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The Determinants of Volatility of Market Price Returns of US Dollar and Euro Futures Contracts Traded in TurkDEX

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Abstract

The volatility of the futures prices is of crucial importance to all participants in the market, especially in the emerging markets like TurkDEX, the newly established derivatives market, where the high volatility of foreign exchange rates can be usually observed. This paper aims to analyze the determinants of the volatility of the US Dollar and Euro futures contracts that are traded in TurkDEX using daily data of closing price, the contract maturity, the volume of contracts traded, and the volume of open interest of each contract. The paper tests the models of individual effects of futures price volatility determinants on the basis of EGARCH(1,1) process and analyzes empirically the relationship of futures price volatility and time to maturity and trading volume and open interest for the period January 5, 2007 to December 28, 2012. The results show that the Turkish Derivatives Exchange deviates from the other developed markets in terms of the determinants affecting the futures price volatility, due to its infancy.

Key words: Volatility, EGARCH, TurkDEX, futures markets

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INTRODUCTION

The volatility of futures contract prices has been widely investigated due to its implications for participants in futures markets. As futures market is characterized by high liquidity and low transaction costs, different volatility patterns are possible and, in turn, their reflections appear differently for each participant in this market. Hedgers, attempting to minimize the risk of potential adverse price changes in the underlying asset, must adjust their hedge ratios in accordance with variations in contract prices. On the other hand, speculators rely on the volatility of futures prices to create profitable opportunities while creating liquidity in the derivative market. The volatility of the futures prices, among other factors, is therefore of crucial importance to all participants in the market, especially in the emerging markets like Turkey where the high volatility of foreign exchange rates can be usually observed. Thus, the importance of prices volatility to all participants in futures markets leads one to ask what the economic determinants of this variable are.

Literature on prices volatility contains numerous examples of papers attempting to identify the important economic variables that influence it. A relatively small subset of this research focuses on the determinants of volatility of futures contract prices. Researchers mostly focus on the behavior of such variables as time to maturity, trading volume and open interest of each contract for explaining the prices volatility by using different models and methods, e.g. Samuelson (1965), Barnhill et al. (1987), Karpoff (1987), Bessembinder and Seguin (1993), Bessembinder et al. (1996), Ripple and Moosa (2007), Okan, Olgun and Takmaz (2009). Moreover, the existing research has come to conflicting conclusions regarding the effect of these variables on prices volatility in emerging and futures markets.

This paper aims at examining the volatility in foreign currency futures contract prices. It analyzes the determinants of volatility and tests empirically the models of individual effects of futures price volatility determinants for US Dollar and Euro futures contracts traded in the Turkish Derivatives Exchange (TurkDEX), one of the fastest growing emerging derivative market. The paper adopts daily market data of US Dollar and Euro futures contracts that are traded in TurkDEX from January 5, 2007 to December 28, 2012. The models of individual effects of futures price volatility determinants were tested on the basis of EGARCH (1, 1) process and the relationship of futures price volatility and time to maturity and trading volume and open interest were analyzed empirically.

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The contribution of the paper is twofold: First, it helps to fill the gap in the literature about the TurkDEX by examining the effects of time to maturity, trading volume, and open interest on volatility persistence. While the most previous studies have focused on Istanbul Stock Exchange for Turkey, there are so limited researches on the newly established derivatives market. Second, the implications of the study are expected to be functional for risk managers and individual investors dealing with Turkish US Dollar and Euro futures contracts.

The next part of the paper will summary the available literature, the third part will explain the methodology used in the paper, the fourth part will summarize the data and empirical findings and finally the fifth part will conclude.

LITERATURE REVIEW

This section includes the relevant literature on prices volatility. As the behavior of each variable considered here has been shown in literature with some conflicting evidences, their relationship with prices volatility is individually discussed below.

