Hacettepe University Graduate School of Social Sciences

Department of Economics

EXAMINING CURRENCY BUBBLES IN TURKISH LIRA/US DOLLAR EXCHANGE RATE

Elmas AY

Master's Thesis

Ankara, 2024

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The jury finds that Elmas AY has on the date of 20/12/2023 successfully passed the defense examination and approves her Master of Thesis titled “Examining Currency Bubbles in Turkish Lira/US Dollar Exchange Rate”.

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ABSTRACT

AY, Elmas. EXAMINING CURRENCY BUBBLES IN TURKISH LIRA/US DOLLAR EXCHANGE RATE, Master's Thesis, Ankara, 2024.

Researchers and policymakers have a keen interest in studying the fluctuations of exchange rates over time. These fluctuations can be driven by theoretical factors, referred to as fundamental drivers, or by bubble behavior. Currency crises are frequently triggered by the bursting of currency bubbles, making it essential to investigate the origins of such bubbles and identify their occurrences. This thesis focuses on examining whether any bubble formations existed in US Dollar/Turkish Lira exchange rate between the period of 1990:1 and 2021:11. To this end, we employ the Generalized Supremum Augmented Dickey-Fuller test (GSADF), as proposed by Philips, Shi, and Yu in 2015, on both the nominal exchange rate of TRY/USD and the deviations of the exchange rate from the relative prices of non-tradable and tradable goods, which are considered fundamental factors. The results indicate the presence of multiple explosive behaviors in nominal exchange rates during 1994, 2001, 2003-2009, and 2018. While relative prices of nontradables provide no explanation for the presence of those explosive movements, relative prices of tradables as a fundamental factor seem to explain some periods of the prolonged extreme fluctuations between 2003-2009 and the ones in 1994 and 2018, but not that in 2001. Thus, our findings suggest that only the movements in 2001 and 2006 are the occurrences of rational speculative bubbles in exchange rate of TRY/USD over the periods of 1990:1-2021:11.

Keywords

TRY/USD, Exchange Rates, Currency Bubbles, GSADF Test

ÖZET (Turkish Abstract)

AY, Elmas. TL/USD DÖVİZ KURUNDA DÖVİZ BALONLARININ İNCELENMESİ, Yüksek Lisans Tezi, Ankara, 2024.

Hem ekonomi araştırmacıları hem de politika yapıcılar döviz kurlarının zaman içinde oynaklığını analiz etmektedirler. Kurlardaki dalgalanmanın altında yatan sebepler teorik itici güçler (temel faktörler) olabileceği gibi kur balonu davranışını da yansıtabilir. Dünya ekonomisindeki döviz krizlerinin çoğu döviz balonu patlamaları tarafından tetiklendiğinden, balon oluşumunun arkasındaki sebeplerin araştırılması ve balon oluşumlarının tespit edilmesi güncel bir konu haline gelmiştir. Bu tezde 1990:1-2021:11 dönemleri boyunca Türk Lirası/ ABD Doları kurunda herhangi bir balon oluşup oluşmadığı araştırılmaktadır. Bu amaçla, Philips, Shi ve Yu (2015) tarafından önerilen Genelleştirilmiş Supremum Düzeltilmiş Dickey-Fuller Test (GSADF) testleri sırayla nominal TRY/USD kuruna ve temel faktörler olarak ele alınan ticarete konu olan ve olmayan malların nispi fiyatlarının döviz kurundan ayrışmalarına uygulanmıştır. Sonuçlar, 1994, 2001, 2003-2009 ve 2018 yıllarında nominal döviz kurunda birden fazla aşırı hareketlilik olduğunu göstermektedir. Ticarete konu olmayan malların göreli fiyatları bu oluşumlar için bir açıklama sağlayamazken, temel bir faktör olarak ticarete konu olan malların göreli fiyatları 2003-2009 arasındaki uzun süren aşırı hareketliliğin bazı dönemlerini, 1994 ve 2018'deki davranışı açıklamakta, ancak 2001'deki aşırı dalgalanmayı açıklamamaktadır. Dolayısıyla bulgular ele alınan örneklem döneminde sadece 2001 ve 2006 yıllarında TL/Dolar kurunda rasyonel spekülatif balon oluşumu olduğuna işaret etmektedir.

Anahtar Sözcükler

TL/Dolar, Döviz Kurları, Kur Balonları, GSADF testi

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ABBREVIATIONS

ADF	Augmented Dickey-Fuller
BRICS	Brasil, Russia, India, China, South Africa
CBRT	Central Bank of the Republic of Turkey
CNY	Chinese Yuan
CPI	Consumer Price Index
EUR	Euro FED Federal Reserve
FX	Foreign Exchange
GBP	British Pound
GSADF	Generalized Sup Augmented Dickey Fuller
IMF	International Monetary Fund
JPY	Japanese Yen
KZT	Kazakhstan Tenge
PPI	Producer Price Index
RMB	Chinese Renminbi
RUB	Russian Ruble
SADF	Sup Augmented Dickey Fuller
TRY	Turkish lira
USD	United States Dollar

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FIGURES

INTRODUCTION

Bubbles in financial markets have been a subject of great interest and concern for policymakers, economists, and all participants in the economy. In the context of finance, a bubble is characterized by an abrupt and unsustainable escalation in the price of an asset, such as stocks or exchange rates, and becomes significantly detached from its intrinsic value, driven primarily by speculation and investor sentiment rather than fundamentals. It has been observed that financial crises can be triggered either by financial bubbles or other economic distress. The Global Financial Crisis of 2008 serves as a significant illustration of the adverse impact that mortgage sector bubbles can have on the worldwide economy, thus highlighting the interconnectedness of both developing and developed economies. Furthermore, it has been noted that dramatic volatilities and speculative movements in financial markets are often observed prior to a crisis. Therefore, it is of utmost importance for economists and policymakers to investigate bubble behavior in financial markets in order to come up with and implement appropriate economic policies before asset prices boom and lead to a crisis.

In this study, particular attention will be paid to currency bubbles. The concept of exchange rate can be regarded as a form of asset valuation, in line with the perspective of **Obstfeld and Rogoff (1995),** by exploring and analyzing the bubble behavior in exchange rates, we can help manage and prevent exchange rate risks and provide useful advice to all economic agents. Policymakers and economic researchers and are particularly interested in understanding whether the movements in exchange rates are driven by theoretically consistent fundamentals or bubble behavior **(Steencamp, 2017)**. If exuberance in exchange rates is caused by bubble behavior, it can lead to explosions in the following periods, threatening financial and economic stability **(Afsar and Dogan, 2019).**

From a conceptual point of view, a bubble is distinguished as the market price of an asset consistently exceeds its fundamental value for an extended period **(Evanoff et al., 2012)**. In general, a significant escalation in asset values is often

pursued by a subsequent decline, leading to a bursting of the bubble. **Ghosh (2016)** has suggested that when the market price significantly increases and deviates from the fundamental value of an asset, a rational price bubble is formed. **Kindelberger and Aliber (2005)** have posited that rational bubbles are created when there is an abrupt increase in asset prices, which attracts new buyers and creates a 'herd psychology', thus leading to a further increase in the price of the asset, pushing it away from its fundamentals. Thus, it is imperative to define an appropriate model for the underlying fundamentals to investigate the existence of rational speculative bubbles. Nonetheless, specifying an accurate model for fundamentals is not a straightforward task given parameter and model uncertainty. This creates a joint hypothesis test problem because testing for the null hypothesis suggesting the absence of bubbles is the same as testing for the null hypothesis of "correct model specification for fundamentals." Therefore, the evaluation of the presence of bubbles and the challenges associated with empirically detecting them continue to be a subject of intense debate among researchers. **(Gürkaynak, 2008)**.

