

WTI OIL SHOCKS IN EASTERN EUROPEAN STOCK MARKETS: A VAR APPROACH

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Abstract: *The 2020 Russia-Saudi Oil Price War was an economic war triggered in March 2020 by Saudi Arabia in response to Russia's refusal to reduce oil production to keep oil prices at a moderate level. In view of these events, this study aims to analyze oil shocks (WTI) in the eastern European stock markets, namely the stock indices of Hungary (BUX), Croatia (CROBE), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX), from September 2019 to January 2021. The results show mostly structural breakdowns in March 2020, while the VAR Granger Causality/Block Exogeneity Wald Tests model shows two-way shocks between oil (WTI) and the stock markets analyzed. These findings show that the hypothesis of portfolio diversification may be called into question. As a final discussion, we consider that investors should avoid investments in stock markets, at least as long as this pandemic last, and rebalance their portfolios into assets considered "safe haven" for the purpose of mitigating risk and improving the efficiency of their portfolios.*

Keywords: *Oil (WTI), Eastern European markets, Shocks, Portfolio diversification.*

1. INTRODUCTION

Globalization has accentuated the integration of international financial markets and has shown that the correlation between international financial markets has increased significantly. Since the mid-2000s, international financial markets have been subject to a number of significant financial crises, notably the *subprime crisis* in the US in 2008, and the sovereign debt crisis in Europe in 2010, which originated in developed economies. These events significantly infected developed economies, however, this significance was not dense in emerging economies. The interdependence and integration of financial markets are quite different concepts, with the interdependence between markets associated with the phenomenon of co-movements between the prices of various markets, even though there are no justified economic bases or sufficient knowledge about the facts that led to this joint movement occurrence. On the other hand, we are dealing with integrated markets when assets with similar risk but belonging to different markets are associated with similar yields. The understanding of the synchronizations between the stock markets, as well as the study on the occurrence of movements, in periods of turbidity, is important for investors, investment fund managers, academics, in various aspects, particularly when it is to implement strategies for diversification of efficient portfolios (Alex-

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The 2020 Russia-Saudi Oil Price War was an economic war triggered in March 2020 by Saudi Arabia in response to Russia's refusal to reduce oil production to keep oil prices at a moderate level. This economic conflict resulted in a sharp drop in the price of oil in the spring of 2020. On March 8, 2020, Saudi Arabia started a price war with Russia, facilitating a quarterly drop of 65% in the price of oil. In the first weeks of March, oil prices in the United States fell 34%, crude oil fell 26% and Brent oil fell 24%. The price war was triggered by a disruption in dialogue between the Organization of the Petroleum Exporting Countries (OPEC) and Russia over proposed cuts in oil production due to the 2020 global pandemic. Russia withdrew from the agreement, leading to the fall of the OPEC alliance. The price of oil had already fallen 30% since the beginning of the year due to the drop in demand. Price war is one of the main causes and effects of the ongoing global stock market crash. In early April 2020 and again in June 2020, Saudi Arabia and Russia agreed to cuts in oil production. The price turned negative on April 20. Oil production can be slowed, but not completely halted, and even the lowest possible production level resulted in higher supply than demand; investors who owned it in their oil futures portfolios even paid to unload oil contracts they thought they would not be able to store (Cardona-Arenas and Serna-Gómez, 2020; Dias, Heliodoro, Alexandre, et al., 2020b; L. Liu, Wang, and Lee, 2020; M. Osagie Adenomon, 2020; Mzoughi, Urom, Uddin, and GUESMI, 2020; Sakurai and Kurosaki, 2020; Salisu, Ebuh, and Usman, 2020; Sharif, Aloui, and Yarovaya, 2020; Villarreal-Samaniego, 2020).

In view of these events, this study aims to analyze oil shocks (WTI) in the eastern European stock markets, namely the stock indices of Hungary (BUX), Croatia (CROBE), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX), from September 2019 to January 2021. The results show the strong co-movements between the WTI index and the Eastern stock markets, as well as clashes between the stock markets analyzed. These findings call into question the hypothesis of efficient portfolio diversification.

This research differs from the studies conducted so far, on the impact of the WTI index on the eastern European stock markets; as far as we know, the authors Xiao and Wang (2020), Alqahtani, Lahiani, and Salem (2020), Naeem, Hasan, Arif, Balli, and Shahzad (2020), Dias, Heliodoro, Alexandre, et al. (2020b) analyzed the oil shocks in the various financial markets, but the research issues, the sample, and the approach was essentially distinct from the one followed in this trial.

In terms of structure, this paper is organized into 5 sections. In addition to the current introduction, section 2 presents a Literature Review on articles on the impact of oil on international financial markets, section 3 describes the methodology and data, section 4 contains the results. Section 5 presents the general discussions of the work.

2. LITERATURE REVIEW

The economic turbulence associated with the global 2020 pandemic has widespread and serious repercussions on financial markets, including the oil war and currency fluctuations. The oil price war between Russia and Saudi Arabia comes after an agreement was reached by the Organization of petroleum exporting countries (OPEC), which led to a collapse in oil prices and a sharp drop in international financial markets in March 2020 (G.Sudha and V.Sornaganesh, 2020).

