The impact of the Dubai International Airport's activity volume on the Emirati stock market

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Abstract: The goal of this research work is to determine the predictive power of the activity volume at the Dubai International Airport (DXB) over the Emirati stock market by applying the GARCH, EGARCH, TGARCH, and PGARCH models. Our results provide evidence that the DXB's passenger traffic has explanatory power over the Emirati stock market. Specifically, we find that the logarithmic monthly change of the DXB's passenger traffic has a positive and significant relationship with the ADX stock market index's monthly log-returns. We also find that two analysed Emirati stock markets indexes have positive and significant relationships with both the crude oil price and the log-returns of a world stock market index.

Keywords: DXB; GARCH; EGARCH; TGARCH; PGARCH; passenger traffic; Dubai; airport; ADX; DFM; stock market; UAE; volatility.

Reference to this paper should be made as follows: Dempere, J.M. and Modugu, K.P. (2022) 'The impact of the Dubai International Airport's activity volume on the Emirati stock market', *Int. J. Business Performance Management*, Vol. 23, Nos. 1/2, pp.118–134.

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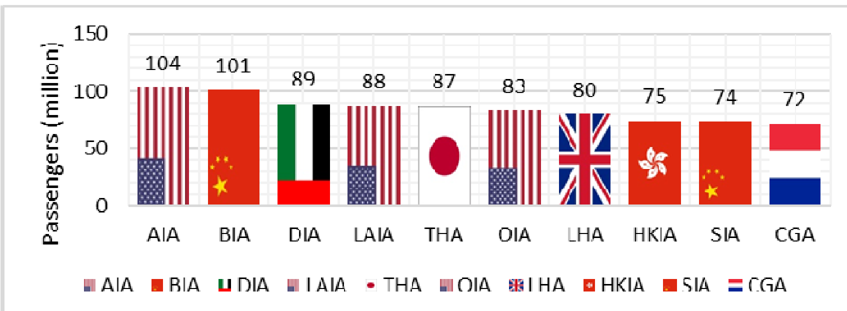
This paper is a revised and expanded version of a paper entitled 'The impact of the Dubai International Airport's activity volume on the Emirati stock market' presented at 2020 4IR Transforming Businesses Conference, Dubai, UAE, 24 September 2020.

1 Introduction

Dubai International Airport (DXB) is the largest airport in the United Arab Emirates (UAE). In 2018, DXB handled 89.1M passengers, placing it as the world's third busiest airport by passenger traffic (PT). Figure 1 shows the 2018 raking of the largest international airports by total PT, where DXB has third place. What makes DXB unique compared to any other airport is that 100% of its PT comes from international flights since there are no domestic flights in the UAE. For this reason, DXB is the world's top busiest airport by international PT. On the other hand, from the +103M passengers in 2018 at Atlanta International Airport (AIA), the world's top busiest airport, only about 11% were international passengers, while around 88% were domestic passengers.

Figure 1 2018 world's busiest airports by PT (see online version for colours)

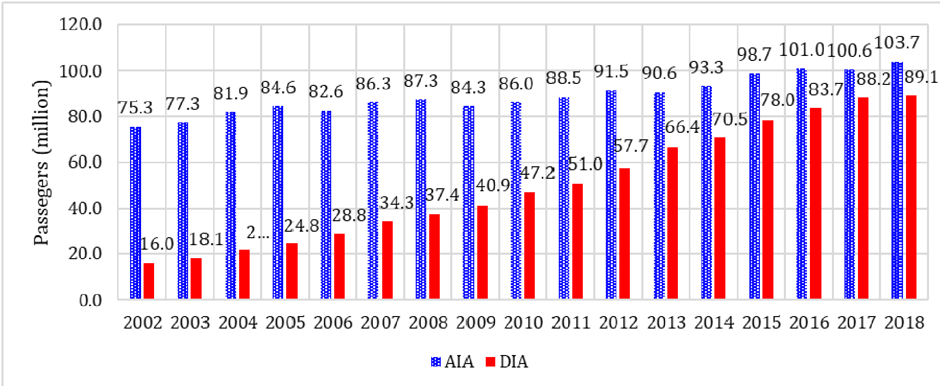


1		AIA:	Atlanta International Airport	6		OIA:	O'Hare International Airport
2		BIA:	Beijing International Airport	7		LHA:	London Heathrow Airport
3		DXB:	Dubai International Airport	8		HKIA:	Hong Kong International Airport
4		LAIA:	Los Angeles International Airport	9		SPIA:	Shanghai Pudong International Airport
5		THA:	Tokyo Haneda Airport	10		CGA:	Charles de Gaulle Airport

Source: Airports Council International (https://aci.aero/)

AIA has been the world's busiest airport by PT since 1998, so when comparing AIA with DXB over the last 16 years, we can conclude that the growth of PT at DXB has been impressive. With only about 16M passengers in 2003, DXB experienced an increase of more than 400% on its PT to almost 90M in 2018. During the same 16-year period, AIA could increase its PT by only 37%. Another way to interpret these numbers is by calculating the compound annual growth rate (CAGR) of PT. The DXB's CAGR is 10.64% per year, while the same rate for AIA is just 1.9% for the same 16-year period. Figure 2 provides a graphical comparison of these two main airports' PT during the last 16 years.

