THE EFFECT OF BRSA DECISIONS ON EXCHANGE RATE EXPECTATIONS

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To my family…

ABSTRACT

Risk-neutral distributions (RND) of currency options are useful for predicting the price movements of future exchange rates, valuing financial derivatives, and applying appropriate monetary policy. This study examines the swap restriction regulations applied by the BRSA to prevent USD/TRY exchange rate shocks after the diplomatic crisis with the USA. These regulations restricted offshore swap transactions in which Turkish banks give foreign currency and receive Turkish Lira to foreign banks at maturity.

Risk-neutral distributions (RND) are obtained for all maturities using the non-parametric Malz approach. The RND findings obtained indicate a deterioration in the expectations regarding the USD/TRY exchange rate for all maturities following the swap restrictions. In addition to the visual representation, sharp movements in exchange rate expectations are displayed with moments of RNDs up to the 4th degree. Moreover, the impact capacity of regulatory decisions taken by the BRSA, the moments of RNDs up to the 4th degree, and the relationship between global factors is examined with the established model. The findings indicate that the effect of the regulations is temporary.

Keywords:

Risk-neutral distributions, Market expectations, Swap transactions, Options, Non-Parametric Malz Approach.

ÖZETÇE

Döviz opsiyonlarının riskten bağımsız dağılımları (RND), gelecekteki döviz kurlarının fiyat hareketlerini tahmin etmek, finansal türevlerin değerlemesini yapmak ve uygun para politikasını uygulamak için kullanışlıdır. Bu çalışma, ABD ile yaşanan diplomatik kriz sonrasında Bankacılık Düzenleme ve Denetleme Kurulu'nun (BDDK) USD/TRY kur şoklarına önlemek için uyguladığı swap kısıtlama düzenlemelerini incelemektedir. Bu düzenlemeler, Türk bankalarının vade sonunda yabancı bankalara döviz verip Türk Lirası aldığı offshore swap işlemlerine sınırlama getirmiştir.

Parametrik olmayan Malz yaklaşımı kullanılarak tüm vadeler için riske duyarsız dağımlımlar (RND) elde edilmiştir. Elde edilen RND bulguları, alınan kararların ardından tüm vadeler için USD/TL kuruna ilişkin beklentilerde bozulmaya işaret etmektedir. Görsel temsilin yanı sıra 4. Dereceye kadar olan RND momentleri ile kur beklentilerine ilişkin keskin hareketler göz önüne serilmiştir. Ayrıca, BDDK tarafından alınan düzenleyici kararların etki kapasitesi, 4. dereceye kadar RND momentleri ve küresel faktörler arasındaki ilişki kurulan model ile incelenmektedir. Bulgular düzenlemelerin etkisinin geçici olduğuna işaret etmektedir.

Anahtar Kelimeler:

Riske duyarsız dağılımlar, Piyasa beklentileri, Swap işlemleri, Opsiyonlar, Parametrik olmayan Malz yaklaşımı.

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CHAPTER I

INTRODUCTION

Economic and financial developments are often analyzed using information embedded in the prices of financial assets by market participants and policymakers operating in the financial markets. In recent years, derivative markets have expanded significantly, and products such as futures and options are gaining popularity. As essential instruments, market participants and policymakers rely on market expectations concerning the future price movements of assets. Estimating a risk-neutral distribution (RND) is one of the most frequently used techniques for extracting expectations. RND estimation can be used to calculate underlying asset prices using options market prices.

The information provided by risk-neutral density regarding the distribution of future asset price values enables us to derive the price of assets. In this perspective, many organizations find the information incorporated in RNDs to be significant. Using RNDs, for instance, central banks routinely monitor changes in market expectations. By implementing this method, they can more effectively monitor and assess market trends and expectations. RNDs are capable of anticipating the possibility of sharp price fluctuations in underlying assets. In this regard, they might be useful in foreseeing crises, vital for policymakers.

The RND estimation methodology is founded on research conducted by [1]. They demonstrated that RND can be expressed as a function of the second derivative of the call option price with respect to the strike price. By applying the findings of [1], it is possible to forecast RND for any underlying asset. Since market participants are interested in the anticipated future values of the exchange rate, RND estimation for exchange rates is highly widespread. Information regarding exchange rates and pricing techniques for FX (Foreign Exchange) options are essential for policymakers regarding exchange rate risk management and financial stability.

Türkiye is a developing country and exchange rate dynamics are fundamental. In this context, policymakers in the Türkiye monitor financial stability and inflation by taking these dynamics under control. All institutions, especially the Central Bank of Türkiye (CBRT) work together to achieve this goal. For this reason, some regulations are made in institutions such as the Banking Supervision and Regulatory Authority (BDDK) to support the decisions taken by the CBRT. In August 2018, Türkiye experienced a diplomatic crisis with the USA. As a result, the Turkish Lira lost value against the US dollar and an exchange rate shock occurred. To reduce the unpredictability in the USD/TRY exchange rate and prevent currency attacks, the CBRT took measures to support financial stability and maintain the effective functioning of the markets. In addition to the CBRT's efforts, the BRSA has made some regulatory changes. The measures the BRSA took are related to the restriction of banks' offshore swap transactions. This study examines three regulations made by the BRSA in August 2018. According to [2], on 13 August 2018 the initial stage of the regulation reform involves setting a limit on the total amount of currency swaps and other products (including spot and future FX transactions) involving foreign counterparties. Local banks receiving FX and paying TRY at the beginning date are limited to not exceeding 50% of their regulatory capital. As a result, no further transactions of this nature should be executed, and maturing transactions should not be renewed, until the present surplus is eliminated. The aforementioned ratio must be calculated individually and consolidated daily. For a designated period, this action has augmented the difficulty for domestic banks to fulfill their foreign exchange requirements when operating from abroad. Additionally, access to the Turkish Lira has been restricted for foreign banks. Local banks were compelled to employ alternative strategies to satisfy their FX requirements. The second step of regulation announcement was made two days later. This phase of the regulation was announced on 15 August 2018, and introduced the restriction on wrong-way transactions, by limiting them at 25 percent of local banks' regulatory capital. The extent of the restriction on wrong-way transactions is enlarged two days after the second step. The third step of regulation on 17 August 2018 is to include derivative transactions such as options and forwards with banks to the previously introduced swap limits, which will receive TRY at maturity, within the scope of the limitation. The swap restriction rate remained the same.

This study generates the RND for the USD/TRY exchange rate by employing the non-parametric Malz approach and an extensive array of European FX options. To estimate RNDs for exchange rates, this method is among the most widely employed due to its adaptability and exceptional data fit. Academic studies and major central banks have acknowledged its advantages. In this study, it is examined how the regulations made by the BRSA affect the RNDs, the moment of RNDs, and market expectations. In addition, the constructed model is used to evaluate whether the changes in RND moments are related to the four global indicators. These are VIX, DXY, JPMVXYG7 Index and JPMVEM1M Index. Detailed information about the global indicators used is in the data section.

The remainder of the study is structured as follows: the next section presents a complete assessment of the literature about the extraction of RNDs, discussing the pros and drawbacks of various extraction methods. The study's data and methodology are then described in depth. The results section covers the RND estimation and model findings in detail, and the conclusion section provides closure.

CHAPTER II

LITERATURE

One of the most critical issues for market participants and policymakers is market expectations because they have to act according to market expectations to make a suitable investment or policy. There are many methods for measuring market expectations to do this. For example, many Central Banks provide information about market expectations from surveys they conduct every month. Another method to evaluate market expectations is to interpret market expectations by examining the price of financial instruments. One of the most suitable financial instruments to do this is options. Market expectations can be followed by obtaining risk-neutral densities (RND) from option prices. For this reason, extensive literature examines market expectations from option prices.

The idea of estimating the RND implied by options prices was first contended by [1]. The motivation for this idea was that derivative markets have a rich source of forward-looking financial expectations. One way to extract this information is to estimate the asset's implicit probability distribution from the observed prices of options contracts on the asset traded in financial markets. The risk-neutral distribution from option prices is widespread in the literature. The purpose of applying this method is to analyze market expectations. [1] demonstrated that the RND can be calculated from option prices. They explained that the second partial derivative of the call-pricing function concerning the strike price is directly related to the RND function.

The approaches utilized in scholarly works to obtain value options or risk-neutral densities fall into two categories: structural and non-structural models. Given the focus of this investigation on non-structural models, a concise overview of the literature regarding structural models is provided. Nonstructural models estimate the RND without considering the price dynamics of the underlying asset, whereas structural models provide an exhaustive description of the stochastic process of the asset. Structural models aim to enhance the [3] by employing empirical characteristics of asset returns to simulate the stochastic process of the underlying asset. Within this framework, two accepted methods exist. The models in question are stochastic volatility and jump diffusion. Structural models are infrequently employed for RND estimation and encompass numerous unidentified parameters.

Non-structural models are concerned with the RND distribution rather than the asset's price dynamics. The models can be categorized into three distinct groups: parametric, semi-parametric, and non-parametric. Parametric models provide a comprehensive description of the RND process, whereas semi-parametric and non-parametric models propose certain methodologies for RND. [4] estimated RND utilizing the parametric procedure. Their study utilized a combination of three lognormal distributions to model RND. They conducted an analysis of crude oil prices during the 1991 Gulf crisis by employing crude oil options. [5] examine fluctuations in risk-neutral densities derived from FX options that were exchange-traded during the period surrounding the Quebec referendum in a separate article. From the options data, they compute the predicted values, standard deviations, and weights using a combination of three lognormal densities to explain the implied exchange rate density. Semi-parametric models comprise additional non-structural models. The primary aim of these models is to provide an approximation of the distribution of option values at maturity. [6] propose the Edgeworth expansion centered on the lognormal distribution as a suitable approximation for option valuation in this regard.