Xiao and Wang (2020), Alqahtani, Lahiani, and Salem (2020), Naeem, Hasan, Arif, Balli, and Shahzad (2020), Dias, Heliodoro, Alexandre, et al. (2020b) analyzed oil shocks in international stock markets. Xiao and Wang (2020) examined the co-movements between crude oil (WTI and Brent) and 8 stock markets; the authors show nonlinear two-way causation relationships between the oil markets and the stock markets. Alqahtani, Lahiani, and Salem (2020) analyzed the impact of international oil prices on the stock markets of gulf cooperation council (GCC) countries from April 7, 2004 to August 15, 2018. The authors show the existence of shocks between oil and stock markets; in view of these results investors and portfolio managers should have some caution in the diversified action of their portfolios in these regional markets. Naeem, Hasan, Arif, Balli, and Shahzad (2020) show that the global financial crisis of 2008 has increased the shocks between BRIC countries stock markets and oil and gold prices. Dias, Heliodoro, Alexandre, et al. (2020b) analyzed the shocks between oil (WTC) and the stock markets of Brazil (BOVESPA), China (SSEC), India (SENSEX), Russia (IMOEX) in the period from January 2019 to May 29, 2020. The authors show shocks between oil (WTC) and the stock markets analyzed, with the exception of the China market.

Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., and Krulický (2020), Dias et al. (2020), Dias and Pereira (2020), He, Liu, Wang, and Yu (2020) analyzed several international stock markets in the context of the global pandemic. Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., and Krulický (2020) examined the diversification of portfolios in the stock markets of Austria (ATX), Slovenia (SBITOP), Hungary (BUDAPEST SE), Lithuania (OMX VILNIUS), Poland (WIG), Czech Republic (PX PRAGUE), Russia (MOEX) and Serbia (BELEX 15), showing that these markets have sharp levels of integration which calls into question the diversification of portfolios in this period of global pandemic. Dias et al. (2020) analyzed the Belgium (index BEL 20), France (index CAC 40), Germany (index DAX 30), USA (index DOW JONES), Greece (index FTSE Athex 20), Spain (index IBEX 35), Ireland (index ISEQ), Portugal (index PSI 20) and China (index SSE), from December 2019 to May 2020, showing that the global pandemic caused sharp imbalances in these regional stock markets. Dias and Pereira (2020) analyzed the evolution of the numbers Covid-19 (confirmed cases and deaths) and the stock markets of Greece (ATG), France (CAC40), Germany (DAX 30), United Kingdom (FTSE 100), Italy (FTSE MID), Spain (IBEX 35), Ireland (ISEQ) and Portugal (PSI 20), in the period from December 2019 to 23 July 2020. The authors suggest that the Covid data do not cause shocks in Europe's stock markets, but evidence emerges of imbalances in the stock markets analyzed due to the uncertainty and pessimism experienced in the global economy. He, Liu, Wang, and Yu (2020) examined the direct effects and repercussions of Covid-19 on the stock exchanges of the People's Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the United States. The authors show that Covid-19 has a negative but short-term impact on the stock exchanges of the affected countries and that the impact of Covid-19 on stock exchanges has two-way effects between Asian, European and American markets.

In summary, this work aims to contribute to the provision of information to investors and regulators in eastern European stock markets, where individual and institutional investors seek diversification benefits, as well as to help to promote the implementation of policies that contribute to the efficiency of these markets. Therefore, the objective of this work is to examine the co-movements between WTI and eastern European stock markets in order to test whether these markets are immune to oil shocks on international markets.

3. METHODOLOGY

3.1. Data

The data analyzed relate to the prices indexes of the stock indices of Hungary (BUX), Croatia (CROBE), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX) and Crude Oil (WTI), from 2 September 2019 to 11 January 2021. The time series have daily scales, and were obtained from the *DataStream* platform, and the prices index is in local currency, to mitigate distortions in exchange rates.

Table 1. The name of countries and their indices used in this paper

Country	Index
Hungary	BUDAPEST IF BUX
Croatia	CRObe
Russia	MOEX
Czech Republic	PRAGUE
Slovakia	SAX 16
Slovenia	SBI TOP
Bulgaria	SOFIX
Crude Oil-WTI Spot Cushing U\$/BBL	WTI

Source: Own elaboration

3.2, Methodology

The development of the research took place through several stages. The characterization of the sample used was made through descriptive statistics, the adherence test of Jarque and Bera (1980), as well as graphs of stability to the residues. As we are estimating time series we should examine the stationary nature of the data series through the tests of Hadri (2000), Levin, Lin, and Chu (2002). To estimate the structural breakdowns in the financial markets, we used the unit root test of Clemente et al. (1998). To evaluate the co-movements between WTI and the Eastern European stock markets under analysis, we used the *VAR Granger Causality/Block Exogeneity Wald Tests model*, which uses Wald's statistic, which tests whether the null hypothesis that the coefficients of the endogenous variables in the variable "cause" are null or not "cause" in the Granger sense of the dependent variable. It should be noted, however, that the result of this test has a high sensitivity to the number of lags considered in the model, so the first concern is to conveniently estimate this value, in order to reach robust evidence (Gujarati, 2004). Additionally, to determine the number of lags to be included in the causality tests, we used the LR: sequential modified LR test statistic (each test at 5% level), and to measure the robustness of the model we applied the VAR Residual Serial Correlation LM Tests.