Volatility and time to maturity

Samuelson (1965) developed a theoretical basis for the relation between the futures price volatility and time to maturity. Often referred to in the literature as the 'Samuelson hypothesis' or the 'maturity effect', this hypothesis argues that the volatility of futures prices should increase as the futures contract approaches expiration. The logic behind this conclusion is that the market is more sensitive to news regarding near-maturity contracts than more-distant contracts, which is indicated by greater volatility for the near-maturity contract. Typically, the maturity variable is a decreasing index, and the expected outcome is to find the estimated coefficient to be significantly negative. Although Samuelson's hypothesis is supported by various empirical studies, there are some exceptions that conflict with this evidence.

In general, the Samuelson hypothesis is more often supported in agricultural futures. Milonas (1986), Khoury and Yourougou (1993), Galloway and Kolb (1996), Bessembinder et al. (1996) and Allen and Cruickshank (2000) are among the research which found evidence supporting the hypothesis for agricultural futures or commodities.

Evidence of the maturity effect in financial futures is much weaker than in agricultural futures. Grammatikos and Saunders (1986) fail to find supportive evidence for the maturity effect in any of the five currency futures in their study. Herbert (1995) studied the relation between volatility and maturity and trading volume for the natural gas futures. The results reported by Herbert fail to support that volatility of future prices increases as maturity approaches, but lead to conclude that trading volume dominates maturity in explaining futures returns volatility. Galloway and Kolb (1996) find support for this effect in only one of the financial commodity futures during the period 1969–1992. Similarly, Chen et al. (1999) document that the futures price volatility of the Nikkei-225 index futures actually decreases as the expiry date approaches. Barnhill et al. (1987) conduct one of the few studies that are able to provide some support for the maturity effect in financial futures.

Bessembinder et al. (1996) suggest that the key condition for the empirical support of the Samuelson hypothesis is the negative covariance between spot price changes and changes in net carry costs. Since this negative covariance is likely to hold for markets trading real assets, but not for those trading financial assets, Bessembinder et al. (1996) predict that the Samuelson hypothesis is more likely to hold for commodity futures than for financial futures. They find strong empirical evidence supporting their hypothesis by examining 11 futures markets including agricultural, energy, metals and financial futures.

Duong and Kalev (2008) found strong support for the Samuelson hypothesis in agricultural futures by utilizing intraday data from 20 futures markets in six futures exchanges, but not for other futures contracts. They also provided supporting evidence that the negative covariance hypothesis of Bessembinder et al. (1996) is the key factor for the empirical support of the Samuelson hypothesis. Thus, they explained the differential support for the Samuelson hypothesis in different futures markets.

Volatility and Volume

Literature shows several earlier studies empirically examined the relation between volume traded and security price variability. Ying (1966), Crouch (1970), Clark (1973), Copeland (1976), Westerfied (1977), Epps and Epps (1976), Rogalski (1978), and Upton and Shannon (1979) are among the representative studies to find a positive association between volume and price variability. There are three theoretical explanations for this relationship (Bhar and Malliaris, 1998; 286):

"One theoretical motivation of these studies is the supply and demand model. From a given initial equilibrium position under certain assumptions, a net increase (decrease) in demand for a stock will cause the stock price to increase (decrease). Therefore one would expect changes in volume transactions to be influenced by price changes. Crouch (1970) and Rogalski (1978) elaborate this theoretical motivation.

A second theoretical motivation is presented in Clark (1973) and in Epps and Epps (1976) who interpret their empirical findings of the dependence between transactions volume and the change in the logarithm of security price, from one period to the other, as evidence for Clark's thesis. Clark (1973) proposed an alternative to Mandelbrot's (1963, 1967, 1973) argument that speculative prices follow stable laws. More specifically, Clark (1973) argued that the distribution of speculative prices is normal when conditioned on its variance, with such price variance being curvilinearly related to trading volume.

Finally, the third theoretical explanation is proposed by Copeland (1976), who develops a sequential arrival of information model which, under certain assumptions, implies a positive correlation between trading volume and price variability. The lagged values of volume may have an ability to predict current volatility, and vice versa."