Non-parametric approaches offer considerable flexibility in the estimation of RND due to the inherent limitations of parametric methods. Non-parametric techniques fall into three distinct categories. Curve-fitting models, tree-based models, and kernel regression models are examples. Using kernel regression, [7] extracted RNDs from S&P 500 index option prices. Kernel regression ensures the consistency of results over time, as opposed to parametric approaches that estimate risk-neutral density for each cross-section of options. Kernel regression takes into account both time series and cross-sectional option prices. The efficacy of kernel regressions is constrained by the substantial amount of data that is demanded. By integrating time series and cross-sectional option prices, kernel regression generates estimates that exhibit temporal consistency. [8] first used a tree-based model in his article. The literature on inferred trees began with three publications published roughly simultaneously. Possibly the most well-known is Rubinstein's 1994 Presidential Address to the American Finance Association, in which he demonstrated how to fit binomial trees that replicate the RNDs retrieved from options prices. It was difficult for Rubinstein to accommodate a well-mannered left tail into the RND. Therefore, he chose to implement a Bayesian prior for the RND using a lognormal density. To improve the approximation, [9] modified Rubinstein's binomial lattice. On the contrary, [10] put forth an alternative extension that utilized an Edgeworth expansion to conform to the RND and subsequently constructed a tree that mirrors the outcome of the expansion. [11] adapted an implied trinomial lattice, whereas [12] derived a binomial tree using option prices. On the contrary, [12] constructed a tree by integrating multiple maturities in order to match RNDs for distinct expiration dates simultaneously.

Another RND estimation method is fitting volatility smile onto the space of strike prices or deltas. The first approach to this issue is the study of [13]. He was the first to propose transforming option prices into implied volatilities, interpolating and smoothing the curve using a cubic spline or a low-order polynomial, and converting the smoothed implied volatilities back into price space and extracting an RND from the resulting dense group of option prices. An additional well-known article on this subject is [14] suggestion to use option deltas rather than strike prices and a quadratic function to smooth the volatility smile, given that delta smiles provide a more consistent degree of smoothness. The volatility smile is modeled in this study with respect to deltas utilizing the constrained cubic spline method as described by [15]. Malz's methodology is extensively used in practice since it is simple to execute and produces accurate results relative to actual data. Comparing the models proposed in prior research, their merits and disadvantages vary. However, nonparametric models are often used due to their adaptability and high data fit.

Much research indicates that the risk-neutral density may be retrieved from market option prices using several distinct techniques. There are many articles examining this comparison. [16] investigated various estimating strategies and concluded that there needs to be more distinction between them. [17] provide a significantly more recent summary of numerous techniques for extracting RNDs, including structural and non-structural methods, parametric, semiparametric, and nonparametric approaches. They also examine multiple estimation strategies for RNDs using options written on the French stock index of CAC40. [18] comprehensively reviews prior research on estimating RNDs. Using both parametric and nonparametric approaches and evaluating the benefits and drawbacks of each, he estimates RNDs for London International Financial Futures and Options Exchange (LIFFE) index options by comparing the advantages and disadvantages of each.

As mentioned, RND is a method to understand and analyze market expectations. Market expectations can be affected by many events. Sometimes, these events can affect the market, such as new information, a new monetary policy announcement, or an election. There are many articles examining the change of RND due to events. Positive news, according to [19] reduces implied volatility and reduces the leftward skewness of the RND function while increasing its kurtosis. Negative news, on the other hand, causes an increase in implied volatility, a leftward shift in the RND, and a reduction in its kurtosis. [20] investigates the functions of the RND in the context of European Central Bank meetings. By employing a curve-fitting technique within the domain of implied volatility, he concludes that the estimated implied RND functions are not observably affected by ECB meetings. [21] examine the market crisis that occurred in September 2008. They investigate intra-day changes in the RND implied by S&P 500 index options and the impact of news on it. [22] examine British elections. Using the two-lognormal technique, they extract the RNDs from FTSE options and find that it helps indicate market sentiment during elections but lacks predictive capacity. Some studies examine how changes in monetary policy affect market expectations. [23] studies the effect of monetary policy decisions on the RNDs derived from options on currencies of new European Union member states. Another is that [24] examines the changes in market expectations on future UK monetary policy from June to November 1992 about the ERM crisis. It generates RNDs from the daily mark-pound exchange rate option prices. Some studies analyze the effect of Central banks' intervention on RND. [25] and [26] analyze the JPY/USD exchange rate reaction that ensued after the Bank of Japan intervention. The initial analysis reaches the conclusion that yen market interventions are correlated with systematic fluctuations in the distribution of the JPY/USD exchange rate. Nevertheless, the findings of the second study indicate that the moments of the exchange rate are not significantly impacted. [27] also examine the Japanese market. They provide evidence that interventions change both the mean and the skewness. [28] conducted a study on the effects of Brazilian central bank swap interventions on the foreign exchange market between 2006 and 2013. The researchers utilize the event study methodology, which is appropriate for analyzing the cumulative impact of intervention events. They examine the effect on the risk-neutral distribution of the BRL/USD exchange rate. Their findings indicate that interventions have little impact on the distribution of exchange rates.

In addition to the studies mentioned above on market expectations, there are also studies on Türkiye, which is the subject of study, in the literature. One of these studies is the study of [29]. They estimated the RND functions for USD/TRY currency options by employing the approach in [14]. They investigated the informal content of RNDs between 2006 and 2008, when financial markets were more volatile. Another study about Türkiye is the study of [30]. Using the approach in [15], they employed FX options to estimate RND for the USD/TRY exchange rate.

CHAPTER III

DATA

This section describes the data utilized in the estimation of risk-neutral density. The first part of this section contains information about data from Bloomberg, the second part is about the option strategies included in the study, and the last part contains delta information. After explaining the data used in the research and delta, RND is focused on. By employing European FX options denominated in USD/TRY, this study computes RND for 1, 3, 6, and 12 months. In order to estimate RND, at-the-money Bloomberg quotations for the USD/TRY currency rate and risk reversal, butterfly strategies with deltas of 10, 25, and 35, and butterfly strategies are utilized. Furthermore, the USD/TRY forward implied rate and USD LIBOR interest rate are employed as domestic and foreign currency rates, respectively, in conjunction with these data. Another input is the USD/TRY current exchange rate data from Bloomberg at the end of the day. To analyze the moments of RNDs in the regression model, the variables VIX, DXY, JPMVXYG7 Index, and JPMVEM1M Index will be utilized. From January 2018 until December 2019, the dataset comprises daily observations of each of the aforementioned variables, with all data sources being Bloomberg.

3.1 Bloomberg Currency Options and Other Data

Option contracts on the USD/TRY exchange rate are traded on both organized and over-the-counter (OTC) markets. However, organized market trade volume is deficient, whereas over-the-counter (OTC) markets are where the majority of options trades transpire. As a result, the data for this analysis are FX option contracts quoted and traded on over-the-counter (OTC) markets, as provided by Bloomberg.

Bloomberg provides data on currency options for various currency pairs and constant maturities. Bloomberg provides the three required contracts for implementing non-parametric approaches. These three contracts are strangles, straddles, and risk reversal. There may be some confusion because the contracts on Bloomberg have different identities than those in the original Malz paper. The only required value for a straddle is the at-the-money implied volatility. The risk reversal is still referred to as such, but the equivalent contract for strangles is now known as a butterfly. The naming convention is uniform across currency combinations, with the first six letters of the code representing the respective currency pair, which is USDTRY for this study. The subsequent letters refer to the form of the contract and its pricing delta. For at-the-money volatility, it's necessary V, for butterflies B, and for risk reversals, R. Also required for the butterfly and risk reversal is a delta value. 10, 25, and 35 delta contracts can be obtained for most currency combinations. The last two letters of the mnemonic represent the range of available constant maturities. To give an example for better understanding, “USDTRY10R1M” is the code used for risk reversal for USD/TRY options with 1-month maturity and 10 delta.

Besides the currency options, there are some variables to use in the regression model. The first of these is DXY. It shows the value of the US dollar against a basket of currencies from the country's major trading partners. The second variable used in the model is VIX. The market's expectations for the relative strength of impending price changes in the S&P 500 indicator are reflected in the real-time hand known as VIX. Market participants carefully follow this indicator in terms of market expectations. The third variable used in the model is the JPMVXYG7 Index. This index shows the level of implied volatility in G7 economies. JPMVEM1M Index constitutes the fourth variable in the model. This index measures the implied volatility of emerging market economies.

3.2 Option Strategies

Options are implemented as part of particular trading strategies. Risk reversal, at-the-money, and butterfly options are all transacted as combinations of standard FX call and put options. Risk reversal, at-the-money, and butterfly option strategies are the most well-known. The subsequent subheading provides details pertaining to three distinct option strategies and various forms of deltas.

3.2.1 At the Money (Straddle)

The implied volatility of a delta-neutral straddle position is what Bloomberg quotes for at-the-money options. Straddle positions involve the purchase of at-the-money call and put options with identical strike prices and maturities, resulting in a portfolio delta of zero. This approach allows investors to profit regardless of the direction of price movement for the underlying asset. Accordingly, the following is a description of the implied volatility quotation at the money:

$$atm_t = \sigma_t(Delta - Neutral\ Straddle) \qquad (1)$$

Figure 1 shows straddle positions. The long straddle involves purchasing a put and a call with the same strike price and expiration date. The long straddle is designed to capitalize on the market price change by taking advantage of increased volatility. Long straddle positions put investor in a position to profit regardless of the direction in which the market's price moves. The other strategy is the opposite. The short straddle entails selling a put and a call option with the same strike price and expiration date. By selling the options, market participants can profit from the premium. They can only profit from a short straddle when the market's volatility is minimal or nonexistent. Profitability will entirely depend on the market's inability to rise or fall.

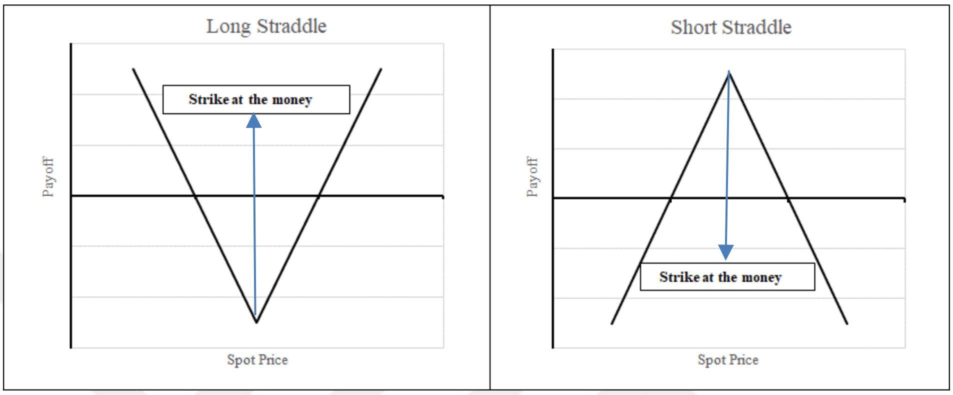

Figure 1: Long and Short Straddle

3.2.2 Butterfly (Strangle)

The butterfly strategy involves a portfolio that includes long positions in out-of-the-money call and put options, as well as short positions in at-the-money call and put options. A butterfly structure can be defined as a merging of a straddle and a strangle. The difference of the average volatility of out-of-the-money call and put options and the volatility of at-the-money call and put options are utilized to calculate this value. Accordingly, the following is a description of the butterfly strategy.

$$btf_t(\delta) = \left(\frac{\sigma_t^{call}(\delta) \; + \sigma_t^{put}(\delta)}{2} \; - \; atm_t \right) \qquad (2)$$

Figure 2 depicts strangle positions. A long butterfly occurs when an investor purchases an out-of-the-money call option and a put option simultaneously. The strike price of the call option is higher than the current market price of the underlying asset, while the strike price of the put option is lower than the asset's market price. If the price of the underlying asset increases, the call option has the potential for unlimited profit, whereas a put option can yield a profit if the price of the underlying asset decreases. An investor executes a short butterfly by selling an out-of-the-money put and a call option simultaneously. This strategy has a restricted potential for profit and is impartial. A profitable short strangle occurs when the price of the underlying asset fluctuates within a narrow range that separates the breakeven and profit positions.

