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Determinants of Exchange Rate Jumps in Türkiye

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ABSTRACT

This study examines the exchange rate jumps in Türkiye between 2013 and 2021 and the factors influencing these jumps. The Turkish Lira experienced a consistent depreciation against other currencies during this period. A closer examination of the depreciation timeline revealed that the Turkish Lira's depreciation was occasionally abrupt and exceedingly pronounced. The primary objective of this research is to identify these episodes of spikes, which can be characterized as jumps in exchange rates amid regular increases. To achieve this, the Pruned Exact Linear Time (PELT) algorithm was employed to detect sudden shifts in the exchange rate. Taking these points as dependent variables, a rare event logistic regression model was utilized to determine the probability of an exchange rate jump. The findings indicate that increased dollarization raises the likelihood of an exchange rate jump, while higher deposit rates and central bank reserves reduce the probability of a jump.

Keywords: Exchange Rate, Dollarization, PELT Algorithm, Logistic Regression, Jump Point.

JEL Classification Codes: B22, C22, F31

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INTRODUCTION

Numerous studies have examined the adverse effects of continuous fluctuations in exchange rates on economic growth. Rodrik (2009) demonstrated that overvalued national currencies in developing countries negatively impacted economic growth. Likewise, Gala and Libânio (2010), Chen (2012), and Habib et al. (2017) highlighted the detrimental consequences of national currency depreciation in developing countries on economic growth. Ağaslan and Alkan (2021) found that although exchange rate volatility in developing countries negatively affected economic growth, its impact on developed countries was considerably smaller. The prevailing conclusion is that exchange rate fluctuations adversely influence economic growth and macroeconomic variables. Consequently, sudden and substantial changes (jumps) in exchange rates, rather than steady shifts, signify a difficult situation for an economy.

In fragile economies, particularly those classified as developing and emerging, such as Türkiye, the production structure heavily relies on imported raw materials and intermediate goods. Exchange rate jumps negatively impact the decision-making processes of economic agents and hinder the establishment of a stable price determination policy for each production unit. In countries with high intermediate imports like Türkiye, sudden exchange rate increases are reflected in manufacturer prices through the pass-through mechanism, causing cost inflation and subsequently affecting consumer prices. This study aims to identify the jump points in the exchange rate against the Turkish Lira and examine how macroeconomic variables influencing the likelihood of currency jumps affect this probability under specific scenarios.

Estimating and predicting exchange rates have long been prominent in international financial markets. Exchange rate markets are continuously traded 24 hours a day across different regions worldwide and are heavily influenced by economic, political, military, and psychological factors. Econometric models and operational research methods are commonly employed in exchange rate estimation and prediction. The prediction of exchange rates began with Brown's

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(1963) moving average method and continued with the exponential smoothing and adaptive exponential smoothing methods proposed by Trigg and Leach (1967). The autoregressive moving average process introduced by Box-Jenkins in the 1970s became one of the most popular methods in exchange rate predictions until the mid-1980s. Although these models aim to predict a specific exchange rate trajectory, they do not account for sudden increases that could be considered extreme observations regarding multiple standard deviations. While it seems implausible to accurately predict such increases, certain variables and parameters within an economy could rapidly depreciate the exchange rate against national currencies.

In the literature, the variables employed in modeling sudden increases (jumps) in financial assets primarily focus on the returns of these assets. A limited number of studies have addressed excessive increases in exchange rates. Andersen et al. (2003) explored the relationship between abrupt exchange rate movements and news, revealing that news has an asymmetric effect on sudden exchange rate shifts. Duffie et al. (2000), Liu et al. (2003), Eraker et al. (2003), and Piazzesi (2005) discussed how jump information influences financial management, while Lee and Mykland (2008) and Tauchen and Zhou (2011) attempted to explain how characterizing the distribution and causes of jumps could improve asset pricing models. Lahaye et al. (2011), Andersen et al. (2007), Lee and Mykland (2008), and Boudt et al. (2011) sought to detect jumps in exchange rates, stock index futures, and US bond futures using the non-parametric statistics they proposed in their studies, correlating the identified jumps with macroeconomic news. Andersen et al. (2010) suggested a test to detect jumps in return series for high-frequency finance data, and Chatrath et al. (2014) examined the impact of macro news on exchange rate jumps. Uzun et al. (2023) explore using machine learning algorithms to forecast jumps in the foreign exchange (FX) market, addressing the challenges posed by currency fluctuations under floating exchange rate regimes. The study identifies jumps using the return ratio to estimated volatility, distinguishing between average high volatility and jumps. The authors highlight the importance of predicting jumps for traders, financial risk managers, and policymakers, given the difficulty in hedging jump risks and the implications for derivative pricing and asset allocation. Ayadi et al. (2024) investigate severe intraday price movements or jumps in emerging financial markets during economic expansion. They focus on identifying jumps in emerging foreign exchange markets and simultaneous jumps in multiple currency markets, known as cojumps. Utilizing data from four emerging currencies across Africa, Asia, Europe, and South America, spanning from 2010 to 2017 with 5-minute frequency quotes, their study reveals that intraday currency jumps and cojumps are notably more frequent and larger compared to developed markets. Manner et al. (2024) explore the risks faced by commodity-exporting countries in Latin America, focusing on fluctuations in commodity prices and exchange rates. The study applies changepoint analysis to endogenously determine dates of changing risks, specifically unconditional volatility and risk spillovers measured by copula-based dependence. The analysis includes the stock markets of Argentina, Brazil, Chile, Mexico, and Peru, identifying how these risks evolve and are influenced by macroeconomic factors. Chae-Deug (2024) investigates the volatile dynamics and discontinuous jumps in the Korean won–US dollar exchange rate during the 2010s, driven by global economic uncertainties and geopolitical tensions. The study addresses the critical need to estimate return volatility accurately and jumps using robust, nonparametric approaches, considering the limitations of traditional parametric models in capturing discontinuous jump components. The empirical analysis uses high-frequency five-minute returns data for the Korean won–US dollar exchange rates from 2010 to 2021. The study employs various jump statistics, including the standard normal Z-type jump statistics, the realized outlying weighted quarticity (ROWQ) jump statistics, and the Gumbel distribution, to determine the occurrence of significant daily jumps. The findings reveal that the severe volatility and frequent jumps in the Korean won–US dollar exchange rates during the 2010s necessitate using non-Gaussian distribution models for accurate jump estimation.

The common focus of these studies is the calculation of jumps over return series. However, the Pruned Exact Linear Time (PELT) algorithm proposed by Killick et al. (2012) enables the detection of sudden change points in datasets, allowing for jump points to be identified without any variable transformations. Using the PELT algorithm, this study detects jump points in their nominal form, without altering the exchange rate series, thereby preserving information.

This research makes two significant contributions to the literature. First, it focuses on detecting exchange rate jumps in Türkiye, and second, it is the first study to identify jump points using the PELT algorithm without transforming the exchange rate series. Moreover, while most studies on jump points concentrate on the effects of macro news, this research investigates how macroeconomic variables influence jump points in exchange rates.

The remainder of this article is organized as follows: Section 2 provides an overview of the factors determining exchange rates; Section 3 outlines the methodology; Section 4 discusses the data; Section 5 presents the empirical evidence; and Section 6 offers conclusions.

FACTORS DETERMINING EXCHANGE RATE

Besides the fact that the exchange rate is an indicator that expresses the value of one country's currency in other countries' currencies, it is a unique asset value. Thus, the economic principles that govern and guide the movements of the different asset prices also apply to the movements of exchange rates (Krugman et al. 2014).