At this juncture, some studies focusing on the currency bubbles use the purchasing power parity condition (PPP) to represent the fundamentals underlying the exchange rate fluctuations **(Bettendorf and Chen, 2013; Jiang et al., 2015 and Hu and Oxley, 2017).** Assuming that PPP provides a correct model specification, one can apply econometric tests such as variance bounds test, unit root test, cointegration tests or right-tailed recursive unit root tests to see if the deviations of exchange rate from PPP condition present any bubble formation. While early tests are criticized in that they cannot capture periodically collapsing multiple bubbles, **Philips et al. (2011; 2015a,b)** develop test techniques to address this problem, called the Supremum Augmented Dickey-Fuller (SADF), and Generalized Supremum Augmented Dickey-Fuller (GSADF). These testing techniques are founded upon right-tailed unit root tests, which enable the examination of explosive behaviors in a time series. The main objective of this research is to examine if

there exist any rational bubble occurrences in the exchange rate of the TRY/USD over the periods of 1990-2021. The reasons for focusing on the bilateral exchange rate between Turkish Lira and US Dollar are two-fold: i) given that most of the global shocks spillover through exchange rate movements, the fragility of the Turkish economy, as one of the developing economies, in terms of price and financial stability depends greatly on Turkish Lira's performance against major currencies and ii) US Dollar remains to be a dominant currency. Following the studies Based on the research conducted by **Hu and Oxley (2017)**, **Jiang et al. (2015), and Bettendorf and Chen (2013)** the GSADF tests are implemented on the nominal TRY/USD exchange rate and the deviations of the exchange rate from relative prices of the two countries (deviations from PPP) by differentiating the roles of relative prices of non-tradable and tradable commodities. Although there are previous studies on bubble formations in bilateral exchange rates between TRY and major currencies such as US Dollar and Euro that employ right-tailed unit root tests (SADF, GSADF), they do not consider the role of fundamentals **(Gülcan et al., 2021; Afşar et al., 2019; Samırkaş, 2021; Korkmaz et al., 2016; Yıldırım et al., 2022; Özdemir, 2022 and Deviren et al., 2014).** They report the occurrences of explosive behavior in exchange rates and view those as bubbles. However, explosive behaviors in a time series does not, on its own, establish the existence of a rational 'speculative' bubble as it might be triggered by explosive movement in underlying fundamentals (**Bettendorf and Chen, 2013)**. Thus, one needs to check if fluctuations in the exchange rate from its underlying factors (fundamentals) exhibit explosive behavior to pin down rational bubble formation. This research project is, to the best of our understanding, the first to consider the roles of relative prices (tradable and nontradable goods) as fundamentals in order to study rational bubble formation in TRY/USD exchange rate.

Our results indicate the existence of multiple explosive behaviors in TRY/USD nominal exchange rate during 1994, 2001, 2003-2009, and 2018, but the occurrences of rational bubbles only in 2001 and 2006.

This thesis is organized as follows. The first chapter presents bubbles definitions, detection techniques, and reviews currency bubble literature. The succeeding chapter offers a brief overview of the major Turkish economic events and the performance of the Turkish Lira. Subsequently, theoretical definitions of rational bubbles and fundamentals, and technical discussions on GSADF test for bubble detection are presented. The fourth chapter initiates the introduction of data and subsequently acquires empirical results. The concluding chapter delves into a discussion of the findings and their implications.

CHAPTER 1

BUBBLE DEFINITIONS, DETECTION TECHNIQUES, AND LITERATURE REVIEW ON CURRENCY BUBBLE

For an extended period, economists and the general public have shown considerable fascination with the phenomenon of financial bubbles and their subsequent bursts. Economists have proposed various definitions for bubbles over the years. Based on the research conducted by **Diba and Grossman (1988)**, a bubble can be characterized as a sustained and deliberate deviation of the price of a financial asset from its intrinsic value, which is not explicable by the underlying economic factors. **Brunnermemeirer (2006)** defines bubbles as dramatic price spikes that exceed the fundamental value and subsequently collapse. In a parallel manner, **Maldonado et al. (2019)** characterize a price bubble in an asset as the disparity between its observed and fundamental values. **Philips and Yu (2011)** have defined bubbles as a condition in which the price of increases grows rapidly far from the real valuation of the assets' intrinsic value; this implies that dramatic increases in asset prices result in a consequent decline. Similarly, **Kindelberger and Aliber (2005)** define a bubble as an increase in asset prices that occurs as a result of a sharp rise in prices of an asset, which generates anticipation of further growth, attracting potential buyers for those assets and thus pushing the prices further away from the underlying fundamentals.

1.1. RATIONAL BUBBLES

Kortian (1995) proposed the theory of "rational bubbles" to explain the divergence of asset prices from their fundamental or intrinsic values. **Blanchard and Watson (1982)** further constructed a theory by proposing a model for rational speculative bubbles, that can explain the increase and swift decline of prices in relation to economic fundamentals. However, this model has two main drawbacks. First and foremost, it suggests that bubbles will experience exponential growth and the

possibility of a stock's price dropping below zero is nonexistent, as rational investors would not expect such a trend to occur. Secondly, the model posits two states of nature: one where the bubble persists and the other signifying the collapse of the bubble. This implies that once the bubble bursts, it is assumed to be incapable of re-emerging. According to **Diba and Grossman (1988),** it was further determined that in order for a rational bubble to be present, the successive differences in stock prices must demonstrate non-stationarity.

Froot and Obstfeld (1991) propose a distinct category of bubbles called "intrinsic bubbles". This form of bubble is deemed rational and depend upon the self-fulfilling expectations held by participants within the market. However, unlike rational speculative bubbles, intrinsic bubbles are driven solely by fundamental factors, like dividends, albeit in a non-linear manner. Periodically, intrinsic bubbles return to their fundamental values. The main contrast between intrinsic bubbles and conventional rational speculative bubbles is rooted in the reality that, in the former notion, deviations stem from a non-linear correlation between fundamentals and prices, rather than external factors that typically do not affect asset values. They also state that intrinsic bubbles effectively capture the market's tendency to overreact to changes in dividends. **(Nneji, Brooks&Ward, 2013).** Briefly, while speculative bubbles that are rational in nature are usually driven by speculation and investor sentiment, intrinsic bubbles are connected to fundamental elements, albeit in a nonlinear fashion.

1.2. BUBBLE DETECTION TECHNIQUES ADOPTED IN EMPIRICAL LITERATURE

The literature on bubble detection methods has been divided into two main categories, namely early econometric methods and advanced econometric methods. The tests that fall under these econometric methods are illustrated in the accompanying figure.

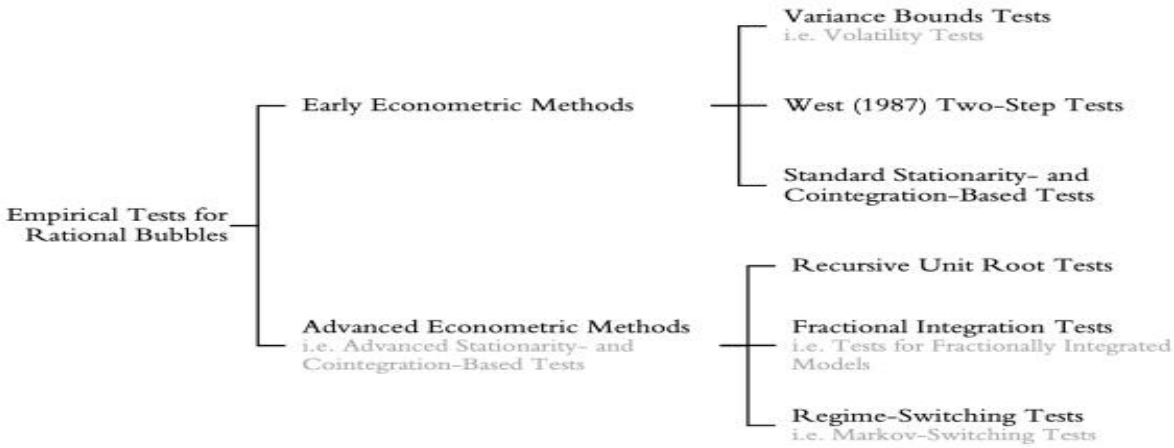

Figure 1: Empirical Tests for Rational Bubbles,

Source: Wöckl, 2019

Over the past decade, progress has been made in the area of bubble detection mechanisms. Generally, researchers in literature have been concentrating on advanced stationarity and co-integration-based methods to identify exuberance in financial markets. Recently developed bubble detection methods include regime switching, fractional integration, and recursive unit root tests. According to the papers, these tests have the advantage of being based on fundamental factors rather than the time series of asset prices, thus avoiding the testing of a joint hypothesis of the presence of rational bubbles and the validity of the model used. However, while one method may fail to detect bubbles in a data set, another may conclude bubble detection in the same data set in many cases. Consequently, the empirical results on bubbles remain inconclusive and are still evolving in different directions **(Wöckl, 2019)**.