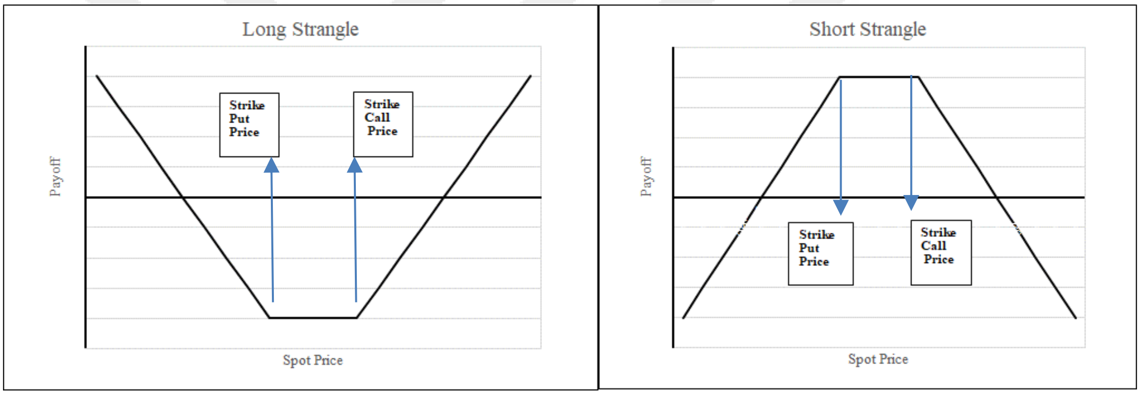

Figure 2: Long and Short Strangle

3.2.3 Risk Reversal

The purchase of an out-of-the-money call option and the selling of an out-of-the-money put option with the identical maturity constitute a risk reversal strategy. The quotation for risk reversal can be expressed as follows:

$$rr_t\,(\delta) = \sigma_t^{call}(\delta) - \sigma_t^{put}(\delta) \tag{3}$$

Figure 3 illustrates positions of risk reversal. In this strategy, a long position aims to generate profits from an increase in the value of the underlying asset, the expense of which is diminished through the selling of the put option. Market participants adopt a short risk reversal position by selling a call option and acquiring a put option.

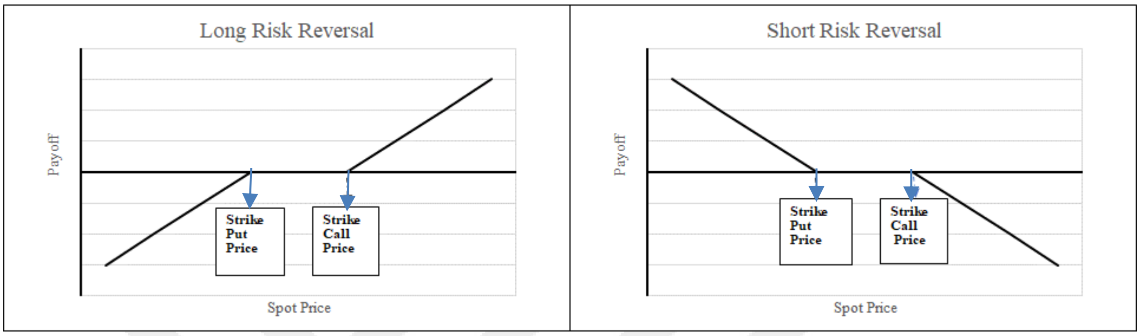

Figure 3: Long and Short Risk Reversal

3.3 Delta

Delta is a critical metric as it represents the ratio of change in the value of an option in relation to a unit change in the price of the underlying asset. The approach is deemed favorable for determining the pricing of currency options due to its provision of an estimation that is exclusively predicated on the asset price, exercise price, and volatility. This signifies that a pricing schedule is furnished to account for fluctuations in the price of the fundamental asset.

Delta can be represented in two forms for FX options: spot delta and forward delta. The USD/TRY market quotation, on the other hand, is determined by the spot delta. The spot delta represents the quantity of foreign currency necessary to purchase one unit of foreign currency at maturity in order to hedge a short option position. The mathematical expression for the spot delta, as described by the Black-Scholes model, is as follows:

$$C_t^{BS} = S_t e^{-rf\tau}\Phi(d_1) - Ke^{-r\tau}\Phi(d_2) \tag{4}$$

$$\delta = \frac{\partial C_t^{BS}}{\partial S_t} = e^{-rf\tau}\Phi(d_1) \tag{5}$$

where $$d_1 = \frac{log\left(\frac{S_t}{K}\right) + (\, r - r_f + \frac{\sigma^2}{2})\tau}{\sigma\sqrt{\tau}} \qquad d_2 = d_1 - \sigma\sqrt{\tau} \tag{6}$$

For a better understanding of the model, it is necessary to know that $r,\ r_f, \Phi, K, \tau, \sigma, and\ S_t$ are abbreviations for domestic currency rate, foreign currency rate, cumulative normal distribution, strike price, time to maturity, implied volatility and spot exchange rate, respectively. Formally, delta can be expressed as a function of a set of known parameters and one unknown parameter. Implied volatility, one of these parameters, is a measure of the uncertainty of the asset price at the expiry date. Delta corresponds to a specific implied volatility value. It is known that the delta can only fluctuate between 0 and 1.

CHAPTER IV

METHODOLOGY

The regression model and RND estimation method are detailed in this section. The RND estimation method is described initially. Data adjustment, which attempts to convert the implied volatilities of structured FX options (e.g., at-the-money, butterfly, and risk reversal) to implied volatilities of vanilla call/put options with variable deltas, is the initial step in RND estimation. Nevertheless, explicit observation of implied volatilities for vanilla options is not possible. For delta levels of 0.10, 0.25, and 0.35, Bloomberg provides information regarding the implied volatility of risk reversal and butterfly structured products, as well as the implied volatility of a delta-neutral straddle for an at-the-money option. Implied volatilities for vanilla call and put options on deltas can be determined by utilizing quotations for risk reversal, butterfly, and at-the-money options. The equations are below:

$$\sigma_t^{call}(\delta) = btf_t(\delta) \; + \; atm_t + \frac{rr_t(\delta)}{2} \tag{7}$$

$$\sigma_t^{put}(\delta) = btf_t(\delta) + atm_t - \frac{rr_t(\delta)}{2} \tag{8}$$

In this stage, the implied volatilities of standard call and put options featuring deltas of 0.1, 0.25, and 0.35 are computed directly utilizing the mentioned equations. The subsequent procedure entails delineating the RND estimation methodology. Initially, the implied volatility levels and obtained delta space are utilized by the clamped cubic spline approach to estimate the implied volatility curve. The volatility curve is estimated by the subsequent equation utilizing deltas derived from call option contracts.

$$\sigma_t^{malz}(\delta) = \gamma_1 + \gamma_2(\delta - \delta(atm_t)) + \gamma_3(\delta - \delta(atm_t))^2 + \gamma_4(\delta - \delta(atm_t))^3 \quad (9)$$

The clamped-cubic spline method generates fitted implied volatility that nearly matches the data by employing implied volatilities for each of the seven daily deltas. After determining implied volatility as a delta function, the prices of call options are ascertained. The risk-neutral density is determined by the second derivative of the call option price with respect to the strike price. The prices of call options are computed for every strike price by employing the implied volatility function in the presence of delta. As demonstrated below, risk-neutral density is calculated by the second derivative of the call option price with respect to the strike price, following the acquisition of the call option pricing for each strike.

$$f_Q(K) = e^{r\tau} \frac{\partial^2 C_t^{BS}(K)}{\partial K^2} \quad (10)$$

Figure 4 summarizes the non-parametric Malz approach. Accordingly, RND estimation can be done in 6 steps. The steps are getting the data used from Bloomberg, making the necessary data adaptations, determining the points for the volatility smile, fitting the curve using the clamped cubic spline method and finding the option price for each strike price and delta. The last step is to obtain risk-neutral distributions by taking the derivative of the calculated option prices according to the strike price.