Figure 2 Comparison of AIA's and DXB's historical PT (see online version for colours)



Source: https://www.dubaiairports.ae; https://www.transtats.bts.gov

According to Ramboll and Oxford Economics (2013), in 2012, the United Nations' World Tourism Organization (UNWTO) announced the world's one-billionth tourist travelling that year. This number was more than double the 435 million travellers registered back in 1990, which represents an average annual growth rate of more than 4%. The UNWTO estimated that for the same year of 2012, the direct impact of the travel and tourism sector on the world's gross domestic product (GDP) was around US$2.1 trillion and provided 101 million jobs. In 2019, the UNWTO (2019) reported that international tourist arrivals grew 5% in 2018 to reach the 1.4 billion mark. At the same time, they report that export earnings generated by tourism grew to USD 1.7 trillion also in 2018.

According to Oxford Economics (2014), the overall total economic impact of the aviation sector on the Dubai economy in 2013 was estimated at US$26.7 billion, comprising a 'core' impact of US$16.5 billion and 'tourism' benefits of US$10.2 billion. This impact was equivalent to 26.7% of Dubai's total GDP, and it was sufficient to support some 416,500 jobs or 21% of Dubai's total employment. They find that for each US$100 of activity in the sector itself, an additional US$72 of value added is created in other industry sectors of Dubai's economy. They also find that for every 100 jobs created in the aviation sector, an additional 116 jobs were created elsewhere in Dubai's economy. These side effects are derived from supply-chain linkages and employee spending.

The goal of this study is to analyse the predictive power of the activity volume at DXB over the Emirati stock market by applying the generalised autoregressive conditional heteroskedasticity (GARCH) model and three asymmetric GARCH family models, namely, the threshold GARCH (TGARCH) model, the exponential GARCH (EGARCH) model, and the power ARCH (PARCH) model.

Our results provide evidence that out of the two DXB's activity-volume-related independent variables analysed in this study, only the PT has explanatory power over the Emirati stock market. However, this result is significant for only one Emirati stock market but insignificant for the other. Specifically, we found that the logarithmic monthly change of the DXB's PT has a positive and significant relationship with the monthly log-returns of Abu Dhabi Securities Exchange (ADX) general index. We also find positive and significant relationships between the two analysed Emirati stock markets indexes with two independent variables: the crude oil price and the selected world stock market index. The results on DXB's cargo traffic were insignificant at conventional levels of confidence in all GARCH models analysed in this study and for both studied Emirati stock market indexes. The tables containing these insignificant results were omitted due to our article's length restrictions for publication purposes.

2 Literature review

The following sections review some articles that analyse one or more of the independent variables considered in this study.

2.1 Oil price and stock markets

Previous studies on the impact of oil prices on the stock market in oil-driven economies have yielded mixed and sometimes contradictory results. Dempere (2019) studies some UAE macroeconomic variables' explanatory power on the Emirati stock market by applying cointegration and Granger causality tests. He finds evidence of unidirectional short-term Granger causality between the Emirati stock market indexes and oil prices. Equally, Daly and Fayyad (2011) study the predictive power of oil returns on stock markets among the Gulf Cooperation Council (GCC) countries, including the US and the UK. They find no significant results during periods of stable oil prices, but during periods of sharp oil price increases, the stock markets of Kuwait, the UAE, and the US can be predicted by these prices.

Similarly, Hammoudeh and Aleisa (2004) analyse the explanatory power of the New York Mercantile Exchange (NYMEX) futures prices on the GCC's stock markets and find significant results only over the Saudi stock market. Likewise, Alqattan and Alhayky (2016) examine the short and long-term relations between oil prices and the GCC countries' stock market prices. They find a positive and significant short-term association between oil price changes and stock market prices in all GCC countries. Equally, Zarour (2006) investigates the impact of oil price changes on the GCC's stock markets and finds that oil prices have explanatory power on these markets, except for Abu Dhabi. Correspondingly, Hammoudeh and Choi (2006) study the short-term relations between GCC's stock market index returns and some selected independent variables. They find that the T-bill rate has a significant relationship with some of the GCC's stock markets. They also find that the WTI or the Brent oil price has no explanatory power on these stock markets.

Likewise, Arouri and Fouquau (2009a) analyse the short-term relations between oil prices and the GCC's stock markets and find a positive and significant stock market reaction in Qatar, Oman, and UAE when oil prices increase. Similarly, Arouri and Fouquau (2009b) examines the long-run impact of oil price shocks over the GCC's stock markets and find that these shocks have an asymmetric impact on the selected stock markets. Furthermore, Arouri and Rault (2012) investigate the long-term relations between GCC's stock market returns and oil prices and find evidence of cointegration between these two variables. They also find that increases in oil prices positively affect stock prices, except for Saudi Arabia.