These earlier studies were followed by Cornell (1981), Tauchen and Pitts (1983), Rutledge (1984), Grammatikos and Saunders (1986), Garcia, Leuthold and Zapata (1986) and others to examine the price variability and volume relationship using data and institutional characteristics from futures markets.

As documented widely in the finance literature, trading volume and price volatility display a positive correlation. Karpoff (1987) cited many previous studies that document positive relation between volatility and volume. But there are different views such as Garcia, Leuthold and Zapata (1986). They found the negative relation between these two variables. In brief, it is generally accepted that there is a relation between trading volume and price volatility indicated by different models and methods. However, the behavior of trading volume and prices volatility in emerging and futures markets remains limited in literature.

For Turkish stock and futures market, there are recent studies to examine the relationship between trading volume and price volatility. Baklaci and Kasman (2006) examine the 25 individual stocks traded in Istanbul Stock Exchange (ISE) in this respect. Okan, Olgun and Takmaz (2009) examined the volume-volatility relationship (dynamic and casual) for the ISE-30 index futures using daily data for the period 2006-2008 in TurkDEX. The results indicate that trading volume as a proxy of information arrivals slightly reduces the persistence of the conditional variance and has a negative impact on volatility in TurkDEX. The findings showed that trading volume and return volatility follow a lead-lag pattern.

Volatility and Open Interest

Open interest is defined as the number of contracts existing in a futures market that have not yet been closed out. It is reported as the number of outstanding contracts at the end of a trading day. Open interest increases from zero when a contract is first listed for trading, falling back to zero on the maturity date of the underlying contract when trading ceases. It typically reaches a maximum about one month before maturity.

In recent studies, by the fact that open interest and its change differ significantly from trading volume, open interest has been suggested as an additional explanatory variable.

Bessembinder and Seguin (1993) examined the relation between price volatility and open interest, which is used as a proxy for market depth. They partitioned open interest into expected and unexpected components, and documented that volatility is negatively related to the expected level of open interest in all eight markets. Their evidence indicates that the effect of volume on volatility depends on whether volume generates changes in open interest. Ragunathan and Peker (1997) have drawn the similar conclusion and revealed that volume and open interest have significant influence to the price volatility of the futures.

Ripple and Moosa (2007), by the contract-by-contract analysis, revealed that trading volume and open interest have a significant impact on volatility and that they dominate the Samuelson-maturity effect. While the results support earlier findings of positive and significant role for trading volume, they also showed the importance of open interest as a determinant of volatility. Feng and Chuan-zhe (2008) demonstrate a negative contemporaneous relationship between the volatility and open interest variable. They conclude that trading volume and open interest are the two important variables that explaining the price volatility of futures contract, which explain majority of the volatility in futures price.

METHODOLOGY

Modeling and forecasting volatility has attracted enormous interest since the variance of time series is important for pricing, calculating risk, and for hedging. Most common method for calculating volatility is using GARCH (1, 1), but EGARCH (the Exponential GARCH) introduced by Nelson (1991) has superior advantages, because it assumes a conditional normal error structure for the errors.

Under the EGARCH(1,1) specification, the conditional variance equation, σ_t^2, is an asymmetric function of one-lagged error terms (ε_{t-1}) and can be written as

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

where ω, α, γ and β are time-independent parameters. To ensure stationarity, β is assumed to be less than one. ε_t, the error term at time t, has a normal distribution with a mean of zero and conditional variance σ_t^2, i.e., $\varepsilon_t \sim N(0, \sigma_t^2)$.

The model also has several advantages over the pure GARCH specification. Since the logarithm of the conditional variance is modeled, even if the parameters are negative, the conditional variance will be positive. So, there is not a need to impose non-negativity constraints on the parameters, α and γ in the EGARCH model. Under the EGARCH specification, asymmetries are allowed, which means that if the relationship between volatility and returns is negative, γ will be negative.

In this paper, the robust standard errors are computed as suggested in Bollerslev and Woolridge (1992). The ARMA (p,q)- EGARCH(1,1) models are estimated using maximum likelihood estimation and the optimal lag lengths are selected according to the Schwarz Bayesian criterion (Schwartz, 1978).