Since the 1970s, due to the acceleration of capital movements and transition to a flexible exchange rate system and with large fluctuations in the exchange rates, the explanation of the changes that took place in exchange rates in the short run came to the fore. In the 1970s, problems such as exchange rate volatility created by flexible exchange rate systems, uncertainty, and which criteria should be considered necessary in the parity formation between countries led both the academics and those working in practice to focus on which economic variables are significant in determining the exchange rate. In this context, while international goods flow that was put forward before 1970 as the main factor determining exchange rates lost importance, the idea that global capital movements were a more explanatory variable in determining the exchange rate began to gain acceptance (Frankel et al. 1996).

Real exchange rate changes may result from changes in the real side of the economy. However, there are many studies on modelling and testing the deviation in Purchasing Power Parity Gelbard and Nagayasu (2004). Purchasing Power Parity (PPP) theory, one of the most accepted approaches in determining the exchange rate, was first introduced in the early 20th century by Gustav Cassel. The PPP approach, which is a theory that aims to determine the exchange rate by establishing a direct relationship between the exchange rate and prices, argues that changes in the exchange rate at any time will be determined by the changes in the relative price levels of countries (Cassel, 1918). Purchasing Parity is a theory to determine the exchange rate by establishing a direct relationship between the exchange rate and prices. Considering exchange rate models especially for the 1970s and 1980s, it is seen that the relationship between Purchasing Power Parity and exchange rate was used intensely in these models. PPP, which claims that the nominal exchange rate is determined according to the difference between domestic and foreign inflation rates, suggests that there may be deviations from the PPP in the short term since it is a long-term approach in determining the equilibrium exchange rate. However, there is no consensus on the validity of PPP in the long term (Mussa, 1986).

Another exchange rate determination model, the Interest Rate Parity (IRP) theorem, differs from the PPP theorem in that it takes into account the macroeconomic structure. It includes the financial account of the balance of payments in the analysis. With its variation in the interest rates, IRP plays a vital role in determining exchange rates since it constitutes a link between the spot and forward exchange rates and speculators' expectations. IRP assumes perfect substitution between domestic and international financial assets. This assumption equalizes various asset return rates, and this equality is known as IRP. While PPP establishes the connection between exchange rates and prices with goods markets, IRP establishes the connection between exchange rates and interest rates through financial markets (Claasen, 1996). In developed and stable financial markets, IRP theory gives more effective results in countries where controls over capital movements, transaction costs and political and national risks are low, investors avoid irrational behaviors, flexible exchange rates are applied, markets are more integrated to each other and borrowing costs and speculative investment movements are low. In underdeveloped countries, new establishment or non-existence of futures markets limited the testing of the theory for these countries (Copeland, 1989).

The fact that changes in only national price levels, money supplies, or current transactions cannot explain exchange rate behavior necessitated financial market approaches to be established. Currencies act more like other financial assets whose prices are determined in organized markets. In addition to the fact that currency changes are highly unpredictable, money supply and demand appears to be the most essential factor in explaining the behavior in exchange rates since the exchange rate is the relative price of two financial assets. It is possible to collect and examine Financial Asset Models in three groups. These models are the Monetary Model, Portfolio Equilibrium Model, and Currency Substitution Model. The most crucial factor in this distinction is whether the investors completely substitute domestic and foreign financial assets in their portfolio (Obstfeld et al. 1995).

According to the Monetary Model, the exchange rate is accepted as the price of a foreign currency in terms of the national currency. Like other relative prices, the exchange rate is determined by national currency stocks' relative supply and demand. This approach suggests that relative supply and demand in capital markets determines the exchange rate, the most basic assumption is that capital movements are free. In other words, there are no obstacles and restrictions in capital movements, nor transaction costs in purchases. If the assumption that national and international bonds are completely substitutable is added to these assumptions, the portfolios will always be in balance. Interest rates in the country will be equal to the total expectation of the international interest rate and the depreciation rate of the national currency. Thus, domestic and foreign capital markets will be reduced to a common market, and only national and international money markets will determine the exchange rate. The Monetary Model, based on market developments, is examined in two different ways according to flexible and sticky prices (Bilson, 1978). In many countries, practical studies for the Flexible Price Model or the Sticky Price Model did not result. This is because the money demand function was not as stable as the Monetarists claim. The assumption that complete substitution exists among financial assets and the assumption regarding PPP was not realistic (Meese and Rose, 1990).

An essential difference between the Monetary Approach and the Portfolio Balance Model is that the Monetary Approach is risk-neutral. Under these conditions, Monetary Approach has been insufficient regarding exchange rate expectations. Portfolio Balance Approach suppressed this shortcoming of the Monetary Approach. In the Portfolio Balance Model, while economic agents create a portfolio with various currencies to minimize exchange rate risks, international investors want to hold non-monetary financial assets based on the risk/return factor. Therefore, the Portfolio Balance Model is based on the distribution of individuals' fixed wealth at a given time among various financial assets consisting of domestic and foreign securities. The Portfolio Balance Model shows how exchange rates are determined more complexly. Although interest rate parity is also valid in this approach, unlike the Monetary Approach, a risk premium is added to the risk avoiders among the total assets in the portfolio. Risk-avoiding individuals hold non-risky domestic assets and risky foreign assets in their portfolios to maximize their benefits. Here, the necessary condition for the individuals' earnings is that the expected return of foreign investments should be higher than the expected return on domestic assets (Claasen, 1996). In summary, Portfolio Balance Approach is a theory that tries to explain fluctuations in exchange rates with changes in the supply and demand of domestic and foreign securities. According to this theory, the demand for money in the foreign exchange market is derived from the demand for financial assets.

In the models examined, economic agents have been assumed to demand only their own countries' currencies. Therefore, the elasticity of substitution between currencies has been assumed to be zero. However, economic agents in one country demand another country's money for many reasons. Empirical studies show that the power of the currency substitution model is low in explaining the exchange rate movements between the currencies of developed countries with low inflation processes and relatively stable currencies. For countries with unstable money and high inflation, the currency substitution model seems to be more appropriate. In these countries experiencing currency substitution, first the currency's function of store of value, then the national currency's feature of being a unit of account, and finally its feature of being a medium of exchange is substituted. This process is not a situation that occurs suddenly but is a process that generally spreads over time. The main reason is the lack of confidence in the economic policies implemented in the country. Besides destabilizing the exchange rate in these countries, money substitution causes fundamental problems such as the decrease in the seigniorage income of the country arising from the prerogative right of coining money. On the other hand, it is challenging to plan and execute monetary policy under these conditions (McKinnon, 1982).

In the statements so far within the framework of the financial markets approach, we have stated that the changes in the exchange rates are driven by the fundamentals such as money stock, interest rates, inflation, real income, and growth rate. However, as a result of the developments that emerged after the 1970s, we can see that the macroeconomic variables observed standardly are insufficient to explain the changes in exchange rates. The situation seems more appropriate, especially for short-term currency movements. Economists have two different views on these developments. The first one concentrates on how unexplained short-term changes are caused by tastes and preferences and by changes arising from technology. The second view is explained by the Speculative Bubbles Theory (Bulut, 2005).

According to this view, exchange rates do not result from a change in fundamental variables but a process formed due to self-fulfilling market expectations. Speculators increase the rate of increase in the exchange rate due to demanding the money that they see as overvalued because they expect that the funds will continue to gain value in the short term before it loses value in line with the fundamental factors and believe to sell the money before the rapid decline begins (Bulut, 2005).