2.2 Interest rates and stock markets

Some prior research works studying the impact of interest rates on stock market returns show mixed and contradicting results. Sbeiti and Hadadd (2012) study the relationship between stock prices and some independent variables like oil prices, short-term interest rates, and domestic credit in some GCC countries. They find that oil prices, interest rates, and domestic credit have a long-term cointegrating relationship with their corresponding national stock markets. Similarly, Naïmy (2007) analyses the impact of oil prices, gold prices, and US interest rates on four GCC's stock markets and finds that interest rates have a positive and significant relationship with these markets. Likewise, Chen (1991) finds significant explanatory power of the default premium, term premium, short-term interest rate, lagged industrial production growth rate, and dividend-price ratio, all on the stock market returns. Finally, Ihsan et al. (2015) examine the impact of inflation rates, exchange rates, and interest rates on the Karachi stock market returns and find no significant results.

2.3 Exchange rate and stock market

Earlier research articles analysing the relation between exchange rates and stock market returns have also yielded diverse and opposing results. Aydemir and Demirhan (2009) find a long-run cointegrating relation between exchange rates and stock market prices in Kuwait, Bahrain, and Oman, but short-term relationships between these variables only in Oman and Kuwait. Similarly, Abouwafia and Chambers (2015) study the impact of changes on interest rates and real exchange rates over some Middle East stock markets. They find that shocks on interest and real exchange rates have a significant short-run impact on the stock markets of countries with independent monetary policies and flexible exchange rates. Likewise, Albaity and Mustafa (2018) examine the long- and short-term relations between oil prices, stock market returns, exchange rates, gold prices, and GDP for all the GCC countries. They identify a long-term cointegrating relationship among these variables. Equally, Olugbenga (2012) finds that exchange rates have a positive and significant short-term impact on the Nigerian stock market, but a negative and significant long-term effect on it. Correspondingly, Hassanain (2017) analyses the association between stock prices and the real exchange rates for Kuwait and Saudi Arabia. They find a significant long-term relationship between the Saudi stock market index and the real exchange rate, and between the former and oil prices.

2.4 Airport activity-volume

Previous research works on airport activity volume are limited, with results that suggest some explanatory power of this dependent variable on the economic activity. Tsui et al. (2014) forecast the airport PT for Hong Kong International Airport using the Boxe-Jenkins SARIMA and ARIMAX models and monthly time series between January 1993 and November 2010. They find a steady growth in Hong Kong's forecasted airport PT. Similarly, Gelhausen et al. (2018) develop a forecasting model for passenger and flight volume at German airports based upon the cointegration theory. Their dependent variable is the annual passenger growth rate. Their independent variables include the European GDP growth rate, the average number of passengers per flight, and some variables representing positive and negative shocks. They find a long-term cointegrating equilibrium relationship among these variables. Likewise, Shen and Chou (2013) study 15 major cargo airports in North America, Asia, and Europe. They find positive long-term relationships for several pairs of the studied airports. Their results suggest a systematic co-movement between the processes of cargo throughputs in each paired airport.

Equally, Wadud (2014) employs the seemingly unrelated regression (SUR) framework to simultaneously model air passenger and cargo demand at the Hazrat Shahjalal International Airport (HSIA) in Dhaka, Bangladesh. He finds that HSIA's air cargo is more price and income elastic than air passenger demand. He forecasts that the passenger demand in 2030 will be 20.1M people, which is much larger traffic than the current terminal capacity of 8M people. Correspondingly, Vanegas (2012) applies cointegration and error correction models to disaggregate tourist arrivals data from Costa Rica, Guatemala, Honduras, Nicaragua, and the US to El Salvador. He finds that the relationship between the number of tourist arrivals to El Salvador and changes in income is elastic and entirely differs from country to country.

Similarly, Selvanathan et al. (2009) study monthly series data of tourist arrivals in Tamil Nadu from 1998 to 2002. Using univariate time-series models, they find robust seasonal patterns in the domestic and foreign tourist arrivals series. Likewise, Marazzo et al. (2010) investigate the relationship between air transport demand (PAX) and the Brazilian economic growth (GDP) between 1966 and 2006. They find that Brazil's GDP and PAX are cointegrated. They also find a strong positive reaction of PAX due to a positive change in the Brazilian GDP. Their results provide empirical evidence of air transportation's multiplier effects on the Brazilian economy.

Likewise, Hu et al. (2015) examine the short-run dynamics, the long-run equilibrium relationships, and the Granger causality associations between economic growth and domestic air PT. They find a long-run equilibrium relationship between economic growth and domestic air PT using quarterly panel data of 29 Chinese provinces from 2006Q1 to 2012Q3. Notably, they find that a 1% increase in the air PT generates an increase of 0.943% in China's real GDP. Finally, Brida et al. (2016) study the causal relationship between air-transport demand and Italy's economic growth from 1971 to 2012. They find that the Italian real GDP and air-transport demand are cointegrated. They also find unidirectional Granger causality from air-transport demand to GDP, which suggests that air-transport expansion plays a crucial role in promoting Italian economic growth.