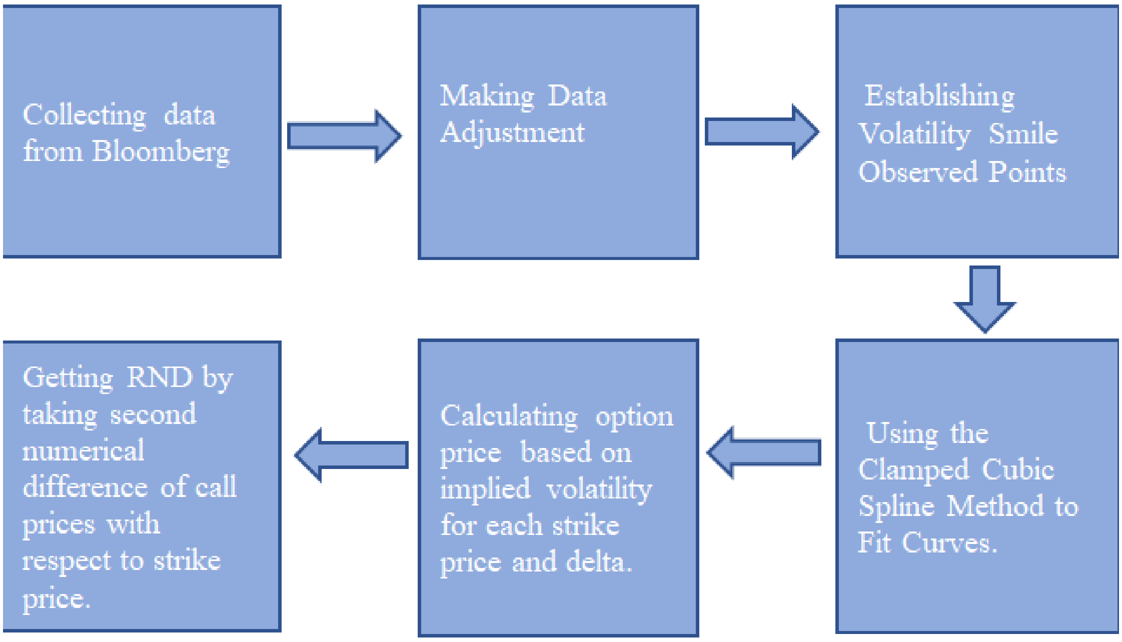

Figure 4: Stages of obtaining RND with Non-Parametric Malz Approach

In the second part of this chapter, the constructed model is discussed. In the regression, the effects of BRSA decisions on the moments of RND are examined using VIX, DXY, JPMVXYG7 Index and JPMVEM1M Index variables. The model contains two dummy variables that indicate whether there is a temporary or permanent effect. The first dummy variable, $dummyTEMP$, shows the temporary effect represents ten working days and, the second dummy variable, $dummyPERM$, examines the permanent effect in the days that have passed since the first day of the decision.

The following model evaluates the temporary and permanent effect produced by the information mentioned above.

$$Moment^{RND} = \beta_0 + \beta_1 VIX + \beta_2 DXY + \beta_3 JPMG7 + \beta_4 JPMEM + \beta_5 dummyTEMP + \beta_6 dummyPERM \tag{11}$$

The moments of RND effect of the decisions the BRSA took have been examined. In this model, the results and detailed information are included in the results section.

CHAPTER V

RESULTS

5.1 Empirical Results

In this part of the study, how the decisions taken by the BRSA affect the USD/TRY exchange rate expectations is examined with the obtained RNDs. In addition to these results, movements of moments up to the 4th degree are analyzed. In the last part of the chapter, whether the effects of the decisions taken in the established model are temporary or permanent and the statistical relationship between global variables are examined. As mentioned in the previous sections, RND provides essential information regarding the expectations of market participants. Therefore, it is an excellent way to interpret the expectations of exchange markets with RND analysis.

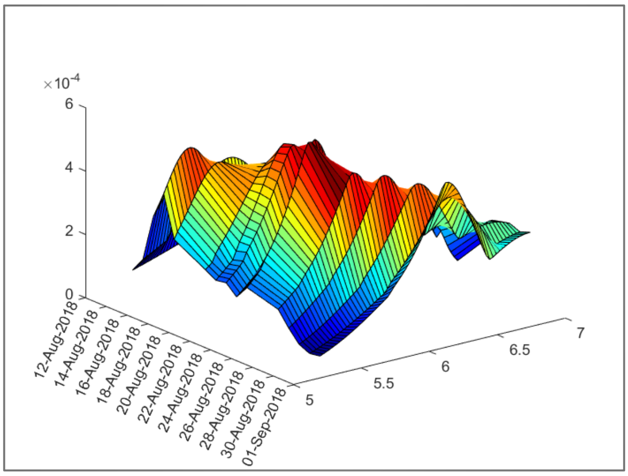

Figure 5: RND (1 Month)

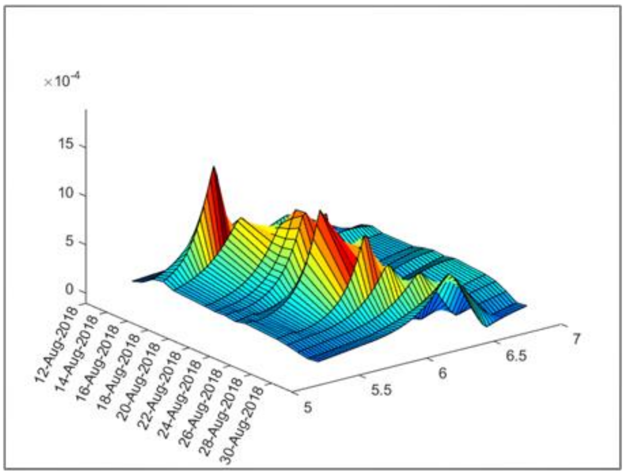

Figure 6: RND (3 Month)

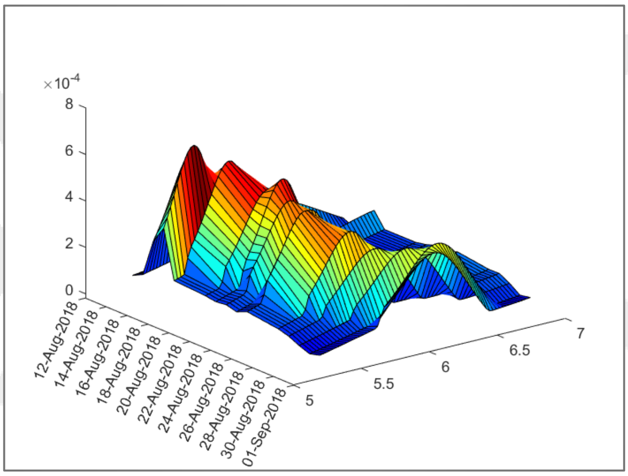

Figure 7: RND (6 Month)

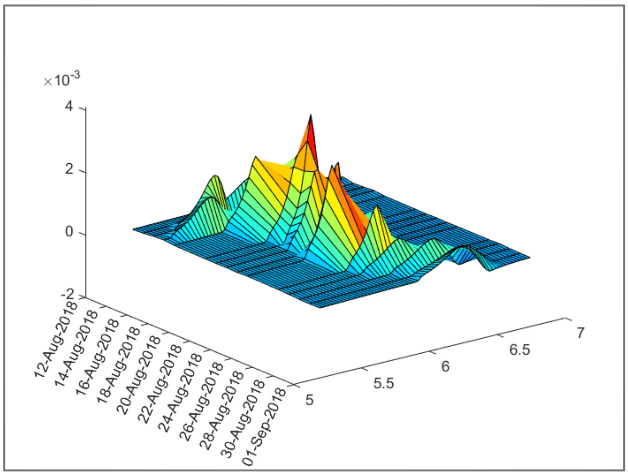

Figure 8: RND (12 Month)

The graphs above show the RND analysis for 1-month, 3-month, 6-month, and 12-month maturities. It includes fifteen working days after the first announcement for

RND estimation. The deterioration in expectations regarding the value of the Turkish lira against the US dollar is reflected in the charts. Although it is valuable to examine the fluctuations in risk-neutral densities at different time intervals, a more illuminating approach would be to scrutinize the methodical transformations of the distribution's moments, specifically the mean, standard deviation, skewness, and kurtosis. The mean in this study signifies the expectations of market participants regarding the USD/TRY exchange rate at maturity. The uncertainty associated with the expectations of market participants is reflected in the standard deviation. The skewness of a risk-neutral distribution, which measures the expectations of market participants regarding the future pattern of exchange rates, signifies the asymmetry of the distribution. Kurtosis is commonly employed to measure the likelihood of extreme events.

Figure 9: Mean of RND

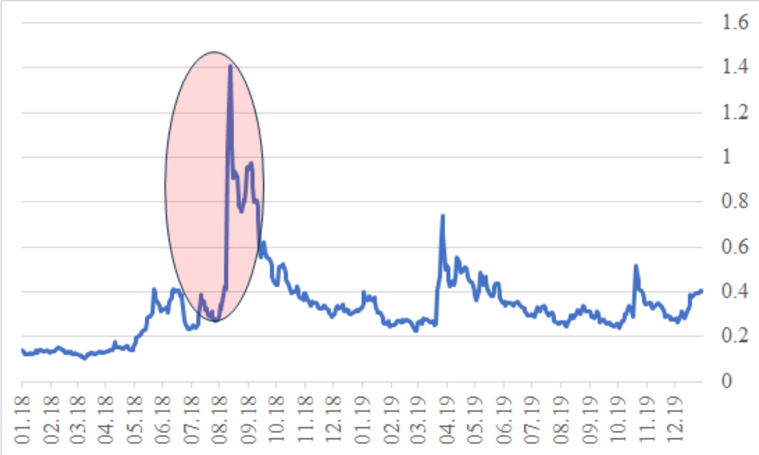

Figure 10: Standard Deviation of RND

Figure 11: Skewness of RND

Figure 12: Kurtosis of RND

As shown above, the progression of moments of 1-month USD-TRY options from 2018 to 2019 is illustrated. The graph's shaded regions indicate the abrupt fluctuations observed in the values. Consistently increasing since the start of 2018, market expectations regarding upcoming exchange rates peaked in August of this year. Following its peak, it has since stabilized at a lower level. The standard deviation of the risk-neutral distribution remains primarily contained inside a band until May 2018. Nevertheless, a substantial increase in the standard deviation is observed, signifying the extent of unpredictability surrounding projections for exchange rates in the third quarter of 2018. The fluctuations in the skewness, a metric used to assess the expectations of market participants regarding the future pattern of exchange rates, were evident during the period spanning from 2018 to 2019. Finally, kurtosis, which measures the probability of major fluctuations in the future exchange rate, shows similar patterns to skewness.

The Table 1 is included to observe the change in the moments of the RNDs related to 1-month maturity. This table consists of the date two weeks before the first announcement by BRSA, the announcement dates, and the date two weeks after the third announcement. According to the table, it is seen that there is an increase in all moments of RND until the first announcement. When the date of the first announcement on August 13 and the date of the last announcement on August 17 are examined, it is observed that all moments of RND have decreased. However, after the last announcement date, there has been an increase in moments of RND. As proof of this, it can be said as 31 August moments of RND values.

Table 1: Implied Moments

Date	Mean	Std. Dev	Skewness	Kurtosis
30.07.2018	4.95	0.28	1.02	4.69
13.08.2018	7.02	1.40	1.47	6.36
15.08.2018	6.12	1.04	1.49	6.62
17.08.2018	6.15	0.94	1.37	6.03
31.08.2018	6.67	0.94	1.50	6.61

After examining the changes in moments of RND, the relationship between global financial developments and moments of RND for 1,3,6 and 12 maturities are reviewed with the established model's help. The based model examines the relationship of each RND moment with VIX, JP Morgan G7 Volatility Index, JP Morgan EM Volatility Index and DXY. At the same time, dummy variables are used to show whether the effect of the announcements is permanent or temporary. As mentioned in the methodology section, the first ten working days after the first announcement is considered to show the temporary effect. For the analysis of the permanent impact, the date from the date of the first announcement until the end of 2019 is considered.

