VOLATILITY SPILLOVER BETWEEN OIL PRICE AND AIRLINE COMPANIES' STOCK MARKET: LOW-COST AND FULL SERVICE CARRIERS CASE

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ABSTRACT

VOLATILITY SPILLOVER BETWEEN OIL PRICE AND AIRLINE' STOCK PRICE: LOW-COST AND FULL SERVICE AIRLINES

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Master's Program in Business Administration

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Oil price volatility is one of the vital factors that explains airline' stock price movements. This thesis investigates volatility spillover effects among three crude oil benchmarks (WTI, Brent, Dubai) and eight airline companies' stock prices (Gol Linheas Aereas, Latam Airlines, Spring Airlines, China Southern Airlines, Nok Air, Thai Airways, Pegasus Airlines, Turkish Airlines). Applying VAR-GARCH-BEKK model, the evidence indicates that there is return and volatility spillover effect between crude oil prices and airline' stock prices. As for the comparison of the low-cost and full service carriers, the impact of volatility spillover between crude oil price and low-cost carriers is more significant than full-service airlines. Airline companies stock prices in Turkey are relatively less effected by the oil price changes than in China, Brazil and Thailand, indicating that spillover effect on account of oil price mainly related with the profiles and features of the air transport industry of four countries.

Keywords: Crude oil price, airlines, return and volatility spillover effect, VAR-GARCH-BEKK

ÖZET

PETROL FİYATLARI İLE HAVAYOLU ŞİRKETLERİ HİSSE SENEDİ FİYATLARI ARASINDA VOLATİLİTENİN YAYILMA ETKİSİ: DÜŞÜK MALİYETLİ VE TAM HİZMET SUNAN HAVAYOLLARI

Mendi, Günseli

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Petrol fiyatlarındaki oynaklık borsa endekslerini etkileyen önemli faktörlerden biridir. Petrol fiyatlarındaki değişim etkisinin büyüklüğü endüstrilerin petrole olan bağlılığına göre değişkenlik göstermektedir. Havayolu şirketlerinde petrol tüketiminin yüksek olması sebebiyle petrol fiyatlarındaki değişim etkisinin de yüksek olması beklenmektedir. Bu çalışma, ham petrol fiyatlarındaki (WTI, Brent, Dubai) oynaklığın düşük maliyetli ve tam hizmet sunan havayolları (Gol Linheas Aereas, Latam Airlines, Spring Airlines, China Southern Airlines, Nok Air, Thai Airways, Pegasus Airlines, Turkish Airlines) üzerindeki etkisini VAR-GARCH-BEKK modelini kullanarak ölçmektedir. Çalışmanın bulgularında; volatilite etkisinin getiri etkisinden daha yüksek olduğu bulunmuştur. Ayrıca, volatilite etkisinin düşük maliyetli havayolları için tam hizmet sunan havayollarına göre daha yüksek olduğu gözlemlenmiştir. Çin, Brezilya ve Tayland'da kuvvetli oynaklık geçişkenliği gözlenirken, Türkiye için bu

geçişkenlik daha zayıf olup, sebebinin ülkelerdeki ulaşım sektöründeki dinamiklerin farklı olduğundan kaynaklandığı düşünülmektedir.

Anahtar Kelimeler: Ham petrol fiyatları, havayolu şirketleri, volatilite ve getiri etkisi, VAR-GARCH-BEKK model

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
ARCH	Autoregressive Conditional Variance
ARMA model	Autoregressive Moving Average model
BEKK model	Baba, Engle, Kraft and Kroner model
GARCH	General Autoregressive Conditional Heteroskedasticity
JB	Jarque –Bera
LM	Lagrange Multiplier
PP	Phillips-Perron test
VAR model	Vector Autoregressive model
WTI	West Texas Intermediate
PED	Price Elasticity of Demand

CHAPTER 1: INTRODUCTION

Oil is a major source for many industry sectors and has a crucial role in economic activity with regards to providing stability into the economy. Oil is used in wide range of sectors such as heating, energy, and transportation. The effect of oil price changes varies according to the amount of the dependence of the sector on oil as a key part of inputs (Maghyereh and Al-Kandari, 2007). Mohanty and Nandha (2011) and Mohanty et al. (2014) also concluded that effect of oil price depends on type of industry; oil-consumer or oil producer.

Malik and Ewing (2009) found an evidence of significant volatility spillover, regarding the effect of oil price shocks on stock market volatility in US. Moreover, Vo (2011) indicated that there is an inter-market dependence in volatility between stock and oil markets in US. Elyasiani et al. (2011) investigated the relationship between US industries stock returns such as coal, utility, building, chemical, plastic, transportation, and metal and oil prices and found an important relationship between oil-futures return and enterprise excess return. McSweeney and Worthington (2007) examined the effect of oil prices on nine industry stock returns from Australia. They found that the energy industry had a strong positive relation with oil price increases, while the transportation, retailing and banking industries exhibited significantly negative relations with oil prices. For the European stock markets, Arouri et al. (2012) reported that there is also a volatility transmission between stock and oil markets.

Airlines industry's fuel consumptions accounting for 23.7% of operating expenses in 2019 (International Air Transport Association, 2019). Changes in crude oil price have an obvious effect on the operating cost of airlines. Low-cost carriers are even more sensitive to changes in oil prices than their higher-cost counterparts. Cost burden gets passed on to consumers through higher fares. Higher fares do not translate directly to lower volumes in air transport- it depends on elasticity of the passenger. However, when reduction in air travel demand occurs, passengers go for other alternative vehicles which affect airlines earnings and finally their stock prices.

Over the 2018-2019 financial year, almost 10 low-cost carriers collapsed, including Cobalt Air (Cyprus), Primera Air (Denmark), VLM Airlines (Belgium), Germania (Germany) and WOW (Iceland) (Zhang, 2019). Small changes in oil prices can put their business under pressure. An aircraft like 737, a narrow body aircraft, consumes around 750 gallons an hour. When this makes a big trip over Trans-Atlantic, slight rise in price eat away all the profits.

In finance literature, oil prices as well as its volatility gain an importancenot only for consumers, but also for investors. Many economic literature have analyzed the impact of oil price fluctuations on various industries and sectors. Lee and Ni (2002) estimated the effect the oil price shocks on demand and supply for several industries and resulted that effect differs for oil-intensive industries and other ones. Nevertheless, there are very few literature on the impact of oil prices changes on airline industry' stock markets. Furthermore, this research topic gains an interesting aspect in recent years. Narayan and Sharma (2011) and Kristjanpoller and Concha (2016) pointed out that crude oil price has a positive influence on the transportation sector/airlines' stock market return and figured out positive impact on 56 airlines. Yun and Yoon (2019) investigated the relationship between crude oil price and stock price of four airlines, namely Korean Air, Asiana Airlines, Air China and China Eastern Airlines. Their findings indicated that smaller airlines' stock prices have a bigger response to oil price changes and Air China and China Eastern Airlines' stock prices are influenced more by oil price movements.

1.1 Aim and Contribution of the Thesis

The aim of this thesis is to investigate the volatility spillover effect between crude oil prices and airline companies' stock market returns. Although airline companies are the biggest oil consumers, there is a little evidence on the impact of oil prices on stock returns of airline companies, including low-cost and full service carriers. Therefore, analyzing this relationship would be an interesting research area. Moreover, it extends earlier research studies through a comprehensive framework to examine the impact of oil price variation on stock returns in two groups of airlines connected with The International Civil Aviation Organization (ICAO); low-cost and full-service carriers, represented respectively; Nok Air and Thai Airways from Thailand, Qantas and Virgin Australia from Australia, Latam Airlines and Gol Linheas Aereas from Brazil, Air Canada and Westjet Airlines from Canada, China Southern Airlines and Spring Airlines from China, StarFlyer and Japan Airlines from Japan, Pegasus Airlines and Turkish Airlines from Turkey and Alaska Airlines and Spirit Airlines from US, all publicly traded on the market.

This thesis makes a three-fold contribution to the existing literature. Firstly, this is a pioneering study for the examination of the role of oil price on both low-cost and full service carriers in airline industry within the same country, namely Brazil, Turkey, Thailand and China. Secondly, the impact of changes in oil price on airline companies' stock returns is an important topic for investors and company administrators and this requires a special attention on low-cost and full-service carriers separately. Thirdly, it allows to inspect return and volatility spillover at the same time by employing VAR-GARCH-in-mean structure with the BEKK representation. From the methodological point of view, previous studies mostly use various existing models, namely, simple OLS, and GARCH models, for example Elyasiani et al. (2011), Hsu (2017). The proposed model is similar to the model of Yun and Yoon (2018), in a recent study, highlight the effect of oil price change on Airline's stock price and volatility for four airlines companies from China and Korea.

1.2 Structure of the Study

This thesis includes six sections, which explore and discuss the effect of oil price volatility on airline companies' stock returns for low-cost and full service airlines. The introduction includes the scope and aim of this research. Second section explains the literature review. Section 3 outlines the statistical tests, followed by the econometric methodology. The data and summary statistics are represented in Section 5. Section 6 discovers the empirical results. Finally, section 7 contains concluding highlights.