4. RESULTS

Figure 1 shows the evolution of central European financial markets, and the WTI index, at levels, from September 2 to January 11, 2021. We easily see that stock markets, and WTI, show significant declines, which coincides with the upheaved oil trade war in 2020.

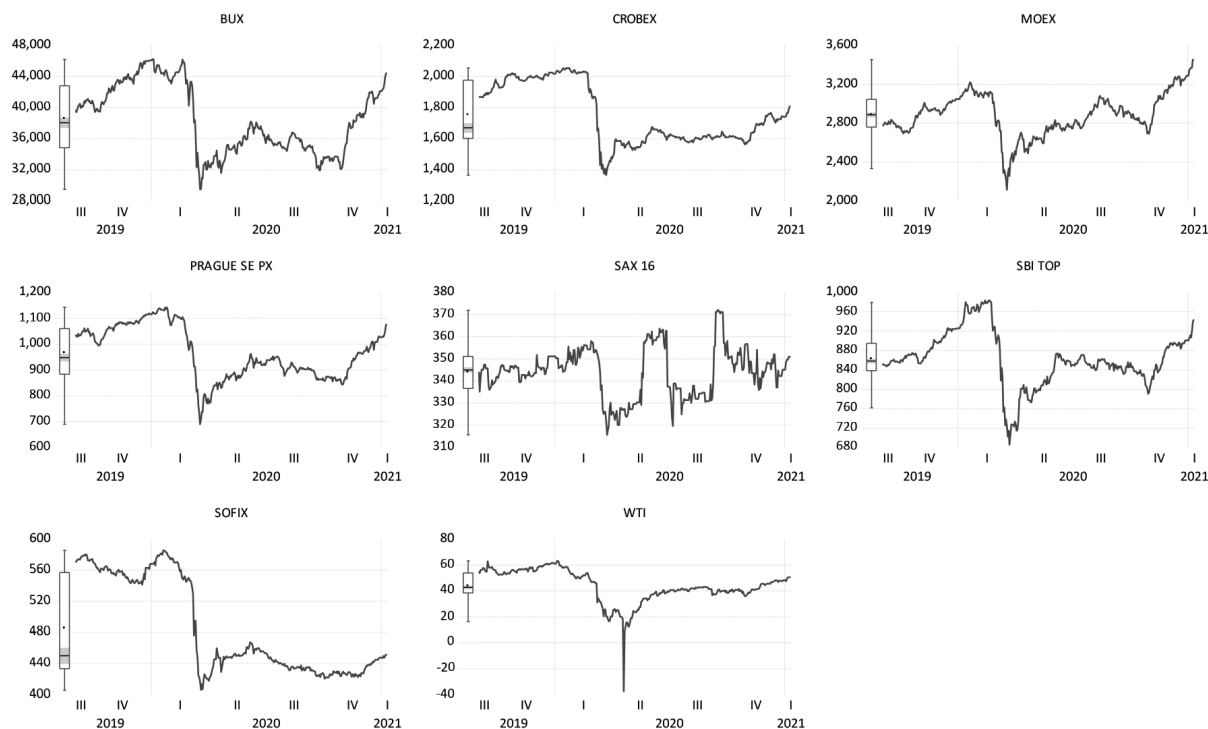


Figure 1. Evolution, in levels, of the eight financial markets in the period from September 2, 2019 to January 11, 2021.

Source: Own elaboration

Figure 2 shows the evolutions in return of the 8 financial markets, namely Budapest (BUX), Croatia (CROBE), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX), Crude Oil (WTI). In all series, a relatively high dispersion around the mean is noted, as well as a relatively synchronized behavior between the data series. Through graphical analysis, high volatility is observed, especially in February, March and April 2020.