We found no previous research article studying the impact of airport activity-volume-related variables on the stock market using the GARCH, EGARCH, TGARCH, and PGARCH models. Therefore, this study's original contribution is to shed light on the explanatory power of the DXB's activity volume-related variables. DXB is one of the most important airports worldwide with unique characteristics described above, and its impact on two of the most important capital markets in the Middle East region has never been analysed before. Our results may be priceless not only for investors and corporations trying to identify variables with explanatory power on the Emirati stock market but also for local and national government policymakers. Indeed, given the relevant economic impact of the aviation sector in the UAE's economy, this study may improve existing approaches to forecast the UAE's economic cycle based on a leading economic indicator like the Emirati stock market.

3 Data

Our analysis involved the following dependent variables: the Abu Dhabi Securities Exchange (ADX) general index and the Dubai Financial Market (DFM) general index. We also study the following independent variables: the DXB's PT and cargo traffic (CARGO), a world market stock index (WORLD), the West Texas Intermediate (WTI) crude oil price, the three-month US Treasury Bill rate (RF), and the UAE's broad effective exchange rate (BEER) index

Monthly data of the two DXB's activity volume-related variables, namely, the DXB's PT and CARGO, were retrieved from the DXB' website. We gathered 216 monthly observations for PT from January 2001 to December 2018 and 96 observations for CARGO from January 2011 to December 2018. Dubai Airports stopped reporting monthly data in December 2018. The available data for 2019 and 2020 is quarterly. Compared to PT, the shorter number of CARGO observations is due to the reduced available monthly data for this independent variable at the DXB's website.

The ADX general index's monthly data were retrieved from the Abu Dhabi Securities Exchange's website, while monthly data on the DFM general index were retrieved from the DFM's website. The ADX stock market index is a free-float market capitalisation-weighted index of stocks listed in ADX with at least five trading days. The DFM stock market index is a free-float market-capitalisation-weighted price index that includes all stocks listed in the DFM.

Monthly prices of the WTI crude oil measured in US dollars per barrel without seasonal adjustments were compiled by the US Energy Information Administration and retrieved from the website of the Federal Reserve Bank (FED) of St. Louis.

The US 3-month Treasury bill (T-bill) is usually referred to as the risk-free (RF) rate. Monthly data on the 3-month US T-bill were compiled by the US Board of Governors of the FED System and retrieved from the website of the FED of St. Louis. The rationale for selecting the US 3-month T-bill as the RF rate is also supported by the pegged exchange rate between the US dollar and the UAE's dirham (AED), which heavily influences the UAE Central Bank's monetary policy regarding interest rates. The selected world equity index (WORLD) was a stock value-weighted index whose monthly data were retrieved from the DataStream database. Monthly data on the BEER for the UAE without seasonal adjustments were compiled by the Bank for International Settlements and retrieved from the website of the FED of St. Louis. The BEER was selected for analysis purposes because it is considered a superior measure of the exchange rates' macroeconomic effects than the nominal exchange rate. As we mentioned above, the AED has been pegged to the US dollar since its inception, making the traditional AED/US dollar exchange rate ineffective for analysis purposes.

4 Methodology

The Augmented Dickey-Fuller (1981) test (ADF henceforth) provides a parametric correction test when the series follows an autoregressive process AR(p), where $p>1$. An alternative test is the Phillips-Perron (1988) test (PP henceforth), which controls for serial correlation since this does not affect the asymptotic distribution of the PP test statistic.

The ADF and PP tests can be calculated, allowing for an intercept only, an intercept combined with a deterministic trend, or none of these options. The ADF and PP tests were estimated under the possible deterministic options listed above, and all of them yielded consistent results. The use of these methodologies was intended to provide robust results. The error term of the following linear regression model was analysed to determine the existence of autocorrelation, namely the existence of ARCH effects $Y = \alpha + \beta_1 X_1 + \cdots + \beta_n X_n + e_t$; where Y is the dependent variable defined as the monthly log-return of both the DFM general index denoted by LOG(DFM) and the ADX general index denoted by LOG(ADX). The serial correlation Lagrange multiplier (LM) test was applied to identify the autocorrelation of the error term e_t. This test's null hypothesis is that there is no serial correlation to a lag of order p, where p is a pre-specified integer. The Breusch-Godfrey (1978) LM test statistic is calculated as the number of observations times the R^2 from the test regression.

The information criteria used in this study as a guide for model assessment purposes were the Akaike (1969) information criterion (AIC), the Schwarz (1978) criterion (SIC), and the Hannan-Quinn (1979) information criterion (HQIC). These criteria are intended to estimate a statistical model's relative value compared to other models for a specific data set. Thus, they provide a quantitative approach for model assessment purposes. The model with the lowest AIC, SC, or HQ is preferred.