CHAPTER 2: LITERATURE REVIEW

There is a mass amount of study discovering the relationships between oil price shocks and stock market returns and many studies in the related literature found a positive relationship. Early studies conducted by Chen et al. (1986) identified oil price as a risk factor for stock prices. Sadorsky (2001) investigated that stock returns of oil and gas companies from Canada were positively influenced by oil price increases. As similar with Sadorsky' (2001) study, Boyer and Filion (2009) found a positive influence of oil prices on stock returns in Canadian market between 1995-2002. Additionally, Wang et al. (2013) compared the effects of oil price shocks on stock markets in the oil-importing and oil-exporting countries. Their results indicated that oil market has a significant influence on stock market. Some studies focused on oil-stock market relationship for one or more net oil-importing countries including Cunado and Perez de Gracia (2014), Bouri (2015), Silvapulle et al. (2017) while some focused on one or more net oil exporting countries including Bjornland (2009), Ramos and Veiga (2013). Additionally, Jung and Park (2011) examined the oil price shocks on two stock market returns; Korea and Norway and documented heterogenous impact. Phan et al. (2015) also concluded that stock returns of oil producers positively influenced by oil price changes.

On the other hand, many studies reported a negative impact of oil prices on stock market returns. Nandha and Faff's (2008) findings suggested that 35 sectors are negatively responded to oil price changes except mining oil andgas sectors. Additionally, some other studies, including Sadorsky (1999), Ciner (2001), and Park and Ratti (2008) examined the linkages between oil price shocks and stock markets in the US and 13 European countries and found a negative relationship, too. Moreover, analyzing the impact of oil price from industrial perspective also important to figure out differences and similarities between several enterprises. Mohanty et al. (2014) figured out the influence of WTI crude oil price on 6 industries; airlines, recreational services, hotels and bars, travel and tourism in US. They found that the crude oil price has a negative impact on the stock prices of airline companiesand the effect was high during the 2008-2009 financial crises. Bjornland (2009) also concluded that while oil price has a negative effect on stock prices of transportation companies, it has positive impact on oil production companies. Malik and Ewing (2009) identified a negative relationship between oil price volatility and stock market returns of several US industries such as technology, consumer services as well as healthcare. Lu and Chen (2010) examined the impact of WTI crude oil price on the stock prices of 160 transportation industries in eight countries. Narayan and Sharma (2011, 2015) analyzed the stock market prices of 560 firms from 14 sectors: energy, electricity, supply, food, medical, manufacturing, engineering, computer, banking, financial, real estate, transportation and general service and found that the impact of oil price on the different industries depends on the enterprise scale and increase in oil price will boost the increase in stock price return of the energy and transportation enterprises . In similar vein, Güler et al. (2010) investigated the impact of oil price volatility on energy stock prices listed in Borsa Istanbul for 2000-2005 and found significant impact of oil changes on stock price and electricity indices. Vardar et al. (2018) investigated the relationship between Brent and 11 industry sector indices from the Borsa Istanbul. Their results indicated that cointegration exists between returns of five of eleven sectoral indices.

Shaeri at al. (2016) examined the oil price risk exposure of two US subsectors; financial and non-financial industries. They found that oil price influenced non-financial subsectors more than financial ones and also found that impact of the crude oil price risk on the airlines is more than on other enterprises. Kristjanpoller and Concha (2016) found positive influence on 56 airlines. Hsu (2017) reported that the crude oil price created impact on six US airlines. Yun and Yoon (2018) investigated the impact of three crude oil price (WTI, Brent, Dubai) on the stock price and volatility of four airline companies from China and Korea using VAR-GARCH-BEKK model. They found that there is a return and volatility spillover effect between crude oil price and stock prices of airlines.

Although several studies have found a negative and positive relationships, still majority of literature reported that there is no connection between oil price and stock markets for example Chen et al. (1986) and Huang et al. (1996). Regarding the oil-importing countries, Al Fayoumi (2009) found that there is no proof that oil price influences the stock market returns in three oil importing countries, namely Turkey, Tunisia, and Jordan. The same picture is drawn by the study of Aspergis and Miller (2009) and Jammazi and Aloui (2010) that oil prices do not affect stock market performance.

CHAPTER 3: STATISTICAL TESTS

3.1 Unit Root Tests

The economic and finance literature has experienced an explosion of unit root tests for stationarity of time series data since the choice of methodology analysis and modeling series depend on their order of integration. There are two approaches: stationarity test that considers as null hypothesis is stationary which is the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (Kwiatoski et al., 1992) test, and unit root tests, such as the Dickey-Fuller test and its augmented version, the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981), and the Phillips-Perron test (PP) (Phillips and Perron, 1988), for which the null hypothesis is on the contrary that the series possess a unit root and hence is not stationary.

Augmented Dickey-Fuller test applies the basic autoregressive unit root test to accommodate general ARMA (p, q) models with unknown orders. The ADF test is based on below equation

$$y_t \;=\beta' D_t \;+\; \phi y_{t-1} + \sum_{n=1}^{p} \psi_t \Delta y_{t-j} \varepsilon_t \qquad (1)$$

where D_t is a vector of constant and trend terms. Δy_{t-j} is the p lagged difference terms which is used for approximation of the ARMA structure of the errors. The error term is also assumed to homoscedastic. The specification of the deterministic terms depends on the assumed behavior of y_t under the alternative hypothesis. Under the null hypothesis, y_t is $I(1)$ which states that $\phi = 1$. The ADF t-statistic and normalized bias statistic are based on the least squares estimated of above equation and are given by

$$ADF_t = \;\; t_{\phi=1} \;\; = \frac{\phi-1}{SE\,(\phi)} \qquad (2)$$

$$ADF_t = \;\; \frac{T\,(\phi-1)}{1-\psi_1-\cdots-\psi_P} \qquad (3)$$

The PP tests reject any serial correlation in the test regression. Test regression for the PP test is;

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \qquad (4)$$

where u_t is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the errors u_t of the test regression by directly modifying the test statistics $t_{\pi=0}$ and T_{π} .

Testing the null hypothesis that the time series y_t is I (0), is described by the KPSS test.

$$y_t = \beta' D_t + \mu_t + u_t \tag{5}$$

$$\mu_t = \mu_{t-1} + \varepsilon_t \text{ , } \varepsilon_t \sim WN\,(0, \sigma_\varepsilon^2) \tag{6}$$

where D_t contains deterministic components, u_t is I (0) and might be heteroskedastic. Null hypothesis which y_t is formulated as H_0 : σ_ε^2=0, implies that μ_t is a constant. The KPSS test statistic is the Lagrange multiplier (LM) or score statistic for testing σ_ε^2=0 against the alternative that σ_ε^2>0 and is given by

$$KPSS = (T^{-2} \sum_{t=1}^{T} \breve{S}_t^2)/\hat{\lambda}^2 \tag{7}$$

where $\breve{S}_t = \sum_{t=1}^{T} \breve{u}_j$, $\breve{u}_t$ is the residual of a regression of y_t on D_t and $\hat{\lambda}^2$ is a consistent estimate of the long-run variance of u_t using $\breve{u_t}$.

3.2 ARCH LM Test

ARCH-LM test by Engle (1982) is used to test for whether there is an ARCH effect or not. The test is based on following equation;

$$r_t^2 = a_0 + a_0\, r_{t-1}^2 + \cdots + a_0\, r_{t-1}^2 + \varepsilon_t \tag{8}$$

$$H_0 : \ a_1 = 0, for\ i = 1,2, \ldots, p$$

$$H_1 : \ a_1 \neq 0, for\ at\ least\ one\ i$$

Under the null hypothesis (of no ARCH effects), the test statistic LM = TR^2 will be distributed as X^2 with p degrees of freedom.

CHAPTER 4: METHODOLOGY

This study is designed to estimate the dynamic conditional correlations by using GARCH model. To apply GARCH type modelling, it is required that the series have to be stationary. Therefore, at first, the study will focus on unit root tests and, then ARCH-LM test is applied to check the existence of any ARCH effect.

4.1 VAR Model

The relationship between more variables are analyzed by utilizing Vector Autoregressive (VAR) model. VAR model is represented as;

$$y_t \;=\; v \;+\; \phi_1 y_{t-1} + \cdots + \phi_P y_{t-P} + \varepsilon_t \qquad (9)$$

where y_t is $n \times 1$ vector of our n time series at time *t*, *v* is $n \times 1$ vector of intercept parameters, $\phi_1, \ldots, \phi_P$ are $n \times n$ matrices of parameters, ε_t is $n \times 1$ vector of error terms.

The estimated VAR equation indicates the effect of own past values and past values of other variables in the model (both up to Pth lag). y_t is stable VAR(P) process if all roots of the characteristic Equation;

$$| I - \lambda\phi_1 - \lambda\phi_2 - \cdots - \lambda\phi_P = 0 \qquad (10)$$

are in absolute value less than one.

However, VAR model is not enough to sufficiently capture the data, due to the heteroskedasticity in it, but the VAR model can be used together with a model which deals with ARCH effects.

4.2 BEKK-GARCH Model

Although it is a very general model, it is not suitable to use in this study. The first drawback is the large number of parameters, making it impractical to use for more than two time series. The second drawback is that the positive definiteness of the conditional covariance matrix, H_t , cannot be confirmed. A solution to these problems, while allowing for volatility transmission, is BEKK model proposed by Engle and Kroner (1995).

The BEKK-GARCH model narrowed down the version of VECH model which requires less parameters. Therefore, the BEKK-GARCH model is frequently used in the literature dealing with volatility transmission to model conditional covariance matrix.