DATA and EMPIRICAL RESULTS

The data consist of the daily prices of United States Dollars and Euro futures contracts that are traded in Turkish Derivative Exchange (TurkDEX) for the period between January 2007 and end of 2012. The data is obtained from the web site of TurkDEX. The data also contains the number of days to maturity, the volume of contracts traded and the volume of open interest. The dates with zero volume of transactions have been dropped from the model.

Figure 1. Daily Return Series for USD and Euro Futures Contracts: 05/01/2007 to 28/12/2012

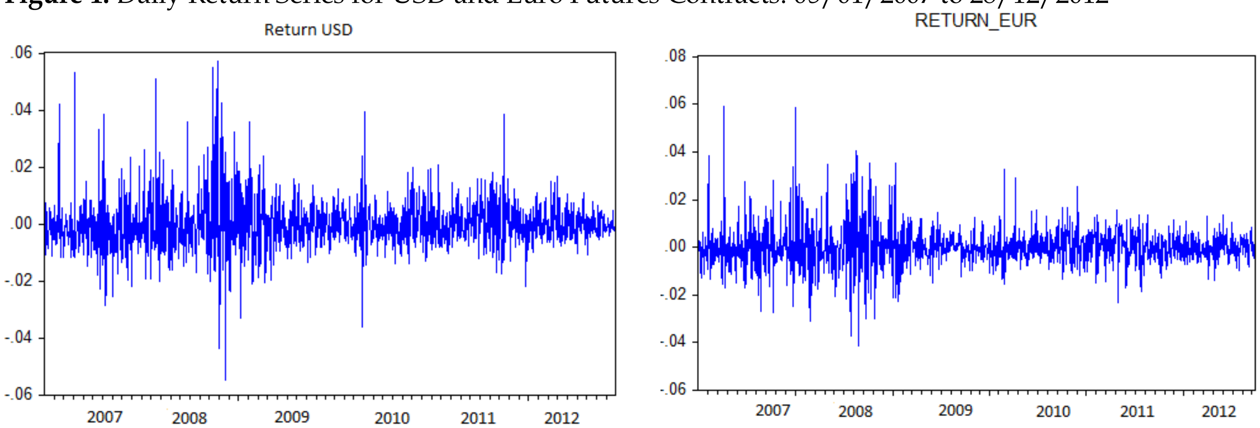

Figure 1 plots the returns of the USD and Euro contracts. It is seen that the returns are moving around an average zero mean and with time varying clustering volatility. There is evidence of volatility clustering, where periods of volatility followed by tranquility.
Table 1 presents the descriptive statistics of the return data. Both the USD and Euro futures contracts have returns about approximately 0.01% and the standard deviation of the USD contracts are slightly higher with 0.93%, whereas the standard deviation of the Euro contracts is 0.87%. Jarque-Bera statistic exceeds the number of observations for both samples, so we reject that the series are normally distributed at the 1% significance level. The kurtosis values of the data are also very high, pointing to the fact that the data are leptokurtic, which is another sign that the series are not normally distributed.

Table 1. Descriptive Statistics for USD and Euro Futures Contract

	Return USD	Return EUR
Mean	0,0001	0,0001
Median	-0,0006	-0,0002
Maximum	0,0574	0,0593
Minimum	-0,0549	-0,0413
Std. Dev.	0,0093	0,0087
Skewness	0,8929	0,7771
Kurtosis	9,2198	8,8546
Jarque-Bera	2570	2188
Probability	0,0000	0,0000
Sum	0,2096	0,2119
Sum Sq. Dev.	0,1262	0,1070
Observations	1473	1431

In order to test for integration of the return data Augmented Dickey Fuller (ADF) tests are performed. Table 2 summarizes the ADF test results. Since the estimated ADF test statistics are less than the 1% critical value, we reject that the hypothesis that series contains a unit root and conclude that the series are stationary.