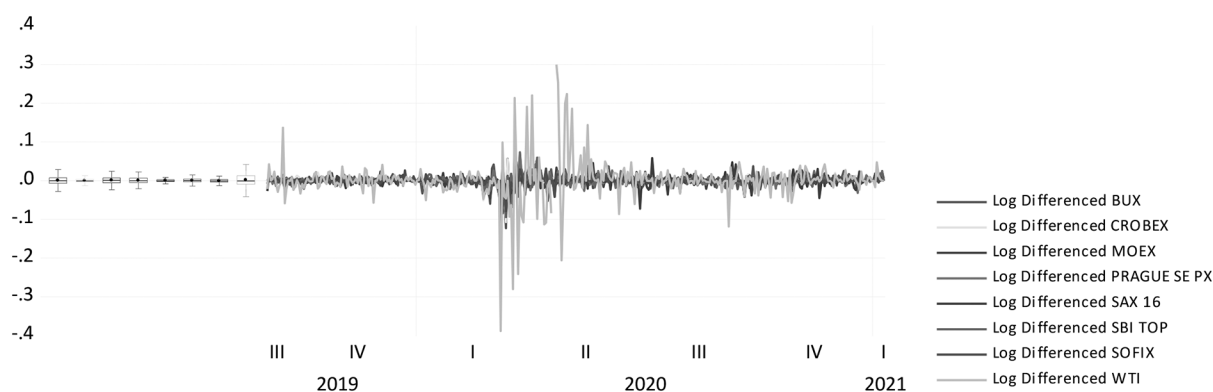


Figure 2. Evolution, in levels, of the 8 financial markets in the period from September 2, 2019 to January 11, 2021.

Source: Own elaboration

Table 2 shows the main descriptive statistics of the yields of the seven Eastern European stock markets and Crude Oil (WTI), as well as the Jarque-Bera adherence test. The analyses of descriptive statistics show profitability, present positive daily averages, with the exception of the stock markets of Croatia and Bulgaria with negative average yields; The Market of Russia (MOEX) presents the highest standard deviation, while the Bulgarian stock market (SOFIX), presents the highest levels of shortness and asymmetry. Additionally, the coefficients of asymmetry and kurtosis are statistically different from those of a normal distribution, and such indications were corroborated with the Jarque-Bera adherence test that rejects the null hypothesis with a significance of 1%.

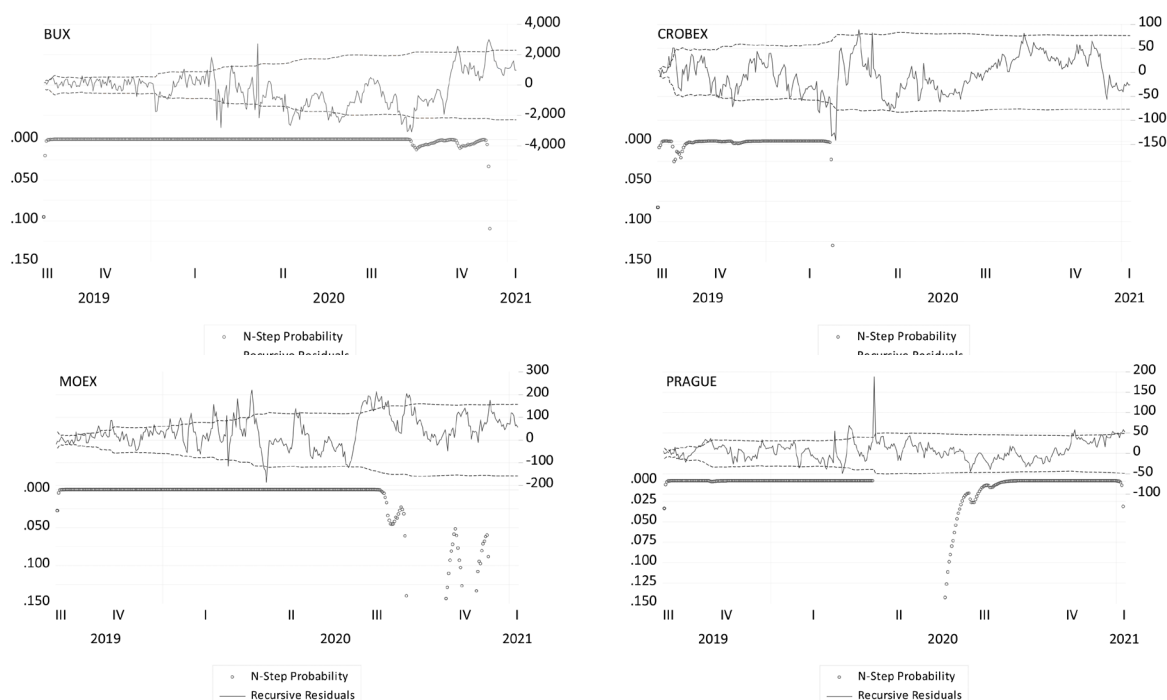
Table 2. Descriptive statistics on profitability of the 8 financial markets from September 2, 2019 to January 11, 2021.

	BUX	CROBEX	MOEX	PRAGUE	SAX 16	SBI TOP	SOFIX	WTI
Mean	0.000454	-6.21E-05	0.000674	0.000176	5.48E-05	0.000389	-0.000542	0.001794
Std. Dev.	0.016651	0.012412	0.014333	0.013931	0.011578	0.011574	0.010270	0.053849
Skewness	-1.650667	-3.570529	-0.969373	-1.194833	-0.100943	-2.318422	-4.552123	-0.261100
Kurtosis	14.20073	33.88451	13.71982	12.85617	11.46669	22.85478	47.87305	20.13644
Jarque-Bera	2011.2***	14821.5***	1750.432***	1517.1***	1057.9***	6131.7***	30923.0***	4335.5***
Observations	354	354	354	354	354	354	354	354

Note: ***, **, * represent significance at 1%, 5% and 10%, respectively.

