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SPILLOVER EFFECT of OIL PRICE FLUCTUATIONS on AIRLINES STOCK RETURNS in BORSA İSTANBUL EXCHANGE DURING the COVID-19 PANDEMIC: A VAR-VECH-TARCH APPLICATION

COVID-19 SALGINI DÖNEMİNDE PETROL FİYATI DALGALANMALARININ BORSA İSTANBUL HAVAYOLU ŞİRKET HİSSE GETİRİLERİNE BULAŞMA ETKİSİ: VAR-VECH-TARCH UYGULAMASI

Caner Özdurak*

Abstract

In our study, the return spillover effect is determined by the mean equation set as VAR model while the volatility spillover effect between crude oil and the stocks of airlines companies is determined via VECH-TARCH model to catch the asymmetric news impact. According to the model results the volatility spillover effect between crude oil price and airlines' stock price is more significant compared to the return spillover effect. In the short term the volatility spillover effect between crude oil price and Turkish Airlines stock price is more significant compared to Pegasus Airlines (PGSUS) and transportation index. Secondly, in the long run the volatility spillover effect between crude oil prices and all three assets are strongly significant. Third, there is no asymmetric news impact between crude oil prices and Pegasus Airlines stocks and transportation index. However, asymmetry exists for Turkish Airlines stocks. Good news from crude oil markets to Turkish Airlines increase the volatility as well.

JEL Codes: C58, G14, L93, E44
Keywords: Spillover, airlines, VAR-VECH-TARCH, crude oil, Turkish Airlines, Pegasus, contagion effect

Öz

Bu çalışmamızda getiri bulaşma etkisi, vektör otoregresif model (VAR modeli) ile belirlenirken, ham petrol fiyatı ile hava yolu şirketleri hisse senedi getirileri arasındaki volatilite bulaşma etkisi varyans denklemleri ile belirlenir. Asimetrik haber etkisini de yakalamak için ise VECH-TARCH modeli tercih edilmiştir. Model sonuçlarına göre, ham petrol fiyatı ile havayolları hisse senedi getirileri arasındaki oynaklık yayılma etkisi, getiri yayılma etkisine göre daha belirgindir. Kısa vadede ham petrol fiyatı ile Türk Hava Yolları hisse senedi fiyatı arasındaki oynaklık yayılma etkisi Pegasus Hava Yolları (PGSUS) ve BİST ulaştırma endeksine göre daha belirgindir. İkinci olarak, uzun vadede ham petrol fiyatları ile üç varlık arasındaki oynaklık yayılma etkisi son derece belirgindir. Üçüncü olarak, ham petrol fiyatları ile Pegasus Havayolları hisse senetleri ve ulaştırma endeksi arasında asimetrik bir haber etkisi saptanamamış olsa da Türk Hava Yolları hisselerinde asimetrik haber etkisi görülmektedir. Ham petrol piyasalarından gelen iyi haberler ise Türk Hava Yolları hisse getirilerinde oynaklığı arttırmaktadır.

JEL Kodları: C58, G14, L93, E44
Keywords: Yayılma, havayolları, VAR-VECH-TARCH, petrol fiyatları, Türk Hava Yolları, Pegasus Hava Yolları, bulaşma etkisi

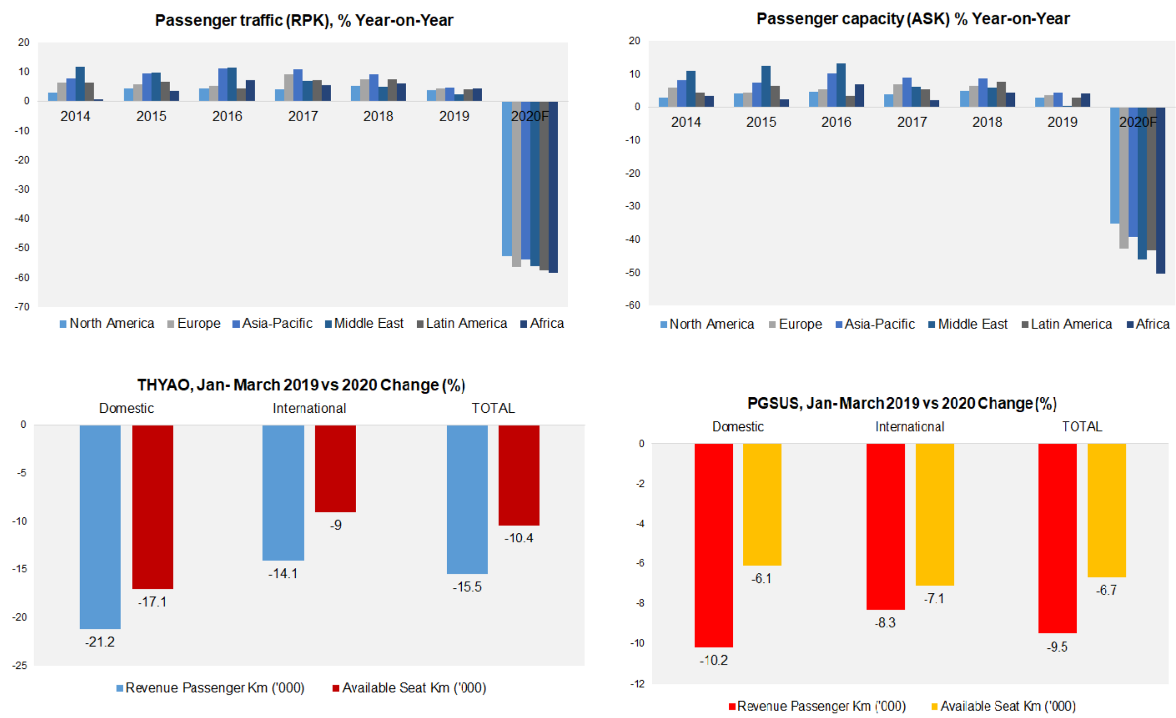
*Yeditepe University Department of Financial Economics, Assitant Professor. E-mail: cozdurak@gmail.com. Phone: +90 (0) 535 835 15 07. ORCID: 0000-0003-0793-7480

1 Introduction

Aviation industry is the rising star of the Turkish economy in the past two decades. With air travel largely suspended across the world due to pandemic, Turkey's aviation sector also has all but plummeted. Istanbul Airport was opened in April on the disappointed the passengers by reports of diverted flights, delays, and long taxi times on its runways. This became an opportunity for Pegasus, as passengers started to choose Sabiha Gökçen International Airport, Istanbul's second outlet on the Asian side of the city. As a result, although Istanbul's new airport was meant to benefit Turkish Airlines Sabiha Gökçen's strategic importance has increased. This unexpected operational buckling boosted Pegasus Airlines stock returns which has outperformed the flag carrier in the middle of 2019.

However, with the outbreak of COVID-19, many governments deployed strict social distancing requirements to limit the spread of the virus. Some governments have indicated that similar measures should be applied to air travel, including that airlines should leave empty seats between passengers which caps the seat load factor of an aircraft. The global airline industry is forecast to lose a record $84 billion this year, which is 3.2 times higher than in the Global Financial Crisis (IATA Economics' Chart of the Week). A return to profitability is assumed to be difficult for the industry even in 2021. Air travel worldwide almost entirely stopped in April 2020. In Figure 1 expected RPKs and ASKs are exhibited which are expected to be 54.7% and 40.4% lower than 2019. Highest decrease is expected to be in Africa for both RPK[2]s and ASK[3]s.

Figure 1: Global and Local Traffic Trends in Aviation Industry



Source and Note: IATA Includes domestic and international traffic, and all commercial airlines. Historical data are subject to revision, Turkish Airlines investor relations documents, Pegasus Airlines investor relations documents

Coherent with the global aviation industry Turkish Airlines and Pegasus Airlines are also expected to lose traffic compared to 2019. In Figure 1 it is exhibited that RPKs and ASKs of Turkish Airlines are expected to decrease 15.5% and 10.4% respectively in total while RPKs and ASKs of Pegasus Airlines are expected to decrease 9.5% and 6.7% respectively in total. Turkish government declared a support package for aviation industry which included VAT decrease in domestic flights from 18% to 1% for 3 months. In this period airlines companies focus

[2] Revenue Passenger Kilometers (RPK) or Revenue Passenger Miles (RPM)* is an airline industry metric that shows the number of kilometers traveled by paying passengers. It is calculated as the number of revenue passengers multiplied by the total distance traveled.
[3] It shows the total number of passenger kilometers that could be generated in order to determine the amount of revenue that comes in compared to the maximum amount.

on health safety rather than ticket price competition. Various support packages were introduced many governments of global aviation industry players such as Alitalia, Air France-KLM, Delta Airlines, Lufthansa, EasyJet, Ryanair, United Airlines, Singapore Airlines and Norwegian Air and SAS. Further, the ticket prices are expected to increase hence the operational costs will also increase due to the new flight requirements such as pre-flight health tests, hygiene packages for passengers and increasing maintenance costs based on cancelled new airplane orders of the operators.

In this context our study will continue with the literature review. After introducing the methodology and dataset in parts three and four we will analyze the impact of crude oil price to Turkish Airlines, Pegasus Airlines stock prices and BIST transportation index by utilizing VAR-VECH-TARCH models in part five. We will make the models for two different periods to distinguish the effect of pandemic to spillover impact and how volatility reactions of the selected assets change. In part six we will conclude and discuss our model results. The novelty of our paper is that it is one of the first studies that covers the impact of pandemic to aviation industry stock behaviors by utilizing complex econometric models.

2 Literature Review

Since crude oil is one the most important catalyzer of the capitalist economics, any change in its price closely influences stock markets (Jones and Kaul, 1996; Miller and Ratti, 2009; Ding et al. 2017, Narayan and Sharma, 2011; Kristjanpoller and Concha, 2016). Ding et al (2017) finds that international crude oil price fluctuations significantly Granger cause Chinese stock market investor sentiment. The positive and negative impact of the rise in oil prices to the company stocks depends on whether it is a producer or a consumer of crude oil (Mohanty and Nandha, 2011). The early literature focused on the spillovers between oil and stock markets. Generally, the rise in crude oil prices will have positive impact on producer company stocks while it is expected to have a negative impact to oil consumer company stocks since it will create extra burden for operational costs. Contradicting with this statement Ulusoy and Ozdurak (2018) examined the impact of oil prices on major energy company stock returns for three different periods via news impact curves and concluded that crude oil or oil derivative product producers' stock react differently to crude oil price shocks. Soyemi et al. (2018) examined the impact of the direct and indirect effects of oil price shocks on quoted energy-related stocks in Nigeria. The companies operating in energy industry who produce crude oil or use oil as input to produce derivative products, there is a possibility to pass through price increases directly to the consumers (Phan et al., 2015). Further thought, Reboredo (2015) focused on systemic risk and dependence between oil and renewable energy markets. He used copulas for modeling the dependence structure to compute the conditional value-at-risk as a measure of systemic risk. Uddin et. all (2020) studies the characteristics of the risk spillover under extreme market scenarios between the US stock market and precious metals (gold, silver, platinum) and oil. Moreover, researchers focused on more specific topics such as the linkages between oil price fluctuations and airline stock prices.