The BEKK representation of the GARCH models a conditional covariance matrix of the error term, ε_t, which is a vector of residuals from the mean equation.

Let be ε_t a martingale difference sequence, a stochastic process with zero conditional mean, i.e.

$$E(\varepsilon_t | \, \Omega_{t-1}) \qquad \textit{almost surely for every t} \tag{11}$$

with conditional covariance matrix being:

$$Cov(\varepsilon_t | \, \Omega_{t-1}) = \; H_t^{-\frac{1}{2}} Cov(z_t | \, \Omega_{t-1} \,) H_t^{-\frac{1}{2}} = \; H_t \tag{12}$$

where $H_t^{\frac{1}{2}}$ is a symmetric positive definite square root of H_t which can be obtained by Cholesky factorisation (Lütkepohl, 2005).

$$\varepsilon_t = \; H_t^{\frac{1}{2}} z_t \, , \qquad z_t \sim i.i.d.(0, I) \tag{13}$$

I is n × n identity matrix, n being the number of variables.

The BEKK-GARCH(p, q) model:

$$H_t = C'C \; + \; \sum_{i=1}^{q} A_i' \varepsilon_{t-1} \varepsilon_{t-1}' \, A_i \;\; + \sum_{i=1}^{p} B_i' H_{t-1} B_i \tag{14}$$

C indicates lower triangular matrix of $n \times n$. A_i and B_i are parameters of $n \times n$ matrices.

The coefficient, a_{ii}, is capturing own volatility spillover, while b_{ii} is capturing own volatility persistence of *i*th variable. Off-diagonal elements of *A* and *B* indicate volatility spillover. Off-diagonal element aij captures the transmission of volatility from *i*th to *j*th variable, while off-diagonal coefficient bij measures the dependence of volatility of jth variable on past volatility of ith variable.

The BEKK-GARCH (1, 1) i.e. case when p = q = 1. In bivariate case matrices from the BEKK model are following:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} \quad C = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix} \quad A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \qquad (15)$$

Individual conditional variances and the covariance from the Ht matrix can be expanded as:

$$h_{11,t} = c_{11}^2 + c_{21}^2 + a_{11}^2\, \varepsilon_{1,t-1}^2 + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^2\, \varepsilon_{2,t-1}^2 + b_{11}^2 h_{11,t-1} + 2b_{11}b_{21}h_{12,t-1} + b_{21}^2 h_{22,t-1} \qquad (16)$$

$$h_{22,t} = c_{22}^2 + a_{12}^2\, \varepsilon_{1,t-1}^2 + 2a_{12}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}^2\, \varepsilon_{2,t-1}^2 + b_{12}^2 h_{11,t-1} + 2b_{11}b_{22}h_{12,t-1} + b_{22}^2 h_{22,t-1} \qquad (17)$$

$$h_{12,t} = c_{21}c_{22} + a_{11}a_{21}\, \varepsilon_{1,t-1}^2 + (a_{11}a_{22} + a_{22}a_{12})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}a_{21}\, \varepsilon_{2,t-1}^2 + b_{11}b_{12}h_{1,t-1} + (b_{11}b_{22} + b_{22}b_{12})h_{12,t-1} + b_{22}b_{12}h_{2,t-1} \qquad (18)$$

The BEKK model is covariance stationary if and only if all the eigenvalues of $[\sum_{i=1}^{q} A_i \otimes A_i + \sum_{i=1}^{p} B_i \otimes B_i]$ are less than one in modulus

Univariate standardized residuals;

$$\varepsilon_t^{JS} = H_{ii,t}^{-1/2}\varepsilon_{i,1} \qquad (19)$$

where $\varepsilon_{i,1}$ is a residual from mean equation of *i*th variable at time t, $h_{ii,t}$ is the corresponding conditional variance from estimated covariance matrix.

Jointly standardized residuals:

$$\varepsilon_t^{JS} = H_t^{-1/2}\varepsilon_{i,1} \qquad (20)$$

where ε_t is a residual vector n × 1 from mean equations.

CHAPTER 5: DATA AND SUMMARY STATISTICS

In this section, the data is explained and the methods are applied to analyze whether there are volatility spillovers between crude oil prices and airline companies' stock prices. For the analysis, econometric software RATS version 9.0 and Eviews were used.

5.1 Data Description

The data used in this analysis are daily price indices selected airline companies from Brazil, China, Turkey and Thailand. The data period is from January 1, 2015 to October, 2019 and the data is obtained from Eikon Database by Thomson Reuters. The list is narrowed to publicly traded full service as well as low cost carriers in the same country.

Three crude oil prices are used; West Texas Intermediate (WTI) from North America, Brent from Europe and Dubai from East Asia. Oil prices are expressed in US$/barrel.

Descriptions of airline companies and countries characteristics are represented in Table 1. In terms of airlines, low cost carriers and full service airlines are presented respectively; Nok Air and Thai Airways from Thailand, Qantas and Virgin Australia from Australia, Latam Airlines and Gol Linheas Aereas from Brazil, Air Canada and Westjet Airlines from Canada, China Southern Airlines and Spring Airlines from China, StarFlyer and Japan Airlines from Japan, Pegasus Airlines and Turkish Airlines from Turkey and Alaska Airlines and Spirit Airlines from US. In all eight countries, 4 countries, namely Thailand, Brazil, China and Turkey are selected to use in the study due to the ARCH-LM test results.

Returns, $R_{i,t}$ are computed as $R_{i,t} = ln\ (P_{i,t}) - ln\ (P_{i,t-1})$, where $P_{i,t}$ denotes the value of crude oil prices and stock prices at time *t*.

Table 1: Descriptions of Sample Countries and Airline Companies

Country	**Oil Exporter or Importer**	**Airline Companies**	**Low-Cost / Full Service Carrier**	**Airline Companies Stock Index**
Australia	Net Importer	Virgin Australia	Low-Cost	Australian Stock Exchange
		Qantas Airways	Full-Service	OTC
Canada	Net Exporter	Westjet	Low-Cost	Toronto Stock Exchange
		Air Canada	Full Service	Toronto Stock Exchange
China	Importer	Spring Airways	Low-Cost	Shanghai Stock Exchange
		China Southern Airlines	Full-Service	New York Stock Exchange
Brazil	Net Exporter	Gol Linheas Aereas	Low-Cost	New York Stock Exchange
		Latam Airlines	Full-Service	OTC
Japan	Importer	Starflyer	Low-Cost	Tokyo Stock Exchange
		Japan Airlines	Full-Service	Tokyo Stock Exchange
Thailand	Importer	Nok Airlines	Low-Cost	Stock Exchange of Thailand
		Thai Airways	Full-Service	Stock Exchange of Thailand
Turkey	Importer	Pegasus Airlines	Low-Cost	Istanbul Stock Exchange
		Turkish Airlines	Full-Service	Istanbul Stock Exchange
US	Importer	Spirit Airlines	Low-Cost	New York Stock Exchange
		Alaska Air Group	Full-Service	New York Stock Exchange

5.2 Descriptive Statistics and Preliminary Analysis

The summary statistics are presented in Table 2 for eight airline companies and crude oil prices. Median values for the stock return of airline companies are close to mean values indicating that the data has normal distribution. Additionally, skewness values are almost zero for all airline companies, except Latam Airlines, Westjet Airlines and Spirit Airlines, meaning that the distribution of the return series is close to normal distribution. There is an excess kurtosis in all cases, which is the highest in WestJet Airlines. Jarque-Bera (JB) Lagrange Multiplier test which tests the normality. Normality test is strongly rejected in all cases. Figure 1 represents the change in the return of the three crude oil prices and stock market prices.

Table 2: Descriptive Statistics for Crude Oil and Airline Companies' Stock Returns

	Mean	**Median**	**Max.**	**Min.**	**Std. Dev.**	**Skewness**	**Kurtosis**	**J-B**
Crude Oil Prices								
WTI	0.0001	0.001	0.137	-0.194	0.027	-0.224	7.680	899.752
Brent	0.0002	0.001	0.136	-0.119	0.025	0.182	5.886	344.368
Dubai	0.0003	0.001	0.138	-0.099	0.026	0.385	6.394	492.978
Airline Companies								
Qantas	0.0009	0.001	0.122	-0.128	0.021	-0.024	6.650	542.534
Virgin Australia	-0.0013	0.000	0.139	-0.241	0.028	-0.505	9.902	1980.995
GOL Linheas Aereas	0.0007	-0.001	0.417	-0.314	0.058	0.686	12.181	3507.603
Latam Airlines	0.0000	-0.001	0.250	-0.106	0.026	1.482	16.369	7633.656
Air Canada	0.0013	0.000	0.146	-0.202	0.028	-0.069	9.606	1777.289
Westjet Airlines	-0.0001	0.001	0.465	-0.282	0.026	4.012	117.829	539385.300
China Southern Airlines	0.0001	0.000	0.163	-0.146	0.032	0.092	6.485	495.723
Spring Airlines	0.0011	-0.001	0.188	-0.106	0.029	0.636	6.704	624.500
Japan Airlines	0.0000	0.000	0.085	-0.079	0.015	0.022	6.129	398.731
StarFlyer	0.0006	0.000	0.163	-0.173	0.024	0.500	16.678	7656.727
Nok Air	-0.0010	-0.001	0.187	-0.267	0.023	-0.733	28.359	26265.170
Thai Airways	-0.0007	-0.001	0.187	-0.161	0.028	0.268	10.124	2077.815
Pegasus Airlines	-0.0002	0.001	0.159	-0.247	0.034	-0.728	8.993	1548.295
Turkish Airlines	-0.0006	0.001	0.115	-0.219	0.032	-0.772	7.053	765.842
Alaska Airlines	0.0001	0.001	0.148	-0.141	0.021	-0.163	9.354	1647.758

