International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2020, 10(3), 245-254.

The Dynamic Linkages between Stock Market and Foreign Exchange Market: Evidence from an Emerging Market

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Received: 22 March 2020 **Accepted:** 18 May 2020 **DOI:** https://doi.org/10.32479/ijefi.9623

ABSTRACT

The paper investigates the dynamic linkages between exchange rate (against US dollar) and the stock market (local currency) of Tunisia from January 2004 to April 2017. In particular, the paper tries to answer if there are any correlations between these variables and how they move in high volatile periods. By using a VEC model and applying the techniques of Granger Causality test, we conclude the existence of a unidirectional relationship between the two variables (from stock prices to exchange rate). Due to persistent long memory and the presence of the asymmetric effect in both markets, we estimate the dynamic correlations between these variables using DCC-FIAPARCH model. Results reveal that volatility shocks create abrupt changes in the dynamic correlations. However, this effect is only short term and do not sustain between consecutive high volatility regimes. Thus, policymakers and investors do not need to be concerned about long run contagion effects. Accordingly, financial managers can obtain more insights in the management of their international portfolio affected by these two variables. This should be particularly important to domestic as well as international investors for hedging and diversifying their portfolio mainly by predicting the path of the exchange rate.

Keywords: Stock Market, Foreign Exchange Market, VECM, Granger Causality, DCC-FIAPARCH
JEL Classifications: D53, F31

1. INTRODUCTION

In an open economy, it is hugely important for the researchers, investors, and policy makers to understand how the dynamic and strategic interactions work between stock and foreign exchange markets. A great deal of research has focused on this correlation because these two markets are the most important segments of the financial system and then are considered as the barometers of the economic growth due their import role played in influencing the development of the country's economy (Nieh and Lee, 2001). In fact, through these markets, the country's exposure towards the outer world is most readily felt.

The present study is an attempt in this direction. Because, investors and fundamentalists believe that there is a relationship between these two variables, which in return leads to the changes or fluctuations in each other. This makes the investors wonder about the causes and consequences due to the volatility of the two markets in question.

Several studies have been made in order to recognize the correlation between the stock market and the foreign exchange market. The traditional "Flow-oriented" and "Stock-oriented" models have been often used to confirm the existence of a relationship between stock prices and exchange rates.

Flow models demonstrate how the exchange rates are determined mostly by a trade balance performance (Dornbush and Fischer, 1980). In fact, exchange rate changes affect international competitiveness and then real output and stock prices. Cakan and Ejara (2013) explain that fluctuation of local currency (depreciation or appreciation) can affect foreign demand and sales and then stock prices. The flow oriented hypothesis were supported by many studies (Chiang et al., 2000; Fang, 2002; Phylaktis and Ravazzolo, 2005; Wongbangpo and Sharma, 2002, Matsubayashi, 2011; Diamandis and Drakos, 2011; Bartram and Bodnar, 2012).

However, the stock oriented model argues that the exchange rate reacts to variations in stock markets and that this correlation is deemed positive. Hence, an increase in the stock market prices leads to an appreciation in the exchange rate. But, fluctuations in stock prices can pressure exchange rate. In fact, money demand and investors 'wealth are linked to stock market performance (Gavin, 1989). The stock oriented hypothesis were supported by many studies (Tai, 2007; Lin, 2012; Tsai, 2012; Tsagkanos and Siriopoulos, 2013; Xie et al., 2020).

The empirical findings on the causal relationship between the two variables have been controversial. Some authors pointed out that exchange rates Granger cause stock prices (Abdalla and Murinde, 1997; Ibrahim, 2000; Doong et al., 2005; Hatemi and Roca, 2005; Pan et al., 2007). While others noticed that stock prices Granger cause exchange rates (Ajayi and Mougoué, 1996; Granger et al., 1998; Doong et al., 2005; Lin, 2012). Other researchers (Solnik, 1987; Tudor and Popescu-Dutaa, 2012) found that changes in the exchange rate do not hold any significant value over stock prices.

Determining the linkages between stock prices and exchange rates is crucial for several reasons. On one hand, the relationship between these two markets may be used as a tool to predict the path of the exchange rate which can have repercussions for the ability of multinational corporations in order to run their exposure to foreign contracts and the exchange rate they deal with. On the other hand, currency is usually considered as an asset in investment funds' portfolio; also, it is very important for the performance of the fund. Indeed, the international investors, multinational corporations and policy makers would benefit from the knowledge of the nature of the relation between stock market and exchange market and then the degree of their integration (Ajayi and Mougoué, 1996).