After the 2008 global financial crisis, empirical research on the crude oil price and stock market volatility spillover became hot topics among researchers and a considerable amount of study were published (see Arouri et. al., 2011; Bouri, 2015, Du and He, 2015). Although different techniques and models were used in the related literature GARCH-BEKK, TARCH-VECH models are in the lead. A multivariate GARCH model-MGARCH-BEKK model was used by Engle and Kroner (1995) to analyze the volatility spillovers. MGARCH-BEKK was preferred by many researchers as Malik and Hammoudeh, (2007); Gomes and Chaibi (2014); Liu et.al, (2017).

However, there are few studies on the spillover effect of crude oil prices on airlines and few studies which analyze this impact to Turkish aviation company stock returns and volatility. Hatty and Hollmeier (2003) show that airlines such as Lufthansa were affected by many macro shocks such as the Gulf war and the Asian financial crisis. Gillen and Lall (2003) study an industry specific issue international transmission of financial and other economic crises and examine the impact of the events of September 11, 2001 on the market value of non-US airlines. Our results contradict with the general literature results which show that crude oil has weak influence of the returns of airline company stocks in Turkey while there is positive influence on airline stock volatilities.

3 Methodology

Usually, financial data suggests that some periods are riskier than others. The goal of such models is to provide a volatility measure, like a standard deviation, then can be used in financial decisions related to risk analysis, portfolio selection and derivative pricing (Engle et al. 1982, 1993). An important characteristic of asset prices is that "bad" news has a more persistent impact on volatility than "good" news has. Most of the stocks have a strong negative correlation between the current return and future volatility. In this context, we can define leverage effect as such volatility tends to decrease when returns increase and to increase when returns decrease. The idea of the leverage effect is exhibited in the figure below, where "new information" is defined and measured by the size of ε_{t-1}. If $\varepsilon_{t-1}=0$, expected volatility (h_t) is 0.

Glosten, Jaganathan, and Runkle (1993) showed how to allow the effects of good and bad news to have different effects on volatility. In a sense, $\varepsilon_{t-1}=0$ is a threshold such that shocks greater than the threshold has different effects than shocks below the threshold. Consider the threshold-GARCH (TARCH) process:

$$h_{t=}\alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \lambda_1 d_{t-1}\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \quad [1]$$

where d_{t-1} is a dummy variable that is equal to one if $\varepsilon_{t-1}<0$ and is equal to zero if $\varepsilon_{t-1}\geq 0$. The intuition behind the TARCH model is that positive values of ε_{t-1} are associated with a zero value of d_{t-1}. Hence if $\varepsilon_{t-1}\geq 0$, the effect of an ε_{t-1} shocks on h_t is $\alpha_1\varepsilon_{t-1}^2$. When $\varepsilon_{t-1}<0$, $d_{t-1}=1$, and the effect of an ε_{t-1} shock on h_t is $(\alpha_1+\lambda_1)\varepsilon_{t-1}^2$. If $\lambda_1>0$, negative shocks will have larger effects on volatility than positive shocks.

3.1 VAR-VECH-TARCH Model

This method is extended from VAR-GARCH which is proposed by Ling and McAleer (2003). An examination of the conditional returns and conditional volatility can be conducted with meaningful estimated parameters via this structure. This method, composed of two parts, namely the VAR model and asymmetric VECH-TARCH model which are used to explore the joint evolution of conditional returns and volatility spillovers between different financial markets. First, the VAR model extends the univariate autoregressive (AR) to vector autoregressive (VAR) by internalizing the related variables into endogenous variables to examine the contagion and spillover effect between major financial markets.

The basic mathematical expression of the VAR model is as follows:

$$R_t = C + A_1R_{t-1} + A_2R_{t-2} + \cdots + A_kR_{t-k} + \varepsilon_t \quad [2]$$

$$\varepsilon_t \;\text{II}_{t-1} \sim N(0, H_t)$$

Where R_t refers to the value of endogenous variables vector at time t, C is the constant vector, matrix A is the estimated coefficients and k is the lag operator. Residual vector ε_t is assumed to be normally distributed with a zero mean and constant variance where the market information available at time t-1 denoted as d_{t-1}. The lag order of *(k)* VAR structure is decided via AIC criterion, FPE criterion, and LR.

In this approach, we incorporate a three-dimensional model to examine the news spillover between different markets. Suppose that our model structure is as follows:

$$\varepsilon_{i,t} = v_{i,t}.h_{i,t}, \quad v_{i,t}\sim N(0,1) \quad [3]$$

$$h_{i.t} = c_i + a_i\varepsilon_{t-1}^2 + \beta_i h_{i,t-1} \quad [4]$$

$$H_t = C^TC + A^T\varepsilon_{t-1}\varepsilon_{t-1}^TA + B^TH_{t-1}B \quad [5]$$

Equation [3] specifies the relation between the residual term $\varepsilon_{i,t}$ and the conditional variance $h_{i.t}.v_{i.t}$ which is normally distributed with a zero mean and constant variance. α, β are the coefficients. $H_{i,t}$ represents the conditional variance-covariance matrix, C represents the lower triangular matrix, A and B are square arrays. If C^TC is positive, then it is almost positive.

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{12,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix}$$

$$C = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \quad A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$$

where $h_{11,t}$, $h_{22,t}$, $h_{33,t}$ in the matrix H_t represent the conditional variances. Matrix A is the ARCH coefficients of the model, a_{11},a_{22},a_{33} represent the ARCH effect while Matrix B is the GARCH coefficients of the model, b_{11},b_{22},b_{33} are the GARCH effect.

In consideration of the asymmetric effect diagonal VECH is:

$$H_t = A_0 + \sum_{i=1}^{p} A_i \otimes H_{t-i} + \sum_{i=1}^{q} B_i \otimes \varepsilon_{t-1}\varepsilon_{t-1}^T \quad [6]$$

where the conditional variance covariance equation of a bivariate (VECH) TARCH model has the following form:

$$VECH(H_t) = C + AVCEH(\varepsilon_{t-1}\varepsilon_{t-1}') + BVECH(H_{t-1}H_{t-1}') + DVECH(\varepsilon_{t-1}\varepsilon_{t-1}')(d_{t-1}) \; [7]$$

where the last term on the RHS of equation [7] depicts the asymmetries. In this context the diagonal bivariate VECH model is as follows:

$$h_{11,t} = C_{01} + a_{11}\varepsilon_{1,t-1}^2 + b_{11}h_{11,t-1} \quad [8]$$

$$h_{12,t} = C_{02} + a_{33}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + b_{22}h_{12,t-1} \quad [9]$$

$$h_{22,t} = C_{03} + a_{33}\varepsilon_{2,t-1}^2 + b_{33}h_{22,t-1} \quad [10]$$

The coefficient a_{11} refers to the ARCH process in the residuals from asset *i* which depicts the fluctuations of the assets reflecting the impact of external shocks on fluctuations. The ARCH effects measure-short-term persistence while the GARCH effect measure long-term persistence. The a_{33} coefficient represents the ARCH process in the second asset residuals. The parameters between asset *i* and asset *j*. The calculation of the time-varying beta coefficient is done as

$$\beta_{it}^{BG} = \hat{h}_{12,t}/\hat{h}_{22,t} \quad [11]$$

where the symbol ^ indicates the estimated values of conditional variance.

4 Data

The data of this paper incorporates six variables which are utilized for three different model systems: Brent crude oil futures (Brent), Dubai Crude Oil (Platts) Financial Futures (Dubai), Crude Oil Contract (WTI), Pegasus Airlines stock prices (PGSUS), Turkish Airlines stock prices (THYAO) and BIST Transportation Index (XULAS). The data set is divided in to two different periods to test the impact of Covid-19 to long-term spillover effects. In this context our data set is daily and cover a more than five years period between 02.01.2015 and 03.06.2020 for the long period. From the first reports on 31 December, the virus has spread across China and reached as far as the US, infecting hundreds so we define the period between 31.12.2019 and 03.06.2020 as the Covid-19 period.

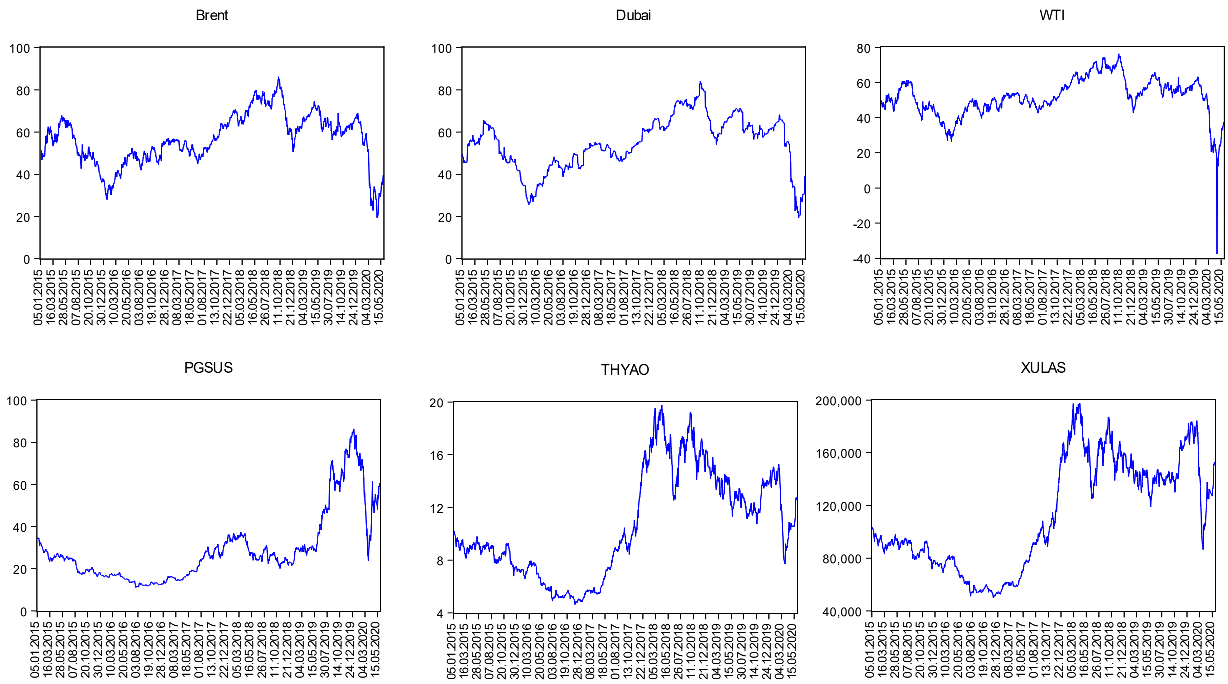


Figure 2: Daily Prices of Brent, Dubai, WTI, PGSUS, THYAO and XULAS

Next, the return of each market is calculated as follows:

$$ln(P_t) - ln(P_{t-1}) \quad [12]$$

where RBRENT, RDUBAI, RWTI, RPGSUS, RTHYAO and RXULAS refers to the return series of related variables.