The Engle and Ng test (1993) was applied to determine the suitability of applying one or more of the asymmetric GARCH family models. This test determines the presence of a leverage effect, which happens when a positive shock has less effect on the conditional variance compared to a negative one (asymmetric volatility). The Engle and Ng test identifies a sign bias or a size bias in the studied time series' volatility. A sign bias occurs when positive and negative shocks have differing impacts on volatility. A size bias happens when the magnitude of a shock determines the impact of future volatility. When the test yields significant results, they constitute evidence to justify some asymmetric GARCH models. The specific version of the Engle and Ng test that we will apply in this study involves the following model:

$$\hat{u}_t^2 = \phi_0 + \phi_1 S_{t-1}^- + \phi_2 S_{t-1}^- \hat{u}_{t-1} + \phi_3 S_{t-1}^+ \hat{u}_{t-1} + v_t;$$

where $\hat{u}_t^2$ denotes the squared residuals of the GARCH model fitted to the returns, ϕ_0 is a constant, S_{t-1}^- is a dummy variable that takes the value of one if $\hat{u}_{t-1} < 0$ and zero otherwise, v_t is an error term, and S_{t-1}^+ is defined as $1 - S_{t-1}^-$. If ϕ_1 is significant, then a sign bias is present. On the other hand, if either ϕ_2 or ϕ_3 is significant, a size bias is present.

Bollerslev (1986) initially proposed the GARCH model. The basic GARCH (1, 1) model can be represented by the two equations:

1 $\quad Y_t = X_t'\theta + \in_t$

2 $\quad \sigma_t^2 = \omega + \alpha \in_{t-1}^2 + \beta \sigma_{t-1}^2$

where the first equation is the mean equation written as a function of exogenous variables X_t' with an error term $\in_t$. The second equation is the conditional variance with a constant term ω, with a lag of the squared residual from the mean equation $\in_{t-1}^2$ intended to measure the impact of news on the volatility from the previous period; and the last period's forecast variance σ_{t-1}^2.

In all the asymmetric GARCH models considered in this study, the conditional mean equation is the same as the one described above, but the conditional variance equation differs from model to model. The TGARCH model was first introduced independently by Zakoïan (1994) and Glosten et al. (1993). In a TGARCH (1, 1) model, the conditional variance equation can be represented as follows:

$$\sigma_t^2 = \omega + \beta\sigma_{t-1}^2 + \alpha \in_{t-1}^2 + \gamma \in_{t-1}^2 I_{t-1}^-$$

where I_{t-1}^- equals one if $\in_t < 0$ and zero otherwise. In this model, positive news, $\in_{t-1} > 0$, and negative news, $\in_{t-1} < 0$, have differential effects on the conditional variance; positive news has an impact of α, while negative news has an impact of $\alpha + \gamma$. If $\gamma \neq 0$, then the news impact is asymmetric. Nelson (1991) initially proposed the EGARCH model. In an EGARCH (1, 1) model, the conditional variance equation can be depicted as follows:

$$Log\left(\sigma_t^2\right) = \omega + \beta \log\left(\sigma_{t-1}^2\right) + \gamma \frac{\in_{t-1}}{\sigma_{t-1}^2} + \alpha \left|\frac{\in_{t-1}}{\sigma_{t-1}}\right|$$

The left-hand side of the equation is the logarithm of the conditional variance, which implies an exponential leverage effect rather than a quadratic one so that forecasts of the conditional variance are sure to be non-negative. The impact is asymmetric if $\gamma \neq 0$. Schwert (1989) first introduced the PGARCH model. In a PARCH (1,1) model, the conditional variance equation can be represented as follows:

$$\sigma_t^\delta = \omega + \beta\sigma_{t-1}^\delta + \alpha\left(\left|\in_{t-1}\right| - \gamma \in_{t-1}\right)^\delta$$

with $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$, $\delta > 0$, and $|\gamma| \leq 1$. α and β are standard GARCH parameters, and γ is the leverage effect parameter, which allows positive and negative innovations (shocks) to have a different effect in the volatility.

5 Results

The logarithmic change rate of non-stationary time series was calculated and denoted as follows: DLOG (variable's name). The ADF and PP tests were then applied to all variables to verify that they are stationary time series. The results for the ADF and PP tests were omitted in this article. Table 1 shows the results for the LM serial correlation test for the linear regression models that contain the dependent and independent variables described above. Our results were verified with the autocorrelation and partial autocorrelation functions of the residuals using up to 36 lags together with the Q-statistics. The tables containing these results were omitted due to the restrictions on the article's length for publication purposes. Most Q-statistics were significant with values lower than 5%, which confirmed serial correlation in all models and the convenience to applying the GARCH family models.