In his publication, **Gürkaynak (2008)** provides a comprehensive analysis of the literature pertaining to econometric tests for identifying rational bubbles within the context of the present valuation of dividends model. While there are studies attempting to quantify and differentiate the contribution of market fundamentals and rational bubbles to asset price movements empirically, the paper concludes that

this is not possible. Consequently, there is still no consensus on which bubble detection methodology should be employed. Furthermore, the paper also identifies several econometric challenges to empirical bubble detection, such as the difficulty in ascertaining the underlying worth of an asset, the potential for the variables used in the tests to not be in a causal relationship, and the difficulty in differentiating bubbles from other market anomalies.

In the existing body of literature, tests aimed at identifying rational bubbles through econometric methods can be broadly categorized into three groups. As outlined in **Gürkaynak's (2008)** research, these assessments fall into the domains of Variance Bounds Tests, West's Two-step Tests, and Integration/Cointegration Based Tests.

1.2.1. Tests for Variance Bounds

Shiller's (1981) and **LeRoy&Porter (1981)** are credited as the originators of variance bounds tests to assess equity prices. The test of Shiller solely provides variance estimations, lacking any statistical significance testing. Conversely, LeRoy&Porter's approach incorporates dividends and equity prices as a unified process, thereby enabling statistical significance testing. Despite this, Shiller's method is simpler and consequently more widely utilized **(Gürkaynak, 2008).**

Shiller and Grossman (1981) utilized findings from their variance-bound test to question the reliability of the present value model. In contrast, **Tirole (1985)** and **Blanchard&Watson (1982)** suggested that the breach of the variance bound could be linked to the existence of bubbles. Despite this, the application of variance bounds tests makes them inadequate for detecting bubbles. **Flavin (1983)** illustrated that employing the mean price as the ultimate ex-post rational price introduces a bias toward rejection in small sample sizes. **Kleidon (1986)** argued that using time-series variances instead of cross-section variances goes against the variance bound. **Marsh and Merton (1983)** offered an illustration of a variance bounds test proving ineffective in cases where dividends and stock prices exhibit

non-stationarity. In order to respond to the Flavin criticism, the variance bounds test has been adapted to incorporate the final observed price as the terminal price. This adjustment, however, poses a difficulty specifically in regards to bubble detection. Scholars such as **Mankiw, Romer, and Shapiro (1985)** have emphasized that in such circumstances, variance bounds tests are not appropriate for identifying bubbles **(Gürkaynak, 2008).**

1.2.2. Tests for West's Two-step

This type of test is a significant test of equity price bubbles because it includes the possibility of a bubble as an alternative hypothesis. This test was cleverly designed to address the problem of conducting simultaneous testing for both model specification and the presence of bubbles by sequentially examining these hypotheses..

In paper, **Gürkaynak(2008)** examines West's two-step approach to identifying asset price bubbles. The author utilizes the Euler equation in the absence of bubbles in order to estimate the discount rate. Additionally, by expressing dividends as an autoregressive process, **Gürkaynak (2008)** establishes a connection between dividends and the fundamental stock price in the market. Through the regression of stock prices on dividends, the actual relationship between the two can be estimated. In cases where there are discrepancies between the estimated effects, it is possible to attribute such inconsistencies to either model misspecification or the presence of bubbles. To further investigate this, West implements several specification tests, including structural break tests, on both the Euler equation and the dividend equation. Notably, his use of a Hausman test to assess coefficient restrictions results in the rejection of the null hypothesis of equal coefficients. Nevertheless, **Gürkaynak (2008)** highlights that this does not invalidate the rejection of the no-bubbles hypothesis, as it could be attributed to other factors such as the peso problem or unanticipated changes in regimes.

1.2.3. Integration/Cointegration-Based Tests

Gürkaynak (2008) further examines the integration/cointegration-based tests for identifying asset price bubbles. This methodology is based upon the hypothesis that asset prices and dividends are non-stationary in time series, but their linear combination may exhibit stationarity if the asset's price is influenced by underlying factors. Consequently, by assessing the stationarity of the linear combination of asset prices and dividends, it is possible to detect whether asset prices are determined by fundamentals or if they are in a bubble.

Among the widely recognized examinations within this category is the unit root test, designed in order to assess the stationarity of a time series of data. However, this test is not appropriate for detecting bubbles because it assumes that the time series has a deterministic trend, while bubbles are characterized by explosive behavior. Therefore, the ADF test method is used instead, which enables the possibility of a stochastic trend in the data

The co-integration test is another assessment that can be conducted in this field of study. This assessment aims to ascertain if two non-stationary time series exhibit a linear relationship in a way that the linear combination of the two becomes stationary. If asset prices and dividends are co-integrated, it implies a long-term connection between the two variables, indicating that asset prices depend on dividends. Therefore, any divergence from this long-term association can be seen as an indication of a bubble. However, **Gürkaynak (2008)** notes that these tests have limitations as well. For example, they may not be able to distinguish between bubbles and fundamental shifts in the underlying economy, and they may be affected by the sample period and the choice of variables used in the test. Therefore, it is imperative to utilize these tests in conjunction with other methods and to interpret their results carefully.

1.3. LITERATURE REVIEW ON CURRENCY BUBBLE

In academic literature, there have been numerous papers that have sought to investigate the detection of bubble behavior in datasets. To analyze such behavior, economists attempt to discover the underlying causes of the abrupt changes in prices. According to **Girdzijauskas (2009),** some economists link bubbles to inflation and posit that the same factors that lead to inflation are also responsible for the formation of bubbles. Conversely, some economists claim that each asset has an intrinsic fundamental value, and bubbles are formed when these values are significantly exceeded. Additionally, some economists advocate chaotic theories, suggesting that bubbles are a result of the communication between economic players in the market **(Girdzijauskas et al. 2009)**.

Research into bubbles in various financial and commodity markets, such as the foreign exchange market, stock market, commodity market, crypto money market, housing market, and precious metal market, has been conducted. For the purpose of this thesis, we shall restrict our review to studies concerning currency bubbles. We shall begin by referring to the papers that utilize early test techniques, and proceed to the paper that employs the GSADF test to detect currency bubbles. Finally, we review empirical studies focusing on bubble behavior in TRY versus major currencies exchange rates.

1.3.1. Bubble Detection Studies with Early Test Techniques

In 1986, **Evans** performed a substantial evaluation of speculative market bubbles within the Sterling/Dollar currency exchange rate during the specific timeframe of 1981-1984. He proposed that a speculative bubble could be identified during any sub-period in which the median of excess holding of an asset was non-zero. The results of the analysis demonstrated that, during the 1981-1984 period, there was significant evidence of price bubbles resulting from irrational expectations.

Meese (1986) conducted a study that examined the presence of asset market bubbles and extraneous variables in the exchange rate markets between the Dollar and the Deutsche Mark, as well as the Dollar and the Pound. The study utilized monthly data from the years 1973 to 1982. Furthermore, **Elwood et al. (1999)** conducted a study in which they investigated the presence of rational bubbles in the exchange rate between the Japanese Yen and the German Deutsche Mark, finding strong evidence of deviation for the Japanese and German exchange rates. They observed that the explosiveness bursts between the end of March and April in the year 1990. The authors did not consider this result to be surprising, there was a significant amount of unrest in the financial markets of both Germany and Japan during that timeframe.

To identify speculative bubbles in the foreign exchange market, n 1987, Woo conducted a study analyzing the bilateral exchange rates between the US Dollar and the currencies of France, Germany, and Japan. **Woo (1987)** applies the bubble-augmented portfolio model while determining bubble formation in the dataset. This model passes the usual test statistics and yields insignificant coefficients when the bubble term is specified incorrectly. Likewise, in **West's (1987)** paper, he employed volatility models, and the outcomes suggested a lack of pieces of evidence for speculative bubbles in the market of foreign exchange.