In Figure 2 daily prices of Brent, Dubai, WTI, Pegasus Airlines, Turkish Airlines and transportation Index are exhibited. The aviation industry's recovery from the destructive coronavirus pandemic is expected to be slow however, Turkish Airlines stocks has rallied by more than 60%, outperforming the 15 emerging-market airline stocks included in the MSCI EM Airlines Index. In addition, Pegasus Airlines stock prices, which does not even feature in the MSCI, have more than doubled. Such detached results from fundamentals is assumed to be related with the increasingly unattractive rates on bank deposit accounts of the investors. The jump in shares of Turkish

Airlines is defined as unsustainable since recovery to 2019 revenue levels is expected to take at least two years according to the equity analysts. Consequently, Table 1 exhibits the descriptive statistics for the returns. The mean values are close to zero for all the returns. The statistics of each return differ from each other, but in common the skewness of each return is not equal to zero and neither is the kurtosis, indicating that each return has typical characteristics of leptokurtosis and fat-tail. It is well known that leptokurtosis and fat-tail are the typical characteristics of financial time series. The J-B statistic of each return is significant from zero, which means none of the returns obeys the normal distribution. Furthermore, the stationarity of the variables has been examined using the Augmented Dickey-Fuller (ADF) unit root test. The null hypothesis of the unit root is rejected for all return series.

Table 1: Descriptive Statistics

	RBRENT	RDUBAI	RPGSUS	RTHYAO	RWTI	RXULAS
Mean	-0.0003	-0.0002	0.0004	0.0002	0.0002	0.0003
Median	0.0009	0.0000	0.0000	0.0000	0.0007	0.0002
Maximum	0.1908	0.2507	0.1383	0.0952	0.3196	0.0895
Minimum	-0.2798	-0.4058	-0.1198	-0.1345	-0.2822	-0.1284
Std. Dev.	0.0282	0.0264	0.0288	0.0245	0.0333	0.0230
Skewness	-0.9619	-2.2102	0.0681	-0.3469	0.3677	-0.4112
Kurtosis	20.4289	64.1883	5.4719	5.2300	26.6204	5.6480
Jarque-Bera	17435.8800	213424.5000	347.5548	309.2920	31669.4700	435.9756
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADF Test Level	-35.58	-20.92	-22.63	-38.96	-36.52	-37.8698
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes: Between parenthesis: p-values. The number of observations is 1361 ADF Tests refer to Augemented Dickey Fuller test for the presence of unit root for long differences

Figure 3 exhibits the daily returns of crude oil markets and airlines companies' stock returns as well as transportation index. In the coronavirus pandemic period crude oil market returns (Brent, WTI, Dubai) experienced all time high fluctuations in the last five years such that the price of US oil has turned negative for the first time in history. This incident showed that producers or traders were essentially paying other market participants to take the oil off their hands due to demand shock from lockdowns and travel restrictions. Also, clusters and relatively high return fluctuations are observed for Turkish Airlines, Pegasus Airlines and transportation index in the pandemic.

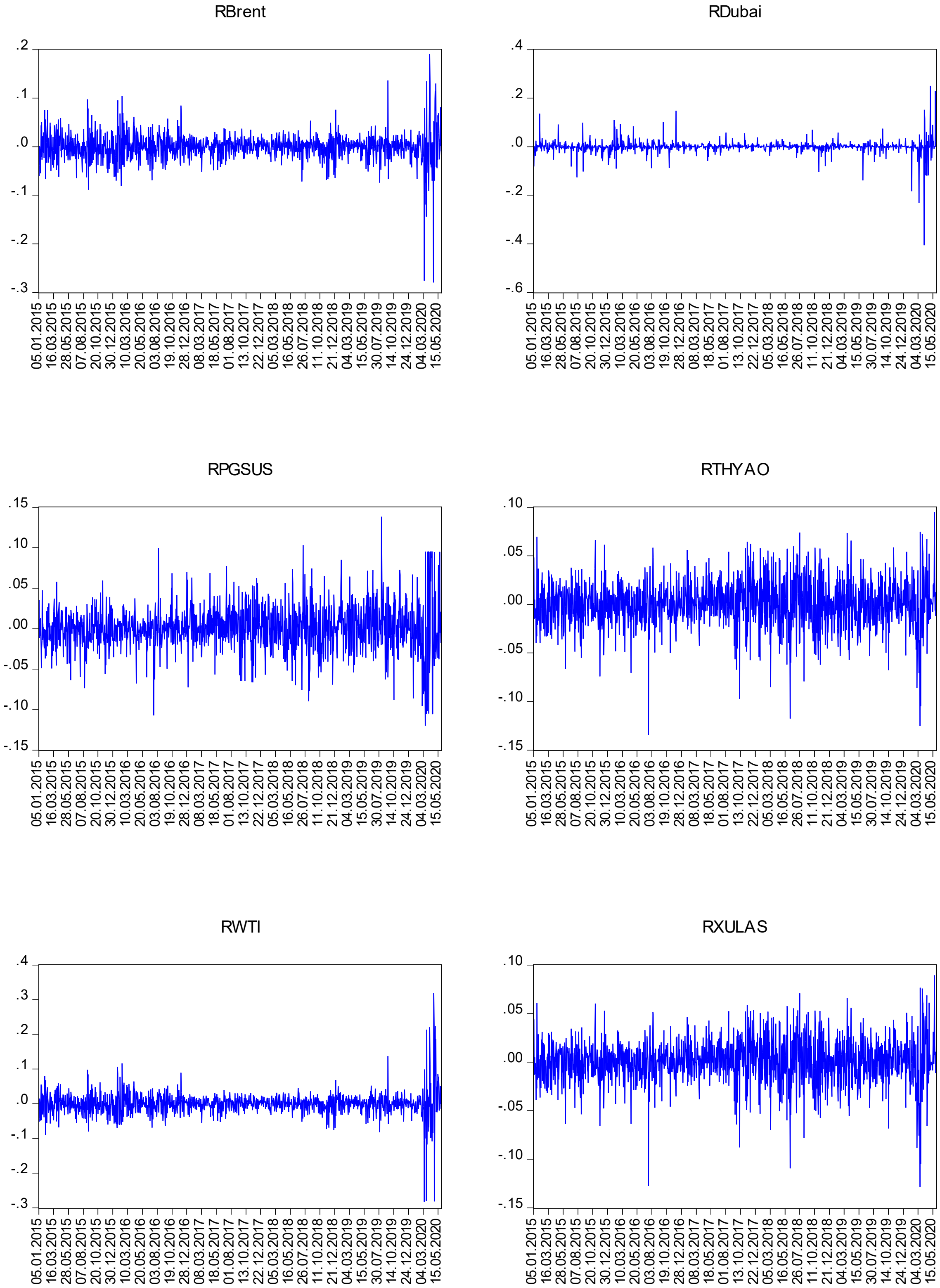


Figure 3: Daily Returns of Brent, Dubai, WTI, PGSUS, THYAO and XULAS

5 Empirical Results

We constructed three different model systems with three different VAR system specifications which are as follows:

VAR System Specification for Model 1: [13]

$$\begin{aligned} RPGSUS_t = {} & \alpha_1 + \beta_1 RPGSUS_{t-1} + \beta_2 RPGSUS_{t-2} + \beta_3 RBRENT_{t-1} + \beta_4 RBRENT_{t-2} + \beta_5 RDUBAI_{t-1} \\ & + \beta_6 RDUBAI_{t-2} + \beta_7 WTI_{t-1} + \beta_8 WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RBRENT_t = {} & \alpha_1 + \beta_9 RPGSUS_{t-1} + \beta_{10} RPGSUS_{t-2} + \beta_{11} RBRENT_{t-1} + \beta_{12} RBRENT_{t-2} + \beta_{13} RDUBAI_{t-1} \\ & + \beta_{14} RDUBAI_{t-2} + \beta_{15} WTI_{t-1} + \beta_{16} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RDUBAI_t = {} & \alpha_1 + \beta_{17} RPGSUS_{t-1} + \beta_{18} RPGSUS_{t-2} + \beta_{19} RBRENT_{t-1} + \beta_{20} RBRENT_{t-2} + \beta_{21} RDUBAI_{t-1} \\ & + \beta_{22} RDUBAI_{t-2} + \beta_{23} WTI_{t-1} + \beta_{24} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RWTI_t = {} & \alpha_1 + \beta_{25} RPGSUS_{t-1} + \beta_{26} RPGSUS_{t-2} + \beta_{27} RBRENT_{t-1} + \beta_{28} RBRENT_{t-2} + \beta_{29} RDUBAI_{t-1} \\ & + \beta_{30} RDUBAI_{t-2} + \beta_{31} WTI_{t-1} + \beta_{32} WTI_{t-2} \end{aligned}$$

VAR System Specification for Model 2: [14]

$$\begin{aligned} RTHYAO_t = {} & \alpha_1 + \beta_1 RTHYAO_{t-1} + \beta_2 RTHYAO_{t-2} + \beta_3 RBRENT_{t-1} + \beta_4 RBRENT_{t-2} + \beta_5 RDUBAI_{t-1} \\ & + \beta_6 RDUBAI_{t-2} + \beta_7 WTI_{t-1} + \beta_8 WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RBRENT_t = {} & \alpha_2 + \beta_9 RTHYAO_{t-1} + \beta_{10} RTHYAO_{t-2} + \beta_{11} RBRENT_{t-1} + \beta_{12} RBRENT_{t-2} + \beta_{13} RDUBAI_{t-1} \\ & + \beta_{14} RDUBAI_{t-2} + \beta_{15} WTI_{t-1} + \beta_{16} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RDUBAI_t = {} & \alpha_3 + \beta_{17} RTHYAO_{t-1} + \beta_{18} RTHYAO_{t-2} + \beta_{19} RBRENT_{t-1} + \beta_{20} RBRENT_{t-2} + \beta_{21} RDUBAI_{t-1} \\ & + \beta_{22} RDUBAI_{t-2} + \beta_{23} WTI_{t-1} + \beta_{24} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RWTI_t = {} & \alpha_4 + \beta_{25} RTHYAO_{t-1} + \beta_{26} RTHYAO_{t-2} + \beta_{27} RBRENT_{t-1} + \beta_{28} RBRENT_{t-2} + \beta_{29} RDUBAI_{t-1} \\ & + \beta_{30} RDUBAI_{t-2} + \beta_{31} WTI_{t-1} + \beta_{32} WTI_{t-2} \end{aligned}$$