Our study contributes to the literature in two ways. First, while the majority of studies focused mainly on developed markets, we examine the link between stock market and foreign exchange market in an emergent market which is Tunisia. Second, we examine the direction of the interdependence of exchange rates and stock prices between stock-exchange markets in Tunisia by considering both the short-run and the long-run dynamics relationship between the two markets.

Using daily data for the period January 2004-August 2017, our results show a significant long term relationship between Tunindex and exchange rate changes. However, a unidirectional causality was found in the short run, running from the Tunindex to the exchange market. Then, we use the DCC-FIAPARCH method in order to explore the dynamic conditional correlations between the two markets. Results revealed that the two variables were correlated in periods of instability and volatility shocks. These findings are particularly important to domestic as well as international investors for hedging and diversifying their portfolio mainly by predicting the path of the exchange rate.

This paper is structured as follows: *section 1* presents the literature review on the linkage between stock market and exchange rates. *Section 2* deals with the data and the methodology used in the paper. *Section 3* presents and discusses the results and *section 4* concludes the paper.

2. LITERATURE REVIEW

Roll (1992) studied US stock prices and exchange rate using daily data over the period 1988-1991 and concluded that there is positive correlation between the two markets. However, Chow et al. (1997) investigated the same markets by using monthly data for the period 1977-1989 and found no correlation between them. Though, after repeating the same study over a longer period of time, they found a positive correlation between the two markets.

According to Abdalla and Murinde (1997), after using a cointegration test to determine the correlation between the two markets for four Asian countries namely; South Korea, Philippines, Pakistan and India, between 1985 and 1994. They concluded the existence of a unidirectional causality from exchange rate to stock prices for South Korea, India and Pakistan while the Philippines causality comes from the opposite direction.

Karmakar and Kawadia (2002) pointed out that the correlation between RS/$ exchange rate and Indian stock market included five composite indices and five spectral indices and had a significant correlation with the movement of stock market. In the case of Singapore, Wu's study (2000) on the two markets during for period of the 1990s concluded a unidirectional causality running from the exchange rate to the stock market. This result was confirmed by Maheen and Ullah (2013) who deduced that, in short-term, exchange rates impact stock prices in Pakistan using the cointegration technique during the period 1998-2009.

Muhammed and Rachid (2002) studied the correlation between the two markets in four South-Asian countries, namely; Pakistan, India, Bangladesh and Sri Lanka, from January 1994 to December 2000. By using the cointegration method, the vector error correction modeling technique and the standard Granger causality test, there appears to be no short-term correlations between variables for all four countries. There was also, no long-term linkages' between stock prices and exchange rates for Pakistan and India. On the other hand, Bangladesh and Sri Lanka seemed to show a bidirectional causality between these two financial variables.

Bhattacharya and Mukherjee (2003) examined the Indian market using information on the BSE Sensitive Index and the exchange rate using monthly data for the period 1990-1991 to 2000-2001. Their results showed an absence of any considerable correlation between stock prices and exchange rate. This causality was also examined by Caporale et al. (2002) who found mixed results between the variables, namely, unidirectional and bidirectional relations in the US, the UK, Canada, Japan, the euro area, and Switzerland using data on the banking crisis between 2007 and 2010.

Pan et al. (2007) studied the dynamic correlation between exchange rates and stock prices for seven East-Asian countries excluding

China. They pointed out that the stock indexes and exchange rates are positively linked. The study showed that the impact was more significant after the Asian currency crisis.

Yau and Nieh (2009) took the case of the exchange rate effects of New Taiwan Dollar against the Japanese Yen on stock prices in Japan and Taiwan and concluded a long-term balance and asymmetry in their relationship. However, Benjamin (2006) was not able to determine a long-term link but there is a linear Granger causality from stock prices to exchange rates in the Brazilian economy.

Zia and Rahman (2011) using the Granger causality test, showed a directional causality between stock-exchange markets during 1995-2010 in Pakistan and found an absence of any link between the two variables, which promotes political instability.

Diamandis and Drakos (2011) used a VECM model on monthly data covering the period 1980-2009 and found that the stock indexes and exchange rates are positively related in Brazil, Argentina, Chile, and Mexico. However, Tsai (2012) discovered an opposite relationship between the stock index and exchange rate in Malaysia, Singapore, South Korea, the Philippines, Taiwan, and Thailand. These results were confirmed by Kubo (2012) in Indonesia, South Korea, and Thailand. However, the author pointed out an opposite relationship running from exchange rate to stock index in Brazil and Russia.