Table 2: Regression Results for Mean

Maturity	Independent Variable	Coefficient	Std. Error	t-Statistic
1 Month	C	0.041	0.02	1.93
	VIX	-0.002*	0.00	-1.75
	JPMVXYG7	-0.046*	0.03	-1.72
	DXY	0.036***	0.01	4.45
	JPMVEM1M	0.131***	0.05	2.77
	Temporary Effect	-0.049***	0.01	-4.66
	Permanent Effect	-0.01*	0.01	-1.70
3 Month	C	0.043	0.02	1.96
	VIX	-0.002*	0.00	-1.78
	JPMVXYG7	-0.039*	0.02	-1.72
	DXY	0.037***	0.01	3.86
	JPMVEM1M	0.132***	0.05	2.86
	Temporary Effect	-0.039***	0.01	-3.77
	Permanent Effect	-0.011*	0.01	-1.80
6 Month	C	0.043	0.02	1.94
	VIX	-0.002*	0.00	-1.75
	JPMVXYG7	-0.048**	0.02	-2.56
	DXY	0.018	0.01	1.60
	JPMVEM1M	0.128***	0.04	2.86
	Temporary Effect	-0.029**	0.01	-2.45
	Permanent Effect	-0.014**	0.01	-2.03
12 Month	C	0.047	0.02	2.28
	VIX	-0.002**	0.00	-2.03
	JPMVXYG7	-0.033*	0.02	-1.81
	DXY	0.02*	0.01	1.69
	JPMVEM1M	0.1***	0.03	3.00
	Temporary Effect	-0.005	0.01	-0.37
	Permanent Effect	-0.017**	0.01	-2.39

*** Significant at 0.01, ** Significant at 0.05, * Significant at 0.1.

Each moment of the RND is examined on a maturity basis. Firstly, the mean of RND is mentioned in Table 2. The DXY variable is statistically significant for mean, especially for the short term. In other words, it can be said that the global strength of the dollar index, DXY, has been effective in the depreciation of the TL. Furthermore, the JPMVEM1M index demonstrates statistical significance for the mean across all maturities. Thus, it can be stated that volatility also influences market expectations in emerging market economies. To comment on the effect of the decisions taken, the impact of the decisions taken on the improvement in the expectations of the market participants on the USD/TRY exchange rate is temporary. In other words, market participants believe that the decisions made by BRSA will not have a lasting impact on the value of TL.

Table 3: Regression Results for Standard Deviation

Maturity	Independent Variable	Coefficient	Std. Error	t-Statistic
1 Month	C	0.357	0.09	4.15
	VIX	-0.009**	0.00	-2.15
	JPMVXYG7	0.038	0.04	1.06
	DXY	0.022	0.01	1.60
	JPMVEM1M	0.072*	0.04	1.91
	Temporary Effect	0.552***	0.06	8.63
	Permanent Effect	0.157***	0.04	3.98
3 Month	C	0.019	0.01	1.57
	VIX	-0.001	0.00	-1.47
	JPMVXYG7	-0.011	0.01	-0.83
	DXY	0.013*	0.01	1.75
	JPMVEM1M	0.1***	0.04	2.73
	Temporary Effect	-0.037***	0.00	-7.98
	Permanent Effect	-0.006	0.00	-1.43
6 Month	C	0.019	0.01	1.52
	VIX	-0.001	0.00	-1.45
	JPMVXYG7	-0.017*	0.01	-1.80
	DXY	0.011	0.01	1.44
	JPMVEM1M	0.082***	0.03	2.79
	Temporary Effect	-0.018***	0.00	-4.64
	Permanent Effect	-0.007	0.00	-1.51
12 Month	C	0.017	0.01	1.81
	VIX	-0.001	0.00	-1.50
	JPMVXYG7	0.023	0.04	0.60
	DXY	0.003	0.01	0.31
	JPMVEM1M	0.031	0.02	1.25
	Temporary Effect	-0.003	0.00	-0.81
	Permanent Effect	-0.008**	0.00	-2.06
*** Significant at 0.01, ** Significant at 0.05, * Significant at 0.1.				

The analysis of the findings proceeds with the standard deviation regression results in Table 3. Standard deviation, a measure of uncertainty, has both temporary and permanent effects for 1-month maturity. As the positive coefficient of standard deviation illustrates, the impact of the decisions leads to an increase in market uncertainty. Empirical evidence demonstrates a transitory impact that mitigates market uncertainty for the 3- and 6-month maturity period. The JPMVEM1M index demonstrates statistical significance concerning maturities of 3- and 6-months. Also, the statistical relationship between standard deviation and VIX is statistically significant regarding global variables for 1-month maturity.

Table 4: Regression Results for Skewness

Maturity	Independent Variable	Coefficient	Std. Error	t-Statistic
1 Month	C	0.005	0.01	0.83
	VIX	0.000	0.00	-0.39
	JPMVXYG7	-0.005	0.01	-0.52
	DXY	0.006	0.01	1.05
	JPMVEM1M	0.009	0.01	0.66
	Temporary Effect	0.004	0.01	0.35
	Permanent Effect	-0.003	0.00	-0.87
3 Month	C	0.005	0.00	1.16
	VIX	0.000	0.00	-0.76
	JPMVXYG7	-0.005	0.01	-0.34
	DXY	0.006	0.01	1.08
	JPMVEM1M	-0.006	0.01	-0.44
	Temporary Effect	0.022**	0.01	2.24
	Permanent Effect	-0.003	0.00	-1.01
6 Month	C	0.001	0.00	0.33
	VIX	0.000	0.00	0.19
	JPMVXYG7	0.003	0.01	0.25
	DXY	0.007	0.00	1.56
	JPMVEM1M	-0.044**	0.02	-2.26
	Temporary Effect	0.021***	0.01	2.73
	Permanent Effect	-0.002	0.00	-0.86
12 Month	C	-0.014	0.01	-1.27
	VIX	0.001	0.00	1.46
	JPMVXYG7	-0.041	0.06	-0.64
	DXY	0.013	0.01	0.97
	JPMVEM1M	-0.048	0.04	-1.07
	Temporary Effect	0.010	0.01	1.12
	Permanent Effect	0.003	0.00	0.63
*** Significant at 0.01, ** Significant at 0.05, * Significant at 0.1.				

In Table 4, upon analyzing the effect of the decisions made on skewness, it is observed that there is no statistically significant variable observed for the 1-month and 12-month maturity. It has been understood that there is only a temporary effect in the 3- and 6-month maturity. Furthermore, it is shown that the global variable with the highest efficacy in effecting skewness is the JPMVEM1M Index.

Table 5: Regression Results for Kurtosis

Maturity	Independent Variable	Coefficient	Std. Error	t-Statistic
1 Month	C	0.025	0.02	1.16
	VIX	-0.001	0.00	-0.86
	JPMVXYG7	-0.005	0.03	-0.15
	DXY	0.031	0.02	1.27
	JPMVEM1M	0.000	0.05	-0.01
	Temporary Effect	-0.005	0.03	-0.15
	Permanent Effect	-0.009	0.01	-0.97
3 Month	C	0.020	0.02	1.13
	VIX	-0.001	0.00	-0.81
	JPMVXYG7	-0.022	0.06	-0.37
	DXY	0.019	0.02	0.88
	JPMVEM1M	-0.084	0.08	-0.99
	Temporary Effect	0.126***	0.04	3.46
	Permanent Effect	-0.011	0.01	-0.74
6 Month	C	-0.010	0.02	-0.43
	VIX	0.001	0.00	0.82
	JPMVXYG7	0.008	0.05	0.16
	DXY	0.030	0.03	1.18
	JPMVEM1M	-0.279**	0.11	-2.45
	Temporary Effect	0.096***	0.03	3.08
	Permanent Effect	-0.006	0.01	-0.51
12 Month	C	-0.062	0.05	-1.16
	VIX	0.003	0.00	1.23
	JPMVXYG7	-0.067	0.14	-0.49
	DXY	-0.003	0.04	-0.09
	JPMVEM1M	-0.229*	0.13	-1.75
	Temporary Effect	0.015	0.04	0.36
	Permanent Effect	0.018	0.02	0.80
*** Significant at 0.01, ** Significant at 0.05, * Significant at 0.1.				

Regression results regarding kurtosis are given in Table 5. Accordingly, similar to skewness, no statistically significant variable or effect is observed when kurtosis is examined for 1-month and 12-month maturity. It has been determined that the made arrangements have a temporary effect on the 3- and 6-month maturities. Additionally, similar to skewness, it is evident from the results that the JPMVEM1M Index is the most significant variable among the model's variables.

After analyzing all the moments of RND, following the BRSA decisions, it is observed that RND moments derived from short-term USD/TRY options have a temporary impact on the improvement of the market participants' future exchange rate expectations and increase market uncertainty. However, the effect decreases as the maturity length increases. Additionally, it can be noted that JPMVEM1M Index is the most significant global indicator for all moments of RND. For detailed information on the results obtained, please refer to the appendix section.

5.2 Robustness

The robustness test of the model established in this section is examined with four different models. The four models used for robustness and my main model are as follows. As said before, $dummyTEMP$ shows the temporary effect and $dummyPERM$ shows the permanent effect.