According to the research conducted by **Wu** in **1995**, the author examined the presence of stochastic exchange rate bubbles between the US Dollar/British Pound and the Japanese Yen/Deutsche Mark. In contrast to previous findings which suggest that the dollar exchange rate is influenced by speculative bubbles during the post-Bretton Woods era, Wu's analysis yielded no substantial evidence of such bubbles for the selected dataset.

Conversely, **Chan et al. (2003)** examined the existence of currency exchange rate bubbles in the periods of interwar European hyperinflation in Poland, Germany, and Hungary. They applied the methodology that extends the Durlauf-Hooker

approach in order to analyze the data and reached the result that there are neither price nor exchange rate bubbles for experienced countries during the hyperinflation period.

Furthermore, the study conducted by **Jirasakuldech et al. (2006)** investigated the presence of rational speculative bubbles in various exchange rates including the British Pound, Canadian Dollar, Danish Krone, Japanese Yen, and South African Rand against the US dollar. The researchers examined crucial fundamental factors such as money supply, income, and interest rates. Based on the testing procedures employed, the results did not reveal any indication of rational speculative bubbles existing between the exchange rate fluctuations and the fundamental variables. Furthermore, cointegration test statistics did not provide evidence for the presence of speculative bubbles between these two components as well.

Maldonado et al. (2012) introduced a model to explain periodic collapses observed in currency exchange rates. This model extends **Van Norden's 1996** model and includes a non-linear specification for the magnitude of bubbles during the period of sustainability, as well as an internal determination of the fundamental exchange rate level.

Van Norden's (1996) research, which focused on detecting speculative bubbles in various datasets, analyzed the Japanese yen, German Mark, and Canadian dollar exchange rates for the time frame between 1977 and 1991. The author argues that the results of the tests are significantly influenced by the specifications of exchange rate fundamentals and other factors. Furthermore, a similar inquiry by **Maria (2016)** investigated the presence of financial bubbles in the GBP/USD, CAD/USD, and JPY/USD exchange rates using monthly data from 1990 to 2013. The Likelihood-Ratio test was employed and the findings revealed strong evidence of bubbles in the examined dataset.

Maldonado et al. (2017) employed a specific method for identifying bubbles in exchange rate series. Their research was focused on examining the behavior of exchange rates against the US Dollar in BRICS countries (which consist of Brazil, Russia, India, China, and South Africa). To conduct their analysis, the authors utilized a bubble model that had been developed in 2012. The aim of their investigation was to assess the existence of exchange rate bubbles in the selected currency pairs within the foreign exchange markets. Their chosen model subsequently confirmed the presence of rational bubbles in exchange rates for all countries. Furthermore, their analysis also revealed that these bubbles were co-integrated across all of the countries, leading the authors to conclude that there is evidence of the international transmission of exchange rate shocks between these selected nations. Additionally, **Maldonado et al. (2019)** continued their research by examining the presence of four types of rational bubbles in the currency pairs of the BRICS countries against the US dollar. In order to calculate the fundamental value of the exchange rate in their research, the authors utilized some structural specifications, namely the modified PPP rule (based on the interest rate differential between countries) and the pure PPP rule. The four types of bubbles that were examined in this study include explosive, multiple, periodically collapsing, and intrinsic bubbles. The authors concluded that for Brazil, India, Russia, and South Africa, there is evidence of at least one type of bubble behavior, whereas China did not experience any bubbles during the period covered by the dataset.

1.3.2. Bubble Detection Studies with GSADF Test

Criticisms of early tests have been raised due to their inability to capture periodically collapsing multiple bubbles. In response to this, **Philips et al. (2011; 2015 a,b)** developed test techniques, known as SADF and GSADF, which depend on right-tailed unit root tests and allow for the examination of explosive behaviors in a time series. For example, **Pavlidis et al. (2012)** carried out research on the

existence of exchange rate bubbles in the explosive regime, analyzing the exchange rate between the Reichsmark and Dollar currency during the period of hyperinflation in Germany. In the paper, the GSADF test statistics proposed by **Philips et al. (2015)** were applied in order to investigate multiple episodes of explosive behaviors for the dataset. They examined the exchange rate between the Reichsmark and the Dollar for the period spanning 1921 to 1923 and explored the periods that could be associated with rational bubbles.

An additional publication examining the existence of rational bubbles in the currency exchange rate was released by **Battendorf and Chen (2013).** They utilized sequential unit root tests, including ADF, SADF, and GSADF, in the investigation of exchange rate bubbles and discovered compelling evidence of explosive behaviors in the exchange rate of the nominal Sterling-Dollar parity. Nevertheless, their interpretation suggests that, despite the observed explosiveness in the exchange rate, it should not be construed as indicative of bubble behavior. They argue that the identified explosiveness aligns with similar behavior in the relative prices of traded goods. Furthermore, it has been asserted that the outcome of the aforementioned study reveals that non-traded goods have a negligible impact on the fluctuation of exchange rates when compared to relative prices of traded goods. So, it is emphasized that only analyzing explosive behavior in asset prices is not a sufficient condition to detect bubble behavior, the choice of underlying fundamentals is also very important to identify bubbles in asset prices. Therefore, this is a crucial issue for policymakers and practitioners while conducting research on bubbles and implementing a policy accordingly.

There is also a paper that investigates multiple bubble behaviors in the exchange rate between the Chinese renminbi and the US dollar by applying the GSADF test. The study by **Jiang et al. (2015)** proposes that each bubble leads to a redistribution of wealth among economic agents since if the bubble collapses, it will lead economists to establish several economic models, experimental tests, and studies. As outlined in the paper, subsequent to the 2005 reform which transitioned

towards a floating exchange rate managed by market forces of supply and demand, they encountered multiple explosive exchange rate bubbles between RMB and Dollar. Additionally, it is asserted that during the period of 2005-2006, there is no evidence of explosive bubble behavior in the nominal exchange rate between the US and China, applicable to both traded and non-traded goods. Only small bubbles are observed for both exchange rates during 2005-2006 and this is caused by structural reform change in 2005. The authors also examined an additional volatile pattern within the exchange rate during the period of 2007-2008, specifically concerning the sole relative price of traded goods which was attributed to the 135% decline in Chinese PPI, while the decline in US PPI amounted to 700%. Therefore, the movement of prices led to explosive behavior in exchange rates. The authors of the article have reached the conclusion that their findings align with those of **Engels (1999), Betts and Kehoe (2006, 2008), and Bettendorf and Chen (2013)**. These studies emphasize that fluctuations in exchange rates among nations are primarily driven by relative prices of traded goods. Hence, China needs to tighten fiscal and monetary policies for an effective bubble-burst scenario.

Additionally, **Hu and Oxley's (2017)** study conducted research to identify bubbles in exchange rates, analyzing data from both developing economies and G10 countries. They aimed that testing for fluctuations in the nominal exchange rate and investigate the causes behind this explosive behaviors. It is stated in the paper that the existence of bubbles is evaluated as a considerable topic in the economy and finance especially subsequent to the onset of the Global Financial Crisis. They have conducted research by applying the GSADF test and exchange rate bubbles have been investigated for emerging economies and G10 countries and reached a conclusion that exchange rate bubbles have been detected in the USD/Mexican Peso between 1994 and 1995. They evaluated this situation as the possibility of bubbly behavior in exchange rate market is more likely when compared to mature G10 economies. Besides testing the explosiveness in the exchange rate, the cause

of the explosiveness of this fluctuation is also investigated in the paper. According to the conclusion of the paper, the cause of explosiveness behavior in exchange rates for emerging economies perhaps because fragile economic policy stances since the results verified that developing economies are prone to exhibiting bubble behaviors in the exchange rate when compared to developed ones **Hu&Oxley (2017).**

Additively, **Rasekhi et al (2017)** published a paper that investigates bubble formation in the foreign exchange market of Iran by applying monthly data for the period between 2002 and 2016. Applying SADF and GSADF test statistics, the results demonstrate that for an examined period there are multiple bubble periods for different dates.