Concerning the effect of exchange rate volatility, Sekmen (2011) used the squared residuals from the auto-regressive moving average (ARMA) models on stock returns for the US between 1980 and 2008. He concluded that exchange rate volatility negatively influenced US stock returns showing that even the availability of hedging instruments could not reduce this negative influence on trade volume.

Olugbenga (2012) investigated the long-term and the short-term effects of exchange rate on the Nigerian stock market development between 1985 and 2009, using the Johansen cointegration test. This research revealed a largely positive stock market performance to exchange rate in the short-run but a significantly negative one in the long-run.

Chkili et al. (2012) used univariate and multivariate GARCH-type models and found bilateral relationships between stock and foreign exchange markets in France and Germany.

Groenwold and Paterson (2013) found a weak correlation between stock prices and exchange rates, but a strong relationship between exchange rates and commodity prices. According to the authors, assuming that commodity prices are influencing stock prices, there will often be a sway between stock prices and exchange rates.

Attari and Awan (2013) found a causality relation from stock returns to exchange rate between 1995-2012 in Pakistan, using a Granger causality test, a vector error correction model (VECM) and a cointegration method. Xie et al. (2020) used a sample of 20 advanced economies and 6 emerging economies and employed the symmetric and asymmetric bootstrap panel granger non causality test. Their results showed also that stock prices are helpful for predicting the exchange rate and not vice versa.

By employing the Johansen test, Zubair (2013) did not find any long-run linkages before and during the financial crisis of 2008, but then he employed the Granger causality model and he found a unidirectional causality in pre-crisis period and an absence of causality during the crisis.

According to Altin (2014), the study of the long-term correlation between exchange rate and Istanbul stock market showed an important link between the exchange rate and BIST 100. This result can be applied on the Turkey's foreign currency composition. Nonetheless, the direction of the impact of foreign currencies on BIST 100 gave different findings. Namely, there is a difference in the impact of each foreign currency on the stock index.

Mitra (2017) found a considerably positive long-run correlation between the real effective exchange rate and the total value of stock transaction in South Africa. He also proved an absence of an integration between stock transactions in the US and South Africa.

Bhuvaneshwari et al. (2017) studied the relationship between the US Dollar and the Indian Rupee from January 2006 to December 2015. They found that both variables are highly correlated. Moreover, Johansen's cointegration test revealed that in the long-run, the variables are not co-integrated. However, the Granger causality test clearly shows a bidirectional causality between the two markets in the short run.

Zhao (2010) examined the dynamic correlation between real effective exchange rate and stock price applying VAR and multivariate generalized autoregressive conditional heteroskedasticity (GARCH). His results revealed the absence of any stable long-term equilibrium correlation between real effective exchange rate and stock price. Furthermore, he confirmed that there's a bidirectional volatility spillovers impacts between the stock market index and exchange rate, showing that the previous innovations in stock market affect hugely upcoming volatility in foreign exchange market, and vice versa.

Sensoy and Sobaci (2014) analyzed the relations between stock market, exchange rate and interest rate in Turkey from January 2003 to September 2013 using VARp-FIAPARCH(1,d,1)-CDCC(1,1) approach. Regarding the stock-fx market relationship, they find a positive relation. The volatility shocks caused an abrupt changes in the correlation levels between these markets which are valid only in the short term and does not maintain between successive high volatility regimes.

Živkov et al. (2016) studied the dynamic nexus between exchange rate and stock returns in short run using the dynamic conditional correlation (DCC) method. Their sample is composed of four major East European countries: the Czech Republic, Hungary, Poland and Russia, for a period of thirteen years. Their results showed that stock conditional volatility has lower influence on DCC than exchange rate conditional volatility. Besides, DCC parameters showed significant time-varying performance, particularly throughout the major financial crisis, confirming that global shocks influence the volatility of DCCs. Principally, it occurred throughout the Global Financial Crisis and European sovereign debt crisis, but the impacts were not linearly.

Agya (2017) investigated the effect of passed return on current return, shocks spillover and volatility transmission between exchange-Stock markets. They applied VAR-GARCH models and the newly developed bivariate GARCH models, in order to calculate the optimal weight and risk minimizing hedging ratio for FX-Stock markets. Their study revealed a bi-directional volatility transmission in both markets and uni-directional shocks spillover from stock to FX market in both models.

Hung (2018) used the EGARCH model to investigate the changing nature of volatility spillovers among foreign exchange markets in the CEE countries. He found that the volatility spillover among these markets decreases considerably. He also pointed out that financial markets have not been transmitted during the crisis period.

3. DATA AND METHODOLOGY

The data used in this study are the Tunisian stock exchange index (Tunindex) and exchange rate expressed in local currency per US Dollars.