Table 1 Tests for serial correlation (see online version for colours)

Model's dependent variables	*LM serial correlation test*	*Optimal number of lags based on AIC, SIC, HQIC*
ADX	4.435260 (0.0352)*	1
DFM	10.01388 (0.0184)*	3

Notes: ***, ** and *denote statistical significance at the 0.1%, 1%, and 5%, of significance level, respectively. The table contains *Obs*R-squared* and their corresponding *Prob. Chi-Square(1)* below in parenthesis. The optimal lag order was based on the AIC, SIC, and HQIC information criteria.

Table 2 Engle and Ng tests for leverage effects (see online version for colours)

Coefficients	*Model's dependent variables*	
	ADX	*DFM*
$\phi_1 S^-_{t-1}$	–0.001218 (0.03100)*	0.008696 (0.0401)*
$\phi_2 S^-_{t-1}\,\hat{u}_{t-1}$	–0.033047 (0.04026)*	–0.003310 (0.04782)*
$\phi_3 S^+_{t-1}\,\hat{u}_{t-1}$	0.052722 (0.0351)*	–0.054229 (0.01716)*

Notes: ***, ** and *denote statistical significance at the 0.1%, 1%, and 5%, of significance level, respectively. The table contains the ϕ coefficients of their corresponding p-values below in parenthesis.

Table 2 shows the results of the Engle and Ng tests. The coefficient ϕ_1 is marginally significant for both models at only a 5% confidence level, which provides evidence of a sign bias. Similarly, the coefficients ϕ_2 and ϕ_3 are also marginally significant for both models at only a 5% level of confidence, which suggests the presence of a size bias. These results imply the suitability of including one or more of the asymmetric GARCH family models in our analysis. Therefore, in addition to the GARCH model, the data were analysed using the TGARCH, EGARCH, and PGARCH models.

Tables 3 and 4 contain the GARCH, EGARCH, TGARCH, and PGARCH models' results for the two Emirati stock market indexes. Table 3 shows the selected independent variables' explanatory power over the monthly log-returns for the DFM stock market index. The results provide evidence of a significant positive relationship between the DFM stock market index's log-returns and the selected world stock market index's log-returns for all analysed GARCH models. These results suggest that the world stock market has predictive power over the DFM stock market. These findings are similar to those of Hammoudeh and Choi (2006), who find that the US Standard & Poor's 500 (S&P 500) has a positive and significant impact on all GCC's stock markets.

Similarly, the crude oil price's monthly log-returns have a significant and positive relationship with the DFM stock market. These results are also significant for all studied GARCH models. The two DXB's activity volume-related variables, namely, the DXB's PT and cargo traffic (CARGO), were both insignificant at conventional levels of confidence. Similarly, the monthly logarithmic change of the BEER and the monthly logarithmic change of the RF rate have no significant relationship with the ADX stock market. Regarding the volatility of the models testing DFM, the coefficient testing the leverage effects are insignificant at conventional confidence levels, except for the TGARCH model, which is marginally significant at the 5% level of confidence. These results suggest the lack of a strong leverage effect in the DFM stock market.

Table 3 Results for the monthly log-returns of DFM index (see online version for colours)

Independent variable	*Log return of the DFM (dependent variable)*			
	GARCH	*TGARCH*	*EGARCH*	*PGARCH*
Mean equation				
C	0.001748 (0.8390)	0.003730 (0.6699)	0.004321 (0.5740)	0.004514 (0.6264)
DLOG(PT)	–0.040967 (0.6428)	–0.012304 (0.8866)	–0.096132 (0.1978)	–0.014889 (0.8695)
DLOG(WORLD)	0.524882 (0.0263)*	0.551784 (0.0134)*	0.497908 (0.0026)**	0.561393 (0.0230)*
DLOG(WTI)	0.235448 (0.0070)**	0.304732 (0.0005)***	0.255915 (0.0038)**	0.256385 (0.0056)**
DLOG(BEER)	0.006421 (0.2868)	0.007132 (0.2740)	0.010157 (0.0689)	0.005839 (0.4192)
D(RF)	–0.188992 (0.7001)	–0.191658 (0.7011)	–0.392694 (0.3570)	–0.063907 (0.8759)
Conditional variance equation				
C	0.003503 (0.2179)	0.001164 (0.1756)	–1.037932 (0.1862)	0.000150 (0.9832)
α	0.178324 (0.1097)	0.110523 (0.0547)	0.356203 (0.0513)	–0.000546 (0.9726)
γ	–	–0.121875 (0.0458)*	0.115533 (0.1177)	–0.024835 (0.9851)
β	0.478519 (0.2074)	0.834354 (0.0000)***	0.833181 (0.0000)***	–0.896164 (0.0000)***
δ	–	–	–	4.074700 (0.8428)
AIC	–1.745755	–1.764150	–1.775534	–1.858349
SIC	–1.574859	–1.576164	–1.587549	–1.653273
HQIC	–1.676528	–1.687999	–1.699384	–1.775276

Notes: ***, ** and * denote statistical significance at the 0.1%, 1%, and 5%, of significance level, respectively. The table contains the coefficients and their corresponding *p*-values below in parenthesis. The values for the Akaike (1969) information criterion (AIC), the Schwarz (1978) criterion (SIC), and the Hannan-Quinn (1979) information criterion (HQIC) have been included in the last three rows of the table.