Given the models studied so far, we can see the difficulty of predicting future exchange rates. Although economists have developed some models to explain the systematical changes in the exchange rates, due to the possibility of unexpected events, the success of these models in estimating exchange rates is limited. The real world is full of unforeseen shocks and surprises. When an unexpected event occurs, this is called "news" in literature. Since macroeconomics variables, such as interest rates, general price level, and output amount, are generally affected by the news, the exchange rates are also affected by them. Short-term movements in exchange rates are sometimes due to unexpected news. As unforeseen events partially determine the exchange rates, the future spot rates get challenging to predict. On the other hand, announcements on key economic variables, like the news effect, cause movements in exchange rates (Peruga, 1996).

In the exchange rate determination models, we have examined, common features like economic agents are homogeneous, complete knowledge is assumed, and economic transactions are done without cost. On the other hand, in these macro models, there were some unrealistic assumptions like information was known by everyone and spread instantly. In exchange rate determination models based on these basic assumptions, exchange rate movements were explained in macroeconomic variables. However, in recent years, Studies on the microstructure of the exchange market have been carried out frequently. Because the current approaches had some shortcomings in determining the exchange rates and the exchange rate movements and the criticism on this was getting more and more intense. For example, the change in exchange rates was much more considerable than the change in economic variables. This situation undermined the reliability of existing exchange rate determination models. Empirical studies made also supported this situation. This movement in exchange rates brought to the fore the view advocating that the microstructure of the exchange market should be examined. Thus, the behaviour of economic agents trading in the exchange market, the organizational structure of institutions and the market, and their relations have become very important. Since the microstructure approach reveals transparency in economic transactions, the unorganized structure of the market, the role of brokers, the place of the exchange market, the efficiency of exchange transactions and the relations between spot and derivative markets, it has brought a new spirit to exchange rate determination models (Bulut, 2005).

Although progress has been made in understanding the exchange rate's long-term movements, the general failure of the models based on rational expectations in terms of macroeconomic variables in the short run to explain exchange rate fluctuations is known as the exchange rate deviation paradox. The disconnection between the exchange rate and macroeconomic indicators is an important issue known and emphasized in international macroeconomics. The macroeconomic determinants of the exchange rate have been discussed since (Meese and Rogoff, 1983) suggested a weak relationship between the exchange rate and essential macroeconomic variables. According to (Meese and Rogoff, 1983), the exchange rates of the exchange rates are highly volatile compared to any model with fundamental variables, such as production amount and money supply. They stated that the predictions produced by traditional exchange rate models were not better than a random walk model.

Since exchange rate determination models were found unsuccessful in terms of short-term exchange rate estimation and that exchange rates are heavily influenced by political developments, especially in developing countries, most developing countries have become a two-money economy. On the other hand, doubts about the independence and transparency of central banks have become one of the main problems in developing countries. In Türkiye, which is a developing country, Fed's tightening monetary policies in 2013 annihilated the independence of the Central Bank of the Republic of Türkiye (CBRT), which was trying to follow policies focused on growth instead of inflation, increased dollarization and reserves were used to stabilize the exchange rate instead of interest rate. In this context, in the study covering the period of 2013-2021, dollarization rate, Central Bank gross reserves, and deposit interest rates that directly impact the residents' savings, were discussed.

METHODOLOGY

PELT (The Pruned Exact Linear Time) Algorithm

The changepoint analysis is defined as determining the points at which statistical characteristics change within a data set. Choosing the change points in a data set has been a significant challenge for many fields and researchers. Changepoint analysis has been used for many different purposes, such as financial modeling (Talih and Hengartner, 2005), bioinformatics for identifying genes associated with specific cancers and other diseases (Muggeo and Adelfio, 2011), detection of credit card fraud (Bolton and Hand, 2002), classification of data in data mining (Mampaey et al. 2011) and signal processing (Kim et al. 2009). There are two different approaches for detecting change points in a data set: exact and approximate. In general, exact methods have more computational complexity than approximate methods, whereas definite methods are more accurate as they seek optimal results (Truong et al., 2020). For example, in the binary partitioning algorithm (Scott and Knott, 1974), a single change point method is used in the entire data set. Still, the mismatch between adjacent windows is measured in the window-based search method (Truong et al., 2020). Both approaches have low computation complexity. On the other hand, the partition neighbour search method (Auger and Lawrance, 1989), which is a precise method that searches the entire partition space using dynamic programming, gives much more accurate results than approximate methods (Bian et al., 2020). However, the most significant disadvantage of the second method is the heavy computational complexity because as the observed data increase, the number of change points increases linearly. In addition to this, (Killick et al., 2012) proposed the PELT method specified as an entirely linear time algorithm, which is an efficient and precise search method in terms of calculation. The primary assumption in PELT is that the number of change points increases linearly with the size of the data and that the change points are not limited to a portion of the data.

Let a time series $\{y_t; t = 1,2,3, \ldots ,n\}$ and m change point $\tau_1, \tau_2, \tau_3, \ldots, \tau_m$ be given. Considering the cost function for fragmentation, (Yao, 1984) and (Jackson et al., 2005) used equation (1) to minimize the method to determine the change points, which they named the optimal fragmentation (OP) algorithm.

$$\sum_{i=1}^{m+1} \left[C\left(y_{(\tau_{i-1}+1):\tau_i} \right) \right] + \beta \qquad (1)$$

Let (1) be the minimum values obtained from equation (1) and $\tau_s = \{\tau : 0=\tau_0 < \tau_{1<} \ldots \tau_m < \tau_{m+1} = s\}$ the possible change points for these $F(s)y_{1:s}$ observations. The $F(0)$ initial value of can be taken as $-\beta$, with a penalty constant β that does not depend on the number or location of the exchange points. When applied as iterations of steps 1-2, change points can be obtained according to the OP algorithm.

Step 1	$F(\tau^*) = \min_{0 \le \tau < \tau^*} [F(\tau) + C(y_{(\tau+1):\tau^*}) + \beta]$ calculated.
Step 2	Change points $cp(\tau^*) = (cp(\tau'), \tau')$ founds by $\tau' = \arg\left\{ \min_{0 \le \tau < \tau^*} [F(\tau) + C(y_{(\tau+1):\tau^*}) + \beta] \right\}$

The basis of the PELT method is the OP algorithm. PELT algorithm modifies the OP algorithm with a change called pruning. The essence of pruning is to remove τ values that can never be minimum from the minimization performed at each iteration of step (1) in the OP algorithm. After pruning, the PELT algorithm is implemented as steps 1-4:

Step 1	$F(\tau^*) = \min_{\tau \in R_{\tau^*}} [F(\tau) + C(y_{(\tau+1):\tau^*}) + \beta]$ value calculated.
Step 2	$\tau^l = \arg\left\{ \min_{\tau \in R_{\tau^*}} [F(\tau) + C(y_{(\tau+1):\tau^*}) + \beta] \right\}$
Step 3	$cp(\tau^*) = [cp(\tau^l), \tau^l]$ change points are taken
Step 4	$R_{\tau^*+1} = \{\tau^* \cap \{\tau \in R_{\tau^*} : F(\tau) + C(y_{\tau+1:\tau^*}) + K < F(\tau^*)\}\}$ in the last case, the points obtained in Step 3 are pruned and the final change points are obtained.

(Killick et al. 2012) demonstrated that the PELT algorithm is superior to all other methods in detecting multiple changes due to their simulation study.