The data for exchange rate and stock market prices are collected from two different sources and covers a period from January 2004 to May 2017. We obtained the daily exchange rates (against US dollar) from the Central Bank of the Republic of Tunisia. While daily Tunindex values (in local currency) were downloaded from the Tunisian Stock Exchange website.

For the exchange rate and stock market, instead of the log-returns we take the actual returns:

$$R_{TUSDTND,t} = LN\left(\frac{P(USD/TND)_t}{P(USD/TND)_{t-1}}\right)$$

$$R_{Tunindex,t} = LN\left(\frac{P(Tunindex)_t}{P(Tunindex)_{t-1}}\right)$$

3.1. Descriptive Statistics

Table 1 reports the descriptive statistics for the Dollar along with the Tunisian stock market index. The table shows a mean return of 0.0002 for Tunindex and 0.0004 for the Dollar yield. Concerning the standard sample, it is equal to 0.0046 for the Tunindex and 0.0053 for the Dollar. The maximum for the dollar yield is 0.0324, while it's 0.0410 for the Tunindex. On the other hand, the minimum for the Dollar yield is -0.0327 and for the Tunindex is -0.0500. The Jarque-Bera test statistics suggest that all variables are non-normally distributed which inferred that stock prices and exchange rate are not normally distributed.

Graphs of chronological fluctuations of our variables during the studied period 2004-2007 are shown in Figures 1 and 2.

3.2. Testing the Data for Stationary

From Table 2, it is identified that the Dollar and Tunindex are found to be non-stationary series at level form but found to be stationary at first difference. Hence, both the data are statistically significant and integrated at order I (1). Therefore, it is understood that the sample data taken for this study are stationary i.e., predictable.

Since these series are integrated, our next step is to investigate whether a long-run relationship exists between the variables. This can be found through using different cointegration methods like VECM framework. The results of stationarity analysis presented in Table 2 show that all the modeled variables are integrated at order I (1). As a result, we will apply the Johansen cointegration tests to discover the long-run relationship between the variables.

3.3. VAR Lag Order Selection Criteria

The VAR model is a successful tool of characterizes the dynamic linkages between economic variables because it establishes only few restrictions (Lastrapes and Koray, 1990). The VAR model also helps inclosing the suitable lag length, which is crucial because of the time delays in the production of information relating to the macroeconomic variables. Particularly, the transmission and incorporation of information into stock returns are not immediate all the time. When delays get reported, not only a lag between the observations of data is noticed, but also the integration of that information into stock returns (Abugri, 2006).

The first step in multivariate cointegration analysis is to choose the right lag selection for the variables. In order to choose the suitable lag length, we used Akaike Information Criteria (AIC) and Schwarz Information Criterion (SIC).

As we can see from Table 3, the SIC shows the optimal lag of 8, and the SC selected lag length of 1. In this study, the lag length has been selected using SIC criterion and we therefore used the optimal lag of 1 (Litkepohl, 1985).

Table 1: Descriptive Statistics

	RT Tunindex	RT Dollar
Mean	0.000214	0.000472
Median	0.000000	0.000289
Maximum	0.032413	0.041086
Minimum	−0.032776	−0.050037
Std. Dev.	0.004610	0.005340
Skewness	−0.010280	−0.520042
Kurtosis	7.880878	15.65156
Jarque-Bera	3354.135	22687.70
Probability	0.000000	0.000000
Sum	0.722057	1.596097
Sum Sq. Dev.	0.071800	0.096320
Observations	3379	3379

Table 2: Results of ADF test

Time series data	ADF Unit Root Test	
Level of significance	At level	At first difference
Dollar	0.9999	0.0001*
Tunindex	0.8397	0.0001*

*,**,*** represent significance at 1%, 5%, and 10% levels.

Figure 1: Fluctuations of the Tunisian Dinar against the US (2004-2017)