Steenkamp (2017) investigated bubble behavior in New Zealand Dollar by applying the GSADF test. In order to analyze the explosive behavior in exchange rates fundamental determinants are used. Utilizing the monthly and quarterly data for chosen currency pairs, the research of **Steenkamp (2017)** found no evidence of explosiveness in the New Zealand Dollar and its fundamentals. Later, **Steenkamp (2018)** published a paper that investigates the explosiveness in G11 currencies using non-stationary volatility methodology. The findings indicate that the occurrence of explosive behaviors in exchange rates is rare in daily intervals. Nevertheless, explosive periods are more likely to persist for extended periods. In addition, the results include evidence that explosive episodes in these currency markets align with heightened market volatility.

Dutt and Ghosh (2019) conducted research on the exchange rate bubbles for US/Indian rupees by applying SADF and GSADF test statistics. Based on the findings of the test, it has been determined that there is evidence to support the presence of bubbles between the late 1990s and early 2000s. Furthermore, there is also evidence of bubbles during the period of 2012-2018, where there was a notable fluctuation in the exchange rate.

Su et al. (2020) utilized the GSADF test to examine various exchange rate bubbles involving the Renminbi (RMB) and Hong Kong Dollar (HKD) through logistic regression over the period from January 1994 to November 2019. The findings of the study reveal multiple instances of bubbles between these two currencies, highlighting short-term bubbles in nominal and long-term bubbles in real exchange rates. Additionally, the research indicates that these exchange rate bubbles predominantly coincide with financial crises. The study notably proposes that RMB bubbles are more common during domestic financial crises, whereas HKD bubbles occur in both domestic and international financial crises. Moreover, the paper highlights the existence of interactions between bubbles in RMB and HKD exchange rates.

Moreover, **Narayan (2020)** examines various bubble types in the exchange rate data of the Japanese Yen, European Euro, Canadian Dollar, and British Pound. The aim is to analyze potential bubble-like behaviors in the dataset using the recent econometric procedure proposed by Philips et al. (2011). The author concludes that there is evidence of bubble behavior in all types of exchange rates during the Covid-19 period. Additionally, the study's results indicate that as markets become more inefficient when comparing the pre-Covid-19 period, bubbly behaviors are more pronounced during the Covid-19 era.

Ahmet et al. (2021) conducted a study to identify exchange rate bubbles in Dollar/Pakistani Rs for the period between 1982 and 2020 applying GSADF test statistics. The authors both studied the exchange rates before and after regime switching. Based on the obtained test results, it can be concluded that the traded goods fundamental accounts for the fluctuations in exchange rates, and this volatility is observed in the exchange rates of Dollar/Pakistani Rs during both regimes. Moreover, it has been further established that the price difference of traded goods serves as an explanatory factor for the aforementioned volatility observed during the managed floating exchange rate regime.

Also, the paper of **Ural (2021)** investigated multiple price bubbles for the exchange rate of USDKZT by using the recursive right tailed GSADF test which was developed by **Philips, Shi, and Yu (2015).** The paper applied the weekly closing price of the nominal exchange rate which is between 2015-2021 and discussed that there are two explosive bubbles in 2018 and 2020. The distinctive contribution of this paper that determined date stamps of exchange rate bubbles is there has not been any previous study on exchange rate bubbles of USDKZT in the literature. According to research, the cause of two explosive behaviors detected in 2018 and 2020 originated from domestic and foreign events. It is also stated that the exchange rate bubbles create herd psychology between investors and create a 'buy' instinct. Therefore, this herd psychology makes the USDKZT exchange rate more sensitive to speculative movements.

Besides the papers that investigate the exchange rate bubbles by adopting SADF and GSADF tests in foreign academic literature, there are also papers that investigate the exchange rate bubbles between the Turkish Lira and major currencies.

1.3.3. Bubble Detection Studies on Turkish Lira versus Some Major Currencies

Several studies have explored bubbles in the Turkish Lira (TRY) concerning various currencies. **Gülcan et al.'s (2021)** research, for instance, delves into the analysis of bubble behaviors in exchange rate market, focusing predominantly on commonly traded currencies, such as the US Dollar, Euro, Japanese Yen, British Pound, and Chinese Yuan. Both the SADF test which is used to detect single bubble detection and the GSADF test which is used to detect multiple bubble detection are used to determine explosiveness in the exchange rate pairs. Based on the paper's findings, there is evidence pointing to the emergence of financial

bubbles in the foreign exchange rates in Turkey. SADF tests indicate bubble formation in the exchange rates of USD/TRY, EUR/TRY, GBP/TRY, and JPY/TRY. However, the paper suggests no indication of bubble detection for the exchange rate of CNY/TRY. Conversely, results from the GSADF test statistics reveal the detection of multiple bubble formations for all exchange rate pairs in the dataset. Additionally, when all the graph analysis of SADF and GSADF tests has been examined, the periods of bubble formations coincide with each other.

In the study of **Deviren et al. (2014)** the TRY/USD, TRY/EUR, TRY/JPY, and TRY/CHF were analyzed to examine bubbles in currency pairs during the global crisis. In this study, the authors employed the methodology established by **Watanabe et al. (2007)** to identify bubbles and crashes in the exchange rates involving the Turkish Lira (TRY). The advantage of the methodology is that it can determine the bubbles and crashes from the past data and the starting and ending points can be identified before the bubble burst. According to the findings of the paper's assessment, crashes in the TRY/CHF exchange rate have typically concluded in comparison to those witnessed in other currencies. Consequently, the authors deduce that as soon as the crashes in the TRY/CHF exchange rate have ceased, it is highly probable that the remaining crashes will also come to an end. Furthermore, the results indicate that the duration of the crash periods for the TRY/EUR and TRY/USD exchange rates are considerably longer in comparison to those observed in other currencies.

Afşar et al. (2019) also conducted a study on the issue of bubbles in exchange rate by applying the GSADF test. The paper states that the bubble burst triggered by the bulge in asset prices has become a threat to economic stability. Therefore, analyzing the bubble formation in foreign exchange market is very crucial for economists, investors, and politicians. The study investigated the explosive patterns of USD/TRY and EUR/TRY exchange rates between 2005:1 and 2018:11. The obtained findings indicate the presence of speculative bubbles throughout the examined time frame for the exchange rate pairs.

Additively, **Samırkaş (2021)** has research on the bubble detection and period length for Turkey's exchange rate market. He contends that after the shift from a fixed exchange rate regime to a flexible exchange rate regime in 2001, exchange rates in Turkey have demonstrated heightened volatility and unpredictability. The paper also has a point on the issue that although the bubbles cannot be evaluated as the only reason for the financial crisis, they can be considered as one of the main indicators that trigger the financial crisis and deepen its effect. For instance, the crises in Mexico (1994), Korea (1997), Brazil (1999), Argentina (2002), and Turkey (2001) are triggered by instability in exchange rate markets. According to the test results, **Samırkaş (2021)** has encountered exchange rate bubbles both in Euro and Dollar. The presence of bubbles in the foreign exchange rate market of Turkey is contingent on the international policy of the country, as these bubble periods align with significant political events.

In a separate study conducted on the Turkish foreign exchange market, **Korkmaz et al. (2016)** examined the impact of bubbles on the USD/TRY, EUR/TRY, BIST100, and gold prices through the utilization of right-tailed SADF and GSADF test statistics. The study employed monthly data and found that while there are no indications of bubble formation in the EUR/TRY exchange rate dataset, compelling evidence exists for the presence of bubbles in both the USD/TRY exchange rate and gold prices.

In addition to the aforementioned studies, a recent paper on exchange rate bubbles in Turkey has been released. The research conducted by **Yıldırım et al. (2022)** delves into the exchange rate dynamics of Brazil, Russia, India, China, South Africa, and Turkey. The authors scrutinize explosive movements in exchange rate pairs using the Supremum Augmented Dickey-Fuller (SADF) and the Generalized Supremum Augmented Dickey-Fuller (GSADF) approaches. The findings indicate that, excluding the US Dollar/Indian Rupee exchange rate, all other exchange rate pairs against the US Dollar exhibit evidence of bubbles. The authors suggest that the developing countries analyzed in the paper are

susceptible to speculative exchange rate movements, which may pose challenges for their economies. Additionally, more stable economies such as China, India, and Russia have currencies that are relatively stable compared to Turkey and South Africa. Consequently, the results of this study can serve as guidance for policymakers in less stable economies.