Table 2 (Continued)

Spirit Airlines	-0.0007	0.000	0.150	-0.270	0.029	-1.299	16.579	7780.599

Figure 1: Return Dynamics of Crude Oil Prices and Airline Companies' Stock Prices

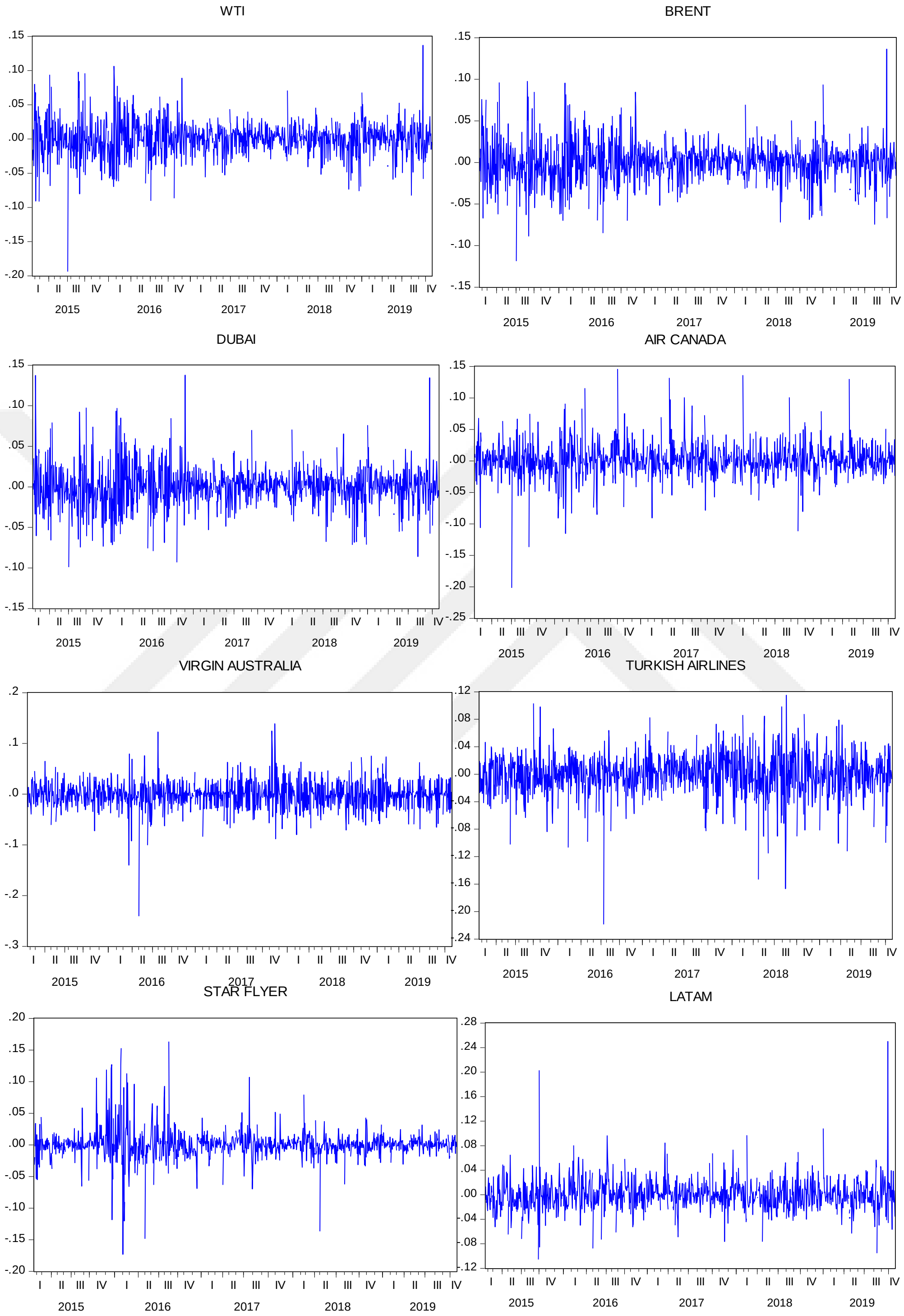


Figure 1 (Continued)

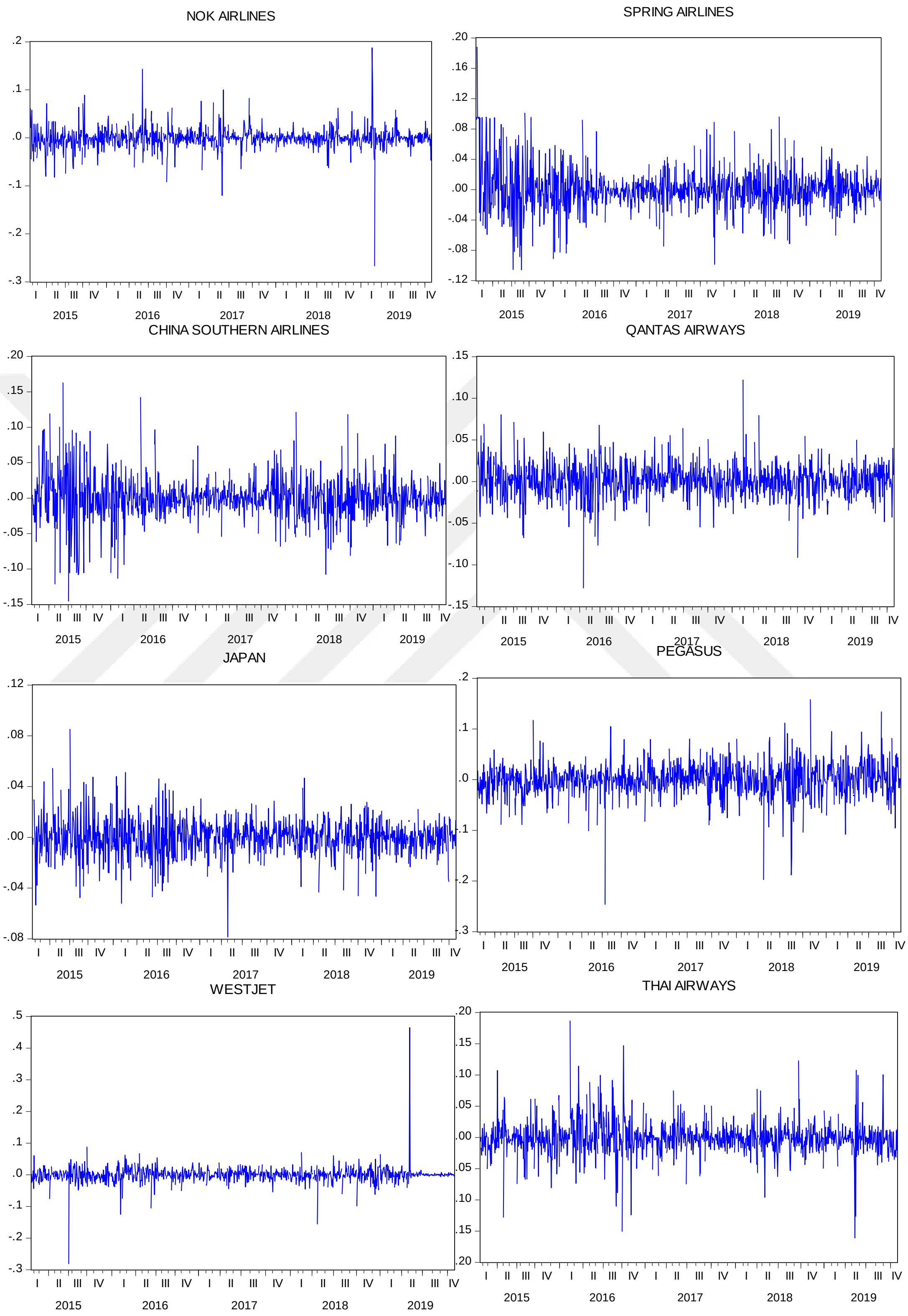
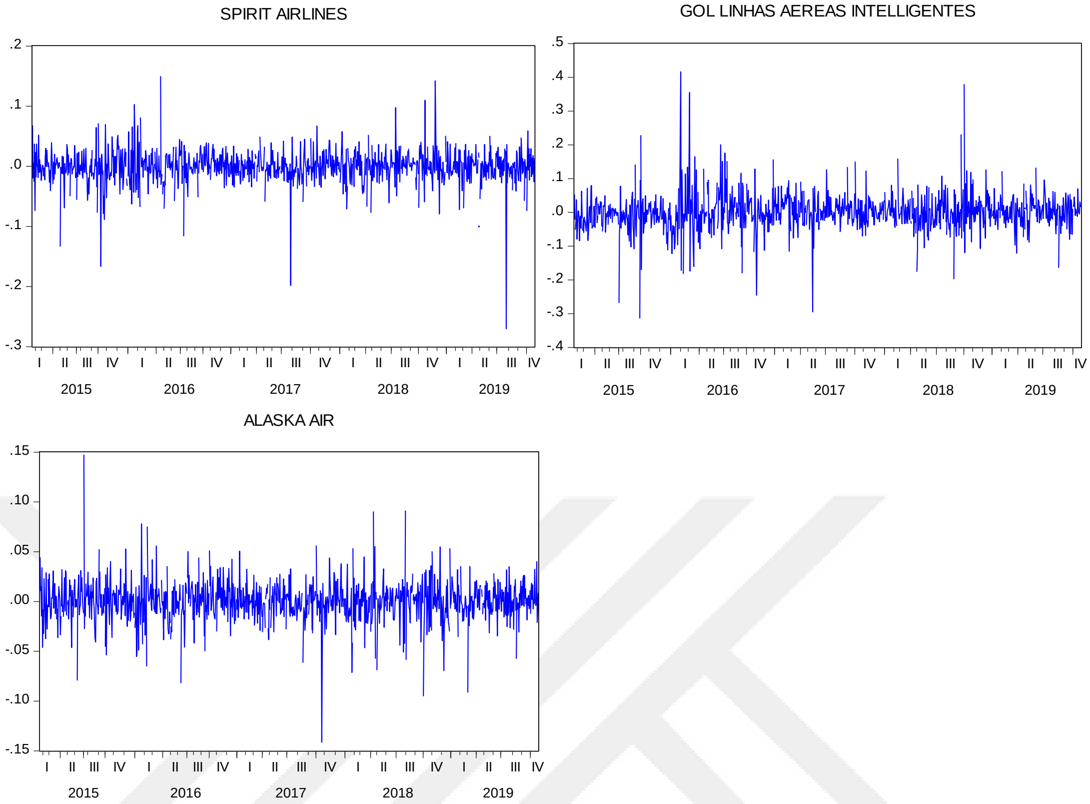