VAR System Specification Model 3: [15]

$$\begin{aligned} RXULAS_t = {} & \alpha_1 + \beta_1 RXULAS_{t-1} + \beta_2 RXULAS_{t-2} + \beta_3 RBRENT_{t-1} + \beta_4 RBRENT_{t-2} + \beta_5 RDUBAI_{t-1} \\ & + \beta_6 RDUBAI_{t-2} + \beta_7 WTI_{t-1} + \beta_8 WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RBRENT_t = {} & \alpha_2 + \beta_9 RXULAS_{t-1} + \beta_{10} RXULAS_{t-2} + \beta_{11} RBRENT_{t-1} + \beta_{12} RBRENT_{t-2} + \beta_{13} RDUBAI_{t-1} \\ & + \beta_{14} RDUBAI_{t-2} + \beta_{15} WTI_{t-1} + \beta_{16} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RDUBAI_t = {} & \alpha_3 + \beta_{17} RXULAS_{t-1} + \beta_{18} RXULAS_{t-2} + \beta_{19} RBRENT_{t-1} + \beta_{20} RBRENT_{t-2} + \beta_{21} RDUBAI_{t-1} \\ & + \beta_{22} RDUBAI_{t-2} + \beta_{23} WTI_{t-1} + \beta_{24} WTI_{t-2} \end{aligned}$$

$$\begin{aligned} RWTI_t = {} & \alpha_4 + \beta_{25} RXULAS_{t-1} + \beta_{26} RXULAS_{t-2} + \beta_{27} RBRENT_{t-1} + \beta_{28} RBRENT_{t-2} + \beta_{29} RDUBAI_{t-1} \\ & + \beta_{30} RDUBAI_{t-2} + \beta_{31} WTI_{t-1} + \beta_{32} WTI_{t-2} \end{aligned}$$

According to the model results the volatility spillover effect between crude oil price and airlines' stock price is more significant compared to the return spillover effect. In Table 2 and Table 3 influence of crude oil returns to airline company stocks and transportation index are exhibited. In the long period models (Table 2), Model 1; β_{27} and β_{31}, in Model 2; β_{11}, β_{12}, β_{15}, β_{21}, β_{22} and β_{23} and finally in Model 3; β_2, β_{11}, β_{13}, β_{14}, β_{18}, β_{21}, β_{22}, β_{23}, β_{24}, β_{25}, β_{26}, β_{27}, β_{28}, β_{29}, β_{30}, β_{31} and β_{32} are statistically significant. However, most of these coefficients belong to Brent, Dubai and WTI which indicates that in the long-run return spillover effect is valid only among crude oil markets. Only β_{18}, β_{25}, β_{26} indicates there is a weak influence between transportation index and oil prices.

Table 2: Estimation results of returns-VAR-VECH-TARCH (1,1) models

Model 1	Coefficient		z-Statistic	P-Value	Model 2	Coefficient		z-Statistic	P-Value	Model 3	Coefficient		z-Statistic	P-Value
β_1	0.222046		1.231969	0.2180	β_1	-0.043387		-1.506239	0.1320	β_1	-0.019078		-0.711472	0.4768
β_2	0.049176		0.330176	0.7413	β_2	0.029762		1.019035	0.3082	β_2	0.064441	***	2.384077	0.0171
β_3	0.002985		0.011486	0.9908	β_3	-0.079918		-1.222357	0.2216	β_3	-0.075847		-1.336443	0.1814
β_4	0.056942		0.210146	0.8336	β_4	0.041196		0.639343	0.5226	β_4	0.033355		0.589544	0.5555
β_5	0.003488		0.021342	0.9830	β_5	0.005328		0.123491	0.9017	β_5	-0.002484		-0.074198	0.9409
β_6	0.065403		0.452577	0.6509	β_6	-0.012852		-0.291243	0.7709	β_6	0.010491		0.278354	0.7807
β_7	0.145165		0.913929	0.3608	β_7	0.034819		0.635277	0.5252	β_7	0.067644		1.399398	0.1617
β_8	-0.003817		-0.022093	0.9824	β_8	-0.015109		-0.30302	0.7619	β_8	-0.011819		-0.241181	0.8094
α_1	-0.002034		-0.290793	0.7712	α_1	0.000203		0.311053	0.7558	α_1	0.000244		0.435529	0.6632
β_9	-0.065358		-0.825454	0.4091	β_9	0.026504		1.171365	0.2415	β_9	0.038784		1.778897	0.0753
β_{10}	0.115126		1.181991	0.2372	β_{10}	0.000529		0.021502	0.9828	β_{10}	0.017766		0.80274	0.4221
β_{11}	0.365943		1.213353	0.2250	β_{11}	-0.103512	***	-2.507924	0.0121	β_{11}	0.089039	**	1.840854	0.0656
β_{12}	-0.068439		-0.168165	0.8665	β_{12}	-0.157711	***	-2.654366	0.0079	β_{12}	0.028574		0.482848	0.6292
β_{13}	-0.196613		-1.510822	0.1308	β_{13}	-0.030324		-0.960868	0.3366	β_{13}	-0.111891	***	-3.109531	0.0019
β_{14}	-0.24163		-1.307861	0.1909	β_{14}	-0.005451		-0.141951	0.8871	β_{14}	-0.163006	***	-4.092515	0.0000
β_{15}	-0.095705		-0.517217	0.6050	β_{15}	0.071869	**	1.860001	0.0629	β_{15}	-0.006218		-0.156566	0.8756
β_{16}	0.197387		0.785194	0.4323	β_{16}	0.130596		2.403782	0.0162	β_{16}	0.0687		1.329645	0.1836
α_2	-0.00566		-1.212063	0.2255	α_2	-0.000479		-0.87805	0.3799	α_2	-0.000253		-0.514294	0.6070
β_{17}	-0.221405		-0.063987	0.9490	β_{17}	-0.001078		-0.048183	0.9616	β_{17}	-0.033909		-1.323166	0.1858
β_{18}	0.239374		0.048853	0.9610	β_{18}	0.008346		0.328566	0.7425	β_{18}	0.050708	*	1.829763	0.0673
β_{19}	0.176129		0.002593	0.9979	β_{19}	0.023068		0.438767	0.6608	β_{19}	0.067678		1.058016	0.2900
β_{20}	0.06306		0.007167	0.9943	β_{20}	0.094466		1.445297	0.1484	β_{20}	0.086738		1.182811	0.2369
β_{21}	-0.218756		-0.007495	0.9940	β_{21}	-0.186704	***	-5.396142	0.0000	β_{21}	-0.18802	***	-5.113847	0.0000
β_{22}	-0.338352		-0.019179	0.9847	β_{22}	-0.096676	***	-2.920487	0.0035	β_{22}	-0.204997	***	-5.439874	0.0000
β_{23}	0.032202		0.000709	0.9994	β_{23}	0.112383	***	2.558436	0.0105	β_{23}	0.101285	**	1.955676	0.0505
β_{24}	0.277359		0.0158	0.9874	β_{24}	0.017042		0.281635	0.7782	β_{24}	0.112244	*	1.76149	0.0782
α_3	-0.006675		-0.036567	0.9708	α_3	-0.0000842		-0.160933	0.8721	α_3	-0.000243		-0.473031	0.6362
β_{25}	0.109561		0.595964	0.5512	β_{25}	0.027518		1.162098	0.2452	β_{25}	0.061711	***	2.627128	0.0086
β_{26}	0.16412		1.229811	0.2188	β_{26}	0.006229		0.254834	0.7989	β_{26}	0.063819	***	2.778158	0.0055
β_{27}	-0.325338	***	-2.334275	0.0196	β_{27}	-0.034882		-0.735768	0.4619	β_{27}	-0.229332	***	-5.095732	0.0000
β_{28}	0.163553		0.301635	0.7629	β_{28}	-0.08246		-1.324125	0.1855	β_{28}	0.149071	***	2.458203	0.0140
β_{29}	-0.13308		-1.011062	0.3120	β_{29}	-0.005117		-0.137274	0.8908	β_{29}	-0.083995	***	-2.465341	0.0137
β_{30}	-0.228565		-0.801471	0.4229	β_{30}	-0.022979		-0.504016	0.6143	β_{30}	-0.155518	***	-3.675125	0.0002
β_{31}	0.285521	*	1.635556	0.1019	β_{31}	-0.013294		-0.268115	0.7886	β_{31}	0.200702	***	4.44231	0.0000
β_{32}	-0.053127		-0.135961	0.8919	β_{32}	0.056919		0.994617	0.3199	β_{32}	-0.09026	*	-1.602418	0.1091
α_4	-0.000981		-0.161572	0.8716	α_4	-0.000364		-0.655701	0.5120	α_4	0.000116		0.214904	0.8298

Notes: ***, ** and * denote the rejection of null hypothesis at 1%, 5% and 10% sigificance levels respectively.
The coefficients are represented in Eq. 13-14-15

Table 3 exhibits the results for the Covid-19 period. In Model 2; β_{10}, β_{14}, β_{20}, β_{24}, β_{27} and β_{31}, in Model 3; β_{11}, β_{18}, β_{26}, β_{28}, β_{29} and β_{31} are significant. Again, most of these coefficients belong to Brent, Dubai and WTI which indicates that also in the covid-19 period return spillover effect is valid only among crude oil markets. Only β_{18}, β_{25}, β_{26} indicates there is a weak influence between transportation index and oil prices. In Model 2; β_{10} and in Model 3; β_{18} and β_{26} shows that there is an influence between Turkish Airlines and transportation index returns with Dubai and WTI oil prices.