Source: Own elaboration

Figure 3 shows the stability tests carried out on the waste of the time series of the eastern European stock markets, namely the stock indices of Budapest (BUX), Croatia (CROBE), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX), and Crude Oil (WTI) for the purpose of corroborating the presence of structural breakdowns. The determination of the structure break is relevant because it has a potentially similar effect to that of the unit roots. Through graphical analysis we can assess the existence of disturbances in variance. Additionally, when examining the graphs and the probability limits of 95% we verified the existence of violation of probability limits, therefore, the time series show an unstable behavior.



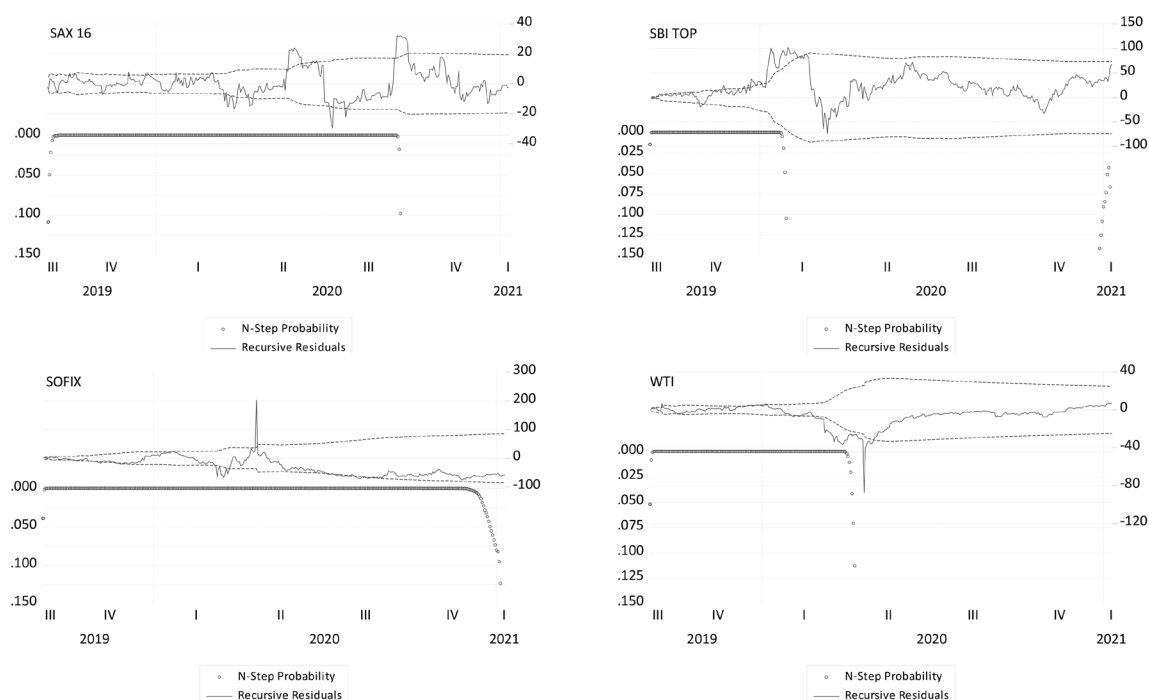


Figure 3. Stability tests carried out on the waste of Europe's 8 financial markets in the period from September 2, 2019 to January 11, 2021.

Source: Own elaboration

As we are estimating time series, we should examine the stationary nature of the data series of the 7 Eastern European stock markets and Crude Oil (WTI). The Tests of Hadri (2000), Levin, Lin, and Chu (2002) performed postulate contrary hypotheses. The intersection of unit root tests shows the temporality of time series in the first differences. However, we must highlight the lags of the tests, which suggest that the time series may not be stable and, in view of this indication, we will perform the test by Clemente et al. (1998) that analyzes the parking with structural breaks (see tables 3 and 4).