Figure 1 (Continued)



The ADF, KPSS and PP unit root tests with three specifications (intercept, trend and intercept and trend) are applied both on the level and first differences of the series and the test results are reported in Table 3.

The results of the return series show significant ADF and PP test results which means rejection of the null hypothesis of unit root while KPSS test results show insignificant which denotes the stationarity null hypothesis cannot be rejected. On the contrary, in level series KPSS tests results show significant results which means rejection of null hypothesis.

Table 3: Unit Root Tests (ADF, KPSS and PP) Results of Crude Oil Prices and Airline Companies' Stock Prices

Variables	Level Series						Return Series					
	ADF		KPSS		PP		ADF		KPSS		PP	
	Inter.	***Trend* + *Inter.***	***Inter.***	***Trend* + *Inter.***	***Inter.***	***Trend* + *Inter.***	***Inter.***	***Trend* + *Inter.***	***Inter.***	***Trend* + *Inter.***	***Inter.***	***Trend* + *Inter.***
Crude Oil Prices												
WTI	-2.179 [0.21]	-2.629 [0.27]	1.934* [0.00]	0.268* [0.00]	-2.054 [0.26]	-2.492 [0.33]	-33.237* [0.00]	-33.221* [0.00]	0.047 [0.86]	0.046 [0.90]	-33.101* [0.00]	-33.085* [0.00]
Brent	-1.932 [0.31]	-2.301 [0.43]	2.142* [0.00]	0.321* [0.00]	-1.806 [0.38]	-2.152 [0.52]	-33.941* [0.00]	-33.925* [0.00]	0.059 [0.78]	0.058 [0.79]	-33.676* [0.00]	-33.661* [0.00]
Dubai	-1.689 [0.43]	-2.052 [0.57]	2.277* [0.00]	0.321* [0.00]	-1.683 [0.44]	-2.065 [0.56]	-34.87* [0.00]	-34.852* [0.00]	0.069 [0.73]	0.069 [0.78]	-34.407* [0.00]	-34.391* [0.00]
Airline Companies												
Qantas	-1.582 [0.49]	-1.992 [0.60]	2.865* [0.00]	0.404* [0.00]	-1.550 [0.51]	-1.932 [0.64]	-32.508* [0.00]	-32.513* [0.00]	0.119 [0.18]	0.066 [0.19]	-32.815* [0.00]	-32.806* [0.00]
Virgin Australia	-1.633 [0.46]	-1.762 [0.72]	2.893* [0.00]	0.663* [0.00]	-1.566 [0.50]	-1.809 [0.70]	-38.421* [0.00]	-38.403* [0.00]	0.087 [0.15]	0.076 [0.38]	-36.623* [0.00]	-36.758* [0.00]
GOL Linheas Aereas	-0.074 [0.95]	-3.020 [0.12]	2.895* [0.00]	0.419* [0.00]	-0.336 [0.92]	-3.142 [0.10]	-30.830* [0.00]	-30.918* [0.00]	0.320 [0.71]	0.119 [0.18]	-32.219* [0.00]	-32.268* [0.00]
Latam Airlines	-1.364 [0.60]	-1.886 [0.66]	1.588* [0.00]	0.521* [0.00]	-1.521 [0.52]	-2.033 [0.58]	-28.606* [0.00]	-28.605* [0.00]	0.161 [1.00]	0.153 [0.54]	-28.869* [0.00]	-28.835* [0.00]

Table 3 (Continued)

Air Canada	0.831 [1.00]	-1.669 [0.76]	3.377* [0.00]	0.479* [0.00]	0.875 [1.00]	-1.637 [0.78]	-30.760* [0.00]	-30.784* [0.00]	0.197 [0.14]	0.072 [0.82]	-32.168* [0.00]	-32.254* [0.00]
Westjet Airlines	-2.541 [0.10]	-2.503 [0.33]	0.246 [0.00]	0.245* [0.00]	-2.490 [0.12]	-2.425 [0.37]	-31.038* [0.00]	-31.083* [0.00]	0.224 [0.89]	0.057 [0.21]	-31.337* [0.00]	-31.450* [0.00]
China Southern Airlines	-2.497 [0.11]	-2.704 [0.24]	0.300 [0.00]	0.206* [0.00]	-2.761 [0.21]	-2.761 [0.21]	-29.627* [0.00]	-29.645* [0.00]	0.139 [0.91]	0.062 [0.33]	-30.682* [0.00]	-30.688* [0.00]
Spring Airlines	-2.853 [0.05]	-4.479* [0.00]	1.960* [0.00]	0.450* [0.00]	-2.853 [0.05]	-4.473* [0.00]	-30.717* [0.00]	-30.802* [0.00]	0.425 [0.22]	0.285 [0.02]	-32.386* [0.00]	-32.402* [0.00]
Japan Airlines	-2.635 [0.08]	-2.593 [0.28]	0.356* [0.00]	0.294* [0.00]	-2.386 [0.15]	-2.332 [0.42]	-33.664* [0.00]	-33.660* [0.00]	0.098 [0.94]	0.059 [0.64]	-33.973* [0.00]	-33.994* [0.00]
StarFlyer	-2.060 [0.26]	-2.481 [0.34]	2.075* [0.00]	0.551* [0.00]	-1.994 [0.29]	-2.431 [0.36]	-28.556* [0.00]	-28.547* [0.00]	0.080 [0.44]	0.055 [0.48]	-27.752* [0.00]	-27.740* [0.00]
Nok Air	-4.279* [0.00]	-4.066* [0.01]	1.461* [0.00]	0.284* [0.00]	-3.709* [0.00]	-3.340 [0.06]	-28.379* [0.00]	-28.402* [0.00]	0.193 [0.20]	0.105 [0.13]	-28.450* [0.00]	-28.607* [0.00]
Thai Airways	-1.190 [0.68]	-1.237 [0.90]	0.658* [0.00]	0.642* [0.00]	-1.332 [0.62]	-1.372 [0.87]	-18.631* [0.00]	-18.656* [0.00]	0.215 [0.43]	0.112 [0.67]	-29.427* [0.00]	-29.427* [0.00]
Pegasus Airlines	-2.389 [0.145]	-2.219 [0.48]	0.379* [0.00]	0.376* [0.00]	-2.515 [0.11]	-2.311 [0.43]	-30.236* [0.00]	-30.391* [0.00]	0.490 [0.87]	0.082 [0.03]	-30.606* [0.00]	-30.749* [0.00]
Turkish Airlines	-2.136 [0.23]	-2.118 [0.53]	0.387* [0.00]	0.408* [0.00]	-2.082 [0.25]	-2.062 [0.57]	-32.419* [0.00]	-32.409* [0.00]	0.150 [0.50]	0.131 [0.48]	-32.909* [0.00]	-32.902* [0.00]

Table 3 (Continued)

Alaska Airlines	-2.284 [0.17]	-2.586 [0.29]	1.091* [0.00]	0.434* [0.00]	-2.324 [0.16]	-2.637 [0.26]	-32.170* [0.00]	-32.154* [0.00]	0.058 [0.90]	0.049 [0.80]	-32.169* [0.00]	-32.154* [0.00]
Spirit Airlines	-2.647 [0.08]	-2.598 [0.28]	0.653* [0.00]	0.294* [0.00]	-2.579 [0.10]	-2.515 [0.32]	-32.401* [0.00]	-32.395* [0.00]	0.097 [0.44]	0.073 [0.45]	-33.279* [0.00]	-33.288* [0.00]

Note: The numerical values in bracket are *p* values. * denotes statistical significance at the 1% level.