Rare Event Logistic Regression Method

One of the most used models in modelling a system consisting of dependent and independent variables is linear regression analysis. One of the most critical constraints of linear regression analysis is that the dependent variable takes continuous values. In the case of discrete values, the logistic regression model is used in the literature. Logistic regression, especially for the circumstances in which the dependent variable takes binary values, is one of the most important statistical and data mining techniques used by statisticians and researchers for analysis of relationships between variables (Arita, 2003; Agresti, 2007; Hastie et al. 2009; Hilbe, 2009; Kleinbaum et al. 2007). One of the most critical advantages of logistic regression is that the value of the dependent variable can predict probability because of the model estimation (Hastie et al. 2009; Karsmakers et al., 2007). Another advantage is that most of the methods used in the logistic regression model analysis follow the same principles used in linear regression (Hosmer and Lemeshow, 2000). Moreover, most unconstrained optimization techniques apply to logistic regression analysis (Lin et al. 2007). Logistic regression model does not need a linear relationship between the dependent and independent variables, normal distribution of error terms, and assumptions such as constant variance requirement. However, the logistic regression model has a significant limitation. The number of realized events "1" and the number of unrealized events "0" observed should be close to each other. If this does not occur, the estimates obtained will not be effective. There are many different approaches regarding determining the optimum number of events. In their studies, (Peduzzi et al., 1996) found that the optimal number of events per variable should be ten or more. In addition, in their simulation study, Bujang et al. (2017) performed the Monte Carlo test using the formula (2).

$event = 100 + EVP\ x\ Size_{\beta}$

In this equation, EVP represents the number of events per variable and the total number of explanatory variables. As a result of the failure to reach the required minimum number of events in both studies, it was determined that the Ordinary Rare Event Logistic Regression method was the appropriate method. The ordinary logistic model can be written as (3).

$$p_i = \left(1 + e^{-\left(\hat{\alpha} + \sum_{i=1}^{k} \beta_i X_i\right)}\right)^{-1} \tag{3}$$

Here, p_i which is a function of k number independent variables, representing the probability of I events' occurrence. α and β are unknown parameters obtained mainly from the likelihood method. This equation is usually linearized by performing a logit transformation. The natural logarithm of an odd number, the ratio of the probability of events, is divided by the probability of unrealized events. The logit form of the model can be expressed as (4) (Kleinbaum and Klein, 2010).

$$\text{logit } p_i = \ln \frac{p_i}{1 - p_i} = \hat{\alpha} + \sum_{i=1}^{k} \hat{\beta}_i X_i \tag{4}$$

As expected, events related to the exchange rate jumps occupy an extremely small place in the total data. The low ratio of events to unrealized events will cause the constant term to be significantly biased. Therefore, the first correction on the known logistic regression method has been made on the constant term to avoid sample bias. The corrected constant term a_0 is based on the predicted $\hat{a}$. The corrected model estimation with τ representing the share of events in the total population and $\bar{Y}$ expressing their share in the sample are given in equation (5).

$$\alpha_0 = \hat{\alpha} - \ln\left[\left(\frac{1-\tau}{\tau}\right)\left(\frac{\bar{y}}{1-\bar{\tau}}\right)\right] \tag{5}$$

Following the correction for the constant term, the undercalculated probability is corrected by adding the correction factor C_i to the estimated probability (5).

$$p_i = \tilde{p}_i + C_i \tag{6}$$

$$C_i = (0.5 - \tilde{p}_i)\tilde{p}_i(1 - \tilde{p}_i)(X_0 V(\beta) X_0' \tag{7}$$

where $\tilde{p}_i$ is the event probability estimated using a_0 with bias correction. X_0 represents the value vector created for each explanatory variable with 1 x $(m + 1)$ dimension, X'_0 represents the transpose of this vector, and $V(\beta)$ represents the variance-covariance matrix.

DATA SETS AND VARIABLES

In the present study, weekly data from December 28, 2012, to September 13, 2021, were collected, yielding a total of 454 observations. As discussed in Section 2, gross foreign exchange reserves, weighted average deposit interest rates, and the ratio of gross foreign exchange reserves to M2 were employed as measures of dollarization to explain currency fluctuations. To identify exchange rate jumps, transactions were conducted using the average buying and selling rates for USD/TRY and EUR/TRY currency pairs, which formed the currency basket. The direct quotation method was applied to calculate the Turkish Lira equivalent for one unit of foreign currency.

When constructing the currency basket, the Turkish Lira equivalent of one US dollar and one Euro were summed and divided by two. Two of the four variables were transformed from their level versions: the percentage change in gross foreign exchange reserves compared to the previous period and the difference in deposit interest rates relative to the prior period. Analyses were conducted using the dollarization and exchange rate jumps levels.

After transformation, we take the abbreviations of variables: Exchange rate jumps, gross foreing exchange reserves, deposit interest rates and dollarization as ERJ, $RSRV_t$, $DLRD_t$, respectively.