(I) $Moment^{RND} = a_0 + a_1 dummyTEMP$

(II) $Moment^{RND} = b_0 + b_1 dummyPERM$

(III) $Moment^{RND} = c_0 + c_1 VIX + c_2 DXY + c_3 JPMG7 + c_4 JPMEM + c_5 dummyTEMP$

(IV) $Moment^{RND} = d_0 + d_1 VIX + d_2 DXY + d_3 JPMG7 + d_4 JPMEM + d_5 dummyPERM$

(V) $Moment^{RND} = e_0 + e_1 VIX + e_2 DXY + e_3 JPMG7 + e_4 JPMEM + e_5 dummyTEMP + e_6 dummyPERM$

Table 6: Regression Results for Robustness Test of Mean

	1 Month							3 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.005					-0.047***		0.005					-0.038***	
	(0.00)					(0.02)		(0.00)					(0.01)	
II	0.017						-0.019*	0.018						-0.02*
	(0.01)						(0.01)	(0.01)						(0.01)
III	0.036	-0.002*	-0.046*	0.036***	0.132***	-0.052***		0.037	-0.002*	-0.039*	0.038***	0.134***	-0.043***	
	(0.02)	(0.00)	(0.03)	(0.01)	(0.05)	(0.01)		(0.02)	(0.00)	(0.02)	(0.01)	(0.05)	(0.01)	
IV	0.039	-0.002**	-0.044*	0.037***	0.130***		-0.011*	0.041	-0.002**	-0.038	0.038***	0.131***		-0.012*
	(0.01)	(0.00)	(0.03)	(0.01)	(0.04)		(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.04)		(0.01)
V	0.041	-0.002*	-0.046*	0.036***	0.131***	-0.049***	-0.01*	0.043	-0.002*	-0.039*	0.037***	0.132***	-0.039***	-0.011*
	(0.02)	(0.00)	(0.03)	(0.01)	(0.05)	(0.01)	(0.01)	(0.02)	(0.00)	(0.02)	(0.01)	(0.05)	(0.01)	(0.01)
	6 Month							12 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.005					-0.026		0.005					-0.004	
	(0.00)					(0.02)		(0.00)					(0.02)	
II	0.019						-0.022*	0.020						-0.023**
	(0.01)						(0.01)	(0.01)						(0.01)
III	0.035	-0.002*	-0.048**	0.019	0.129***	-0.033***		0.038	-0.002**	-0.033*	0.021*	0.101***	-0.011	
	(0.02)	(0.00)	(0.02)	(0.01)	(0.05)	(0.01)		(0.02)	(0.00)	(0.02)	(0.01)	(0.03)	(0.02)	
IV	0.041	-0.002*	-0.047**	0.019*	0.127***		-0.015**	0.047	-0.002**	-0.033	0.020*	0.099***		-0.017**
	(0.02)	(0.00)	(0.02)	(0.01)	(0.04)		(0.01)	(0.02)	(0.00)	(0.02)	(0.01)	(0.03)		(0.01)
V	0.043	-0.002*	-0.048**	0.018	0.128***	-0.029**	-0.014**	0.047	-0.002**	-0.033*	0.020*	0.100***	-0.005	-0.017**
	(0.02)	(0.00)	(0.02)	(0.01)	(0.04)	(0.01)	(0.01)	(0.02)	(0.00)	(0.02)	(0.01)	(0.03)	(0.01)	(0.01)

Robust standard errors are presented in parentheses. *,**,*** represents statistical significance at 10%, 5% and 1% levels respectively.

The results of the mean are found in Table 6. According to the table, the significance level of the effect remains unchanged for maturities of 1, 3, and 12 months. The sole distinction lies in the absence of any transient impact in Regression I pertaining to the 6-month maturity. Furthermore, in comparison to Regression V, the main regression model, it is observed that the significance level of the JPMVEM1M Index is statistically significant for all regressions. There is no substantial difference in statistical significance observed across the equations for other global variables.

Table 7: Regression Results for Robustness of Standard Deviation

	1 Month							3 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.322					0.625***		0.001					-0.036***	
	(0.04)					(0.09)		(0.00)					(0.01)	
II	0.220						0.164***	0.009						-0.012
	(0.05)						(0.06)	(0.01)						(0.01)
III	0.444	-0.008	0.037	0.016	0.054	0.604***		0.016	-0.001	-0.011	0.013	0.101***	-0.039***	
	(0.10)	(0.01)	(0.05)	(0.02)	(0.03)	(0.08)		(0.01)	(0.00)	(0.02)	(0.01)	(0.04)	(0.00)	
IV	0.389	-0.011*	0.020	0.009	0.083		0.173***	0.017	-0.001	-0.009	0.014*	0.1***		-0.007
	(0.12)	(0.01)	(0.03)	(0.01)	(0.05)		(0.05)	(0.01)	(0.00)	(0.01)	(0.01)	(0.03)		(0.00)
V	0.357	-0.009**	0.038	0.022	0.072*	0.552***	0.157***	0.019	-0.001	-0.011	0.013*	0.10***	-0.037***	-0.006
	(0.09)	(0.00)	(0.04)	(0.01)	(0.04)	(0.06)	(0.04)	(0.01)	(0.00)	(0.01)	(0.01)	(0.04)	(0.00)	(0.00)
	6 Month							12 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.001					-0.017***		0.001					-0.004	
	(0.00)					(0.00)		(0.00)					(0.00)	
II	0.009						-0.012	0.009						-0.011**
	(0.01)						(0.01)	(0.00)						(0.01)
III	0.015	-0.001	-0.016*	0.011	0.083***	-0.02***		0.013	-0.001	0.023	0.003	0.032	-0.006*	
	(0.01)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)		(0.01)	(0.00)	(0.04)	(0.01)	(0.02)	(0.00)	
IV	0.018	-0.001	-0.016*	0.011	0.082***		-0.008	0.017	-0.001	0.023	0.003	0.031		-0.009**
	(0.01)	(0.00)	(0.01)	(0.01)	(0.03)		(0.00)	(0.01)	(0.00)	(0.04)	(0.01)	(0.02)		(0.00)
V	0.019	-0.001*	-0.017*	0.011	0.082***	-0.018***	-0.007	0.017	-0.001	0.023	0.003	0.031	-0.003	-0.008**
	(0.01)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.00)	(0.01)	(0.00)	(0.04)	(0.01)	(0.02)	(0.00)	(0.00)

Robust standard errors are presented in parentheses. *,**,*** represents statistical significance at 10%, 5% and 1% levels respectively.

Table 7 presents the outcomes of robustness tests pertaining to the standard deviation. There is no serious alteration in the statistical significance of the impact of the decisions made on the standard deviation, in comparison to the main regression model, Regression V. Additionally, there are no critical changes in the statistical significance of the global variables between regressions.

Table 8: Regression Results for Robustness of Skewness

	1 Month							3 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.001					0.003		0.000					0.021	
	(0.00)					(0.02)		(0.00)					(0.01)	
II	0.003						-0.003	0.002						-0.003
	(0.00)						(0.00)	(0.00)						(0.00)
III	0.003	0.000	-0.005	0.006	0.009	0.003		0.004	0.000	-0.005	0.007	-0.006	0.021**	
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)		(0.00)	(0.00)	(0.02)	(0.01)	(0.01)	(0.01)	
IV	0.005	0.000	-0.005	0.006	0.009		-0.003	0.007	0.000	-0.005	0.006	-0.006		-0.003
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)		(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)		(0.00)
V	0.005	0.000	-0.005	0.006	0.009	0.004	-0.003	0.005	0.000	-0.005	0.006	-0.006	0.022**	-0.003
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
	6 Month							12 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.001					0.018		0.001					0.007	
	(0.00)					(0.01)		(0.00)					(0.01)	
II	0.001						0.000	-0.003						0.006
	(0.00)						(0.00)	(0.00)						(0.01)
III	0.000	0.000	0.003	0.008	-0.044**	0.020***		-0.012	0.001	-0.041	0.013	-0.048	0.011	
	(0.00)	(0.00)	(0.01)	(0.00)	(0.02)	(0.01)		(0.01)	(0.00)	(0.06)	(0.01)	(0.04)	(0.01)	
IV	0.003	0.000	0.002	0.007	-0.044**		-0.002	-0.013	0.001	-0.041	0.013	-0.048		0.003
	(0.00)	(0.00)	(0.01)	(0.00)	(0.02)		(0.00)	(0.01)	(0.00)	(0.06)	(0.01)	(0.05)		(0.00)
V	0.001	0.000	0.003	0.007456	-0.044**	0.021***	-0.002	-0.014	0.001	-0.041	0.01325	-0.048	0.010	0.003
	(0.00)	(0.00)	(0.01)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)	(0.00)	(0.06)	(0.01)	(0.04)	(0.01)	(0.00)

Robust standard errors are presented in parentheses. *,**,*** represents statistical significance at 10%, 5% and 1% levels respectively.

Table 8 provides information regarding skewness. Consequently, there are no statistically significant variables or effects observed in any of the five regressions for the 1-month and 12-month maturity. The absence of a temporary effect in Regression I differs from the main equation, Regression V, for maturities of 3 and 6 months.

Table 9: Regression Results for Robustness of Kurtosis

	1 Month							3 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.003					-0.009		0.000					0.121***	
	(0.01)					(0.05)		(0.01)					(0.04)	
II	0.010						-0.011	0.005						-0.004
	(0.01)						(0.01)	(0.01)						(0.01)
III	0.020	-0.001	-0.005	0.032	0.001	-0.008		0.014	-0.001	-0.022	0.019	-0.083	0.122***	
	(0.02)	(0.00)	(0.04)	(0.03)	(0.05)	(0.02)		(0.02)	(0.00)	(0.06)	(0.02)	(0.08)	(0.03)	
IV	0.025	-0.001	-0.005	0.031	0.000		-0.010	0.027	-0.001	-0.026	0.016	-0.082		-0.007
	(0.02)	(0.00)	(0.03)	(0.03)	(0.05)		(0.01)	(0.02)	(0.00)	(0.05)	(0.02)	(0.08)		(0.01)
V	0.025	-0.001	-0.005	0.031	0.000	-0.005	-0.009	0.020	-0.001	-0.022	0.019	-0.084	0.126***	-0.011
	(0.02)	(0.00)	(0.03)	(0.02)	(0.05)	(0.03)	(0.01)	(0.02)	(0.00)	(0.06)	(0.02)	(0.08)	(0.04)	(0.01)
	6 Month							12 Month						
	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect	C	VIX	JPMVXYG7	DXY	JPMVEM1M	T. Effect	P. Effect
I	0.003					0.081		0.004					0.009	
	(0.01)					(0.04)		(0.01)					(0.03)	
II	-0.002						0.010	-0.019						0.033
	(0.01)						(0.02)	(0.02)						(0.03)
III	-0.013	0.001	0.008	0.030	-0.278**	0.093***		-0.053	0.003	-0.068	-0.004	-0.231*	0.021	
	(0.02)	(0.00)	(0.05)	(0.02)	(0.12)	(0.03)		(0.05)	(0.00)	(0.14)	(0.04)	(0.13)	(0.04)	
IV	-0.005	0.001	0.005	0.027	-0.277**		-0.003	-0.061	0.003	-0.068	-0.003	-0.229*		0.019
	(0.02)	(0.00)	(0.06)	(0.03)	(0.12)		(0.01)	(0.05)	(0.00)	(0.15)	(0.04)	(0.13)		(0.02)
V	-0.010	0.001	0.008	0.0298	-0.279**	0.096***	-0.006	-0.062	0.003	-0.067	-0.003064	-0.229*	0.015	0.018
	(0.02)	(0.00)	(0.05)	(0.03)	(0.11)	(0.03)	(0.01)	(0.05)	(0.00)	(0.14)	(0.04)	(0.13)	(0.04)	(0.02)

Robust standard errors are presented in parentheses. *,**,*** represents statistical significance at 10%, 5% and 1% levels respectively.

