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 futures contract prices has been widely investigated due to its implications for participants in futures markets. 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 is therefore of crucial importance to all participants in the market. Keeping the high volatility of foreign exchange rates in Turkey, it is necessary to understand the determinants of the volatility of the foreign exchange futures contracts.

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, 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 GARCH(1,1) process and analyzes empirically the relationship of futures price volatility and time to maturity and trading volume and open interest.

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Introduction

In this article, volatility in foreign currency futures contract prices is examined. 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 importance of prices volatility to all participants in futures markets leads one to ask the question: What are the economic determinants of this variable? It is the purpose of this paper to analyze the determinants of volatility and to test empirically the models of individual effect and joint 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 market by using daily data.

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 from February 7, 2005 to September 29, 2011. 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 paper tests the models of individual effects of futures price volatility determinants on the basis of GARCH (1,1) process and analyzes empirically the relationship of futures price volatility and time to maturity and trading volume and open interest.

Previous Literature

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. Moreover, the existing research has come to conflicting conclusions regarding the effect of such variables as time to maturity, trading volume and open interest of each contract on volatility.

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). The GARCH is superior to most volatility models since it is more parsimonious and avoids overfitting.

The GARCH model developed by Bollerslev (1986) and Taylor (1986) allows the conditional variance to be dependent upon previous own lags, so that the conditional variance equation can be expressed as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 \tag{1}$$

Following Equation 1, GARCH(1,1) model is specified as:

$$R_t = c_0 + \varepsilon_t \tag{2}$$

$$\varepsilon_t | \psi_{t-1} \sim N(0, h_t) \quad h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{3}$$

Data and Empirical Results

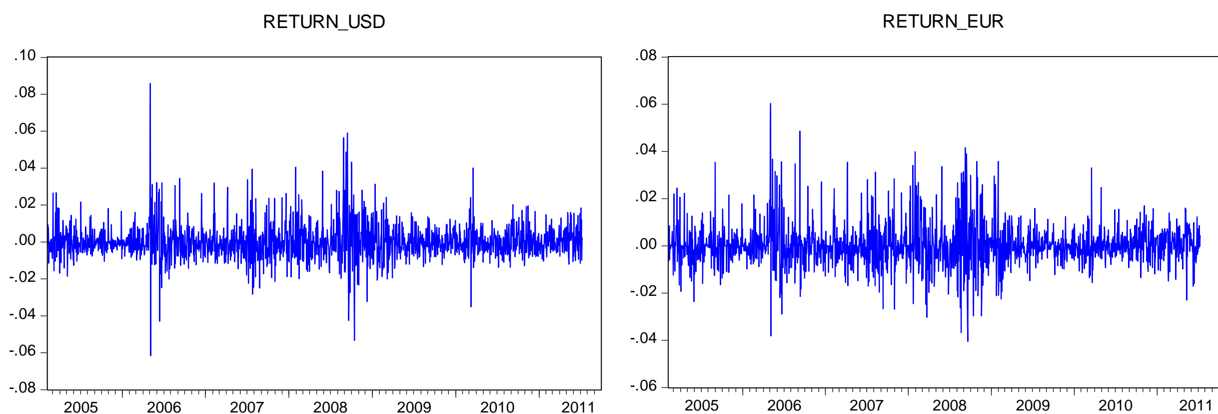
The data consist of the daily prices of United States Dollars and Euro futures contracts that are traded in Turkish Derivative Exchange (TurkDEX) for the period between February 7, 2005 to September 9, 2011.The data is obtained from the web site of TurkDEX. The data also contains the number of days to maturity, the volume of contracts traded and the volume of open interest.

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. In order to analyze the characteristics of the return data Table 1 presents the descriptive statistics.