Additionally, **Özdemir (2022)** utilizes right-tailed unit root tests for the purpose of identifying the formation of bubbles in the exchange rate of the Turkish Lira against the top five currencies traded in the financial market. These currency pairs for the exchange rates are as follows: USD/TRY, GBP/TRY, EUR/TRY, CNY/TRY, and RUB/TRY. The author used the data of these currency pairs for the period between 2015 and 2021 and applies SADF and GSADF test statistics to analyze all five currencies with sub-period including the pre-Covid19 era. This study's empirical findings illustrate that for each exchange rate pair, there are positive bubbles and during the Covid period the multiple bubbles are intensified. These results can be interpreted as the foreign exchange market becoming more inefficient when it is compared to the period of pre-Covid19.

CHAPTER 2

A REVIEW OF THE TURKISH ECONOMY AND THE RECENT PERFORMANCE OF THE TURKISH LIRA IN THE PAST FOUR DECADES

Turkish economy is composed of a wide variety of industries, including manufacturing, construction, agriculture, and services, and is strategically situated at the intersection of Europe and Asia, making it a significant trading and investment hub. In the 1980s, the country undertook economic reforms such as free market liberalization, privatization, and trade liberalization, resulting in increased foreign investment and economic growth. The 1990s saw the implementation of IMF-backed economic programs, which aimed to control inflation, promote fiscal discipline, and implement structural reforms. This period was marked by strong economic growth and low inflation in the 2000s. The rise in foreign investment and reforms, particularly in the banking sector, bolstered the economy. However, in the 2010s, Turkey faced challenges such as regional conflicts and political instability, resulting in a deceleration in economic growth and a rise in inflation. The Turkish lira has experienced significant devaluations, particularly in 2018 and 2019.

Throughout the previous four decades, the Turkish lira has undergone significant volatility, notably during the initial periods of 1990s and 2000s. During these times, there were drastic devaluations, and the Turkish economy was struck by severe crises in 1994 and 2001, resulting in a substantial decrease in TRY. Likewise, during the 2008-2009 global financial crisis, the Turkish lira depreciated against the US dollar. More recently, in 2018 and 2019, the Turkish lira underwent a significant devaluation, largely owing to the tensions between Turkey and the United States. Nevertheless, the causes of these fluctuations have varied depending on various elements in different periods.

In this chapter, we will briefly explain major economic conditions and the fluctuations in the Turkish Lira during these periods.

2.1. 1994 CURRENCY AND ECONOMIC CRISIS

During the crisis in 1994, Turkey encountered a severe economic shock that had significant consequences for economy. As a result of the crisis, the economy of Turkey underwent a decline of 6%, representing the most significant degree of output decline in the entire span of the Turkish Republic's history **(Celasun, 1998). Özatay (2000)** identifies the specific factors that triggered the crisis, including a sharp increase in US interest rates, a lack of policy coordination between monetary and fiscal authorities, high levels of external debt, and inconsistent exchange rate policies in his paper. The paper also discusses the policy response to the crisis which included a series of stabilization measures aimed at restoring macroeconomic stability and reducing the external vulnerability of Turkish economy.

Amidst the crisis of 1994, the Turkish Lira suffered a significant depreciation. The ineffective intervention of the Turkish government and its inadequate implementation of reforms also contributed to the devaluation of the TL. At the beginning of the crisis, the Turkish Lira/US Dollar exchange rate was at 1.0 TL/1.45 US Dollars, but at the peak of the crisis, this rate increased to 1.0 TL/1.80 US Dollars **(Özatay, 2000)**. Thus, the Turkish Lira underwent a devaluation of over 50% against the US Dollar, and the inflation rate surged to three-digit levels. **(Celasun, 1998).** As a result, the devaluation of the TL had serious impacts on the Turkish economy during the crisis, leading to an increase in the cost of imports and inflation.

2.2. 2001 BANKING AND CURRENCY CRISIS

The 2001 Banking Crisis in Turkey was a major financial crisis that shook the country's banking system and had significant impacts on the overall economy. The

crisis arose as a consequence of a convergence of both endogenous and exogenous factors. A key internal factor was the inadequate management of the banking sector, particularly the lack of supervision and regulation of banks. This, combined with a weak financial structure and excessive lending to politically connected businesses without appropriate risk assessments, led to significant non-performing loans in the banking system. Furthermore, the Turkish economy was susceptible to external shocks. The crisis was exacerbated by global factors, including the worldwide economic slowdown and the repercussions of the 9/11 terrorist attacks, leading to a substantial reduction in foreign currency inflows. This resulted in intense pressure on the exchange rate and the balance of payments, further aggravating the crisis **Aysan & Ceyhan (2010).**

During the crisis, the loss of confidence in the banking system obliged depositors to withdraw their deposits from banks. Therefore, government intervention has begun as a necessary issue in order to avert the failure of the banking system. To tackle crisis, government implemented a comprehensive reform program, including the restructuring and consolidation of the banking sector such as an introduction of new bankruptcy law **Kesebir (2018).** This program also included the strengthening of banking regulations to prevent similar crises from occurring in the future. Additionally, the International Monetary Fund (IMF) granted financial assistance to Turkey as part of a bailout program aimed at mitigating and eradicating the adverse impact of the crisis on the Turkish economy.

On February 19th, it was announced that there was a significant political crisis between the Prime Minister and the President following a National Security Council meeting. This announcement caused the overnight interest rates to increase to 2058% the next day and 4019% the following day. As a consequence of the declaration, the banking industry rushed to foreign currency, but the Central Bank was unable to meet the demand as the US markets were closed, resulting in a loss of $7.5 billion in reserves. The depletion of reserves and high-interest rates led to the Central Bank gradually accepting the devaluation, and on January 23rd, the

Turkish lira was allowed to freely float. This caused the exchange rate of the dollar to increase from 685 thousand liras to 958 thousand liras. As a result of these events, the Undersecretary of the Treasury and Governor of the Central Bank resigned, and Economy Minister was replaced **Özatay & Sak (2002)**.

2.3. THE GLOBAL FINANCIAL CRISIS OF 2008

The Financial Crisis profoundly impacted the global economy, leading to significant job losses, bankruptcies, and a contradiction in economic activity. The financial crisis can be attributed to the collapse of the housing market in the United States and the significant prevalence of delinquent loans, specifically subprime mortgages. This has subsequently led to the insolvency of major financial establishments in the United States, and the subsequent dissemination of this crisis to the international financial sector. It additionally revealed vulnerabilities in the global financial system, prompting demands for increased regulation and supervision of the financial industry **(Nanto, 2009)**.

The global crisis had a considerable effect on the Turkish economy primarily through four channels. Firstly, the trade channel experienced a substantial decline in export levels. Secondly, expectations played a crucial role, with household expectations worsening during the financial turmoil, leading to a reduction in consumption levels. The third channel was foreign capital flows, witnessing a decrease in cross-border lending throughout the crisis period. The ultimate outcome was reflected on the credit side, as financial institutions reduced their loaning practices, leading to a substantial downturn in economic performance and a rise in unemployment **Yörükoğlu & Atasoy (2010)**.