Table 2. Augmented Dickey Fuller Test

	Return USD	Return Euro
ADF Test Statistic	-36.7773	-37.1447

Note: Critical value for the ADF test for 1% significance is -3.4341.

Using EGARCH (1,1) model the mean equation and the variance equation is estimated for the return series. Table 3 exhibits the estimate results.

Table 3. EGARCH(1,1) Model Estimates

Dollar			Euro	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Mean Equation				

C	-8.33E-05	0.000198	5.51E-05	0.000181
Variance Equation				
ω	-0.2156***	0.0373	-0.3489***	0.0517
α	0.1745***	0.0184	0.2099***	0.0173
γ	-0.0202**	0.0101	-0.0019	0.0103
β	0.9911***	0.0035	0.9799***	0.0048

*** and ** represents statistical significance at 1% and 5% level, respectively.

In order to test the determinants of volatility the paper reestimates the EGARCH model by including variance regressors in the mean equation. The study will consider the impact of volatility of each variable separately.

First, the effect of maturity on the volatility is analyzed. Most of the empirical research note that volatility increases as maturity decreases (Samuelson hypothesis). Combining the number of days to the maturity with the EGARCH model, we estimate the following equation:

$$\log \sigma^2_{j,t} = \omega_j + \beta_j \ln(\sigma^2_{j,\,t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma^2_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma^2_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \ln T_t \quad (2)$$

where t denotes the number of days to maturity of the contract. If δ is statistically significant, we will be able to conclude that the maturity has a significant effect on the volatility of the futures contracts. Table 4 shows the estimates.

Table 4. Volatility and Maturity

Variable	Coefficient	Std. Error	Coefficient	Std. Error
Mean Equation				
C	7.73E-05	0.00022	0.000218	0.00017
Variance Equation				
ω	-11.3950***	0.2838	-8.4773***	0.2965
α	0.4578***	0.0277	0.7132***	0.0431
γ	0.0198	0.0180	0.1070***	0.0289
β	-0.0684**	0.0306	0.2312***	0.0318
LnT	0.3321***	0.0261	0.1962***	0.0190

*** and ** represents statistical significance at 1% and 5% level, respectively.

The results show that the coefficients of time to maturity for both dollar and euro contracts are positive and statistically significant implying that the volatility decreases as the contract approaches to maturity. Our findings are in contrast with the Samuelson hypothesis, but supported by the papers of Rutledge (1976) and Chen et.al. (1999). Why the volatility decreases when the time to maturity decreases is explained by Anderson and Danthine (1983). They justified that if the volatility of future prices decreases as maturity approaches, it denotes that much underlying uncertainty has already been resolved and the prices tended to stabilize.

Further, the paper analyzes the effect of volume traded on the volatility of the prices. In order to quantify and test the effect of volume, the following equation will be tested:

$$\log \sigma^2_{j,t} = \omega_j + \beta_j \ln(\sigma^2_{j,t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma^2_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma^2_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \ln Vol_t \quad (3)$$

Vol stands for the volume of contracts traded. Table 5 summarizes the estimate results. The coefficient for the volume for dollar contracts has statistical significance at 1% level, whereas the coefficient is very small. The positive relation of the volume with volatility is also reported in Ying (1966), Crouch (1970), Clark (1973), Copeland (1976), Westerfield (1977), Epps and Epps (1976), Rogalski (1978) and Upton and Shannon (1979). The coefficient of euro contracts on the other hand is negative. The negative coefficient may be due to few number of investors with similar speculation. The same relationship is also supported in Garcia, Leuthold and Zapata (1986).