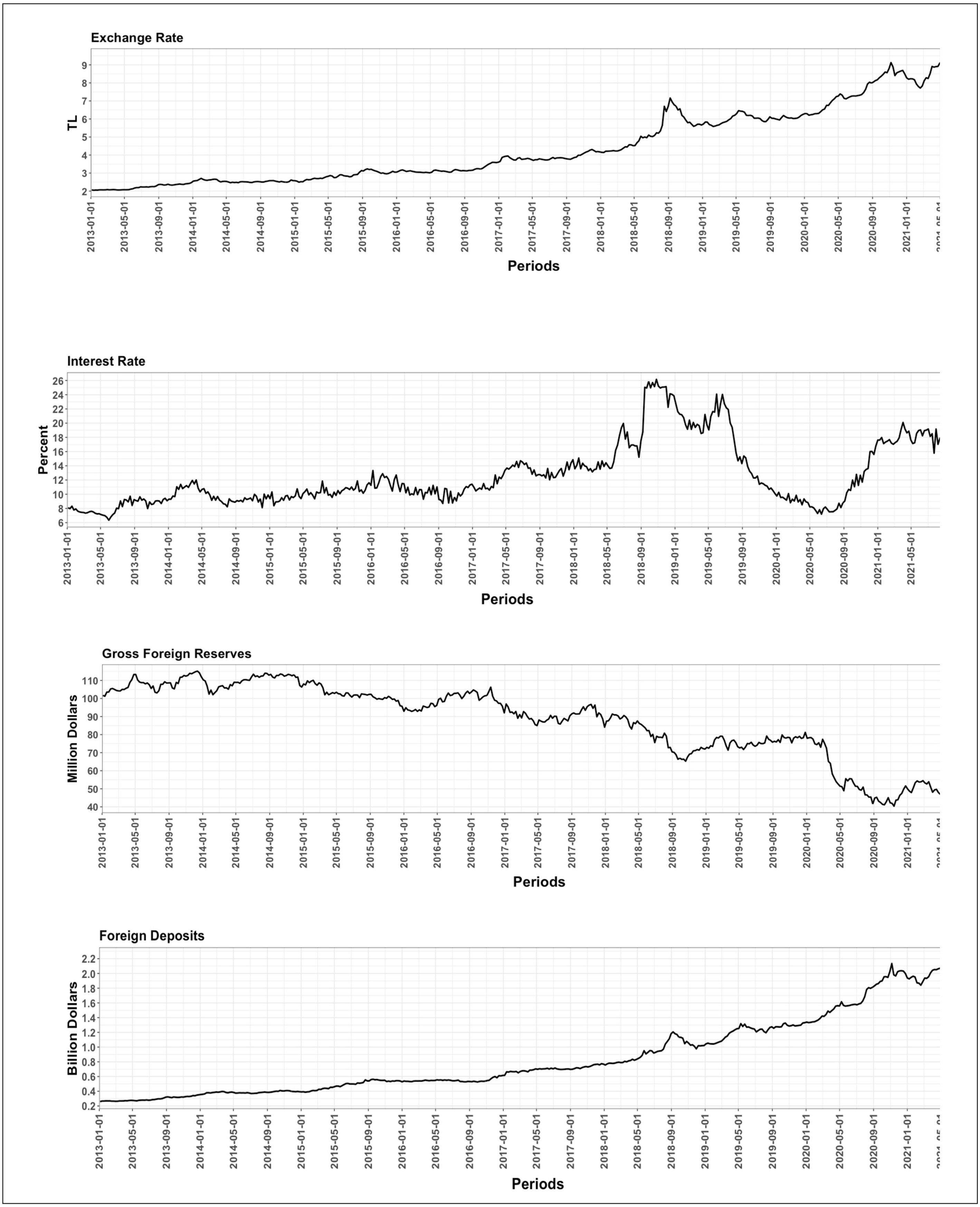

Figure 1: The trend of the variables at the level over time

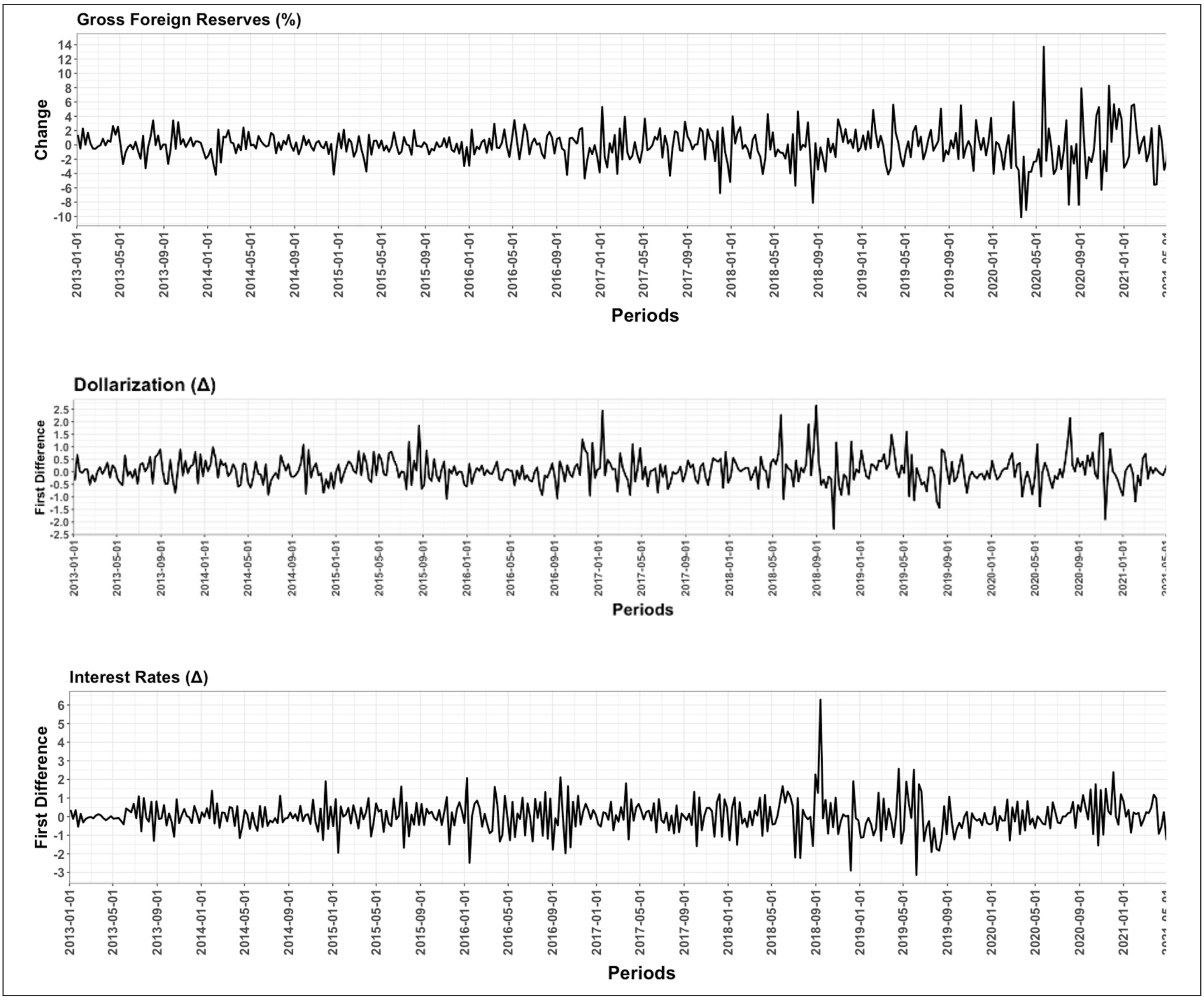

Figure 2: Trend of the variables after transformation over time

In Fig. 1 and Fig. 2, changes of the variables at the level and after transformation over time are shown, respectively.

Determining Dollarization

Ratio of foreign currency deposits to M2 was used in obtaining the dollarization variable (Ağaslan and Gayaker, 2019). The phenomenon of dollarization is a frequently encountered situation in developing economies. Especially in high inflation countries, the US dollar undertakes the functions of both being a medium of exchange, determining the unit of account and being an instrument of a store of value (Fuentes, 2009). The trend of the variable obtained over time is shown in Figure 3.

Determining the Exchange Rate Jumps

The exchange rate jump (*ERJ*) used in the study was essentially created by detecting the points where sudden changes (jumps) occur in the exchange rate series. The PELT algorithm suggested by (Killick et al., 2012) was used to determine the points where the statistical properties of the exchange rate series change. This algorithm is used to determine the optimal points where the statistical properties of a data set change. The exchange rate jumps were determined with Algorithm 1.

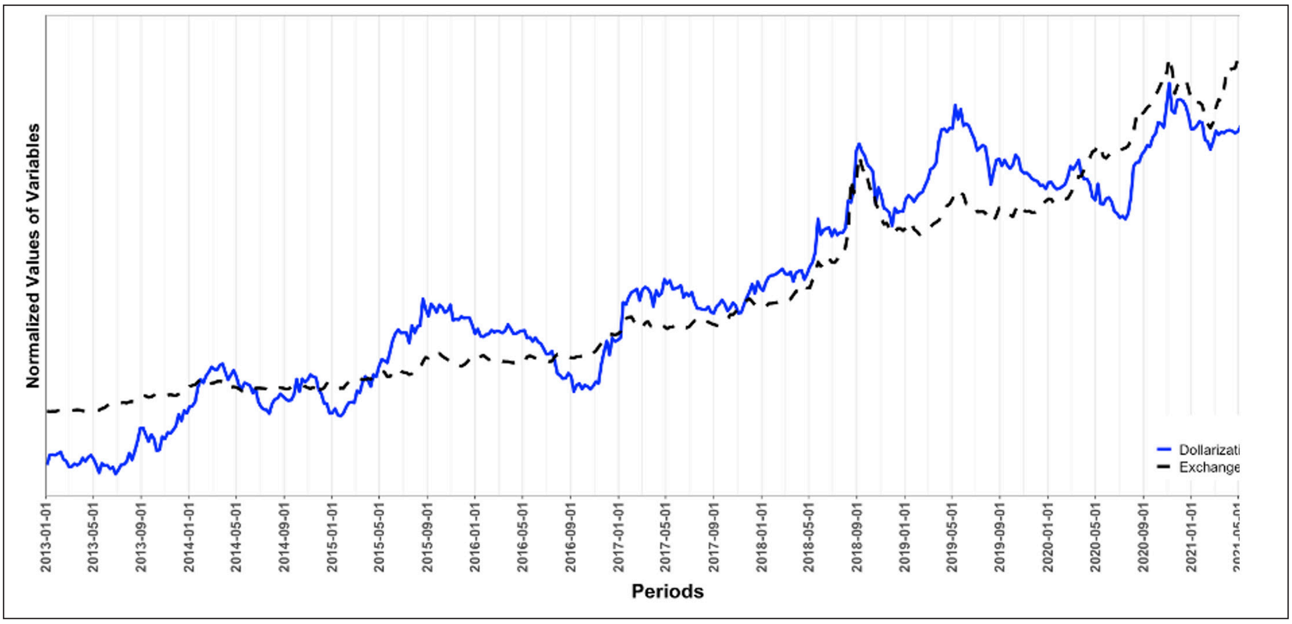

Figure 3: The trend of dollarization and exchange rate variables over time

Algorithm 1:	**Creating the Exchange Rate Jumps**
Step 1	Optimal change points were determined by applying the PELT algorithm to the Exchange Rate.
Step 2	Among the determined change points, those with an upward change were chosen.