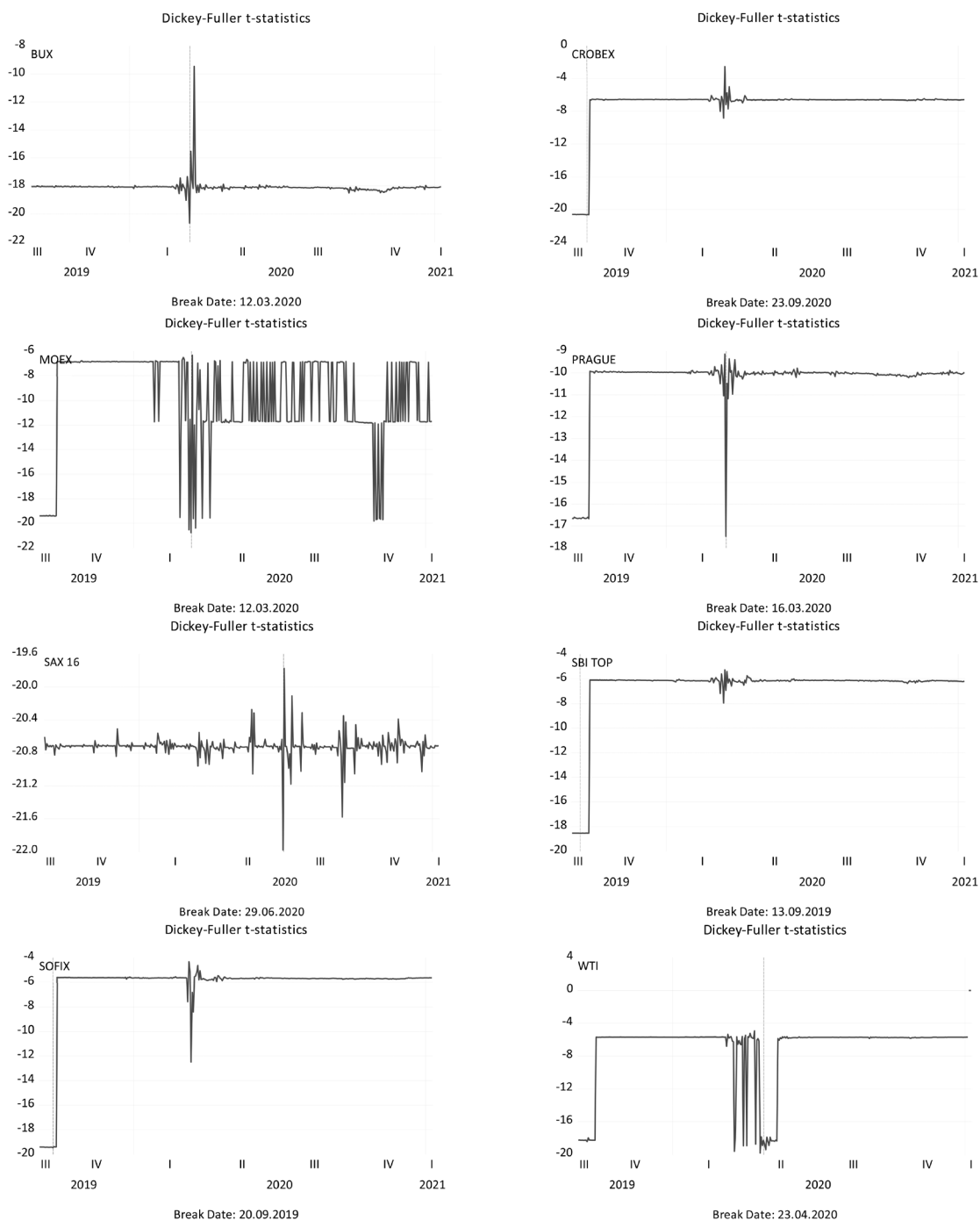
Table 3. Levin, Lin, and Chu parking test (2002), applied to the 8 financial markets of Europe, from September 2, 2019 to January 11, 2021.

Method		Statistic			Prob.**		
Levin, Lin & Chu t*		-34.5961			0.0000		
Series	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Note
D(BUX)	-0.93576	371735	24864.	0	16	31.0	354
D(CROBEX)	-0.55923	350.01	51.194	2	16	14.0	352
D(MOEX)	-0.87141	1416.2	15.625	1	16	191.0	353
D(PRAGUE)	-0.69468	142.10	37.920	1	16	7.0	353
D(SAX 16)	-1.09964	15.406	0.5797	0	16	81.0	354
D(SBI TOP)	-0.62732	79.328	11.420	5	16	17.0	349
D(SOFIX)	-0.49905	21.869	3.3382	4	16	13.0	350
D(WTI)	-1.67107	14.082	0.5940	1	16	58.0	353
Pooled		T-Stat	SE Reg	mu*	sig*	Note	
		-0.91464	-35.446	1.025	-0.503	0.719	2818

Note: ** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

All other tests assume asymptotic normality.

Source: Own elaboration.



Note: Lag Length (Automatic Length based on SIC). Break Selection: Minimize Dickey-Fuller t-statistic

Figure 4: Parking tests with structural breaks by Clemente et al. (1998), return, referring to the 8 financial markets, in the period from September 2, 2019 to January 11, 2021.

Source: Own elaboration

Figure 4 shows the results of unitary root tests, with structural breaks, by Clemente et al. (1998); the results suggest sharp breaks in the stock indices BUX (12/03/2020), CROBE (26/09/2019), MOEX (12/03/2020), PRAGUE (16/03/2020), SAX 16 (29/06/2020), SBI TOP (13/09/2019), SOFIX (20/09/2019), and WTI (22/04/2020). These findings are corroborated by the authors Sansa (2020), He, Liu, Wang, and Yu (2020), who show structural breakdowns in financial markets, resulting from the uncertainty in international financial markets.

Table 4. Hadri stationary test (2000), applied to the 8 financial markets of Europe, from September 2, 2019 to January 11, 2021.

from September 2, 2019 to January 11, 2021.