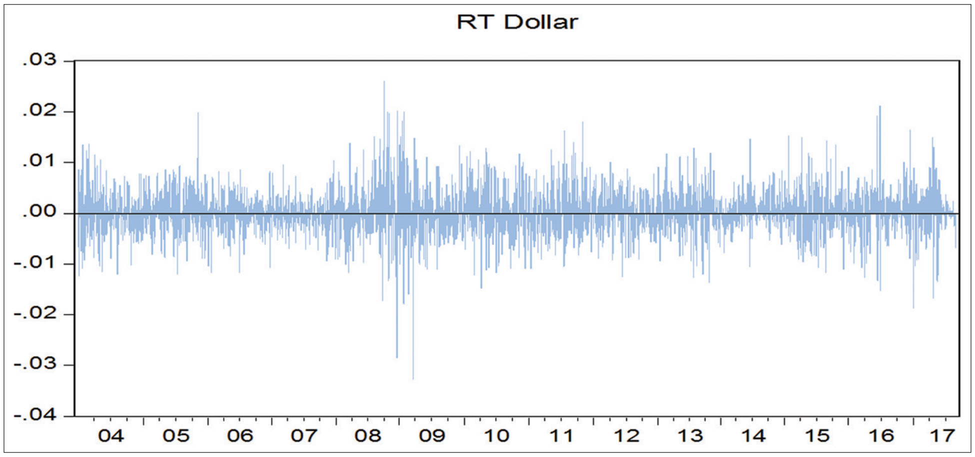


Figure 2: Tunindex fluctuations (2004-2017)

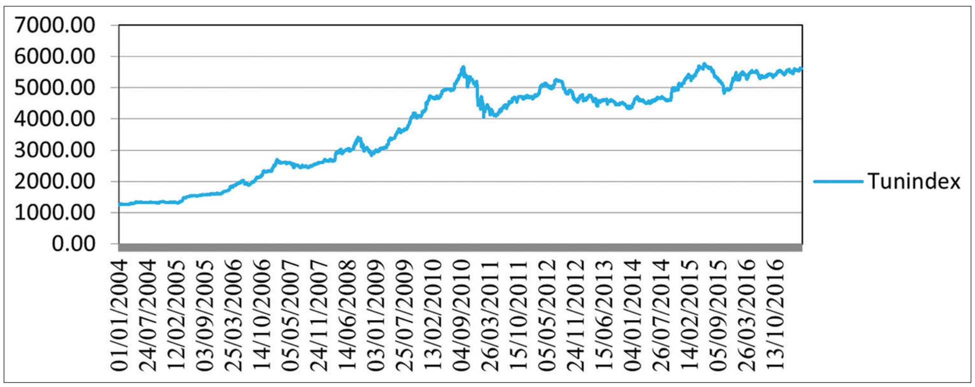


Table 3: VAR Lag Order Selection Criteria

Lag	Log L	LR	FPE	AIC	SC	HQC
0	26210.02	NA	6.06e-10	−15.54911	−15.54547	−15.54781
1	26323.43	226.6167	5.68e-10	−15.61402	15.60312*	15.61012*
2	26329.12	11.37098	5.67e-10	−15.61502	−15.59686	−15.60853
3	26330.72	3.187074	5.68e-10	−15.61360	−15.58817	−15.60451
4	26333.99	6.520601	5.68e-10	−15.61316	−15.58047	−15.60147
5	26335.17	2.357682	5.69e-10	−15.61149	−15.57153	−15.59720
6	26337.38	4.403680	5.70e-10	−15.61043	−15.56321	−15.59354
7	26345.80	16.76584	5.68e-10	−15.61305	−15.55856	−15.59357
8	26353.85	16.01033*	5.67e-10*	15.61545*	−15.55370	−15.59337

*indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

To decide what VAR model will be applied in this work, after determination of unit roots and integration at first order, Johansen cointegration tests are used to discover whether cointegration exists between these two variables. Cointegration analysis is crucial. Indeed, if the error term generating from the linear combination of two variables is stationary, then there is cointegration among both variables. The inexistence of cointegration among the two variables, means that there's no long-term association between them.

3.4. Johansen's Cointegration Method

Johansen's cointegration test is applied to find a stationary linear combination and a long-run cointegrating equilibrium among the non-stationary variables.

Since the variables are considered to be I (1), the cointegration method is suitable to estimate the long run association between the exchange rate and the stock index. To discover the number of cointegrating vectors, we will use first Trace statistic and then the Maximal Eigenvalue. The results of Trace statistics and Maximum Eigenvalue are shown in Table 4.

Tables 4 shows that the estimated value of the Trace test is greater than the corresponding critical value when the null hypothesis is tested. This result is significant at the 5% level, suggesting that there is at least one co-integrating equation in the system. This co-integrating equation means that a linear combination exists between the variables; therefore, there exists a long-term relationship between the two markets over the sample period, particularly, between the exchange rate for the Dollar and the Tunindex.

In order to confirm the results of the Johansen's Trace test, we also display the results of the Maximum Eigenvalue Test between exchange market and the Stock market. By doing so, the Maximum Eigenvalue Test also shows one cointegrating equation at the 5% level confirming the Trace test. Hence, these two tests confirm the existence of a long-term relationship over the sample period existing between both exchange markets and the Tunindex. Consequently, the Trace statistic and Maximal Eigen statistic identified one cointegrating vector.