Since the study aims to detect the exchange rate jumps in Türkiye, Algorithm 1 was applied to the daily exchange rate series, and then the resulting change points were reported weekly. This way, it was tried to determine jump points more in detail. The 2nd Stage in Algorithm 1 is also crucial in creating the exchange rate jumps. Because the PELT algorithm also detects downstream transformations in the data set. With the use of the 2nd stage, it is ensured that only the upward changes from the downward change point of the exchange rate jumps remain. In the light of this information, the *ERJ* is defined as follows:

$$ERJ_i = \begin{cases} 1 & \text{If time } i \text{ is the change point obtained as a result of Algorithm 1} \\ 0 & \text{in other cases} \end{cases}$$

The exchange rate jumps and the currency variable created after Algorithm 1 are given together in Fig. 4. In addition, jump points are seen in detail in Table 1.

The Turkish economy went through a period of improvement since it strengthened the banking sector after the crisis in 2001, ensured political stability, started full membership negotiations with the European Union, and the abundance of capital flows across the world. These developments stabilized exchange rates until the 2008 USA mortgage crisis. Although Türkiye experienced economic difficulties during the 2008 USA crisis, with the low interest rate and abundant monetary policy of the developed countries, there was no significant volatility in exchange rates until the middle of 2013 the CBRT was able to increase its reserves.

Starting from the day May 22, 2013, the Fed announced that it would reduce its bond purchases and increase interest rates in the future, the era of abundant money in the world came to an end. This process lasted until the Covid-19 epidemic in 2020, and with the pandemic in the world, low interest rate and abundant money period began again. However, it seems as if the threat of inflation emerging in the world will reintroduce the countries to the contractionary monetary policy process from 2022.

Exchange rates in Türkiye have shown a continuous upward trend since 2013. It is possible to say that this is due to some domestic and foreign economic and political developments. The study's start date was 2013 because of the emergence of currency jumps in Türkiye and many developing countries since that date. Dollarization, the CBRT reserves, and deposit rates discussed as variables in the study are the critical factors that determine the level and volatility of exchange rates. It is possible to say that these variables were affected by domestic and foreign

Table 1: Jump points calculated daily between 2013 and 2021

Jump Point	Exc Rate	**Jump Point**	Exc Rate	**Jump Point**	Exc Rate
21-06-2013	2.226	**20-03-2018**	4.388	**14-04-2020**	7.084
20-12-2013	2.442	**16-05-2018**	4.819	**07-08-2020**	7.829
05-03-2015	2.687	**31-07-2018**	5.298	**29-09-2020**	8.396
17-08-2015	2.997	**13-08-2018**	6.379	**28-10-2020**	8.867
08-11-2016	3.323	**09-04-2019**	6.023	**01-03-2021**	8.163
06-01-2017	3.690	**18-12-2019**	6.198	**23-03-2021**	8.663
24-10-2017	4.025	**13-03-2020**	6.626	**26-04-2021**	9.121

political developments, and therefore they are essential variables in observing political instability.

Table 1 shows the emerging jumps in exchange rates from 2013 to mid-2021. In the emergence of these jumps, the impact of domestic and international economic and political developments is very high. Now let's briefly summarize the reasons for the jump dates at the exchange rate given in the Table 1, respectively.

The date of 21.06.2021 was after 22.05.2013 when the Fed announced that it would reduce its bond purchases and coincides with the period when street demonstrations protesting the government in the country known as "Gezi Park Events" were intense. In the same way, the date of 20.12.2013 also coincides with a date after the Fed and Gezi events.

The date of 05.03.2015 coincided with the period when the political tension before the general elections in June 2015 was high and when the CBRT kept the policy rate low, although exchange rates tended to increase. The date of 17.08.2015 is significant in coinciding with the period when the government's power of being in control alone was lost after the June elections. The coalition government could not be formed. The decision to renew the elections was made, and the terrorist events increased.

08.11.2016 is after the failed military coup attempt in the country in July. On the other hand, efforts the CBRT, whose exchange rates continued to increase, reserves started to melt, having problems in its foreign capital entrances, to keep interest rates low through political interventions were effective in currency jumps in this period despite the Fed's decision to start interest rate hike in December 2015.

In the same way, the decrease in the reserves of the CBRT, keeping the policy interest rate low, the CBRT using its reserves instead of interest rate to stabilize the exchange rates, worsening of expectations in the country, increase in dollarization and the tension created by the referendum for the transition from the parliamentary system to the country-specific presidential system in April 2017 were influential in the exchange rate jump on 06.01.2017. In addition to the conditions as mentioned earlier, the public's acceptance of the presidential system with the referendum was effective in the exchange rate jump on 24.10.2017.

In the exchange rate jumps on 20.03.2018 and 16.05.2018, the presidential election that would be held in June 2018, the CBRT's keeping policy interest rates low against rising inflation and risks, declining gross reserves, and hardening in political rhetoric towards international investors were effective. The exchange rate jump on 13.08.2018 was the highest among the currency jumps we have mentioned so far. The main reason for this was the political debate called "priest Brunson between the USA under the leadership of Trump and Türkiye.

The most important reason for the exchange rate jump on 09.04.2019 was the efforts of the Government to cancel the Istanbul municipal elections as a result of the local elections held in March 2019. Another effect was the government's prohibiting significantly Turkish banks' TL lending limits to the London swap market after the exchange rate jump on 13.08.2018. The foreign investors perceived this as abolition of the convertibility of TL and capital control.

The exchange rate jump on 18.12.2019 was entirely due to domestic political developments. Because before this date, while deterioration of Türkiye's relations with the United States and the European Union continued, unlike the world, the CBRT started to decrease policy rates with political pressure and instead of using the interest weapon to prevent exchange rate increase it realized its reserve sales in a non-transparent manner through public banks. Domestic and foreign investors perceived these developments as