The volatility spillover effect among crude oil prices and airline companies' stock prices is analyzed by means of a conditional heteroskedasticity model. Therefore, ARCH-LM test is performed to check whether there exists any ARCH effect or not. The ARCH-LM test results, reported in Table 4, imply the presence of ARCH effect in the residuals of the return series for all the sample with the exception of Qantas, Air Canada, Westjet Airlines, Japan Airlines and Spirit Airlines. Accordingly, it is appropriate to estimate the return series of all three crude oil and Brazil, China, Thailand and Turkey's full service and low-cost airline companies by utilizing alternative ARCH specifications.

Table 4: ARCH-LM Test Results for Crude Oil and Airline Companies' Stock Returns

	ARCH-LM statistics (NR2)	**Prob. Chi-square (1)**
Crude Markets		
WTI	14.102	0.000*
Brent	18.289	0.000*
Dubai	11.338	0.001*
Airlines Company		
Qantas	0.212	0.645
Virgin Australia	15.138	0.000*
GOL Linheas Aereas	61.190	0.000*
Latam Airlines	11.702	0.001*
Air Canada	1.042	0.308
Westjet Airlines	0.005	0.942
China Southern Airlines	48.869	0.000*
Spring Airlines	81.443	0.000*
Japan Airlines	1.073	0.300
StarFlyer	44.360	0.000*
Nok Air	8.095	0.004*
Thai Airways	6.049	0.014*
Pegasus Airlines	16.247	0.000*
Turkish Airlines	10.974	0.001*
Alaska Airlines	3.927	0.048**
Spirit Airlines	0.131	0.718

Note: *, ** denote statistical significance at the 1, 5% levels, respectively.

CHAPTER 6: EMPIRICAL RESULTS

The empirical results of return and volatility spillover between crude oil prices (WTI, Brent and Dubai) and airline companies' stock prices; namely Gol Linheas Aereas (Brazil), Latam Airlines (Brazil), Spring Airlines (China), China Southern Airlines (China), Nok Air (Thailand), Thai Airways (Thailand), Pegasus Airlines (Turkey), Turkish Airlines (Turkey) are obtained from estimating multivariate GARCH model, reported in Tables 5-10. Based on the results of the VAR-BEKK-GARCH model, uni-directional, bi-directional and no spillovers between crude oil prices and airline companies' stock returns are found. As for the case of WTI crude oil price; Gol Linheas Aereas, Spring Airlines, China Southern Airlines experience uni-directional spillover between WTI oil price and their stock markets. Moreover, Latam Airlines, China Southern Airlines, Spring Airlines and Turkish Airlines experience uni-directional spillover between Brent crude oil price and their stock markets. For Dubai; Spring Airlines, China Southern Airlines, Pegasus Airlines and Turkish Airlines experience uni-directional spillover. Among all airlines, interestingly, no bi-directional spillover effect is observed for three crude oil prices.

Table 5 reveals the estimated results from the spillover effect between WTI crude oil price and both low-cost and full service carriers in airline companies' stock price. In the mean equation, the coefficient of $\delta(1)_{21}$ is statistically significant and carries a negative value only for WTI-Gol Linheas Aereas. This result indicates that the return of WTI crude oil price has a negative influence only on the stock return of Gol Linheas Aereas; however, it has no influence on other low-cost or full service carriers. In the variance equation, the coefficient of a_{12} is representing the shock effect from the WTI crude oil price to the stock price of airline companies and it is statistically significant for WTI - Gol Linheas Aereas (Brazil) ,WTI – Spring Airlines (China) , WTI – China Southern Airlines (China), WTI – Nok Air (Thailand), WTI – Thai Airways (Thailand). This result indicates that WTI crude oil price has a shock effect on listed company's stock prices. b_{12} is significant for China's two airlines; Spring Airline (China) and China Southern Airlines (China) , as well as Latam Airlines (Brazil) and Nok Air (Thailand). This means that existence of volatility spillover is acceptable for these four airlines.

Table 7 represents the estimated results of the return and volatility spillover effect among Brent crude oil price and both low-cost and full service carriers in airline companies' stock prices. In the mean equation, the coefficient of $\delta(1)_{21}$ is not significant. This means that the return of Brent crude oil has a significant impact on the stock return of the eight airline companies. In the variance equation, the coefficient of a_{12}, representing the shock effect from the Brent crude oil price to the stock price of airline companies, is statistically significant for Brent – Spring Airline (China), Brent – China Southern Airlines (China) and Brent – Nok Air (Thailand). This means that there is a shock effect between Brent crude oil prices and Spring and China Southern Airlines and Thailand's low-cost airlines which is Nok Air. b_{12} is not statistically significant for Turkey's airlines and Thailands's Nok Air, indicating that Brent crude oil has a significant impact on the volatility of all other airlines.

The results of volatility spillover effect between Dubai crude oil price and selected airline companies' stock prices are represented in Table 9 As in the case of Dubai crude oil, the estimated value of the $\delta(1)_{21}$ is not significant, demonstrating that there is no return spillover effect between Dubai crude oil price and the all eight airline companies' stock prices. In the variance equation, b_{12} is significant for all airline companies with the exception of Gol Linheas Aereas (Brazil) and Nok Air (Thailand), indicating that the fluctuation of Dubai crude oil price has a significant impact on the volatility of remaining six airline companies' stock prices.

In brief, WTI crude oil price and Gol Linheas Aereas (Brazil) has a negative return spillover effect. In the variance equation, the volatility of WTI crude oil price has a significant influence on the volatility of Gol Linheas Aereas (Brazil), Spring Airlines (China), China Southern Airlines (China), Nok Air (Thailand) and Thai Airways (Thailand). The volatility of Brent has an impact on China's two airlines; Spring Airlines (China) and China Southern Airlines (China) and Thailand' low-cost airline; Nok Air. On the other hand, differently, Dubai crude oil price has no return spillover effect on eight airline companies' stock prices. The volatility of Dubai crude oil price has a significant influence on the volatility of Latam Airlines (Brazil), Spring Airlines (China), China Southern Airlines (China), Thai Airways (Thailand), Pegasus Airlines (Turkey), and Turkish Airlines (Turkey).

The impact of three crude oil prices on airline companies' stock prices differs for low-cost and full service airlines. The first reason can be stated as the price changes from supplier to supplier during international trading, while quoting crude oil price. Moreover, airline companies are often listed in multiple markets which make changes in transactions. For example, China Southern Airlines is listed in Hong Kong Stock Exchange, Shanghai Stock Exchange and New York Stock Exchange whereas Spring Airlines is listed only in Shanghai Stock Exchange.

When comparing between return and volatility spillover effects, the volatility spillover effects between the crude oil prices and airline companies' stock prices is found to be more significant than return spillover effects. Compared with the low-cost and full service carriers, full service carriers have a relatively greater ability of resisting the crude oil price risk due to the several advantages in business scope. The spillover effect is mostly observed in low-cost carriers.

Finally, when comparing the influence of the crude oil price on airline companies' stock prices of Brazil, China, Thailand and Turkey, it is found that the return and volatility spillover effects between the crude oil price and Turkey is almost insignificant, and on the contrary, the influence of crude oil price on the stock prices of China's two airlines and low-cost carriers from Thailand and Brazil is more serious. The domestic transport components in China and Brazil is very high; for instance, train, bus and many other vehicles are substitutes for air transportation; therefore, there is high price elasticity of demand (PED). However, in Turkey's air transport market, international routes have fewer substitutes; hence, has a lower PED.

Table 5: Estimated Results of Volatility Spillover between WTI Crude Oil Prices and Airline Companies’ Stock Prices on VAR-BEKK-GARCH Model

	Brazil		***China***		***Thailand***		***Turkey***	
	Low-Cost	***Full-Service***	***Low-Cost***	***Full-Service***	***Low-Cost***	***Full-Service***	***Low-Cost***	***Full-Service***
	GOL LINHEAS AEREAS	**LATAM AIRLINES**	**SPRING AIRLINES**	**CHINA SOUTHERN AIRLINES**	**NOK AIR**	**THAI AIRWAYS**	**PEGASUS AIRLINES**	**TURKISH AIRLINES**
Panel A - Mean Equation								
$\delta(1)_{11}$	0.0709*** [1.955]	0.1417* [4.093]	-0.0831** -2.350	0.0413 [1.350]	0.0369 [0.896]	0.0219 [0.586]	0.0384 [1.217]	-0.0128 [-0.404]
$\delta(1)_{12}$	0.0873 [1.332]	-0.0385 [-1.247]	-0.0474** -1.656	-0.0743** [-2.268]	-0.0293 [-1.153]	-0.0437 [-1.365]	-0.0440 [-1.097]	-0.0363 [-0.963]
μ_1	0.0017 [0.968]	-0.0003 [-0.389]	0.0000 0.036	0.0007 [0.843]	-0.0010 [-1.624]	-0.0016*** [-1.929]	0.0005 [0.411]	-0.0004 [-0.423]
$\delta(1)_{21}$	-0.0303** [-2.460]	0.0024 [0.072]	-0.0349 -1.288	0.0017 [0.076]	0.0168 [0.482]	-0.0011 [-0.037]	-0.0008 [-0.035]	0.0093 [0.360]
$\delta(1)_{22}$	-0.0527*** [-1.702]	-0.0367 [-1.023]	-0.0489 -1.580	-0.0562*** [-1.955]	-0.0425 [-1.348]	-0.0429 [-1.365]	-0.057*** [-1.768]	-0.0581*** [-1.886]
μ_2	0.0004 [0.502]	0.0005 [0.701]	0.0005 0.654	0.0007 [0.830]	0.0006 [0.706]	0.0006 [0.799]	0.0004 [0.493]	0.0004 [0.439]
Panel B - Variance Equation								