Table 4 displays the relationships between the selected independent variables over the ADX stock market index's monthly log-returns. These results show a significant positive relationship between the ADX stock market and the selected world stock market index's log-returns for all analysed GARCH models. These results also support the notion that the world stock market has predictive power over the ADX stock market. Likewise, the crude oil price's (WTI) monthly log-returns have a positive relationship with the ADX stock market. However, these results are significant at conventional levels of confidence only for the EGARCH and PGARCH models. The same results for the GARCH and TGARCH models are significant at only a 10% level of confidence, which is not considered a conventional level of confidence by most authors.

Table 4 Results for the monthly Log-returns of Abu Dhabi stock market index (see online version for colours)

Mean equation				
Independent variable	*Log Return of the ADX (dependent variable)*			
	GARCH	*TGARCH*	*EGARCH*	*PGARCH*
C	–0.000015 (0.9974)	0.006305 (0.0000)***	0.004378 (0.0000)***	0.003663 (0.4449)
DLOG(PT)	0.106099 (0.0256)*	0.111516 (0.0019)**	0.115243 (0.0016)**	0.099863 (0.0314)*
DLOG(WORLD)	0.309408 (0.0016)**	0.446201 (0.0000)***	0.480406 (0.0000)***	0.403414 (0.0000)***
DLOG(WTI)	0.087015 (0.0880)	0.069208 (0.0692)	0.078831 (0.0377)*	0.118455 (0.0134)*
DLOG(BEER)	–0.002252 (0.4826)	0.002780 (0.2865)	0.005282 (0.0322)	0.002582 (0.4165)
D(RF)	–0.480580 (0.0669)	0.007389 (0.9711)	–0.097719 (0.7080)	–0.183359 (0.5609)
Conditional variance equation				
C	0.000096 (0.2369)	0.000044 (0.0076)**	0.024924 (0.8231)	0.000170 (0.9327)
α	0.257313 (0.0023)**	0.088804 (0.0000)***	–0.046134 (0.6090)	0.081213 (0.0408)*
γ	–	–0.219839 (0.0000)***	0.182622 (0.0000)***	–0.979719 (0.0000)***
β	0.769007 (0.0000)***	1.006883 (0.0000)***	0.998986 (0.0000)***	0.950085 (0.0000)***
δ	–	–	–	0.556691 (0.0824)
AIC	–2.690906	–2.893911	–2.546331	–2.826176
SIC	–2.498708	–2.682493	–2.334913	–2.595538
HQIC	–2.612861	–2.808062	–2.460481	–2.732522

Notes: ***, ** and * denote statistical significance at the 0.1%, 1%, and 5%, of significance level, respectively. The table contains the coefficients and their corresponding *p*-values below in parenthesis. The values for the Akaike (1969) information criterion (AIC), the Schwarz (1978) criterion (SIC), and the Hannah-Quinn (1979) information criterion (HQIC) have been included in the last three rows of the table.

Similarly, the only DXB's activity volume-related variable significant at conventional confidence levels was the logarithmic change of the PT. The DXB's cargo traffic was insignificant at conventional levels of confidence, so this result was omitted. The PT has a positive relationship with the ADX stock market, which is significant in all analysed GARCH models. Finally, the monthly logarithmic change of the BEER and the change of the RF rate has no significant relationship with the ADX stock market. Regarding the volatility of the models testing ADX, the results are all significant at conventional levels of confidence, which confirms a strong leverage effect in the DFM stock market.

Tables 3 and 4 include the values for the Akaike (1969) information criterion (AIC), the Schwarz (1978) criterion (SIC), and the Hannan-Quinn (1979) information criterion (HQIC). Accordingly, the most effective model for forecasting purposes is the PGARCH for DFM while the most effective model for ADX is the TGARCH model. However, these models can be improved even further (the AIC, SIC, and HQ can be reduced even further) by using the GARCH-in-Mean model or by including one or more autoregressive (AR) or moving average (MA) factors with one or more lags as independent variables. However, such additional improvements were not included in this article since finding the optimal forecasting model was not the primary goal of this study.

6 Discussion and limitations

The two Emirati stock market indexes analysed in this study were the Abu Dhabi Securities Market General Index (ADX) and the DFM General Index (DFM). These indexes are based on the stock prices of companies listed in these two Emirati bourses respectively. Our analysis assumed no significant differences in the economic environment where these companies operate so that the independent variables analysed in this study should have a similar impact on both indexes. However, this assumption seems to be wrong.