Turkish Economy was hit negatively by the export channels during the global financial crisis. Although Turkey's exports saw significant growth after 1994 and 2001 crisis, as a result of substantial depreciations in value of the TRY during the global crises, there was a notable decrease in export revenues. The earnings of exports decreased more than 20% in 2009. Since the EU which is the biggest

export partner of Turkey has been affected by the global financial crisis deeply, Turkey's export performance has fallen accordingly **(Cömert & Çolak, 2016).**

During the crisis, due to the decrease in the expectations of consumers and investors, consumption levels and investment spending declined. Negative developments and thoughts on the future economy cause a decline in consumption expenditure. Also, there was a contradiction in investment expenditure during the global financial crisis **(Cömert & Çolak, 2016).**

The crisis transmitted into developing economies through financial channels. Closely linked developing countries have experienced exchange rates and liquidity shocks. However, Turkey was not affected by severe turmoil. When it compared to the crisis in 1994 and 2001, Turkish financial system recovered fast after the global financial crisis **(Cömert & Çolak, 2016).**

During the crisis, the authorities adopted some fiscal, monetary, and financial policies to mitigate the negative effects. A comprehensive fiscal policy package was announced in March 2009 **(Uygur, 2010).** After, subsequent fiscal actions were taken accordingly. For instance, some tax regulations and reductions were applied. With the help of these fiscal policies, recovering the macroeconomic fundamentals was aimed. Beside the fiscal policies, The Central Bank of Turkey took some monetary actions to stabilize the inflation. CBRT attempted to increase the money supply by decreasing interest rates during the crisis. This made it easier for banks to lend and helped to stimulate the economy. Also, it took various measures to provide forex liquidity to banks during the crisis and provide some financial assistance for banks in order to prevent bankruptcies **(Cömert & Çolak, 2016).**

2.4. THE BRUNSON CASE

The Brunson Case had a considerable economic impact on both Turkey and the United States. Subsequent to Brunson's apprehension, the United States imposed

economic sanctions on Turkey, including sanctions on Turkish government officials and tariffs on Turkish steel and aluminum imports. As a consequence of the imposed sanctions, the value of the Turkish Lira plummeted, and inflation and unemployment rose exponentially. The long-term collaboration between Turkey and the United States reached unprecedented lows during the summer of 2018 **(Abuselidze & Mamaladze, 2019).**

In the second half of 2018, the case of Andrew Brunson, an American citizen who had been detained in Turkey since 2016, caused one of the most severe currency shocks that Turkey had experienced in recent years. The US dollar, which had started at 3.8 Turkish Lira in 2018, reached 7.2 Turkish Lira in July and August due to the political and economic tensions between the US and Turkey, resulting in a near doubling of the value of the dollar. Consequently, the Turkish Lira hit its historic low against the dollar **(Şanlı, 2021).**

CHAPTER 3

SPECIFICATION OF FUNDAMENTALS AND TECHNICAL NOTES ON GSADF TEST AS A BUBBLE DETECTION METHOD

3.1. DEFINITION OF RATIONAL BUBBLE AND SPECIFICATION OF FUNDAMENTALS

In this study, we will apply the GSADF test in order to detect the formation of an exchange rate bubble in USD/TRY by defining some fundamentals. Priorly, we should take a glance at the theoretical background of the formation of exchange rates. This section largely borrows from **Bettendorf and Chen (2013).**

Following **Bettendorf and Chen's (2013)** research, **Obstfeld and Rogoff (1996)** claimed that the nominal exchange rate can be likened to the price of an asset. This suggests that the exchange rate is influenced by both anticipated and current values of fundamental factors. Hence, it is posited that the exchange rate can be expressed in the following manner:

$$s_t = (1-\lambda) \sum_{j=0}^{k} \lambda^j E_t[f_{t+j}] + \lambda^{k+1} E_t[s_{t+k+1}], \qquad (1)$$

in the equation above s_t denotes the nominal exchange rate and f_t denotes market fundamentals at the time *t.* Also, λ refers to the discount factor. When the transversality condition is applied,

$$lim_{k\to\infty} \lambda^k E_t[s_{t+1}] = 0 \qquad (2)$$

by this, we guarantee that over the long term, the exchange rate will depend only on the expected future fundamentals. However, in the absence of the transversality condition, a situation may arise where the exchange rate is susceptible to an explosive rational bubble. Assuming the bubble follows an AR(1) process, it can be characterized as:

$$b_t = 1/\lambda\, b_{t-1} + \varepsilon_t \qquad (3)$$

If the first-order coefficient 1/λ is greater than 1, then the bubble will exhibit an explosive process. Error is defined by $\varepsilon_t \sim \mathrm{NID}(0, \delta)$. Consequently, we can represent the exchange rate as:

$$s_t = s_t^f + b_t \quad \text{or} \quad s_t - s_t^f = b_t \qquad (4)$$

In the equation above, s_t^f encompasses all forthcoming economic fundamentals while b_t signifies the bubble component. The assumption is made that s_t exhibits a linear dependence on the economic fundamental f_t, according to the research by **Bettendorf and Chen (2013)**.

In accordance with the Purchasing Power Parity Model, economic fundamentals for nominal exchange rate can be characterized as the disparities in prices:

$$f_t = p_t - p_t^* \qquad (5)$$

In the equation above, p_t and p_t^* indicate the price indices for both domestic and foreign markets with a natural logarithm. The domestic price index can be defined as the geometric mean of the prices of both traded and non-traded goods within a country, which is formalized as follows:

$$p_t = (1 - \alpha)\, p_t^T + \alpha(p_t^N), \quad (6)$$

In the equation above p_t^T represents the price index for traded goods and p_t^N denotes the price index for non-traded goods. As a similar way, we can define foreign price indices:

$$p_t^* = (1 - \beta)\, p_t^{T*} + \beta\, (p_t^{N*}), \quad (7)$$

Further, we can formalize price differential f_t by subtracting equations (6) and (7) side by side. Therefore, it can also be divided into two components: traded goods, denoted by f_t^T, and non-traded goods, denoted by f_t^N:

$$p_t - p_t^* = (p_t^T - p_t^{T*}) + \alpha\, (p_t^N - p_t^T) - \beta\, (p_t^{N*} - p_t^{T*}) \quad (8)$$

As is well known, Balassa-Samuelson hypothesis postulates that the disparity in the prices of non-tradables and tradables can be attributed to the disparities in productivity levels between countries **(Balassa, 1964).** Accordingly, the countries with higher productivity levels tend to have higher wages, thus resulting in higher prices for non-tradable goods. Thus, deviations of nontradable prices may play a fundamental role in exchange rate movement. Although tradable goods are subject to global competition and trade and thus one might expect more uniform tradable

prices across countries, we can see substantial deviations of relative prices of tradables due to shocks to terms of trade, in which case relative price of tradables can lead to movement in exchange rates. Therefore, we are to consider the impacts of relative prices of tradables and nontradables separately one by one, following the studies by **(Bettendorf&Chen, 2013; Jiang et al., 2015 and Hu&Oxley, 2017).** In the subsequent chapter, we shall endeavor to analyze the volatile behavior of the United States Dollar-Turkish Lira exchange rate (st) by employing the GSADF test technique. Thus, in what follows, we shall seek to elucidate the evolution of the GSADF test method, and the bubble detection processes associated with it.

3.2. THE EVOLUTION OF THE GSADF TEST

In our thesis, we will utilize the GSADF test, which allows researchers to detect multiple bubbles in a dataset. **El Montasser (2016)** has contended that traditional unit root and cointegration test statistics might not be able to confirm the existence of bubbles in cases where there are periodic bubble collapses. To address this deficiency in econometric literature, **Philips, Wu&Yu (2011), Philips&Yu (2011), and Philips, Shi&Yu (2013)** devised an approach that significantly facilitates testing procedures for detecting bubble behavior, including its starting and ending points. This innovative approach has made it possible to detect multiple bubble behavior in real time.

The recently introduced model aims to identify periods of speculative bubbles as they occur. The idea behind this approach is to detect the bubbles at the moment they emerge, not after burst. The initial premise underlying the model is the recognition that the dynamic qualities of bubbles differ significantly from those exhibited by random walking behavior. As such, a novel recursive econometric approach has been developed that relies upon lightly explosive unit roots as a means of detecting and characterizing bubbles **(Gülcan et all., 2021).** The fundamental concept behind their methodology is to assess the presence of

explosiveness in data through the application of recursive right-tailed unit root tests. Thus, their proposed model deviates from conventional left-tailed tests for stationarity.

Philips&Yu (2011) claim that their proposed test possesses discrimination power due to the sensitivity to changes and the sensitivity is more than left-tailed unit root test alternatives. Also, traditional unit root tests have restricted efficacy in reveal bubble formations since the bubbles periodically disappear. To overcome this weakness, **Philips and Yu (2011)** offer supremum of the Augmented Dickey-Fuller (ADF) t-statistics that are recursively determined. The SADF test can be defined as the recursive estimation of the ADF model.

