A contribution to overcoming the European gas crisis? The example of Germany, *Heliyon*, vol. 10, № 2, e23974, https://doi.org/10.1016/j.heliyon.2024.e23974

30. Prokopowicz, D. 2023, Energy crisis of 2022 in Poland as a result of the war in Ukraine and years of neglect in the development of renewable energy sources, *International Journal of New Economics and Social Sciences*, vol. 17, № 1, https://doi.org/10.13140/RG.2.2.33873.30568

31. Fabra, N. 2023, Reforming European electricity markets: Lessons from the energy crisis, *Energy Economics*, vol. 126, 106963, https://doi.org/10.1016/j.eneco.2023.106963

32. Forbes, K. J. 2012, The «Big C»: Identifying contagion, *NBER Working Paper Series*, vol. 18465, https://doi.org/10.3386/w18465

33. Cebotari, L., Paierele, A. 2023, The energy crisis and the measures taken by the European Union to Overcome It, *Geopolitical perspectives and technological challenges for sustainable growth in the 21st century*, p. 663—671, https://doi.org/10.2478/9788367405546-061

34. Diebold, F. X., Yilmaz, K. 2009, Measuring financial asset return and volatility spillovers, with application to global equity markets, *The Economic Journal*, vol. 119, № 534, p. 158—171, https://doi.org/10.1111/j.1468-0297.2008.02208.x

The authors

Dr Andrey M. Terekhov, Senior Researcher, Lobachevsky Nizhny Novgorod State University; Associate Professor, Russia Russian State University of Justice, Russia.

E-mail: terehoff.t@yandex.ru

https://orcid.org/0000-0002-2356-4533

Prof Anton O. Ovcharov, Chief Researcher, Lobachevsky Nizhny Novgorod State University, Russia.

E-mail: anton19742006@yandex.ru

https://orcid.org/0000-0003-4921-7780