The results regarding kurtosis are shared in Table 9. Accordingly, similar to skewness, no statistically significant variables and effects are found for 1 month of maturity. Also, neither temporary nor permanent effects are noticed in all regression models for the 12-month maturity. The statistical significance of the effect does not change for the 3-month maturity, but only a change is observed in the significance level of the temporary effect for the 6-month maturity.

CHAPTER VI

CONCLUSION

The implied risk-neutral density of foreign currency options is a crucial tool utilized by market players to ascertain their market outlook on the future movement of exchange rates and to value derivative products that are linked to the same underlying asset. These densities also yield insights into market volatility, market trend, and the likelihood of high-risk scenarios for future currency exchange rates. Estimating and analyzing changes in RND is crucial due to the diverse range of uses it has. This study employs approach in [15], which is a widely used method for estimating risk-neutral density (RND). The RND for the USD/TRY exchange rate is estimated for different maturities using this methodology.

This study analyzes the impact of the BRSA's decisions on restricting banks' off-shore swap transactions on USD/TRY exchange rates using RND estimation and an established model. Initially, RND projections derived from USD/TRY options over all time periods are acquired, revealing a deteration in expectations for the Turkish Lira throughout all maturities. Aside from visual, moments of RND are computed to describe the form of the distributions. These characteristics aid in drawing conclusions regarding the current condition of expectations and the progression of market trends throughout time. In the third quarter of 2018, there was a significant increase in the mean and standart deviation. Therefore, it can be asserted that the prospects for the USD/TRY exchange rate in the future have worsened, leading to an escalation in the volatility of the exchange rate.

Finally, using the established model, it is looked into whether decisions made with moments up to the fourth degree and global changes have an effect. From the established model, it is seen that the decisions taken decelerate the volatility in the market and temporarily improve the deterioration in the expectations of market participants, and the improvement is not permanent in the long run.

APPENDIX A

7.1 1-Month Maturity

Dependent Variable: D(MEAN)
Method: Least Squares
Date: 11/15/23 Time: 20:58
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 516 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 8 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.041364	0.021437	1.929564	0.0542
VIX	-0.001826	0.001045	-1.747626	0.0811
D(JPMVXYG7)	-0.046022	0.026817	-1.716127	0.0867
D(DXY)	0.035624	0.008008	4.448685	0.0000
D(JPMVEM1M)	0.131198	0.047302	2.773643	0.0057
D 1	-0.049154	0.010541	-4.663202	0.0000
D 2	-0.009717	0.005732	-1.695111	0.0907

R-squared	0.254986	Mean dependent var	0.004428
Adjusted R-squared	0.246204	S.D. dependent var	0.081139
S.E. of regression	0.070446	Akaike info criterion	-2.454457
Sum squared resid	2.526011	Schwarz criterion	-2.396854
Log likelihood	640.2498	Hannan-Quinn criter.	-2.431884
F-statistic	29.03482	Durbin-Watson stat	1.690746
Prob(F-statistic)	0.000000	Wald F-statistic	5.939762
Prob(Wald F-statistic)	0.000005		

Dependent Variable: STDDEV
Method: Least Squares
Date: 11/15/23 Time: 21:04
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 516 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 8 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.357067	0.085997	4.152077	0.0000
VIX	-0.008900	0.004144	-2.147813	0.0322
D(JPMVXYG7)	0.037723	0.035683	1.057146	0.2909
D(DXY)	0.022214	0.013906	1.597419	0.1108
D(JPMVEM1M)	0.071824	0.037579	1.911270	0.0565
D 1	0.552271	0.064003	8.628797	0.0000
D 2	0.156779	0.039358	3.983456	0.0001

R-squared	0.484906	Mean dependent var	0.334023
Adjusted R-squared	0.478834	S.D. dependent var	0.168602
S.E. of regression	0.121717	Akaike info criterion	-1.360766
Sum squared resid	7.540828	Schwarz criterion	-1.303164
Log likelihood	358.0776	Hannan-Quinn criter.	-1.338193
F-statistic	79.86143	Durbin-Watson stat	0.178811
Prob(F-statistic)	0.000000	Wald F-statistic	104.0073
Prob(Wald F-statistic)	0.000000		

Dependent Variable: D(SKEWNESS)
Method: Least Squares
Date: 11/15/23 Time: 21:13
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 516 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 6 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004649	0.005628	0.826109	0.4091
VIX	-0.000120	0.000305	-0.392207	0.6951
D(JPMVXYG7)	-0.005214	0.010112	-0.515668	0.6063
D(DXY)	0.006246	0.005969	1.046419	0.2959
D(JPMVEM1M)	0.008909	0.013488	0.660524	0.5092
D 1	0.004277	0.012156	0.351873	0.7251
D 2	-0.002797	0.003208	-0.871782	0.3837

R-squared	0.009525	Mean dependent var	0.000912
Adjusted R-squared	-0.002151	S.D. dependent var	0.037205
S.E. of regression	0.037245	Akaike info criterion	-3.729121
Sum squared resid	0.706082	Schwarz criterion	-3.671519
Log likelihood	969.1133	Hannan-Quinn criter.	-3.706549
F-statistic	0.815802	Durbin-Watson stat	1.805900
Prob(F-statistic)	0.557929	Wald F-statistic	0.410890
Prob(Wald F-statistic)	0.871917		

Dependent Variable: D(KURTOSIS)
Method: Least Squares
Date: 11/15/23 Time: 21:19
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 516 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 6 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.024784	0.021385	1.158959	0.2470
VIX	-0.000980	0.001138	-0.860967	0.3897
D(JPMVXYG7)	-0.005347	0.034523	-0.154893	0.8770
D(DXY)	0.031234	0.024627	1.268285	0.2053
D(JPMVEM1M)	-0.000301	0.049050	-0.006136	0.9951
D 1	-0.004802	0.033039	-0.145355	0.8845
D 2	-0.009489	0.009777	-0.970590	0.3322

R-squared	0.008113	Mean dependent var	0.002664
Adjusted R-squared	-0.003580	S.D. dependent var	0.131471
S.E. of regression	0.131706	Akaike info criterion	-1.203013
Sum squared resid	8.829381	Schwarz criterion	-1.145411
Log likelihood	317.3774	Hannan-Quinn criter.	-1.180441
F-statistic	0.693853	Durbin-Watson stat	1.986197
Prob(F-statistic)	0.654704	Wald F-statistic	1.183324
Prob(Wald F-statistic)	0.313647		

7.2 3-Month Maturity

Dependent Variable: D(MEAN)
Method: Least Squares
Date: 11/15/23 Time: 21:28
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 514 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.043292	0.022089	1.959930	0.0506
VIX	-0.001903	0.001067	-1.782518	0.0753
D(JPMVXYG7)	-0.038909	0.022653	-1.717568	0.0865
D(DXY)	0.037443	0.009703	3.858976	0.0001
D(JPMVEM1M)	0.132341	0.046255	2.861126	0.0044
D 1	-0.039438	0.010454	-3.772380	0.0002
D 2	-0.011150	0.006188	-1.801990	0.0721

R-squared	0.264144	Mean dependent var	0.004258
Adjusted R-squared	0.255436	S.D. dependent var	0.081505
S.E. of regression	0.070329	Akaike info criterion	-2.457747
Sum squared resid	2.507689	Schwarz criterion	-2.399974
Log likelihood	638.6410	Hannan-Quinn criter.	-2.435104
F-statistic	30.33232	Durbin-Watson stat	1.706618
Prob(F-statistic)	0.000000	Wald F-statistic	3.530448
Prob(Wald F-statistic)	0.001965		

Dependent Variable: D(STD_DEVIATION)
Method: Least Squares
Date: 11/15/23 Time: 21:31
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 514 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 4 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019117	0.012201	1.566917	0.1178
VIX	-0.000861	0.000587	-1.466006	0.1433
D(JPMVXYG7)	-0.010517	0.012676	-0.829668	0.4071
D(DXY)	0.013120	0.007477	1.754612	0.0799
D(JPMVEM1M)	0.100480	0.036863	2.725766	0.0066
D 1	-0.036914	0.004624	-7.983451	0.0000
D 2	-0.005805	0.004052	-1.432735	0.1525

R-squared	0.359667	Mean dependent var	0.000358
Adjusted R-squared	0.352089	S.D. dependent var	0.051972
S.E. of regression	0.041834	Akaike info criterion	-3.496696
Sum squared resid	0.887287	Schwarz criterion	-3.438923
Log likelihood	905.6509	Hannan-Quinn criter.	-3.474053
F-statistic	47.46263	Durbin-Watson stat	1.483555
Prob(F-statistic)	0.000000	Wald F-statistic	23.83167
Prob(Wald F-statistic)	0.000000		

Dependent Variable: D(SKEWNESS)
Method: Least Squares
Date: 11/15/23 Time: 21:36
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 514 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 6 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005396	0.004666	1.156266	0.2481
VIX	-0.000185	0.000245	-0.757039	0.4494
D(JPMVXYG7)	-0.004659	0.013713	-0.339724	0.7342
D(DXY)	0.006371	0.005918	1.076572	0.2822
D(JPMVEM1M)	-0.006321	0.014469	-0.436882	0.6624
D 1	0.022147	0.009906	2.235692	0.0258
D 2	-0.003288	0.003245	-1.013455	0.3113

R-squared	0.017932	Mean dependent var	0.000661
Adjusted R-squared	0.006310	S.D. dependent var	0.033578
S.E. of regression	0.033472	Akaike info criterion	-3.942699
Sum squared resid	0.568025	Schwarz criterion	-3.884925
Log likelihood	1020.274	Hannan-Quinn criter.	-3.920056
F-statistic	1.542965	Durbin-Watson stat	2.074103
Prob(F-statistic)	0.162088	Wald F-statistic	2.322607
Prob(Wald F-statistic)	0.031933		