4. RESULTS AND ANALYSIS

4.1. Vector Error Correction Model (VECM)

The presence of cointegration between variables suggests a long term relationship among the variables under consideration. Then, the VEC model can be applied. The main motivation for The VEC model was applied so we can avoid the potential misspecification bias inherent in the VAR in first difference. The VAR can't explore long-term relations, in addition it's incapable in determining short-term relations in the presence of cointegration.

We then estimate a VECM model for the two variables. The VEC model allows us to discover the correction terms that reflect effects of deviation of the links among the variables from long-run equilibrium and short-run parameters. The long run relationship between exchange rate and the stock market for one co-integrating vector in Tunisia in the period 2004-2017 is displayed below in Table 5.

Following Johansen and Jeselius (1990), the normalized cointegrating equation shows that, in the long run, there is a clear and reliable positive relationship between stock prices and the exchange rate for the Dollar.

The results in Table 6 present the adjustment coefficients for the set of variables used in our investigation along with the short run dynamics. The ECT in D(RT_Dollar) is found to be statistically significant with the anticipated negative sign. The adjustment coefficient associated with the stock price index is (−0.028671) for the Dollar. This is sufficient to reject any no cointegration hypothesis and confirms the presence of a stable long-run relationship between Exchange rates and the Tunisian stock market index. This is in line with the finding in Johansen cointegration test presented previously, suggesting a bi-directional long run relationship between stock price index and exchange rate.

Table 4: Johansen cointegration results

Series: RT dollar/RT tunindex Unrestricted cointegration rank test (trace)			
Hypothesized no. of CE(s)	**Trace statistic**	**5% critical value**	**Probability**
None*	2430.922	15.49471	1.000
At most 1*	1004.965	3.841466	0.0000
Unrestricted cointegration rank test (Maximum Eigenvalue)			
Hypothesized No. of CE(s)	**Max-Eigen statistic**	**5% critical value**	**Probability**
None*	1425.957	14.26460	1.0000
At most 1*	1004.965	3.841466	0.0000

Table 5: Vector error correction estimates/long-run dynamics

RT dollar	RT tunindex
1.0000	−0.032744
Standard error	0.01841
T-statistic	−1.77870

4.2. Granger Causality Test

After the confirmation of cointegration by the Johansen and Juselius (1990) test in the unrestricted VAR, a long-run relationship was found between the dynamic regressors. Since we have found a cointegration between the stock-exchange markets, so there must be a Granger causality between the two variables in question in at least one direction. We apply Granger causality test in order to explore the direction of causality between the stock market and the exchange market.

Despite the several empirical studies that aimed to discover the linkages between the stock returns and the exchange market, the direction of the causality is still unclear in both empirical and theoretical literature. Therefore, it is mandatory to use the Granger causality test to discover whether changes in exchange rate cause changes in stock prices or changes in stock prices cause exchange rate, using first-differenced log data.

The results are reproduced in Table 7.

The p-value for the first null hypothesis for the Table 7 is statistically significant at the 5% level. Therefore, Tunindex does not Granger causes the exchange rates for the Dollar and it appears that Granger causality runs one-way from stock market to the exchange market. This is consistent with Abdalla and Murinde (1997), Ajayi et al. (1998), Salisu and Ndako, 2018 and Xie et al. (2020) who found a causality running from the stock price to the exchange market supporting the stock oriented hypothesis.

4.3. DCC-FIAPARCH Methodology

Derived from the bivariate DCC-GARCH (1,d,1), the multivariate DCC-FIAPARCH (1,d,1) proposed by Tse and Tsui (2002), the fractionally integrated APARCH affords a better understanding of

Table 6: Vector error correction estimates/short-run dynamics

	Δ(RT_Dollar)	**Δ (RT_Tunindex)**
ECT	−1.018367	−0.028671
Δ(rdt_dollar (−1))	0.028194	0.019136
Δ(rdt_tunindex(−1))	−0.009223	−0.399448
R-squared	0.496161	0.159139
F-Statistic	1107.198	212.7887

Table 7: Results of granger causality test

Null hypothesis	F-statistic	Probability
Tunindex does not Granger cause the Dollar	3.36204	0.0348*
The Dollar does not Granger cause Tunindex	1.48712	0.2262

*indicates statistically significance at 5% level the volatility dynamics by permitting long memory and asymmetry in volatility. The dynamic conditional correlation (DCC)-GARCH models have been used in many studies (Chkili and Nguyen, 2014; Sensoy and Sobaki, 2014; Moore and Wang, 2014; Wong, 2017; Yang, 2017). The objective of this methodology is to "address the issues of the return interrelatedness and volatility spillovers between the two financial markets" (Hung, 2019; Xie et al., 2020).