Dempere (2019) was the first to suggest a listing pattern or criterion by region for companies listed on each stock exchange in the UAE. This finding might explain why the studied independent variables' explanatory power deviates significantly depending on the Emirati stock market index under consideration. If the listing pattern or criterion by region suggested by Dempere (2019) exists, then companies headquartered in Dubai would be listed primarily in the DFM while companies headquartered in Abu Dhabi, Ras Al Khaimah, Sharjah, or Fujairah would be listed primarily in the ADX.

Our mixed results for each Emirati bourse also contradict some perceptions about the primary economic driving forces and industry sectors predominating on each emirate. According to the Statistics Center Abu Dhabi (2019), the oil industry's contribution to Abu Dhabi's GDP was 40.4% in 2018. Alternatively, Winkler (2018) informs that oil production represented about 50% of Dubai's GDP in the past, but today this sector accounts for less than 1% of such GDP. The relative importance of the oil industry between Dubai and Abu Dhabi may lead to the wrong perception that changes in our independent variable of crude oil price (WTI) should have a significant impact on our first dependent variable (ADX) but an insignificant impact on our second one (DFM.) Our results provide evidence that changes in oil prices have a positive and significant impact on both studied Emirate bourses. Therefore, these results suggest that the high degree of economic diversification achieved by the emirate of Dubai does not help to avoid the volatility that changes in oil prices bring to the DFM.

Similarly and according to the Government of Dubai (2019), the economic activities that might be more sensitive to changes in the two DXB's activity volume-related variables analysed in this article are accommodation and food service, transportation and storage, and wholesale and retail trade activities. These activities accounted for roughly 42% of Dubai's GDP during the first quarter of 2019. Our results contradict Dubai's perceived exposure to changes in the DXB's activity volume since these independent variables were statistically insignificant in all analysed models applied to DFM. The economic impact of the Dubai's aviation sector measured by the DBX's activity volume in this study and reported by Oxford Economics (2014) quoted above seems insignificant, at least from an Emirati stock market perspective. Similarly, our results contradict the perceived lack of economic diversification in Abu Dhabi and the other emirates with companies listed in the ADX. The positive and significant relationship between the DXB's PT and the ADX for all analysed models suggest that the companies listed in the ADX seem to be exposed to the volatility associated with changes in the DXB's activity volume.

A possible explanation for our mixed results might be the limited number of companies included in the ADX and the DFM. Although most companies listed in the DFM and the ADX are the largest publicly traded companies in the UAE, their small number (around 60+ on each bourse) might not represent the thousands of private companies that do businesses in the country. Therefore, we cannot derive meaningful generalisations regarding the impact of changes in the DXB's activity volume in the UAE.

There is an academic consensus on considering the stock market as a leading economic indicator. For a stock market index to be considered a valid economic indicator measurement, it must reflect the country's primary economic activities where the index's companies operate. For example, the S&P 500 Index not only contains the 500 most significant US stocks but also covers the leading US companies from the most critical US industry sectors. The same cannot be said for the two Emirati indexes considered in this study. More than 50% of the the DFM index's companies are banks, investment, financial services, and insurance companies. Similarly, more than 45% of the ADX index's companies belong to the banking and insurance sector. However, according to the UAE Ministry of Economy (2020) the financial and insurance activities contributed only 5.5% to the UAE's GDP in 2019.

The lack of an Emirati stock market, which can be considered a valid representative of the whole country (instead of parts of it), should be reflected by foreign and local investors and national and local government policymakers. This deficiency should be considered when inferring meaningful relationships between the Emirati stock market and some independent variables considered relevant for analysis purposes.

One possible extension of this research work might be analysing stock indexes representing only those industry sectors that might be more sensitive to the DXB's activity volume but combining companies from both bourses. An approach like this might result cumbersome due to the availability of data for such an endeavour. Although the proposed extension might require some extra time and effort, researchers with proper resources should complete such extension.

7 Conclusions

The goal of this research work was to study the predictive power of the activity volume at the Dubai International Airport (DXB) over the Emirati stock market by applying the generalised autoregressive conditional heteroskedasticity (GARCH) model and three asymmetric GARCH family models, namely, the GARCH, EGARCH, TGARCH, and PGARCH models. Our results suggest that out of the two DXB's activity-volume-related variables analysed in this study, only the PT has explanatory power over the Emirati stock market. However, this result is only significant for the Abu Dhabi stock market, but insignificant for the DFM. Specifically, we found that the logarithmic monthly change of the DXB's PT has a positive and significant relationship with the ADX stock market index's monthly log-returns. We also find positive and significant relationships between the two analysed Emirati stock markets indexes and the crude oil price, and the selected world market stock index.

We also find that the DXB's cargo traffic has no significant relationship with any of our dependent variables. These results were insignificant at conventional confidence levels in all GARCH models analysed in this study and for both studied Emirati stock market indexes. The tables containing these insignificant results were omitted due to this article's length restrictions for publication purposes. One possible explanation for the lack of significant cargo traffic results compared to PT may be the limited number of monthly observations (216 vs. 96) for cargo traffic available at the DXB's website.

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