Dependent Variable: D(KURTOSIS)
Method: Least Squares
Date: 11/15/23 Time: 21:39
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 514 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.020079	0.017780	1.129281	0.2593
VIX	-0.000825	0.001013	-0.814948	0.4155
D(JPMVXYG7)	-0.021965	0.059528	-0.368990	0.7123
D(DXY)	0.019000	0.021551	0.881628	0.3784
D(JPMVEM1M)	-0.084304	0.084906	-0.992903	0.3212
D 1	0.125673	0.036313	3.460821	0.0006
D 2	-0.010989	0.014820	-0.741485	0.4587

R-squared	0.042010	Mean dependent var	0.002170
Adjusted R-squared	0.030673	S.D. dependent var	0.160520
S.E. of regression	0.158039	Akaike info criterion	-0.838426
Sum squared resid	12.66298	Schwarz criterion	-0.780653
Log likelihood	222.4755	Hannan-Quinn criter.	-0.815783
F-statistic	3.705510	Durbin-Watson stat	2.101972
Prob(F-statistic)	0.001292	Wald F-statistic	5.284667
Prob(Wald F-statistic)	0.000027		

7.3 6-Month Maturity

Dependent Variable: D(MEAN)
Method: Least Squares
Date: 11/15/23 Time: 21:46
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC
maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.042729	0.021995	1.942688	0.0526
VIX	-0.001754	0.001005	-1.746008	0.0814
D(JPMVXYG7)	-0.048348	0.018916	-2.555920	0.0109
D(DXY)	0.018418	0.011490	1.602977	0.1096
D(JPMVEM1M)	0.127560	0.044679	2.855000	0.0045
D_1	-0.028769	0.011755	-2.447448	0.0147
D_2	-0.013771	0.006767	-2.034843	0.0424

R-squared	0.204139	Mean dependent var	0.004384
Adjusted R-squared	0.194531	S.D. dependent var	0.084394
S.E. of regression	0.075742	Akaike info criterion	-2.309185
Sum squared resid	2.851190	Schwarz criterion	-2.250538
Log likelihood	588.9146	Hannan-Quinn criter.	-2.286180
F-statistic	21.24682	Durbin-Watson stat	1.728729
Prob(F-statistic)	0.000000	Wald F-statistic	1.967836
Prob(Wald F-statistic)	0.068619		

Dependent Variable: D(STD_DEVIATION)
Method: Least Squares
Date: 11/15/23 Time: 21:51
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 6 from AIC
maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019089	0.012569	1.518789	0.1295
VIX	-0.000812	0.000558	-1.454197	0.1465
D(JPMVXYG7)	-0.016607	0.009233	-1.798655	0.0727
D(DXY)	0.010715	0.007460	1.436249	0.1516
D(JPMVEM1M)	0.082151	0.029432	2.791183	0.0055
D_1	-0.017578	0.003791	-4.637055	0.0000
D_2	-0.007092	0.004710	-1.505804	0.1328

R-squared	0.286652	Mean dependent var	0.000681
Adjusted R-squared	0.278041	S.D. dependent var	0.046560
S.E. of regression	0.039561	Akaike info criterion	-3.608161
Sum squared resid	0.777836	Schwarz criterion	-3.549514
Log likelihood	916.2566	Hannan-Quinn criter.	-3.585156
F-statistic	33.28583	Durbin-Watson stat	1.435740
Prob(F-statistic)	0.000000	Wald F-statistic	8.250943
Prob(Wald F-statistic)	0.000000		

Dependent Variable: D(SKEWNESS)
Method: Least Squares
Date: 11/15/23 Time: 21:54
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001371	0.004215	0.325181	0.7452
VIX	3.81E-05	0.000198	0.191859	0.8479
D(JPMVXYG7)	0.003049	0.012158	0.250814	0.8021
D(DXY)	0.007456	0.004779	1.560003	0.1194
D(JPMVEM1M)	-0.044471	0.019717	-2.255453	0.0245
D 1	0.020715	0.007577	2.733902	0.0065
D 2	-0.002318	0.002705	-0.856840	0.3919

R-squared	0.109101	Mean dependent var	0.000986
Adjusted R-squared	0.098346	S.D. dependent var	0.040802
S.E. of regression	0.038744	Akaike info criterion	-3.649891
Sum squared resid	0.746045	Schwarz criterion	-3.591244
Log likelihood	926.7726	Hannan-Quinn criter.	-3.626886
F-statistic	10.14390	Durbin-Watson stat	1.848277
Prob(F-statistic)	0.000000	Wald F-statistic	3.027371
Prob(Wald F-statistic)	0.006457		

Dependent Variable: D(KURTOSIS)
Method: Least Squares
Date: 11/15/23 Time: 21:57
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010214	0.023778	-0.429538	0.6677
VIX	0.000984	0.001207	0.815508	0.4152
D(JPMVXYG7)	0.008291	0.051414	0.161259	0.8720
D(DXY)	0.029800	0.025251	1.180165	0.2385
D(JPMVEM1M)	-0.278969	0.114000	-2.447096	0.0147
D 1	0.095514	0.031037	3.077380	0.0022
D 2	-0.006090	0.011960	-0.509192	0.6108

R-squared	0.128717	Mean dependent var	0.004409
Adjusted R-squared	0.118199	S.D. dependent var	0.234578
S.E. of regression	0.220279	Akaike info criterion	-0.174052
Sum squared resid	24.11585	Schwarz criterion	-0.115405
Log likelihood	50.86117	Hannan-Quinn criter.	-0.151047
F-statistic	12.23720	Durbin-Watson stat	1.828079
Prob(F-statistic)	0.000000	Wald F-statistic	2.788792
Prob(Wald F-statistic)	0.011205		

7.4 12-Month Maturity

Dependent Variable: D(MEAN)
Method: Least Squares
Date: 11/15/23 Time: 22:03
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 7 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.047039	0.020602	2.283300	0.0228
VIX	-0.001919	0.000947	-2.027267	0.0432
D(JPMVXYG7)	-0.033153	0.018277	-1.813958	0.0703
D(DXY)	0.019861	0.011775	1.686771	0.0923
D(JPMVEM1M)	0.099534	0.033222	2.996051	0.0029
D_1	-0.005304	0.014427	-0.367664	0.7133
D_2	-0.016608	0.006955	-2.387778	0.0173

R-squared	0.141306	Mean dependent var	0.004605
Adjusted R-squared	0.130940	S.D. dependent var	0.083761
S.E. of regression	0.078085	Akaike info criterion	-2.248256
Sum squared resid	3.030313	Schwarz criterion	-2.189609
Log likelihood	573.5604	Hannan-Quinn criter.	-2.225250
F-statistic	13.63100	Durbin-Watson stat	1.735337
Prob(F-statistic)	0.000000	Wald F-statistic	2.904325
Prob(Wald F-statistic)	0.008589		

Dependent Variable: D(STD_DEVIATION)
Method: Least Squares
Date: 11/15/23 Time: 22:05
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 4 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017063	0.009441	1.807371	0.0713
VIX	-0.000609	0.000407	-1.495648	0.1354
D(JPMVXYG7)	0.022505	0.037574	0.598958	0.5495
D(DXY)	0.002540	0.008295	0.306162	0.7596
D(JPMVEM1M)	0.030872	0.024787	1.245492	0.2135
D_1	-0.002929	0.003626	-0.807750	0.4196
D_2	-0.008460	0.004110	-2.058279	0.0401

R-squared	0.012966	Mean dependent var	0.001226
Adjusted R-squared	0.001050	S.D. dependent var	0.110239
S.E. of regression	0.110181	Akaike info criterion	-1.559596
Sum squared resid	6.033487	Schwarz criterion	-1.500949
Log likelihood	400.0183	Hannan-Quinn criter.	-1.536591
F-statistic	1.088084	Durbin-Watson stat	2.928545
Prob(F-statistic)	0.368336	Wald F-statistic	2.273968
Prob(Wald F-statistic)	0.035564		

Dependent Variable: D(SKEWNESS)
Method: Least Squares
Date: 11/15/23 Time: 22:07
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 6 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013660	0.010787	-1.266369	0.2060
VIX	0.000749	0.000513	1.459982	0.1449
D(JPMVXYG7)	-0.040718	0.063280	-0.643467	0.5202
D(DXY)	0.013250	0.013609	0.973649	0.3307
D(JPMVEM1M)	-0.047967	0.044811	-1.070433	0.2849
D_1	0.010037	0.008962	1.119986	0.2633
D_2	0.002800	0.004425	0.632731	0.5272

R-squared	0.011570	Mean dependent var	0.000892
Adjusted R-squared	-0.000363	S.D. dependent var	0.172812
S.E. of regression	0.172843	Akaike info criterion	-0.659075
Sum squared resid	14.84773	Schwarz criterion	-0.600428
Log likelihood	173.0868	Hannan-Quinn criter.	-0.636069
F-statistic	0.969566	Durbin-Watson stat	2.852922
Prob(F-statistic)	0.445173	Wald F-statistic	1.068730
Prob(Wald F-statistic)	0.380223		

Dependent Variable: D(KURTOSIS)
Method: Least Squares
Date: 11/15/23 Time: 22:09
Sample (adjusted): 1/03/2018 12/31/2019
Included observations: 504 after adjustments
HAC standard errors & covariance (Prewhitening with lags = 5 from AIC maxlags = 7, Bartlett kernel, Newey-West fixed bandwidth = 6.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.062331	0.053754	-1.159554	0.2468
VIX	0.003249	0.002641	1.230186	0.2192
D(JPMVXYG7)	-0.067480	0.138365	-0.487695	0.6260
D(DXY)	-0.003064	0.035428	-0.086494	0.9311
D(JPMVEM1M)	-0.229193	0.131163	-1.747400	0.0812
D_1	0.014863	0.041448	0.358601	0.7200
D_2	0.018268	0.022922	0.796952	0.4259

R-squared	0.033542	Mean dependent var	0.003721
Adjusted R-squared	0.021875	S.D. dependent var	0.417222
S.E. of regression	0.412633	Akaike info criterion	1.081276
Sum squared resid	84.62230	Schwarz criterion	1.139923
Log likelihood	-265.4817	Hannan-Quinn criter.	1.104282
F-statistic	2.874857	Durbin-Watson stat	2.629017
Prob(F-statistic)	0.009194	Wald F-statistic	1.444115
Prob(Wald F-statistic)	0.195823		

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VITA

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