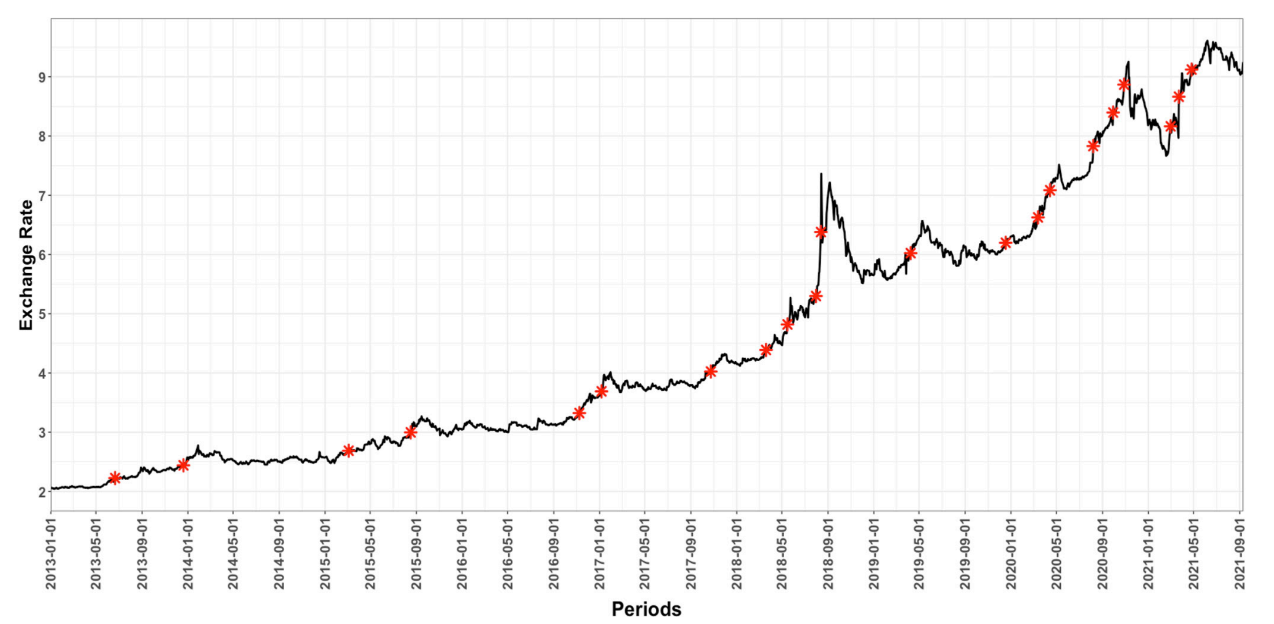

Figure 4: Exchange rate and Jump Points

the country's priority was not to reduce inflation but grow instead. The CBRT started to follow a growth-oriented monetary policy with political pressures instead of its duty of price stability. These developments further increased the belief that the CBRT was not independent. The currency jumps on 13.03.2020, 14.04.2020, 07.08.2020, 29.09.2020, 28.10.2020, and 01.03.2021 took place due to the effects of the Covid-19 epidemic.

During this period, while the gross reserves of the CBRT melted, its net reserves decreased to negative. Besides, in this period, the CBRT governors and the managers of the Bank were frequently dismissed as a result of political interventions. This caused the country not to attract foreign capital, although there was plenty of money in the world due to the pandemic.

and credibility due to political pressures, whose net reserves were negative and policy interest was low. On the other hand, dollarization increased in the country, and inflation rates increased due to the exchange rate pass-through, and inflation expectations deteriorated. The dismissal of a relatively credible the CBRT governor and appointment of a governor that prioritizes growth rather than low interest and inflation with political intervention led to an increase in exchange rate jumps.

When Fig. 4 is examined, the optimal change points are determined before the sudden changes. The numbers of 1 and 0 related to the obtained *ERJ* variable are given in 2.

When Table 2 is examined, it is seen that data number qualified as "1" in the *ERJ* covers a part of 4.63%.in the total number of data.

Table 2. Rate of jump points to total data

	Classification		
	1 (Jump Points)	0 (Regular Point)	Total
Frequency	21	433	454
Percent	4.63	95.37	100

Finally, the most crucial reason for the exchange rate jumps on 23.03.2021 and 26.04.2021 was the dismissal of the former finance minister, who was appointed as the head of the CBRT in November 2020 and whose relative credibility was high, with the political intervention at midnight on 20.03.2021. The new president appointed in November 2020 took over a CBRT without independence

EMPIRICAL RESULTS

In the study, equation (1) was estimated. Since the dependent variable *ERJ* was categorically created here, it should be estimated by the logistic regression model. Besides, there should be a balance between the number of realized events and the number of unrealized events in logistic regression. The number of realized events in the study was 21. In other words, it constitutes approximately 4.63% of the entire data set. In such cases, estimating logistic regression in the classical sense will result in biased estimates. On the other hand, (King and Zeng, 2001) proposed a correction for a small number of unrealized events. Model (1) is estimated by applying this correction suggestion and the results obtained are presented in Table 3.

$$ERJ_t = \beta_0 + \beta_1 RSRV_t + \beta_2 IR_t + \beta_3 DLRD_t + \varepsilon_t \quad t = 1,2,\ldots,454 \tag{1}$$

Table 3. Estimation results for model 1

Dependent Variable (ERJ)	Coefficients	Robust Std Error	Z	P>|z|	Odds ratio
IR	-0.191*	0.113	-1.688	0.091	0.826
RSRV	-0.181**	0.091	-1.979	0.048	0.835
DLRD	0.849***	0.340	2.494	0.013	2.337
Constant	-3.209	0.261	-12.293	0.000	0.040

When Table 3 is examined, it is seen that the estimations obtained regarding the coefficients of the IR, RSRV, and DLRD variables are statistically significant at 10%, 5%, and 1% significance levels. According to the results obtained, while a decrease of 100 basis points in deposit rates increases the probability of a currency jump (1/0.826) = 1.211 times, a 1% reduction in the reserves of the CBRT similarly increase the probability of a currency jump (1/0.835) = 1.198 times. On the other hand, an increase of 1% in dollarization increases the probability of currency jumps 2.337 times.

Examining the Risk of Currency Jump under Different Situations

In this part of the study, using the estimates obtained from model (1), six different scenarios were set for currency jump risk under the reserves of the CBRT and different values of deposit interest rates. These scenarios reveal the possibility of an upward jump in the exchange rate in an optimistic, a pessimistic and a normal course. Among the variables in the study, except for dollarization, The CBRT has a direct effect on the change of other variables. As dollarization is shaped according to trust to the national currency, the effect of the CBRT on this variable is indirect. At this point, optimistic, pessimistic and normal situations are based on the increase or decrease in dollarization. Weekly highest increase in dollarization in the time period covered by the study is 2.64%. This value is considered as the worst possible situation (pessimistic). On the other hand, the biggest decrease in dollarization in the same period was 2.26%. This is considered as the best possible condition (optimistic). Finally, according to the current situation the absence of any change in dollarization was considered as the normal situation. The scenarios created were designed to be a total of six on two different variables and by constructing three different events. Here, brief information about the scenarios is given in Table 4.

If Table 4 is to be explained in detail, it is useful to go through an example. For instance, Scenario 1 states that:

If the increase in dollarization is 2.64% weekly and there is no change in deposit interest, it shows how the weekly change in gross reserves changes the exchange

Table 4. Created Scenarios

Scenarios		Definition of Scenario	Variable that changes jump probability
1	Pessimistic	2.64% increase in dollarization	
2	Normal	No change in dollarization	
3	Optimistic	2.26% decrease in dollarization	Gross Foreign Reserves
4	Pessimistic	2.64% increase in dollarization	
5	Normal	No change in dollarization	
6	Optimistic	2.26% decrease in dollarization	Interest Rate (Deposit)