Table 5 (Continued)

c_{11}	0.0286* [5.834]	0.0097* [6.322]	0.0028* 7.836	-0.0022* [-4.120]	0.0065* [5.811]	0.0068* [5.459]	0.0284* [11.016]	0.0241* [5.013]
c_{21}	-0.0022** [-2.110]	0.0149* [9.525]	0.0016* 3.681	-0.0011** [-2.066]	-0.0027* [-4.761]	-0.0018** [-2.006]	-0.0006 [-0.539]	0.0008 [0.727]
c_{22}	0.0014* [2.984]	0.0000 [5.747]	0.0003 0.220	0.0000 [9.423]	-0.0000 [-0.003]	0.0013* [2.544]	0.0000 [1.712]	0.0000 [2.119]
a_{11}	0.4505* [6.413]	0.3559* [7.395]	0.2563* 12.942	0.2070* [10.058]	0.4199* [7.963]	0.3319* [7.480]	0.4762* [8.527]	0.4047* [7.440]
a_{12}	-0.0343** [-2.018]	0.0181 [0.405]	0.0862* 16.579	0.0887* [7.559]	-0.0584** [-2.005]	-0.0469** [-2.269]	-0.0122 [-0.585]	-0.0060 [-0.271]
a_{21}	-0.5449* [-4.753]	0.0861** [2.050]	-0.0217 -1.486	-0.0135 [-0.706]	-0.0983* [-3.802]	-0.1906* [-5.499]	-0.0661 [-0.744]	-0.0246 [-0.328]
a_{22}	0.1892* [5.596]	0.3869* [9.868]	0.0736* 40.687	0.0808* [3.732]	0.1622* [7.799]	0.1618* [6.397]	0.1308* [7.325]	0.1247* [7.46388]
b_{11}	0.7019* [6.553]	0.8619* [19.508]	0.9607* 219.429	0.9754* [203.957]	0.8679* [28.332]	0.9022* [38.440]	0.2932 [1.380]	0.5169** [2.092]
b_{12}	0.0226 [1.551]	0.0662*** [1.667]	-0.0268* -36.204	-0.0207* [-7.317]	0.0225** [2.033]	0.0150 [1.013]	-0.0129 [-0.509]	-0.0332 [-1.548]
b_{21}	0.2491* [2.804]	-0.3168* [-7.807]	0.0014 0.542	0.0022 [0.768]	0.0457* [6.270]	0.0490* [3.201]	0.08405*** [1.632]	0.0333 [0.791]

Table 5 (Continued)

b_{22}	0.9688* [70.824]	0.7161* [13.792]	0.9919* 669.568	0.9908* [399.598]	0.9796* [166.601]	0.9816* [162.986]	0.9913* [305.606]	0.9928* [427.694]

Notes: 1. For the mean equation; μ_1 and μ_2 are constant terms. 2. 1 denotes airline companies' stock prices, 2 denotes crude oil prices. 3. $\delta(1)_{11}$ and $\delta(1)_{22}$ is variable's own lagged effects. $\delta(1)_{12}$ indicates lagged spillover effects in mean from oil price to stock market and $\delta(1)_{21}$ indicates lagged spillover effect from stock market to oil price. 4. For the variance equation; c_{11}, $c_{21}$and c_{22} are constant terms. 5. a_{11} and a_{22} represent the ARCH effect in two variables. 6. a_{12} measures the spillover effect of a previous shock in airline industry on the current volatility of stock market, and a_{21} measures the spillover effect in the opposite direction. 7. $b_{11}$and b_{22}indicate the GARCH terms, which measure volatility persistence of each series. 8. b_{12} measures the spillover effect of the last period's variance of oil price on the current variance of stock market and b_{21} measures the spillover effect in the opposite direction. 9. Numbers in square brackets correspond to t-statistics. * , ** and *** indicate statistical significance at the 1%, 5% and 10% level respectively.

Table 6: Summary of Estimated Results for the Conditional Mean and Conditional Variance Equations – WTI

	GOL LINHEAS AEREAS	LATAM AIRLINES	SPRING AIRLINES	CHINA SOUTHERN AIRLINES	NOK AIR	THAI AIRWAYS	PEGASUS AIRLINES	TURKISH AIRLINES
Panel A. Mean spillovers between OP_t and , SR_t								
OP_t SMR_t	→		→	→		→		→
Panel B. Shock Transmission between OP_t and , SR_t								
OP_t SMR_t	↔	→	→	→	↔	↔		
Panel C. Volatility Spillovers between OP_t and , SR_t								
OP_t SMR_t	→	↔	→	→	↔	→	→	

Notes: OP_t, SR_t indicate oil price change, and stock market returns, respectively. Only significant results in the conditional mean and variance equations from Tables 5/7/9 are reported in Panels A, B and C. → indicates the direction of shock and volatility spillovers, while ↔ indicates bidirectional shock and volatility spillovers.

Table 7: Estimated Results of Volatility Spillover between BRENT Crude Oil Prices and Airline Companies' Stock Prices on VAR-BEKK-GARCH Model

	Brazil		***China***		***Thailand***		***Turkey***	
	Low-Cost	***Full-Service***	***Low-Cost***	***Full-Service***	***Low-Cost***	***Full-Service***	***Low-Cost***	***Full-Service***
	GOL LINHEAS AEREAS	**LATAM AIRLINES**	**SPRING AIRLINES**	**CHINA SOUTHERN AIRLINES**	**NOK AIR**	**THAI AIRWAYS**	**PEGASUS AIRLINES**	**TURKISH AIRLINES**
Panel A - Mean Equation								
$\delta(1)_{11}$	0.0677*** 1.758	0.1524* 4.146	-0.0759** -2.169	0.0489 1.558	0.0489 1.288	0.0100 0.284	0.0431 1.383	-0.0142 -0.436
$\delta(1)_{12}$	-0.0263 -0.376	-0.0523*** -1.711	-0.0629** -2.212	-0.0787** -2.249	-0.0414 -1.534	-0.0413 -1.097	-0.0972 -2.077	-0.0767*** -1.789
μ_1	0.0022 1.219	-0.0003 -0.372	0.0002 0.257	0.0008 0.816	-0.0009 -1.383	-0.0005 -0.596	0.0006** 0.552	-0.0003 -0.252
$\delta(1)_{21}$	-0.0155 -1.285	0.0079 0.268	0.0089 0.338	0.0107 0.504	0.0195 0.636	0.0128 0.529	-0.0019 -0.087	0.0106 0.488
$\delta(1)_{22}$	-0.0604*** -1.915	-0.0479 -1.530	-0.0608*** -1.829	-0.0671** -2.279	-0.0423 -1.330	-0.0685** -2.170	-0.0643** -2.013	-0.0634** -1.975
μ_2	0.0007 0.862	0.0005 0.694	0.0009 1.133	0.0008 1.043	0.0008 1.015	0.0006 0.838	0.0008 0.982	0.0007 0.919
Panel B - Variance Equation								

Table 7 (Continued)

c_{11}	0.0228* 5.733	0.0095* 5.828	-0.0027* -4.317	0.0025* 4.629	0.0047* 4.299	0.0065* 4.183	0.0297* 19.854	0.0273* 10.515
c_{21}	-0.0022** -2.358	0.0132* 8.341	-0.0018*** -1.741	0.0013** 2.121	-0.0038* -5.996	0.0004 0.201	-0.0016 -0.898	-0.0006 -0.483
c_{22}	0.0021* 3.704	0.0000 1.153	0.0027** 2.079	0.0000 3.565	-0.0000 -1.019	0.0000 9.066	0.0021 1.411	0.0024** 2.057
a_{11}	0.3695* 8.249	0.3328* 6.675	0.2489* 10.312	0.2156* 9.774	0.3121* 5.727	0.2568* 5.219	0.4619* 8.333	0.4146* 8.357
a_{12}	-0.0171 -1.237	-0.0048 -0.129	0.0617** 2.512	0.0879* 6.782	-0.0482** -2.142	0.0213 0.915	-0.0053 -0.171	0.0008 0.025
a_{21}	-0.3426* -3.945	0.0839*** 1.828	-0.0137 -0.644	0.0254* 0.984	-0.1172* -4.842	0.0312 1.017	-0.0246 -0.352	0.0036 0.066
a_{22}	0.2019* 6.768	0.3877* 9.644	0.1967* 3.696	0.0946 3.223	0.2221* 6.908	0.2332* 8.479	0.1795* 5.942	0.1768* 5.403
b_{11}	0.8258* 17.282	0.8819* 19.433	0.9634* 136.898	0.9727* 201.398	0.9216 * 37.923	0.9278* 36.692	-0.1524 -0.780	0.3040 1.318
b_{12}	0.0186*** 1.853	0.0769** 2.119	-0.0166*** -1.879	-0.0213* -7.012	0.0125 1.114	0.1281* 10.796	0.0235 0.278	0.0002 0.003
b_{21}	0.1434* 3.087	-0.3156* -7.589	-0.0027 -0.437	-0.0023* -0.577	0.0572* 6.924	-0.1744* -10.976	0.1489 1.513	0.0677 0.996

Table 7 (Continued)

b_{22}	0.9653* 86.672	0.7359* 15.273	0.9696* 62.211	0.9888* 269.614	0.9628* 99.970	0.9608* 105.722	0.9763* 82.189	0.9790* 84.403

Note: See notes from Table 5.