Table 3 Estimation results of returns-VAR-VECH-TARCH (1,1) models during Covid-19 pandemic

Model 1	Coefficient	z-Statistic	P-Value	Model 2	Coefficient		z-Statistic	P-Value	Model 3	Coefficient		z-Statistic	P-Value
β_1	0.222046	1.231969	0.2180	β_1	0.131876		0.65986	0.5093	β_1	0.253229		0.808869	0.4186
β_2	0.049176	0.330176	0.7413	β_2	0.116106		0.60626	0.5443	β_2	0.148264		0.982668	0.3258
β_3	0.002985	0.011486	0.9908	β_3	-0.023212		-0.08135	0.9352	β_3	-0.001016		-0.237924	0.8119
β_4	0.056942	0.210146	0.8336	β_4	-0.014186		-0.03513	0.9720	β_4	0.000757		0.182139	0.8555
β_5	0.003488	0.021342	0.9830	β_5	-0.001486		-0.01019	0.9919	β_5	-0.016809		-0.088587	0.9294
β_6	0.065403	0.452577	0.6509	β_6	0.020709		0.10016	0.9202	β_6	0.002469		0.013335	0.9894
β_7	0.145165	0.913929	0.3608	β_7	0.054913		0.28151	0.7783	β_7	0.065129		0.444694	0.6565
β_8	-0.003817	-0.022093	0.9824	β_8	-0.000523		-0.00205	0.9984	β_8	0.0000183		0.000128	0.9999
α_1	-0.002034	-0.290793	0.7712	α_1	-0.000893		-0.15105	0.8799	α_1	0.017059		0.796639	0.4257
β_9	-0.065358	-0.825454	0.4091	β_9	-0.057282		-0.59162	0.5541	β_9	10.47227		0.445204	0.6562
β_{10}	0.115126	1.181991	0.2372	β_{10}	0.282761	***	2.12668	0.0334	β_{10}	2.437058		0.171289	0.8640
β_{11}	0.365943	1.213353	0.2250	β_{11}	0.385047		1.31844	0.1874	β_{11}	1.078906	***	3.741067	0.0002
β_{12}	-0.068439	-0.168165	0.8665	β_{12}	-0.10195		-0.30777	0.7583	β_{12}	-0.109266		-0.40242	0.6874
β_{13}	-0.196613	-1.510822	0.1308	β_{13}	-0.193598		-1.41062	0.1584	β_{13}	-0.248051		-0.015215	0.9879
β_{14}	-0.24163	-1.307861	0.1909	β_{14}	-0.255904	***	-1.97780	0.0480	β_{14}	2.774779		0.23973	0.8105
β_{15}	-0.095705	-0.517217	0.6050	β_{15}	-0.090417		-0.43111	0.6664	β_{15}	4.387696		0.40891	0.6826
β_{16}	0.197387	0.785194	0.4323	β_{16}	0.141388		0.59670	0.5507	β_{16}	-0.128577		-0.015508	0.9876
α_2	-0.00566	-1.212063	0.2255	α_2	-0.004171		-1.05546	0.2912	α_2	1.765807		0.952084	0.3411
β_{17}	-0.221405	-0.063987	0.9490	β_{17}	-0.234614		-0.58450	0.5589	β_{17}	-0.261778		-1.037437	0.2995
β_{18}	0.239374	0.048853	0.9610	β_{18}	0.350438		0.72683	0.4673	β_{18}	0.330073	***	3.172304	0.0015
β_{19}	0.176129	0.002593	0.9979	β_{19}	0.351102		0.24658	0.8052	β_{19}	0.003409		0.951159	0.3415
β_{20}	0.06306	0.007167	0.9943	β_{20}	-1.993314	***	-3.35380	0.0008	β_{20}	-0.003353		-0.944648	0.3448
β_{21}	-0.218756	-0.007495	0.9940	β_{21}	-0.10916		-0.14255	0.8866	β_{21}	0.278785		1.132282	0.2575
β_{22}	-0.338352	-0.019179	0.9847	β_{22}	0.171494		0.37725	0.7060	β_{22}	-0.211992		-0.874208	0.3820
β_{23}	0.032202	0.000709	0.9994	β_{23}	-0.081527		-0.12323	0.9019	β_{23}	-0.032653		-0.244576	0.8068
β_{24}	0.277359	0.0158	0.9874	β_{24}	1.192995	***	2.45273	0.0142	β_{24}	0.154616		0.836527	0.4029
α_3	-0.006675	-0.036567	0.9708	α_3	-0.008157		-0.59183	0.5540	α_3	-0.00426		-0.178235	0.8585
β_{25}	0.109561	0.595964	0.5512	β_{25}	-0.008072		-0.05737	0.9542	β_{25}	-0.291093		-1.385658	0.1659
β_{26}	0.16412	1.229811	0.2188	β_{26}	0.28638		1.31933	0.1871	β_{26}	0.289409	***	2.638544	0.0083
β_{27}	-0.325338	-2.334275	0.0196	β_{27}	-0.247248	**	-1.88168	0.0599	β_{27}	0.004508		1.617327	0.1058
β_{28}	0.163553	0.301635	0.7629	β_{28}	0.113727		0.18796	0.8509	β_{28}	-0.004453	*	-1.681953	0.0926
β_{29}	-0.13308	-1.011062	0.3120	β_{29}	-0.045912		-0.50389	0.6143	β_{29}	-0.188015	*	-1.758216	0.0787
β_{30}	-0.228565	-0.801471	0.4229	β_{30}	-0.253349		-1.16615	0.2436	β_{30}	-0.047608		-0.289316	0.7723
β_{31}	0.285521	1.635556	0.1019	β_{31}	0.288354	*	1.60949	0.1075	β_{31}	0.332877	***	2.067039	0.0387
β_{32}	-0.053127	-0.135961	0.8919	β_{32}	-0.01843		-0.04847	0.9613	β_{32}	0.02716		0.112755	0.9102
α_4	-0.000981	-0.161572	0.8716	α_4	-0.004164		-0.81255	0.4165	α_4	-0.004657		-0.170299	0.8648

Notes: ***, ** and * denote the rejection of null hypothesis at 1%, 5% and 10% sigificance levels respectively.
The coefficients are represented in Eq. 13-14-15

In Model 1 the relationship between Pegasus Airlines, Brent, WTI and Dubai Crude oil is analyzed. The own conditional ARCH effects (a_{ii}) is not significant even at the %10 level for PGSUS but significant for Brent, WTI and Dubai at 1% level. These results indicate that crude oil markets are influenced by the volatility of their own markets while Pegasus is not. Furthermore, there is significant volatility spillover over effects among Pegasus, Brent and WTI in the short term since $a_{12}, a_{14}, a_{23}, a_{24} and\ a_{34}$ are statistically significant at the 1% level while Pegasus and Dubai spillover, a_{13}, is significant at 5% level. Moreover, the conditional GARCH effects (b_{ii})in matrix B are all significant at %1 level for all related markets in Model 1. Consequently, for the long-term volatility spillovers, the volatility spillover between Pegasus Airlines, Brent, WTI and Dubai Crude are all significant at 1% level that are $b_{12}, b_{13}, b_{14}, b_{23}, b_{24} and\ b_{34}$. As a result, we can conclude that a volatility spillover between the mentioned markets strongly exists in the long term which is consistent with the economic theory that the impact of a shock in financial markets is reflected to real economy with a lagged effect. Finally, the D matrix refers to the asymmetric coefficients of all crude oil markets are positive and significant at 1% level. Positive coefficients mean that good news increase the volatility for all markets in Model 1. The coefficients of $d_{23}, d_{24} and\ d_{34}$ are all positive which indicates that good news from one crude oil market to other crude oil market increases the volatility. However, asymmetric volatility does not exist between Pegasus and all other crude oil markets since d_{12}, d_{13}, d_{14} coefficients are not significant even at %10 level.

In Model 2 the relationship between Turkish Airlines, Brent, WTI and Dubai Crude oil is analyzed. The own conditional ARCH effects (a_{ii}) is not significant even at the %10 level for THYAO but significant for Brent, WTI and Dubai at 1% level. These results indicate that crude oil markets are influenced by the volatility of their own markets while Turkish Airlines is not. Furthermore, there is significant volatility spillover over effects among Turkish Airlines, Brent, WTI and Dubai in the short term since $a_{12}, a_{13}, a_{14}, a_{23}, a_{24} and\ a_{34}$ are statistically significant at the 1% level. Moreover, the own conditional GARCH effects (b_{ii})in matrix B are all significant at %1 level for all related markets in Model 2. Consequently, for the long-term volatility spillovers, the volatility spillover between Turkish airlines and crude oil is significant at 1% level for all related assets that are $b_{12}, b_{13}, b_{14}, b_{23}, b_{24} and\ b_{34}$. As a result, we can conclude that volatility spillover between mentioned markets strongly exists in the long term. Finally, the D matrix refers to the asymmetric coefficients of all markets are positive and significant at 1% level. Positive coefficients mean that good news increase the volatility for all markets in Model 2. The coefficients of $d_{12}, d_{13}, d_{14}, d_{23}, d_{24} and\ d_{34}$ are all positive which indicates that good news from Turkish Airlines to crude oil market increases the volatility. Moreover, good news from crude oil markets to Turkish Airlines increase the volatility as well.

In Model 3 the relationship between BIST Transportation Index, Brent, WTI and Dubai Crude oil is analyzed. The own conditional ARCH effects (a_{ii}) is significant for BIST Transportation Index, Brent, WTI and Dubai at 1% level. These results indicate that all mentioned assets are influenced by the volatility of their own markets. Furthermore, there is significant volatility spillover over effects among BIST Transportation Index, Brent, WTI and Dubai in the short term since $a_{12}, a_{13}, a_{14}, a_{23}, a_{24} and\ a_{34}$ are statistically significant at the 1% level. Moreover, the own conditional GARCH effects (b_{ii})in matrix B are all significant at %1 level for all related markets in Model 4. Consequently, for the long-term volatility spillovers, the volatility spillover between Bist Transportation Index and crude oil is significant at 1% level for all related assets that are $b_{12}, b_{13}, b_{14}, b_{23}, b_{24} and\ b_{34}$. As a result, we can conclude that volatility spillover between mentioned markets strongly exists in the long term. However, the D matrix refers to the asymmetric coefficients of all markets are positive but not significant at even 10% level. Briefly, asymmetric volatility does not exist for BIST Transportation Index and crude oil markets

Table 4: Estimation results of volatility-VAR-VECH-TARCH (1,1) models for full period