Table 1. Descriptive Statistics for USD and Euro Futures Contract

	RETURN USD	RETURN EUR
Mean	0.0002	0.0003
Std. Dev.	0.0098	0.0092
Skewness	0.9372	0.8640
Kurtosis	11.2427	7.7773
Jarque-Bera	4989.892	1802.341
	(0)	(0)
Sum	0.414325	0.456078
Sum Sq. Dev.	0.159256	0.140550

Figure 1. Daily Return Series for USD and Euro Futures Contracts: 07/02/2005 to 29/09/2011



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	-19.1724	-30.2557

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

Using Maximum Likelihood GARCH (1,1) model (Equation 3) is estimated for the return series. Table 3 exhibits the estimate results. For stationarity the results should satisfy $\alpha_1 + \beta_1 < 1$ condition. For both futures contracts the sum of alpha and beta is less than one, as required by the theory.

Table 3. GARCH(1,1) Model Estimates

	Estimate Values for USD		Estimate Values for Euro	
	Coefficient	Standard Error	Coefficient	Standard Error
α_0	4.51E-05	0.0002	0.0002	0.0002
α_1	0.1099***	0.0061	0.0894***	0.0069
β_1	0.8662***	0.0082	0.8853***	0.0075

*** represents statistical significance at 1% level.

In order to test the determinants of volatility the paper reestimates the GARCH 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 GARCH model, we estimate the following equation:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \delta \ln t \tag{4}$$

t denoted 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

	Estimate Values for USD		Estimate Values for Euro	
	Coefficient	Standard Error	Coefficient	Standard Error
α_0	4.88E-06***	6.30E-07	4.10E-06***	4.88E-07
α_1	0.1111***	0.0056	0.0884***	0.0064
β_1	0.8738***	0.0072	0.8940***	0.0063
δ	-1.46E-07***	2.22E-08	-1.19E-07***	1.79E-08

*** represents statistical significance at 1% level.

The results show that both for USD and Euro time to maturity has a negative statistically significant effect on the volatility which is in contrast with Samuelson hypothesis. This finding is also supported by Chen et al. (1999). But despite the statistical significance the coefficient for the maturity variable is very small, showing that the effect on the volatility is very low.

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:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \varphi_1 \ln Vol_t \tag{5}$$

Vol stands for the volume of contracts traded. Table 5 summarizes the estimate results. The coefficient for the volume has statistical significance at 1% level, whereas again 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).

Table 5. Volatility and Trading Volume

	Estimate Values for USD		Estimate Values for Euro	
	Coefficient	Standard Error	Coefficient	Standard Error
α_0	1.43E-06***	1.54E-06	6.19E-06***	1.27E-06
α_1	0.1090***	0.0059	0.0870***	0.0075
β_1	0.8681***	0.0081	0.8914***	0.0084
φ	1.43E-07***	2.35E-07	-7.67E-07***	1.99E-07

*** represents statistical significance at 1% level.

The paper later investigates the effect of open interest on the volatility. The volume of open interest is also tested in the variance equation:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \varsigma_1 \ln OI_t \tag{6}$$

OI represents the volume of open interest. According to the estimate results which are presented in Table 6, the volume of open interest is not a significant volatility factor for USD futures contracts. Euro futures contracts are in line with the recent literature pointing to the effects of open interest on volatility, but again the coefficient is very low.

Table 6. Volatility and Open Interest

	Estimate Values for USD		Estimate Values for Euro	
	Coefficient	Standard Error	Coefficient	Standard Error
α_0	2.82E-06**	1.39E-06	6.58E-06***	1.23E-06
α_1	0.1085***	0.0059	0.0855***	0.0074
β_1	0.8700***	0.0078	0.8900***	0.0084
ς	-9.60E-08	2.93E-07	-1.33E-06***	3.02E-07

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

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 February 7, 2005 to September 29, 2011.

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, GARCH (1,1) model is used for calculating the volatility of the futures returns. Putting the determinants in the variance regression, the paper aims to analyze the effects of maturity, trade volume and open interest on the volatility.

The results of the study show that as a contract approaches to maturity the volatility decreases. Trading volume also has a positive and statistically significant affect. Despite the statistical significance of these two variables, their magnitude is very low. The Euro futures contracts' volatility is also affected from open interest, but again with very small coefficients. The volatility seems not to be affected by these variables.

Finally to conclude, the main variables that are considered significant factors that affect the futures price volatility in the literature are not found to have an effect in USD and Euro future contracts. The study should be further extended in order to determine the significant factors affecting the futures price volatility.

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