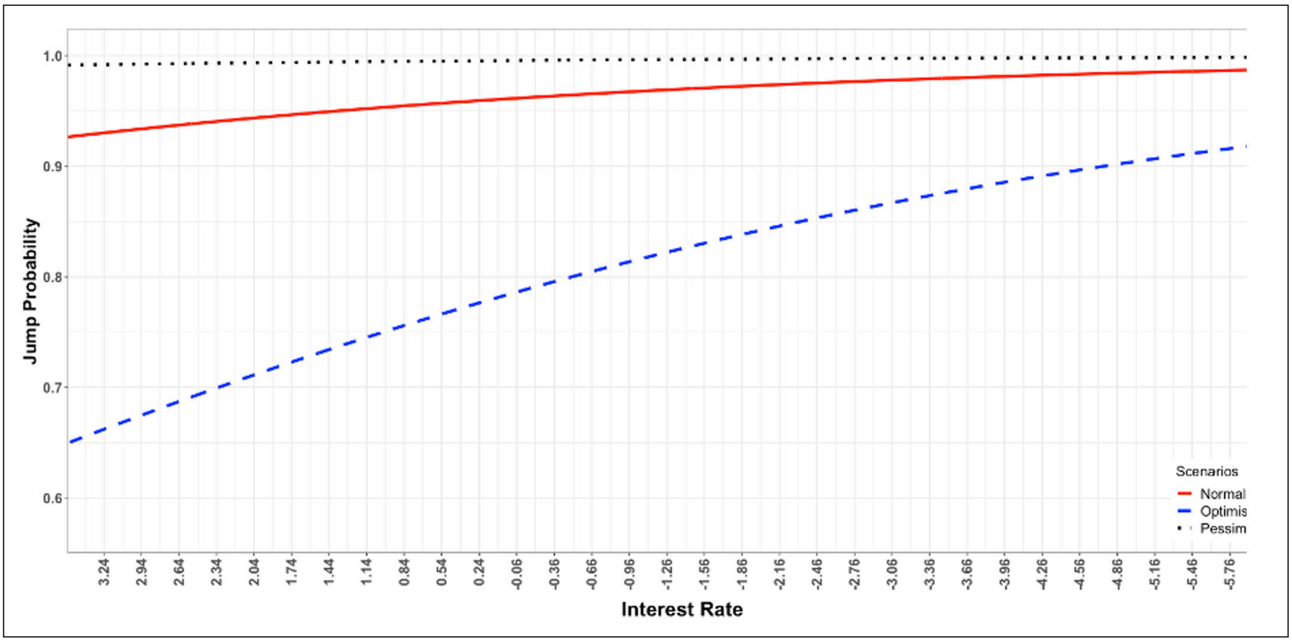

Figure 5: Graphs for scenarios 1,2 and 3 (probability of the exchange rate jumps of change in deposit interest in response to the change in constant and gross reserves)

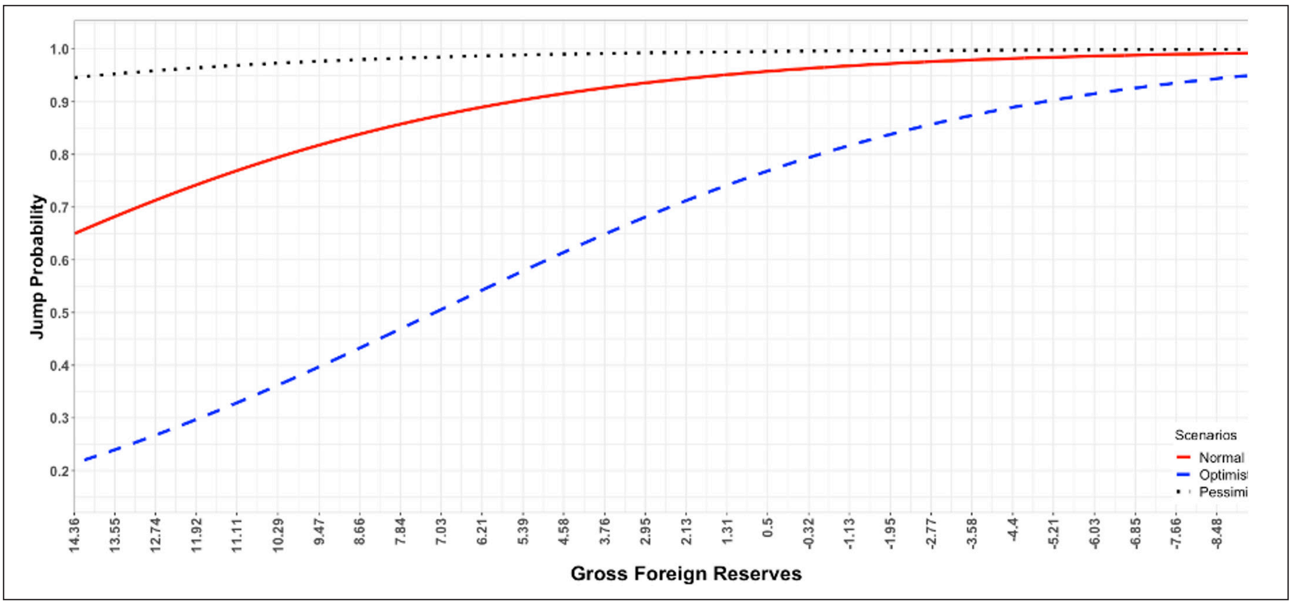

Figure 6: Graphs for scenarios 4.5 and 6 (probability of currency jump of change in reserves in response to change in constant and deposit interest rate)

rate jump risks. On the other hand, scenario 6 states the following:

In cases where the decrease in dollarization is 2.26% weekly, and there is no change in gross reserves, it expresses how the weekly change in the deposit rate changes the exchange jump risk. When Fig. 5 is examined, how the first three scenarios affect the jump risk is seen. In other words, Fig. 5 shows how the probability of a currency jump changes compared to weekly changes in gross reserves when interest is held constant. When all cases are examined, it is seen that the decrease in gross reserves increases the risk of currency jump quite rapidly. Despite that, in the pessimistic situation, even if the weekly increase in gross reserves is 14.36%, the probability of an exchange rate jump is above 0.90. In the optimistic scenario, the case that the probability of a currency jump exceeds 0.50 is the case that the increase in reserves is below 6.46%.

When Fig. 6 is examined, it is seen that the change in reserves is constant. Under a pessimistic scenario, regardless of the change in deposit rates, the country's probability of a currency jump is close to 1. However, in the optimistic scenario, even if there is a high increase in deposit rates, the risk of a currency jump is above 0.60. This means that the probability of a currency jump is affected by gross reserves rather than changes in interest rates.

CONCLUSION

This study examines the factors behind sudden upward fluctuations in exchange rates in Türkiye from 2013 to 2021. A logistic regression model incorporating exchange rate, dollarization, deposit interest rates, and CBRT's gross foreign reserves was established, with the PELT algorithm detecting exchange rate fluctuations. Results indicate that increased dollarization raises the likelihood of exchange rate jumps, while higher deposit rates and CBRT reserves reduce this probability.

Analyses under optimistic, normal, and pessimistic scenarios reveal that decreasing gross reserves substantially raises the risk of currency jumps. The most critical factor affecting exchange rate jumps was identified as a decline in gross reserves. During the study period, the Turkish Lira depreciated steadily, with both external and internal factors contributing to its negative differentiation compared to other developing countries' currencies. Frequent changes in CBRT leadership, low interest rates to defend the Lira, and non-transparent sale of CBRT reserves were among the most significant causes of exchange rate jumps. Furthermore, the government's imposition of a growth-priority monetary policy undermined CBRT's independence, leading to capital outflows and increased vulnerability of the Turkish Lira.

To address these challenges, policies ensuring CBRT's purpose and instrument independence should be implemented, focusing on price stability and strengthening reserves. Implementing a positive real interest rate policy in line with inflation rates and providing a transparent, predictable, and safe investment environment will contribute to long-term growth. Additionally, long-term, stable, and coherent policy bundles can help eliminate dollarization, a significant issue in Türkiye's economy.

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