Model 1	Coefficient	z-Statistic	P-Value	Model 2	Coefficient	z-Statistic	P-Value	Model	Coefficient	z-Statistic	P-Value
C(1,1)	-8.74E-07 ***	-3.6323	0.0003	C(1,1)	3.16E-05 ***	4.1161	0.0000	C(1,1)	1.79E-05 ***	5.2575	0.0000
C(1,2)	-6.46E-07	-0.2931	0.7694	C(1,2)	-5.20E-06 **	-1.9020	0.0572	C(1,2)	1.07E-06	0.8782	0.3799
C(1,3)	-3.02E-07	-0.5463	0.5849	C(1,3)	-1.77E-06	-1.5119	0.1306	C(1,3)	1.72E-07	0.1933	0.8467
C(1,4)	-1.41E-07	-0.0729	0.9419	C(1,4)	-3.79E-06	-1.5151	0.1297	C(1,4)	1.31E-07	0.1084	0.9137
C(2,2)	7.40E-05 ***	12.2089	0.0000	C(2,2)	7.68E-05 ***	12.2956	0.0000	C(2,2)	1.62E-05 ***	6.3245	0.0000
C(2,3)	3.46E-05 ***	13.3564	0.0000	C(2,3)	3.54E-05 ***	13.4078	0.0000	C(2,3)	4.34E-06 ***	4.2918	0.0000
C(2,4)	6.19E-05 ***	11.7863	0.0000	C(2,4)	6.33E-05 ***	11.9518	0.0000	C(2,4)	1.41E-05 ***	6.3602	0.0000
C(3,3)	1.34E-05 ***	11.8647	0.0000	C(3,3)	1.33E-05 ***	12.0014	0.0000	C(3,3)	3.73E-06 ***	5.5889	0.0000
C(3,4)	2.85E-05 ***	11.9615	0.0000	C(3,4)	2.84E-05 ***	12.2622	0.0000	C(3,4)	4.00E-06 ***	3.4741	0.0005
C(4,4)	5.42E-05 ***	10.5606	0.0000	C(4,4)	5.42E-05 ***	10.7541	0.0000	C(4,4)	1.71E-05 ***	6.0831	0.0000
A1(1,1)	0.0013	1.0691	0.2850	A1(1,1)	0.0070	1.5000	0.1336	A1(1,1)	0.0585 ***	4.3973	0.0000
A1(1,2)	0.0100 **	2.1440	0.0320	A1(1,2)	-0.0237 ***	-2.9965	0.0027	A1(1,2)	0.0844 ***	7.9807	0.0000
A1(1,3)	0.0032 **	1.9418	0.0522	A1(1,3)	-0.0076 ***	-2.7757	0.0055	A1(1,3)	0.0361 ***	6.9190	0.0000
A1(1,4)	0.0123 **	2.1442	0.0320	A1(1,4)	-0.0288 ***	-2.9932	0.0028	A1(1,4)	0.0836 ***	7.9704	0.0000
A1(2,2)	0.0787 ***	8.5109	0.0000	A1(2,2)	0.0803 ***	8.2424	0.0000	A1(2,2)	0.1217 ***	11.8096	0.0000
A1(2,3)	0.0249 ***	5.3947	0.0000	A1(2,3)	0.0257 ***	5.4703	0.0000	A1(2,3)	0.0521 ***	8.8240	0.0000
A1(2,4)	0.0965 ***	9.4661	0.0000	A1(2,4)	0.0975 ***	9.1152	0.0000	A1(2,4)	0.1205 ***	11.2412	0.0000
A1(3,3)	0.0079 ***	2.9976	0.0027	A1(3,3)	0.0083 ***	3.0554	0.0022	A1(3,3)	0.0223 ***	5.5792	0.0000
A1(3,4)	0.0306 ***	5.4725	0.0000	A1(3,4)	0.0313 ***	5.5469	0.0000	A1(3,4)	0.0515 ***	8.4589	0.0000
A1(4,4)	0.1183 ***	9.9954	0.0000	A1(4,4)	0.1185 ***	9.5534	0.0000	A1(4,4)	0.1193 ***	9.8807	0.0000
D1(1,1)	0.0003	0.2909	0.7711	D1(1,1)	0.0663 ***	5.1055	0.0000	D1(1,1)	0.0000	0.0001	0.9999
D1(1,2)	0.0079	0.5816	0.5608	D1(1,2)	0.1140 ***	9.1043	0.0000	D1(1,2)	0.0000	0.0001	0.9999
D1(1,3)	0.0040	0.5826	0.5602	D1(1,3)	0.0576 ***	9.4976	0.0000	D1(1,3)	0.0000	0.0001	0.9999
D1(1,4)	0.0068	0.5810	0.5612	D1(1,4)	0.0997 ***	8.7416	0.0000	D1(1,4)	0.0000	0.0001	0.9999
D1(2,2)	0.2052 ***	9.4335	0.0000	D1(2,2)	0.1961 ***	9.0994	0.0000	D1(2,2)	0.0000	0.0001	0.9999
D1(2,3)	0.1039 ***	15.1904	0.0000	D1(2,3)	0.0991 ***	15.6123	0.0000	D1(2,3)	0.0000	0.0002	0.9999
D1(2,4)	0.1758 ***	8.5108	0.0000	D1(2,4)	0.1714 ***	8.2430	0.0000	D1(2,4)	0.0000	0.0001	0.9999
D1(3,3)	0.0526 ***	10.9850	0.0000	D1(3,3)	0.0501 ***	11.7529	0.0000	D1(3,3)	0.0000	0.0003	0.9998
D1(3,4)	0.0890 ***	13.7152	0.0000	D1(3,4)	0.0866 ***	13.9468	0.0000	D1(3,4)	0.0000	0.0002	0.9999
D1(4,4)	0.1506 ***	7.2940	0.0000	D1(4,4)	0.1499 ***	7.0884	0.0000	D1(4,4)	0.0000	0.0001	0.9999
B1(1,1)	1.0014 ***	1009.6590	0.0000	B1(1,1)	0.9046 ***	50.9411	0.0000	B1(1,1)	0.9072 ***	75.6839	0.0000
B1(1,2)	0.8635 ***	132.0327	0.0000	B1(1,2)	0.8192 ***	80.4439	0.0000	B1(1,2)	0.8845 ***	115.3221	0.0000
B1(1,3)	0.9711 ***	438.0327	0.0000	B1(1,3)	0.9235 ***	99.8672	0.0000	B1(1,3)	0.9401 ***	148.3190	0.0000
B1(1,4)	0.8807 ***	135.0438	0.0000	B1(1,4)	0.8383 ***	81.4980	0.0000	B1(1,4)	0.8855 ***	110.2102	0.0000
B1(2,2)	0.7446 ***	66.2049	0.0000	B1(2,2)	0.7420 ***	61.7780	0.0000	B1(2,2)	0.8625 ***	96.2922	0.0000
B1(2,3)	0.8373 ***	129.4051	0.0000	B1(2,3)	0.8363 ***	121.3370	0.0000	B1(2,3)	0.9167 ***	183.6206	0.0000
B1(2,4)	0.7594 ***	71.9675	0.0000	B1(2,4)	0.7592 ***	68.6497	0.0000	B1(2,4)	0.8634 ***	99.1501	0.0000
B1(3,3)	0.9417 ***	225.0395	0.0000	B1(3,3)	0.9428 ***	226.0348	0.0000	B1(3,3)	0.9743 ***	335.0902	0.0000
B1(3,4)	0.8540 ***	133.6372	0.0000	B1(3,4)	0.8558 ***	132.8558	0.0000	B1(3,4)	0.9176 ***	169.5260	0.0000
B1(4,4)	0.7745 ***	67.8849	0.0000	B1(4,4)	0.7769 ***	67.2878	0.0000	B1(4,4)	0.8642 ***	86.9222	0.0000

Notes: ***, ** and * denote the rejection of null hypothesis at 1%, 5% and 10% sigificance levels respectively. In Model 1, Pegasus Airlines, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively. In Model 2, Turkish Airlines, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively. In Model 3, Bist Transportation Index, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively.

Table 5 Estimation results of volatility-VAR-VECH-TARCH (1,1) models during Covid-19 pandemic