Table 5. Volatility and Trading Volume

Variable	Coefficient	Std. Error	Coefficient	Std. Error
Mean Equation				
C	-0.00063***	0.00019	2.49E-05	0.000178
Variance Equation				
ω	-14.1381***	0.3400	-0.2077***	0.0385
α	0.2994***	0.0281	0.1672***	0.0156
γ	0.08450***	0.0227	0.0163	0.0118
β	-0.3225***	0.0253	0.9812***	0.0043
lnVol	1.81E-08***	8.99E-10	-0.0081***	0.0013

*** represents statistical significance at 1%.

The futures market has a unique feature than the stock market that there is a certain amount of open interest. Open interest is considered as an additional measure about the trading activity in the market. Open interest can proxy the potential for a price change while trading volume assesses the strength of a price level. The change in the level of open interest can also measure the direction of capital flows relative to that contract Ferris et. al (2002). The paper further investigates the effect of open interest on the volatility.

$$\log \sigma^2_{j,t} = \omega_j + \beta_j \ln(\sigma^2_{j,t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma^2_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma^2_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \ln OI_t \tag{4}$$

Table 6. Volatility and Open Interest

Variable	Coefficient	Std. Error	Coefficient	Std. Error
Mean Equation				
C	3.93E-05	0.000195	-3.50E-05	0.000177
Variance Equation				
ω	-0.5517***	0.0919	-0.3499***	0.0563
α	0.1485***	0.0173	0.2018***	0.0203
γ	0.0084	0.0124	0.0228*	0.0139
β	0.9885***	0.0035	0.9635***	0.0067
lnOI	0.0287***	0.0058	-0.0199***	0.0031

*** and * represents statistical significance at 1% and 10% level, respectively.

OI represents the volume of open interest. According to the estimate results which are presented in Table 6, the volume of open interest is a significant volatility factor for both USD and Euro futures contracts. The coefficient is positive for dollar contracts but negative for the euro contracts. The negative coefficient of the dollar contracts supports the findings of Ragunathan and Peker (1997), who conclude that open interest enhances market depth and there are lower volatility shocks associated with a given volume in deeper markets.

Open interest can proxy the potential for a price change while trading volume assesses the strength of a price level. The change in the level of open interest can also measure the direction of capital flows relative to that contract. The positive coefficient on the other hand can be explained by the diverse direction in the open interest positions, which further increase the volatility in the market.

CONCLUSIONS

This paper has investigated the determinants of volatility for the USD and Euro futures contracts that are traded in Turkish Derivative Exchange (TurkDEX). TurkDEX fills an important gap in Turkey, being the only and first derivative market. Being established in February 2005, TurkDEX provided the trade of Euro and USD futures contracts. Thus, the paper analyzed the determinants of volatility, which are considered as time to maturity, volume of trade and open interest for the period January 5, 2007 to December 28, 2012.

The paper first checks for stationarity of the return series through the application of Augmented Dickey Fuller (ADF) test. Ensuring that the series are stationary, EGARCH (1,1) model is used for calculating the volatility of the futures returns. The preference of the EGARCH model is due to its superiority over the other models, about relaxing various assumptions about the characteristics of the data and the consideration of the asymmetries in the model. Considering the determinants in the variance regression, the paper aims to analyze the effects of maturity, trade volume and open interest on the volatility.

According to the results, for both of the contracts time to maturity has a positive and statistically significant effect. The results explain that in the Turkish Derivatives Exchange, the underlying uncertainty resolves as the contract approaches to maturity. Thus, the volatility of the future prices declines. Total volume of the contracts traded is also statistically significant. The coefficient is positive for the dollar contracts, but yet it is very small, indicating a small effect. The volatility of the euro contracts is negatively affected from the trading volume. This is thought to happen because of the investors with similar beliefs about the movement of the euro. Open interest is another variance regressor in the model. It is a proxy for the depth of the market. The coefficient for the dollar contracts is positive and statistically significant, a feature which is not very common in the literature and for the euro contracts negative and statistically significant. The positive coefficient can be justified with the notion that open interest increases market depth and deeper markets absorb the shocks. The positive coefficient on the other hand can be explained by the diverse direction in the open interest positions, which further increase the volatility in the market.

Finally to conclude, this study analyzed the main determinants that are considered as the significant factors that affect the futures price volatility in the literature. The results show that the Turkish Derivatives Exchange deviates from the other developed markets with the results, due to its infancy. The study should be further extended in order to determine the other factors affecting the futures price volatility of the currency contracts.

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