- Long memory test

First, we test whether there's a long memory in the conditional variance of return series. To do so, we use the two mainly-applied long memory (LM) tests, the log periodogram regression (GPH) test of Geweke and Porter-Hudak (1983) and the Gaussian semi parametric (GSP) test of Robinson (1995), to absolute returns. The results of the both LM tests are presented below in Table 8.[1]

We must reject the null hypothesis that states the absence of long-range memory for exchange and stock markets (absolute) returns at the 1% significance level. Therefore, this confirms the presence of long memory impacts for both the Tunisian stock market and the exchange markets, which need to be accounted for when modeling their conditional volatility.

1 m denotes the bandwidth for the Geweke and Porter-Hudak (1983) (GPH) test, the Gaussian semi parametric (GSP) test of Robinson (1995) and the rescaled variance test. The values in parentheses are standard errors. T is the sample size.

Table 8: Long memory test results

	Dollar		Tunindex	
GPH test applied to absolute return				
$m=T^{0.5}$	0.617545	[0.0000]	0.408381	[0.0000]
$m=T^{0.6}$	0.514213	[0.0000]	0.407718	[0.0000]
GSP test applied to absolute return				
m=T/8	0.34023	[0.0000]	0.312417	[0.0000]
m=T/16	0.43414	[0.0000]	0.361363	[0.0000]

- DCC-FIAPARCH estimation

Here, we introduce the DCC-FIAPARCH estimation in the Table 9[2].

In order to investigate the dynamic linkages between the Tunisian stock market and the exchange market (Dollar/ TND), we apply the bivariate DCC-FIAPARCH model. In fact, the FIAPARCH is so flexible since it allows exploring the dynamic conditional correlations between the two markets in the bivariate system. Furthermore, since our study covers the period of 2004-2017 that witnessed several important economic, social, political and geopolitical events, we can also explore the underlying effect of such events on the dynamic relationships between the exchange and stock markets.

The results of the estimation of the bivariate DCC-FIAPARCH (1,d,1) model between the Tunindex and the Exchange market (Dollar/TND) is given in Table 9. The one-lag return (AR(1)) is positive and statistically significant at the 1% level for all cases. We observe that the fractional differencing parameters (*d*) are significant in all cases, which validates the existence of long memory in the conditional volatility showed previously.

The corresponding d-FIGARCH among the stock and exchange markets is 0.821147 and 0.237604 for the Dollar/Tunindex. The ARCH and the GARCH coefficients in the DCC-FIAPARCH are highly significant at the conventional levels for all the markets.

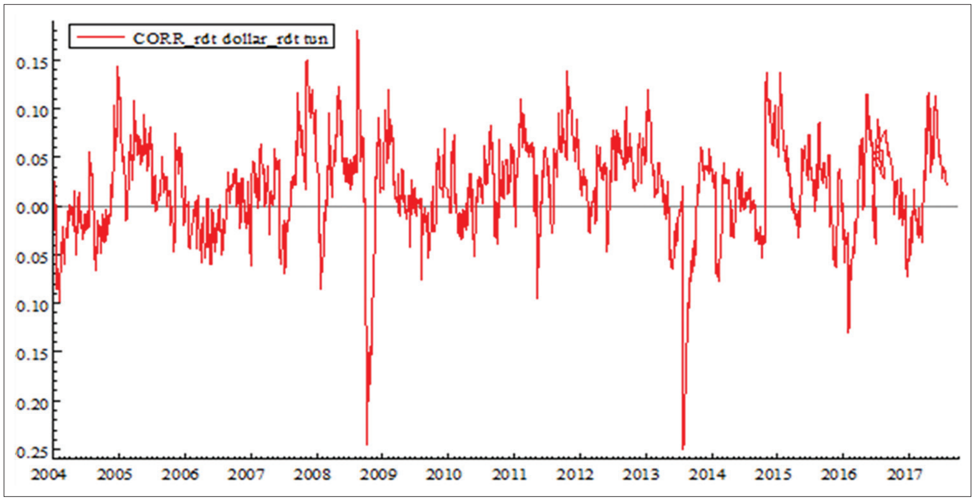
The power term (δ) is positive and highly significant as well. In

2 C(m) and C(v) are the constants of the mean and variance equations, respectively. AR(1) refers to the autoregressive parameter of the mean equation. The optimal lag length of the mean equations was selected by using the AIC and BIC information criteria. Q2 (.) is the Ljung-Box test for autocorrelation applied to squared standardized residuals. Standard deviations are reported in parentheses. P-values of statistical tests are presented in brackets. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 9: Estimation results of the bivariate FIAPARCH (1, d, 1) model