Model 1	Coefficient	z-Statistic	P-Value	Model 2	Coefficient	z-Statistic	P-Value	Model 3	Coefficient	z-Statistic	P-Value
C(1,1)	0.00022	0.6769	0.4984	C(1,1)	2.41E-04	0.7893	0.4300	C(1,1)	1.78E-04	1.1236	0.2612
C(1,2)	1.69E-05	0.1509	0.8800	C(1,2)	1.01E-05	0.1263	0.8995	C(1,2)	9.80E-06	0.1249	0.9006
C(1,3)	-6.78E-06	-0.0123	0.9902	C(1,3)	-5.95E-06	-0.0523	0.9583	C(1,3)	-7.77E-06	-0.0955	0.9239
C(1,4)	-8.33E-06	-0.1097	0.9126	C(1,4)	2.16E-05	0.3420	0.7323	C(1,4)	1.03E-06	0.0198	0.9842
C(2,2)	0.000138	0.6589	0.5100	C(2,2)	8.79E-05	0.7629	0.4455	C(2,2)	7.22E-05	0.8345	0.4040
C(2,3)	3.11E-05	0.0262	0.9791	C(2,3)	7.15E-05	0.7573	0.4489	C(2,3)	8.04E-05	1.1314	0.2579
C(2,4)	4.89E-05	0.3723	0.7097	C(2,4)	5.97E-05	0.6069	0.5439	C(2,4)	5.87E-05	0.7924	0.4281
C(3,3)	3.31E-05	0.0259	0.9794	C(3,3)	4.68E-05	0.8119	0.4169	C(3,3)	1.77E-05	0.6811	0.4958
C(3,4)	1.27E-05	0.0155	0.9876	C(3,4)	1.95E-05	0.2549	0.7988	C(3,4)	3.43E-05	0.8038	0.4215
C(4,4)	2.67E-05	0.3912	0.6956	C(4,4)	3.45E-05	0.4854	0.6274	C(4,4)	3.93E-05	0.7036	0.4817
A1(1,1)	0.152413	0.7166	0.4736	A1(1,1)	0.0706	0.6323	0.5272	A1(1,1)	0.1189	0.9071	0.3643
A1(1,2)	0.359166	1.3132	0.1891	A1(1,2)	0.2356	1.0696	0.2848	A1(1,2)	0.3133	1.4436	0.1488
A1(1,3)	0.137561	0.1403	0.8884	A1(1,3)	0.0253	0.4336	0.6646	A1(1,3)	0.0234	0.2912	0.7709
A1(1,4)	0.265044	1.1932	0.2328	A1(1,4)	0.1829	1.0143	0.3105	A1(1,4)	0.2298	1.4504	0.1469
A1(2,2)	0.846389	1.6822	0.0925	A1(2,2)	0.7862 *	1.8716	0.0613	A1(2,2)	0.8254 *	1.7871	0.0739
A1(2,3)	0.324168	0.1425	0.8867	A1(2,3)	0.0843	0.4115	0.6807	A1(2,3)	0.0616	0.2911	0.7710
A1(2,4)	0.624586 *	1.7514	0.0799	A1(2,4)	0.6104 *	1.6866	0.0917	A1(2,4)	0.6054 **	1.8854	0.0594
A1(3,3)	0.124157	0.0711	0.9433	A1(3,3)	0.0090	0.2115	0.8325	A1(3,3)	0.0046	0.1495	0.8812
A1(3,4)	0.239217	0.1408	0.8880	A1(3,4)	0.0655	0.4067	0.6842	A1(3,4)	0.0452	0.2905	0.7714
A1(4,4)	0.460909	1.5573	0.1194	A1(4,4)	0.4740	1.4235	0.1546	A1(4,4)	0.4440 ***	1.7537	0.0795
D1(1,1)	1.00E-06	0.0000	1.0000	D1(1,1)	0.0000	0.0000	1.0000	D1(1,1)	0.0000	0.0000	1.0000
D1(1,2)	1.00E-06	0.0000	1.0000	D1(1,2)	0.0000	0.0000	1.0000	D1(1,2)	0.0000	0.0000	1.0000
D1(1,3)	1.00E-06	0.0000	1.0000	D1(1,3)	0.0000	0.0000	1.0000	D1(1,3)	0.0000	0.0000	1.0000
D1(1,4)	1.00E-06	0.0000	1.0000	D1(1,4)	0.0000	0.0000	1.0000	D1(1,4)	0.0000	0.0000	1.0000
D1(2,2)	1.00E-06	0.0000	1.0000	D1(2,2)	0.0000	0.0000	1.0000	D1(2,2)	0.0000	0.0000	1.0000
D1(2,3)	1.00E-06	0.0000	1.0000	D1(2,3)	0.0000	0.0000	1.0000	D1(2,3)	0.0000	0.0000	1.0000
D1(2,4)	1.00E-06	0.0000	1.0000	D1(2,4)	0.0000	0.0000	1.0000	D1(2,4)	0.0000	0.0000	1.0000
D1(3,3)	1.00E-06	0.0000	1.0000	D1(3,3)	0.0000	0.0000	1.0000	D1(3,3)	0.0000	0.0000	1.0000
D1(3,4)	1.00E-06	0.0000	1.0000	D1(3,4)	0.0000	0.0000	1.0000	D1(3,4)	0.0000	0.0000	1.0000
D1(4,4)	1.00E-06	0.0000	1.0000	D1(4,4)	0.0000	0.0000	1.0000	D1(4,4)	0.0000	0.0000	1.0000
B1(1,1)	0.765572 ***	3.3426	0.0008	B1(1,1)	0.7136 ***	2.1794	0.0293	B1(1,1)	0.7550 ***	4.1354	0.0000
B1(1,2)	0.587267 ***	5.2873	0.0000	B1(1,2)	0.5773 ***	3.6204	0.0003	B1(1,2)	0.5949 ***	4.7378	0.0000
B1(1,3)	0.943792 ***	6.6500	0.0000	B1(1,3)	0.8527 ***	4.3178	0.0000	B1(1,3)	0.8805 ***	8.1081	0.0000
B1(1,4)	0.735352 ***	6.5055	0.0000	B1(1,4)	0.7092 ***	4.2941	0.0000	B1(1,4)	0.7322 ***	7.3227	0.0000
B1(2,2)	0.45049 ***	3.8542	0.0001	B1(2,2)	0.4671 ***	3.1293	0.0018	B1(2,2)	0.4688 ***	3.3187	0.0009
B1(2,3)	0.72398 ***	7.5499	0.0000	B1(2,3)	0.6898 ***	5.8839	0.0000	B1(2,3)	0.6938 ***	6.5505	0.0000
B1(2,4)	0.564086 ***	6.7901	0.0000	B1(2,4)	0.5738 ***	5.1243	0.0000	B1(2,4)	0.5770 ***	5.4347	0.0000
B1(3,3)	1.163502 ***	50.4277	0.0000	B1(3,3)	1.0188 ***	18.0057	0.0000	B1(3,3)	1.0269 ***	19.8479	0.0000
B1(3,4)	0.906538 ***	25.5130	0.0000	B1(3,4)	0.8474 ***	16.9915	0.0000	B1(3,4)	0.8540 ***	19.0014	0.0000
B1(4,4)	0.706326 ***	13.1577	0.0000	B1(4,4)	0.7049 ***	9.4869	0.0000	B1(4,4)	0.7101 ***	9.4704	0.0000

Notes: ***, ** and * denote the rejection of null hypothesis at 1%, 5% and 10% sigificance levels respectively. In Model 1, Pegasus Airlines, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively. In Model 2, Turkish Airlines, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively. In Model 3, Bist Transportation Index, Brent, Dubai and WTI are represented by 1,2,3 and 4 respectively.

However, the volatility of crude oil markets has a significant influence on the volatility of Turkish Airlines, Pegasus, and Transportation Index both in the short and long term. The results show that the influence of three different crude oil markets to airlines stock prices and transportation index is different. Moreover, our models indicate that in the short-term the volatility spillover effect between the crude oil markets and the transportation index is found to be more significant compared to airlines stocks. Additionally, in the long run the volatility spillover effect between all three crude oil markets and all selected assets is almost the same. In other words, the impact of crude oil market to transportation index is stronger in the short-term.

In Table 5, we can see the results of the VAR-VECH-TARCH models applied for the period between end of 31.12.2019 and 03.06.2020 which we name Covid-19 period. Differing from long-term models, during Covid-19 period in the short term for all models' volatility spillover does not exist since $a_{12}, a_{13}, a_{14}, a_{23}, a_{24} and\ a_{34}$ are not significant even at10% level. Also, asymmetry does not exist since $d_{12}, d_{13}, d_{14}, d_{23}, d_{24} and\ d_{34}$ are all statistically insignificant. Only the in the long-term volatility spillover exists between airlines stocks, transportation index and crude oil markets since $b_{12}, b_{13}, b_{14}, b_{23}, b_{24} and\ b_{34}$ are all significant in all models.

In Figures 4-6 we can see the covariance and correlation coefficients of related markets for three different models. Considering Model 1, after the Covid-19 pandemic is announced by WHO correlation coefficient fluctuation range between Pegasus airlines and crude oil markets is all time high in the last five years. Based on our VAR-VECH-TARCH models, we can also claim that the large correlation coefficients for the Turkish Airlines, BIST Transportation Index and crude oil markets in Model 2 and Model 3 indicate the contagion effect of the pandemic to both transportation industry and crude oil markets due to global economic downturn. In all models the return linkage airlines stocks, transportation index and crude oil markets decreased significantly during Covid-19 pandemic period. The airlines experienced the hardest hit by the COVID-19 pandemic as governments have applied wide ranging travel restrictions. Consequently, if planes are not flying and no one's driving to work, the world needs less oil which caused global demand to slump. As a result, the covariance between Pegasus airlines transportation index and crude oil markets decreased significantly while it increased between Turkish Airlines and oil prices.