Table 8: Summary of Estimated Results for the Conditional Mean and Conditional Variance Equations – BRENT

	GOL LINHEAS AEREAS	LATAM AIRLINES	SPRING AIRLINES	CHINA SOUTHERN AIRLINES	NOK AIR	THAI AIRWAYS	PEGASUS AIRLINES	TURKISH AIRLINES
Panel A. Mean spillovers between OP_t and , SR_t								
OP_t SMR_t		→	→	→				→
Panel B. Shock Transmission between OP_t and , SR_t								
OP_t SMR_t	→	→	→	↔	↔			
Panel C. Volatility Spillovers between OP_t and , SR_t								
OP_t SMR_t	↔	↔	→	↔	→	↔		

Note: See notes from Table 6.

Table 9: Estimated Results of Volatility Spillover between DUBAI Crude Oil Prices and Airline Companies' Stock Prices on VAR-BEKK-GARCH Model

	Brazil		***China***		***Thailand***		***Turkey***	
	Low-Cost	**Full-Service**	**Low-Cost**	**Full-Service**	**Low-Cost**	**Full-Service**	**Low-Cost**	**Full-Service**
	GOL LINHEAS AEREAS	**LATAM AIRLINES**	**SPRING AIRLINES**	**CHINA SOUTHERN AIRLINES**	**NOK AIR**	**THAI AIRWAYS**	**PEGASUS AIRINES**	**TURKISH AIRLINES**
Panel A –Mean Equation								
$\delta(1)_{11}$	0.0797** 2.097	0.15586* 4.625	-0.0722** -2.308	0.0433 1.302	0.0504 1.416	0.0074 0.202	0.0263 0.832	-0.017 -0.534
$\delta(1)_{12}$	-0.0051 -0.075	-0.0421 -1.419	-0.0509*** -1.736	-0.0886** -2.457	-0.0237 -0.965	-0.0416 -1.269	-0.0891** -2.127	-0.0669*** -1.664
μ_1	0.0019 1.054	-0.0002 -0.279	-0.0002 -0.256	0.0006 0.732	-0.0009 -1.397	-0.0005 -0.543	0.0009 0.884	0.0000 0.020
$\delta(1)_{21}$	-0.0072 -0.509	0.02319 0.701	0.0083 0.316	0.0023 0.096	0.0142 0.408	0.0261 1.065	0.0076 0.330	0.0149 0.647
$\delta(1)_{22}$	-0.0818** -2.466	-0.0819* -2.349	-0.1035* -3.235	-0.0970* -3.232	-0.0836* -2.711	-0.1075* -3.373	-0.0951* -3.044	-0.0927* -2.927
μ_2	0.0007 0.905	0.0007 0.895	0.0004 0.477	0.0007 0.882	0.0009 1.113	0.0008 1.045	0.0008 1.019	0.0008 1.040
Panel B - Variance Equation								

Table 9 (Continued)

c_{11}	0.0268* 5.243	0.0096* 6.563	0.0025* 5.145	0.0022* 5.382	0.0047* 4.205	0.0066* 4.152	0.0288* 12.739	0.0268* 10.139
c_{21}	-0.0016 -1.332	0.0146* 10.691	0.0019* 4.747	0.0011 2.269	-0.0032* -4.620	0.0003 0.170	-0.0017 -1.558	-0.0017*** -1.908
c_{22}	0.0023* 4.049	-0.0000 -2.690	-0.0000 -7.576	-0.0000 -0.016	0.0000 8.906	0.0000 1.682	-0.0000 -4.775	0.0014** 2.233
a_{11}	0.3984* 6.507	0.3339* 6.877	0.2497* 11.478	0.2069* 10.196	0.3118* 6.006	0.269* 5.652	0.486* 8.245	0.4219* 8.448
a_{12}	0.0007 0.039	-0.0169 -0.402	0.0908* 6.912	0.0871* 8.799	-0.0437*** -1.756	0.02003 0.708	0.0070 0.268	0.0099 0.863
a_{21}	-0.3368* -2.673	0.0771*** 1.732	-0.0205 -1.484	-0.0108 -0.548	-0.0986* -4.483	0.0258 0.835	-0.0715 -1.14360	-0.0246 -0.421
a_{22}	0.1680* 5.239	0.3976* 9.915	-0.0318* -2.593	0.0183 0.745	0.1858* 6.567	0.2299* 7.431	0.1324* 7.049	0.1349* 7.441
b_{11}	0.7756* 10.229	0.8788* 22.183	0.9638* 172.949	0.9753* 239.868	0.9249* 39.125	0.9245* 36.067	0.2459 1.122	0.3304 1.508
b_{12}	0.01473 0.971	0.0822** 2.287	-0.0244* -7.249	-0.0201* -9.170	0.0085 0.775	0.1383* 9.477	0.0588*** 1.757	0.0375* 6.599
b_{21}	0.1119 1.590	-0.3135* -8.568	-0.0024 -1.268	0.0019 0.858	0.0447* 6.273	-0.1666* -12.217	0.0831 1.545	0.0865*** 1.886

Table 9 (Continued)

b_{22}	0.9748*	0.7143*	0.9936*	0.9945*	0.9739*	0.9595*	0.9829*	0.9832*
	97.253	16.261	668.666	637.759	124.669	100.113	143.431	229.282

Note: See notes from Table 5.

Table 10: Summary of Estimated Results for the Conditional Mean and Conditional Variance Equations – DUBAI

	GOL LINHEAS AEREAS	**LATAM AIRLINES**	**SPRING AIRLINES**	**CHINA SOUTHERN AIRLINES**	**NOK AIR**	**THAI AIRWAYS**	**PEGASUS AIRLINES**	**TURKISH AIRLINES**
Panel A. Mean spillovers between OP_t and , SR_t								
OP_t SMR_t			→	→			→	→
Panel B. Shock Transmission between OP_t and , SR_t								
OP_t SMR_t	→	→	→	→	↔			
Panel C. Volatility Spillovers between OP_t and , SR_t								
OP_t SMR_t		↔	→	→	↔	↔	→	↔

Note: See notes from Table 6.

CHAPTER 7: CONCLUSION

This dissertation analyzes return and volatility spillover effect between three crude oil prices - WTI, Brent and Dubai – and the stock prices of eight airline companies- Gol Linheas Aereas, Latam Airlines, Spring Airlines, China Southern Airlines, Nok Air, Thai Airways, Pegasus Airlines, and Turkish Airlines. While estimating the return spillover effect, mean equations is used and for the determination of volatility spillover effect, variance equation is used by employing VAR-BEKK-GARCH model.

First, between WTI crude oil price and Gol Linheas Aereas, there exists a return spillover and return of WTI crude oil price has a negative impact on low-cost airline's from Brazil. On the contrary, no return spillover effect is observed for other two crude oil benchmarks and selected airlines.

The volatility spillover effects between the crude oil prices and the airline companies' stock prices are more significant than the return spillover effects. Spillover effect is observed for three oil benchmarks on China's two airlines; Spring and China Southern and does not observed for any of crude oil prices on Turkey's two airlines. The volatility spillover effect is also observed between Latam Airlines and all three crude oil prices. As it seen from the test results, China and Brazil's airline companies' stock prices are more sensitive to oil price changes, because they have many substitute transportation choices such as train, bus and many other choices. Therefore, the price elasticity of demand is higher for China and Brazil. This also shows that oil exporter and oil importer countries also effected in same way from oil price change, as can be seen from Brazil and China

This thesis differs from the majority of studies in the literature in terms of its analyzes on the relationship between three different crude oil prices and both low-cost and full service airline companies' stock prices taking into account volatility spillovers. This relationship is of extreme importance to policymakers. As a recommendation, they should periodically monitor and evaluate the performance of low-cost and full service airline companies and establish different support programs for domestic and international connectivity. The results will help practitioners to understand the oil price risk both on low-cost and full service carriers in the airline/transportation industry and improve the airlines' ability to deal with the crude oil price risk. Moreover, this study conducts comparative analysis of crude oil prices on airline companies not only between low-cost and full service carriers within the same country, but also between four countries.

The results obtained in this thesis might be also interests of portfolio managers, investors, and management team. Portfolio managers and investors can utilize information emanating from the crude oil price volatility to predict the expected volatility in the airline companies' stock prices. This volatility spillover mechanism across these series is important in order to make appropriate investment decisions. Investors who aims to invest in low-cost or full service carriers should analyze the companies according to their flight routes, types of aircraft whether it is narrow body or not. In terms of portfolio allocation, investors are better off taking into account global oil price developments and their potential volatility spillovers effects on airline companies' stock prices. In addition, management team of low-cost airlines should consider carefully the oil consumption while arranging transatlantic routes because two types of airlines have different sensitivities on oil price increase.

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