Method	Statistic	Prob.**		
Hadri Z-stat	0.78067	0.2175		
Heteroscedastic Consistent Z-stat	-0.58845	0.7219		
Intermediate results on D(UNTITLED)				
	Variance			
Series	Lm	Hac	Bandwidth	Note
D(BUX)	0.2082	530994.2	8.0	355
D(CROBEX)	0.1341	837.4791	12.0	355
D(MOEX)	0.1580	2055.180	8.0	355
D(PRAGUE)	0.2027	269.4124	9.0	355
D(SAX 16)	0.0279	13.73427	6.0	355
D(SBI TOP)	0.0963	165.7788	12.0	355
D(SOFIX)	0.1198	46.71800	13.0	355
D(WTI)	0.1381	4.632343	14.0	355

Note: ** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Source: Own elaboration.

To analyze the significance of causality relationships between the financial markets in analysis, the *VAR Granger Causality/Block Exogeneity Wald Tests model* was applied. To determine the number of lags to be included in the causality tests, we used the LR: sequential modified LR test statistic (each test at 5% level), which suggests 10 lags (see table 5).

Table 5. VAR Lag Order Selection Criteria, from September 2, 2019 to January 11, 2021.

Lag	LogL	Lr	Fpe	Cbl	Sc	Hq
0	8030.962	In	1.89e-31	-48.04169	-47.95041*	-48.00529*
1	8140.091	212.3772	1.44E-31	-48.31192	-47.49036	-47.98436
2	8226.022	163.1140	1.26e-31	-48.44325	-46.89140	-47.82451
3	8340.234	211.3264	9.37e-32	-48.74392	-46.46180	-47.83400
4	8426.771	155.9733	8.22E-32	-48.87887	-45.86647	-47.67778
5	8499.645	127.8563	7.83E-32	-48.93200	-45.18933	-47.43975
6	8593.648	160.4243	6.59e-32*	-49.11166*	-44.63871	-47.32823
7	8654.454	100.8583	6.78e-32	-49.09254	-43.88930	-47.01794
8	8707.798	85.92573	7.32E-32	-49.02873	-43.09522	-46.66296
9	8765.379	89.99087	7.74E-32	-48.99029	-42.32650	-46.33335
10	8825.302	90.78256*	8.11E-32	-48.96588	-41.57181	-46.01776

Source: Own elaboration

Table 6. VAR Residuals Test, from September 2, 2019 to January 11, 2021.

Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	78.95130	64	0.0988	1.240908	(64, 1379.2)	0.0990
2	91.50767	64	0.0136	1.444744	(64, 1379.2)	0.0137
3	81.54046	64	0.0687	1.282791	(64, 1379.2)	0.0689
4	95.94926	64	0.0060	1.517282	(64, 1379.2)	0.0060
5	93.92517	64	0.0088	1.484197	(64, 1379.2)	0.0088
6	80.30698	64	0.0819	1.262829	(64, 1379.2)	0.0821
7	69.79313	64	0.2891	1.093378	(64, 1379.2)	0.2895
8	85.56653	64	0.0372	1.348071	(64, 1379.2)	0.0373
9	96.38754	64	0.0055	1.524453	(64, 1379.2)	0.0055
10	82.93244	64	0.0559	1.305340	(64, 1379.2)	0.0561
11	74.30488	64	0.1777	1.165939	(64, 1379.2)	0.1779

Source: Own elaboration

In table 6 we can verify the autocorrelation test to the residues with 11 lags, which validates the VAR Lag Order Selection Criteria test at 10 lags. A smaller number of lags increases the degrees of freedom, a greater number of lags decreases the problems of autocorrelation; in view of this we estimate a VAR with 10 lags for the time series concerning the stock markets of Eastern Europe and WTI.

The results of the Granger causality tests are shown in Table 7 for the stock markets of Budapest (BUX), Croatia (CROBEX), Russia (MOEX), Czech Republic (PRAGUE), Slovakia (SAX 16), Slovenia (SBI TOP), Bulgaria (SOFIX), and Crude Oil (WTI). The results show two-way sharp shocks between WTI and Eastern European stock markets, namely WTI (7 out of 7 possible), CROBEX (6), PRAGUE (6), SBI TOP (6), SOFIX (6), BUX (5), MOEX (5), while SAX 16 (2) has clashes with WTI and the Russia (MOEX) stock index. These findings show that the assumption of the hypothesis and efficiency of the markets may be questionable, since the prediction of the movement of a given market can be improved if the out-of-lag movements of the other markets are considered, thus enabling the occurrence of arbitrage operations. These findings are validated by the authors Xiao and Wang (2020), Alqahtani, Lahiani, and Salem (2020), Naeem, Hasan, Arif, Balli, and Shahzad (2020), Dias, Heliodoro, Alexandre, et al. (2020b) that show sharp shocks between Crude Oil and stock markets.

Table 7. Causality Tests of Granger / Block Exogeneity Wald Tests, from September 2, 2019 to January 11, 2021.