	Dollar/Tunindex			
	Dollar		Tunindex	
Panel A : Results				
Cst(M)	0.000179	(7.3219e005)	0.000358	(9.1702e005)
AR(1)	0.000690	(0.018999)	0.250675	(0.021036)
Cst(V) x 10^6	10.283918	(14.081)	18.493098	(20.115)
d-FIGARCH	0.821147	(0.075497)	0.237604	(0.076028)
ARCH (ϕ1)	0.132377	(0.063378)	0.411366	(0.25380)
GARCH (β1)	0.930127	(0.025596)	0.335511	(0.22513)
APARCH (γ)	−0.264335	(0.18972)	0.080923	(0.057516)
APARCH (δ)	1.368704	(0.20619)	1.679082	(0.17736)
Panel B : Dynamic conditional correlations				
Average correlations (ρ)	0.016880		(0.021728)	
Panel C : Model's statistics and diagnostic tests				
Student-df	5.187952		(0.26724)	
Log L		13577.6		
AIC		−16.275435		
Hannan-Quinn		−16.262473		
$Q^2(10)$	49.6074	[0.0000003]	3.96980	[0.9486991]
$Q^2(20)$	69.2526	[0.0000002]	11.8789	[0.9201813]

Figure 3: Plots of dynamic conditional correlation of the dollar/tunindex



addition, the γ coefficient is negative. Therefore, these results reveal that the empirical model we applied is appropriate and flexible enough to contain the most important stylized facts of stock and exchange market returns counting the volatility clustering, long memory and asymmetric volatility. In addition, Student-df was found significant for all cases, which confirms the suitability of the Student-t distribution in volatility models.

The average conditional correlations (ρ) is positive and highly significant. The coefficient is 0.016880.

Figure 3 demonstrates the evolution of the DCC estimates between the Dollar exchange rate and the Tunindex from 2004 to mid-2017. These dynamics reveal a number of interesting facts. First, the behavior of the DCC series is relatively dissimilar, proposing that the Tunisian stock market has a different co-movement with the Exchange rate for the Dollar. Then, the dynamic conditional correlations between the Stock-Exchange markets vary extensively over the study period and typically fluctuate between −0.25 and 0.2. This important volatility is due to several important economic, financial and geopolitical events. In fact, they are low when international economies pass through financial recessions like the famous recent subprime crisis that started in the USA in 2007 and lasted till 2008. During this crisis, the DCC dropped sharply to reach a value of −0.24. After that, the relationships between the Stock-Exchange markets usually increased following signs of economic recovering. Later on, the European debt crisis, and lately, the Arab spring events influenced the correlation between the two markets.

During the Arab spring events, particularly during the Tunisian Revolution that took place in late 2010 and early 2011, we can notice that the DCC between both exchange markets and the Tunindex Dropped sharply reaching −0.09. After that, the DCC was stagnant until 2013, and it was varying between −0.10 and 0.14. However, it decreased dramatically in mid-2013 to reach −0.25. In fact, this plummet was due to disturbing events that the country has witnessed.

First, the assassination of anti-Islamist opponent Chokri Belaïd in February the 6th, which caused a deep political crisis and the fall of a first government led by the Islamists of Ennahda, also, the assassination of an anti-Islamist opposition MP, Mohamed Brahmi in 25th of July, all these crimes led to a dramatic decline in the DCC correlation. Afterwards, until 2017 DCC between the two markets showed an unstable performance that varied between −0.12 and 0.15 for the Dollar/Tunindex.

As a matter of fact, the results of the DCC estimations between the exchange market and the stock market were not very significant in terms of correlation because of two main reasons: First, because the Tunisian stock market is small and not very developed and second, because the number of multinationals and foreign investments established in the country is not huge.

5. CONCLUSION

The relationship between stock markets and exchange rates has preoccupied the minds of economists and have been subjected to extensive research since they both play important roles in influencing the development of countries. The study examined the causal relationship between Tunisian stock prices and exchange rate for the Dollar against the Tunisian Dinar by using the daily data for the period from January 2004 to August 2017.

Results show a significant long term relationship between Tunindex and exchange rate changes. However, a unidirectional causality was found in the short run, running from the Tunindex to the exchange market. Then, in order to explore the dynamic conditional correlations between the two markets in the bivariate system, we use the DCC-FIAPARCH method that revealed that the two variables were correlated in periods of instability and volatility shocks. These results are particularly important to domestic as well as international investors for hedging and diversifying their portfolio mainly by predicting the path of the exchange rate.

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