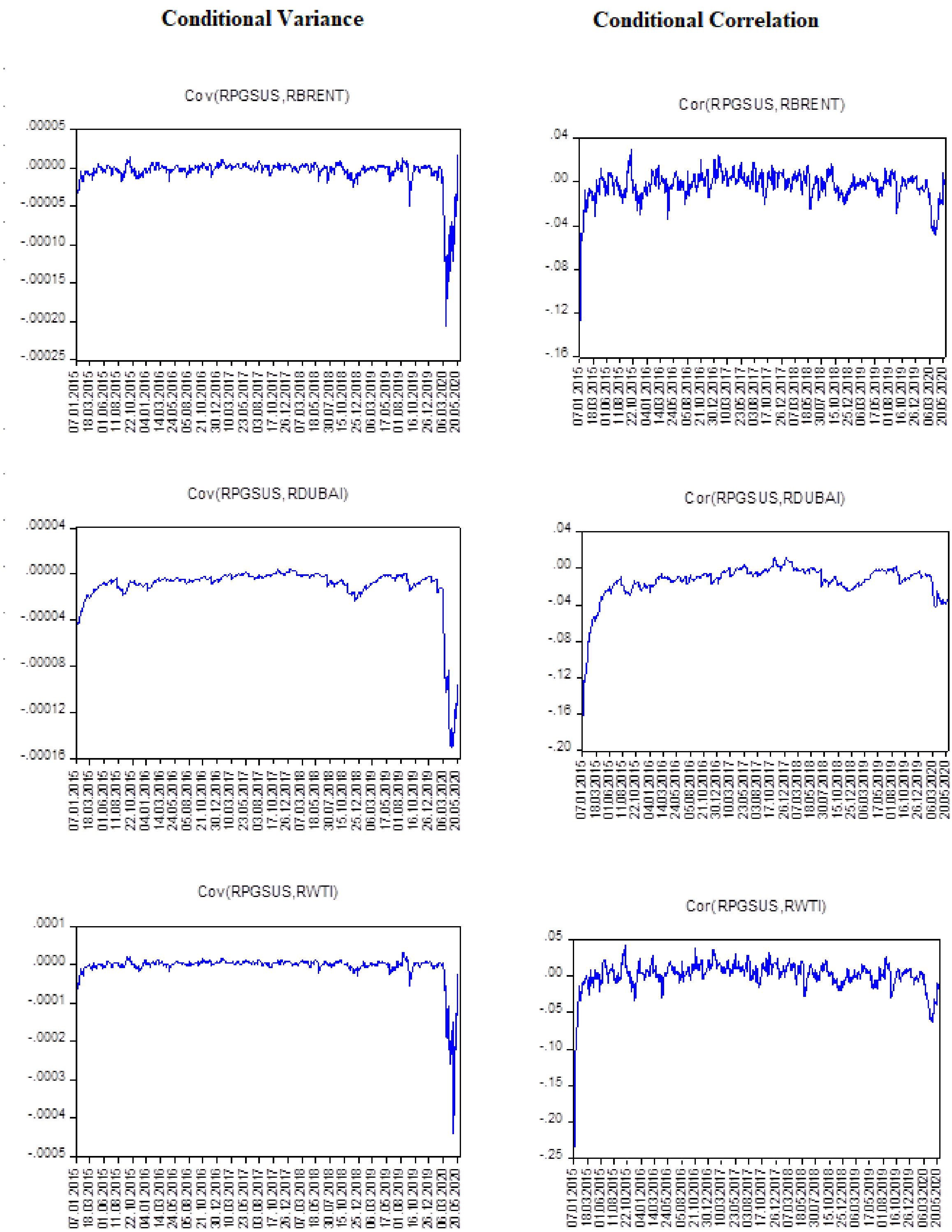


Figure 4: Conditional Variance for Model 1

Conditional Variance **Conditional Correlation**

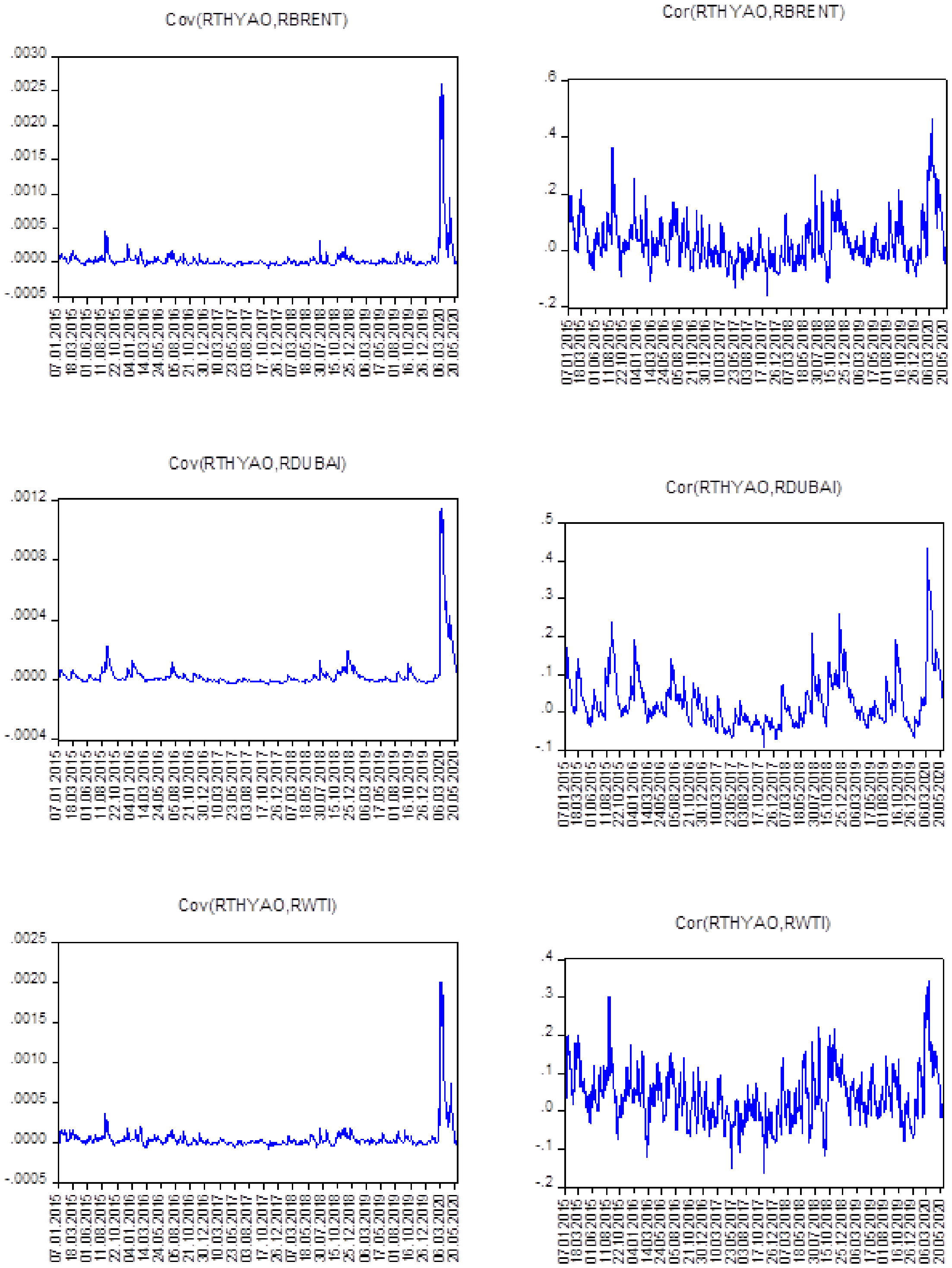


Figure 5: Conditional Variance and Correlation for Model 2

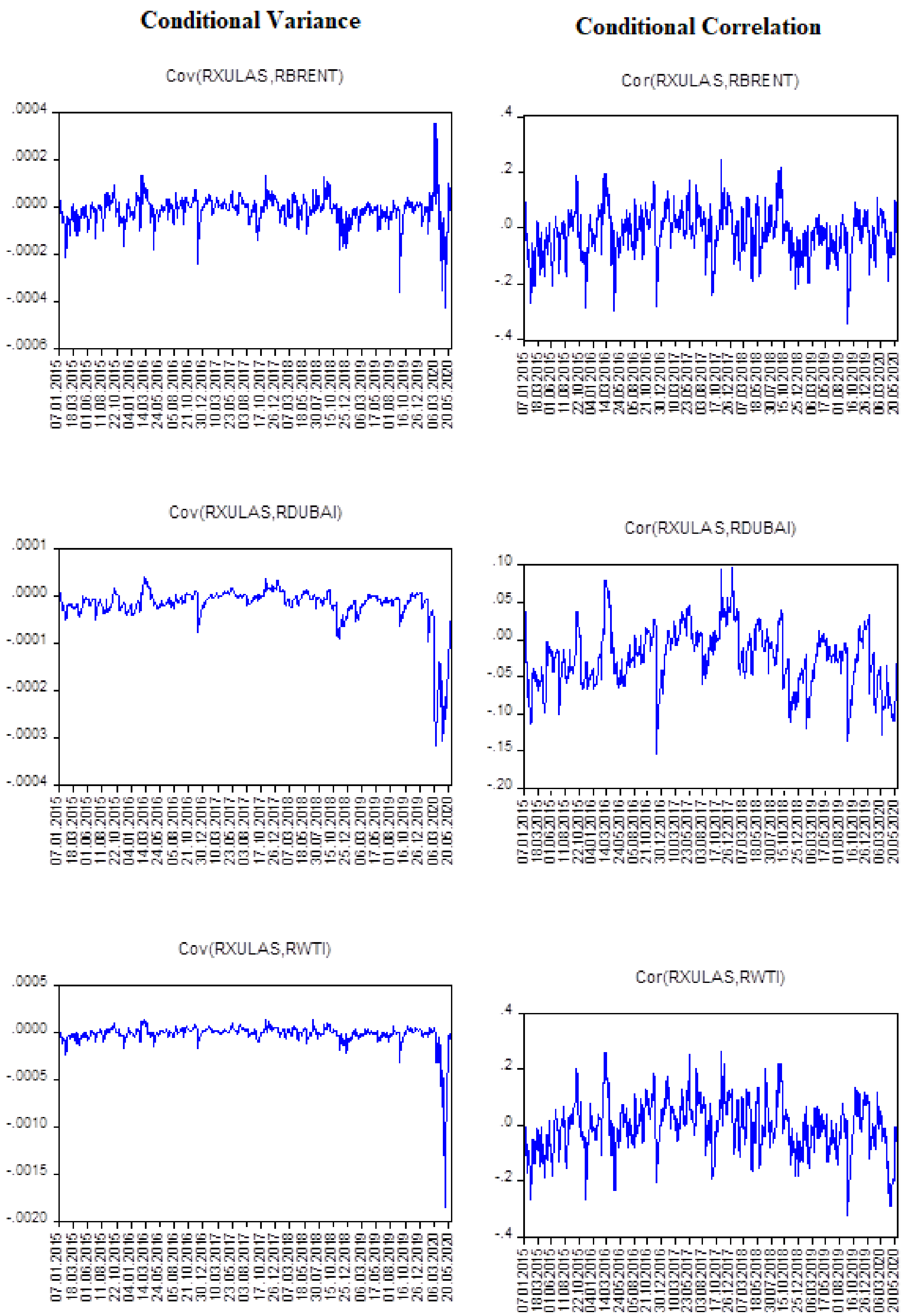


Figure 6: Conditional Variance and Correlation for Model 3

6 Conclusion

In the pandemic period the expectation in aviation industry is the ticket prices will not decrease significantly since the health and safety issue will be the top priority. The rise in crude oil prices increases the oil expenditure of airlines and leads to the rise in the total cost incurred. Based on audited financial reports Turkish Airlines has a hedge[4] ratio of 48% with a two-way collar hedge option at 35 dollars while Pegasus Airlines has a hedge ratio of 100% at 60 dollars strike price. Compared with small and medium sized airlines companies, the large companies have a relatively greater ability of reacting to the international crude oil price fluctuations due to the advantageous of asset scale and financing sources. So, the financial positions of the companies against oil prices are also consistent with the huge covariance fluctuations during the pandemic. Turkish Airlines has a more flexible and lower cost hedge position in this oil crush period compared to Pegasus Airlines. BİST transportation index is also mainly driven by Turkish Airlines stock which explains the similarity of index reactions to oil price volatility as exhibited in Model 2 and Model 3. Further, the volatility spillover effect between crude oil price and the stock price of Turkish Airlines is determined via the variance equation set as the VECH-TARCH model to catch the asymmetric news impact as well. According to the model results the volatility spillover effect between crude oil price and airlines' stock price is more significant compared to the return spillover effect. transportation index and oil prices. Only in the Covid-19 period there is an influence between Turkish Airlines and transportation index returns with Dubai and WTI oil prices. The research highlights are as follows:

First, there is no return spillover effect between crude oil prices and airlines stock prices. The same relationship exists also for transportation index. Secondly, in the short term the volatility spillover effect between crude oil price and Turkish Airlines stock price is more significant compared to Pegasus Airlines and transportation index. Third, in the long run the volatility spillover effect between crude oil prices and all three assets are strongly significant. Forth, there is no asymmetric news impact between crude oil prices and Pegasus Airlines stocks and transportation index. However, asymmetry exists for Turkish Airlines stocks. Good news from crude oil markets to Turkish Airlines increase the volatility as well. This study distinguishes itself from the majority of the literature that it focuses on analyzing the crude oil price airlines stock prices and transportation index in Borsa İstanbul and discuss the impact of the change in crude oil prices on them both in the long-run and specifically in the covid-19 pandemic. Also, the methodology we utilized in the paper, VAR-VECH-TARCH model, is the originality which is rarely used by the researchers in the related literature.

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[4] In order to keep fuel price risk at minimum level Turkish Airlines has developed a hedging strategy. According to this strategy hedging transactions are done for the tenor of at most the next 24 months and up to 60% of the forecasted fuel consumption of the following month. To hedge fuel price risk, derivative products are designed on crude oil, as the underlying asset since the crude oil and jet fuel prices are strongly correlated

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