Null Hypothesis:	Note	F-Statistic	Prob.
CROBEX does not Granger Cause BUX	346	5.69983	7.E-08
BUX does not Granger Cause CROBEX		1.40462	0.1767
MOEX does not Granger Cause BUX	346	3.67392	0.0001
BUX does not Granger Cause MOEX		5.15719	5.E-07
PRAGUE does not Granger Cause BUX	346	2.86241	0.0020
BUX does not Granger Cause PRAGUE		3.64061	0.0001
SAX 16 does not Granger Cause BUX	346	0.68923	0.7345
BUX does not Granger Cause SAX 16		1.41183	0.1735
SBI TOP does not Granger Cause BUX	346	7.38134	1.E-10
BUX does not Granger Cause SBI TOP		2.30116	0.0127
SOFIX does not Granger Cause BUX	346	9.53497	6.E-14
BUX does not Granger Cause SOFIX		2.03207	0.0297
WTI does not Granger Cause BUX	334	3.68278	0.0001
BUX does not Granger Cause WTI		3.46809	0.0002
MOEX does not Granger Cause CROBEX	346	6.93822	7.E-10
CROBEX does not Granger Cause MOEX		8.02118	1.E-11
PRAGUE does not Granger Cause CROBEX	346	1.97742	0.0351
CROBEX does not Granger Cause PRAGUE		8.46398	3.E-12
SAX 16 does not Granger Cause CROBEX	346	0.81027	0.6189
CROBEX does not Granger Cause SAX 16		1.90390	0.0439
SBI TOP does not Granger Cause CROBEX	346	2.98974	0.0013
CROBEX does not Granger Cause SBI TOP		5.60654	1.E-07
SOFIX does not Granger Cause CROBEX	346	6.24072	1.E-08
CROBEX does not Granger Cause SOFIX		4.94031	1.E-06
WTI does not Granger Cause CROBEX	334	3.76993	8.E-05
CROBEX does not Granger Cause WTI		6.77669	1.E-09

PRAGUE does not Granger Cause MOEX	346	3.54124	0.0002
MOEX does not Granger Cause PRAGUE		5.01766	9.E-07
SAX 16 does not Granger Cause MOEX	346	0.40062	0.9460
MOEX does not Granger Cause SAX 16		1.22508	0.2737
SBI TOP does not Granger Cause MOEX	346	6.02939	2.E-08
MOEX does not Granger Cause SBI TOP		4.40757	8.E-06
SOFIX does not Granger Cause MOEX	346	7.45435	1.E-10
MOEX does not Granger Cause SOFIX		4.07718	3.E-05
WTI does not Granger Cause MOEX	334	4.65539	3.E-06
MOEX does not Granger Cause WTI		5.04551	8.E-07
SAX 16 does not Granger Cause PRAGUE	346	0.82241	0.6072
PRAGUE does not Granger Cause SAX 16		1.21640	0.2792
SBI TOP does not Granger Cause PRAGUE	346	6.39602	5.E-09
PRAGUE does not Granger Cause SBI TOP		3.46976	0.0002
SOFIX does not Granger Cause PRAGUE	346	7.52665	9.E-11
PRAGUE does not Granger Cause SOFIX		3.41856	0.0003
WTI does not Granger Cause PRAGUE	334	2.52353	0.0062
PRAGUE does not Granger Cause WTI		4.43079	8.E-06
SBI TOP does not Granger Cause	346	1.28692	0.2365
SAX 16 does not Granger Cause SBI TOP		0.87334	0.5585
SOFIX does not Granger Cause	346	1.53807	0.1245
SAX 16 does not Granger Cause SOFIX		0.42656	0.9333
WTI does not Granger Cause SAX 16	334	1.65242	0.0912
SAX 16 does not Granger Cause WTI		1.70412	0.0788
SOFIX does not Granger Cause SBI TOP	346	7.96135	2.E-11
SBI TOP does not Granger Cause SOFIX		2.42949	0.0084
WTI does not Granger Cause SBI TOP	334	4.82750	2.E-06
SBI TOP does not Granger Cause WTI		4.34235	1.E-05
WTI does not Granger Cause SOFIX	334	2.94509	0.0015
SOFIX does not Granger Cause WTI		4.84227	2.E-06

Source: Own elaboration

5. CONCLUSION

The overall conclusion to be withheld and sustained in the results obtained, through tests carried out with econometric models show that oil (WTI) causes shocks in all stock markets in Eastern Europe. We also found that these co-movements are two-way, i.e., the shocks are from WTI to the stock markets, but also from the stock indices to the WTI. These findings show that hypothesis and efficiency of the markets may be questionable, since the prediction of the movement of a given market can be improved if the out-of-lag movements of the other markets are considered, thus enabling the occurrence of arbitrage transactions. In conclusion, we consider that the global pandemic of 2020 and the war over petroleum affected the properties of the markets analyzed. These findings are relevant to regulators and supervisors as well as to individual and institutional investors operating in these regional markets, when they want to maximize the profitability and diversification of their portfolios.

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