Philips, Shi&Wu (2015) uncovered that while the recursive approach consistently estimates the start and end dates of the initial bubble during the presence of multiple bubbles in the dataset, its reliability diminishes for subsequent ones. To address this issue, they introduced the concept of a generalized supremum ADF test **(Baum&Otero, 2020).**

3.3. THE GSADF TEST FOR BUBBLE DETECTION

In this paper, we will apply the GSADF test which defined as the extended version of the SADF model devised by **Philips, Wu, and Yu (2011).** The GSADF diagnosis is based on the idea of a sequential right-tailed ADF test. However, this diagnostic expands the sample set to a more flexible range **(Gülcan et al., 2021).** Unlike the SADF test, which fixes the starting point of the sample data, the GSADF test model adjusts start and end points within a convenient window

range.

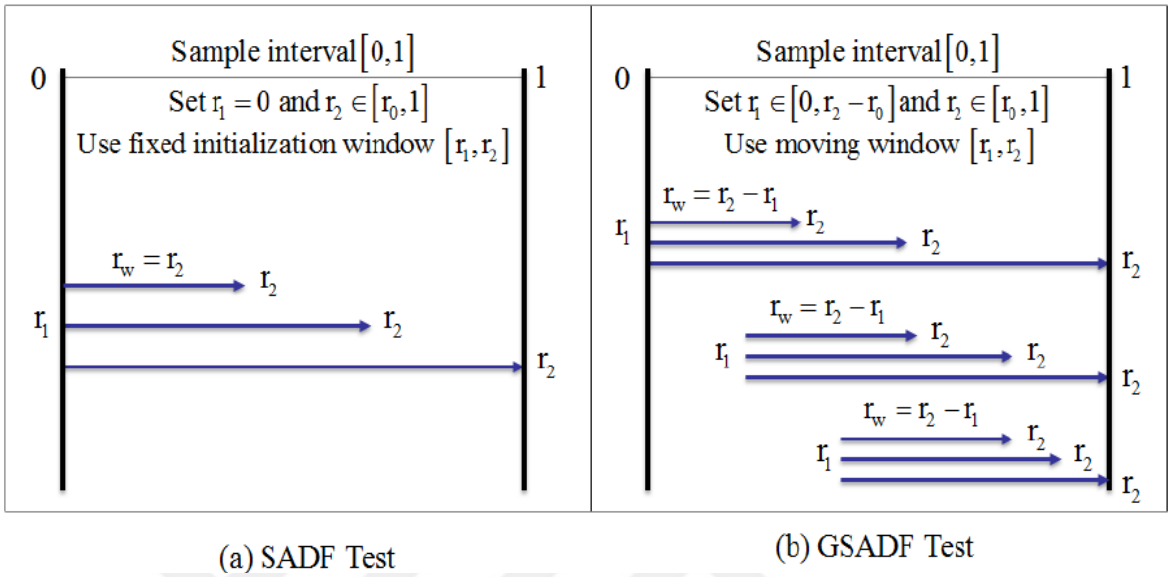

Figure 2: The Sample Sequences and Window Widths of the SADF and the GSADF Test

Source: (Baum&Otero, 2020)

In the figure above, the sample sequences of SADF and GSADF tests are illustrated. The SADF and GSADF tests can be formally defined as:

$$SADF\ (r0) = sup\ \{ADF0r2\},\ r2\epsilon[r0,\ 1]$$

$$GSADF\ (r0) = sup\ \{ADFr1r2\},\ r2\epsilon[r0,\ 1],\ r1\epsilon[0,\ r2-r0]$$

where $r_w = r_2 - \square_1$ is the rolling window which has a starting point $\square_1$ and ending point r_2. GSADF test statistics can be described as the largest ADF test statistics across all possible ranges of r_1 and r_2. Since GSADF test statistics are more flexible by covering more sub-sample data, SADF has a good performance in finding out explosiveness in multiple sections for selected data. However, it can be stated that the GSADF test also can detect potential multiple bubbles in the dataset.

In general, various factors impact the results of bubble detection, including the choice of full sample or sub-sample, minimum window size (r_0), lag length, and the model specification under the null hypothesis **(Hu&Oxley, 2017).** Firstly, GSADF test results may differ according to the use of a full sample or sub-sample. Secondly, the GSADF test window size r_0 affects the GSADF distribution because it should be large enough to let initial estimation and it should not be too large to pass up early bubble detection. In the paper of Philips, Shi, and Yu in 2015, they proposed a rule for the selection process that follows a straightforward formula, $r_0=0.01+1.8/\sqrt{T}$ which is practical and easy to apply in practice. Furthermore, the decision regarding the lag is of utmost importance: an over-specified lag length can lead to more severe size distortion in the GSADF test. Consequently, this paper adopts a small, fixed lag approach when applying the GSADF test statistics, The critical values are calculated from 2000 iterations of Monte Carlo simulations.

CHAPTER 4

DATA AND EMPIRICAL FINDINGS

4.1. DATA

In this thesis, we concentrate on the bilateral USD/TRY exchange rate. The monthly USD/TRY exchange rate data used in this study is derived from the Central Bank of the Republic of Turkey (CBRT) for the period between January 1990 and December 2021. Additionally, the time series for consumer price indices (CPI) and producer price indices (PPI) for both Turkey and the United States were obtained from the International Financial Statistics of the International Monetary Fund (IMF).

The dataset consists of 383 monthly observations spanning from January 1990 to December 2021. Each series is converted into its natural logarithmic form. The software utilized for this paper is E-Views. For all GSADF applications, a window size of 39 observations was optimally chosen as suggested by **Philips, Shi and Yu (2013)**, which corresponds to about 10% of the sample size. Starting with a maximal lag of 12, the optimal lag length is ascertained based on the Akaike Information Criterion (AIC). The critical values are derived via the utilization of Monte Carlo simulations consisting of 2000 iterations.

Figure 3 presents the overall pattern in the USD/TRY exchange rate over the sample period.

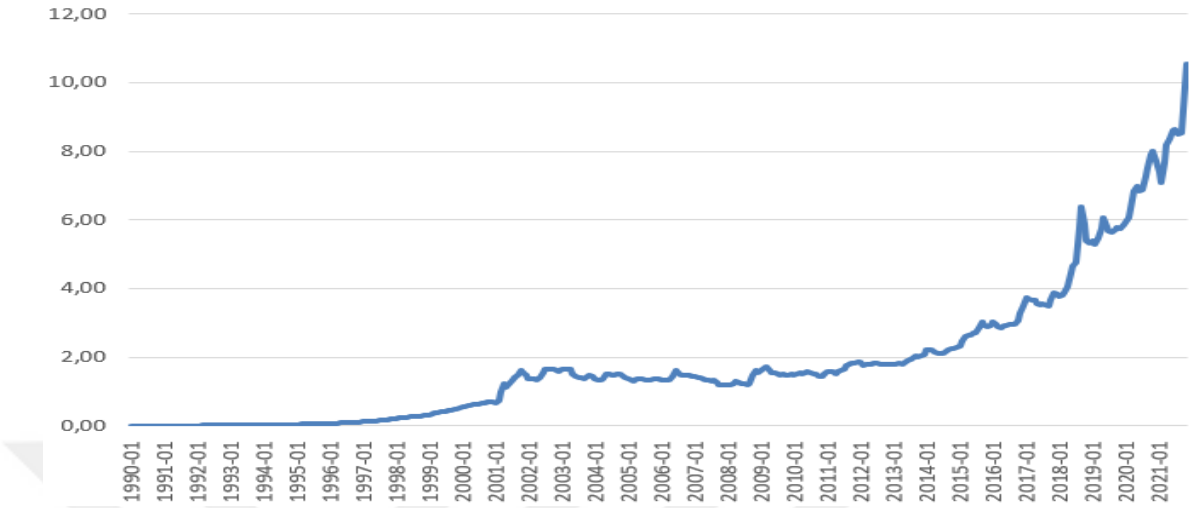

Figure 3: Nominal USD/TRY Exchange Rate

We observe an upward trend in the nominal exchange rate of USD/TRY. Especially in 2001, the exchange rate of USD/TRY rise steeply and continue to fluctuate in an upward trend. Although there is a slight fluctuation from around 2000 until 2014 when the FED started to relax its quantitative easy (QE) policy, we observe sharp increases after 2014.

Figures 4 and *Figure 5* depict CPI and PPIs of Turkey and the US. While CPI of the US is rather stable, CPI of Turkey has an upward trend, rising sharply beginning with 2011. The behaviors of PPIs look rather similar over time.

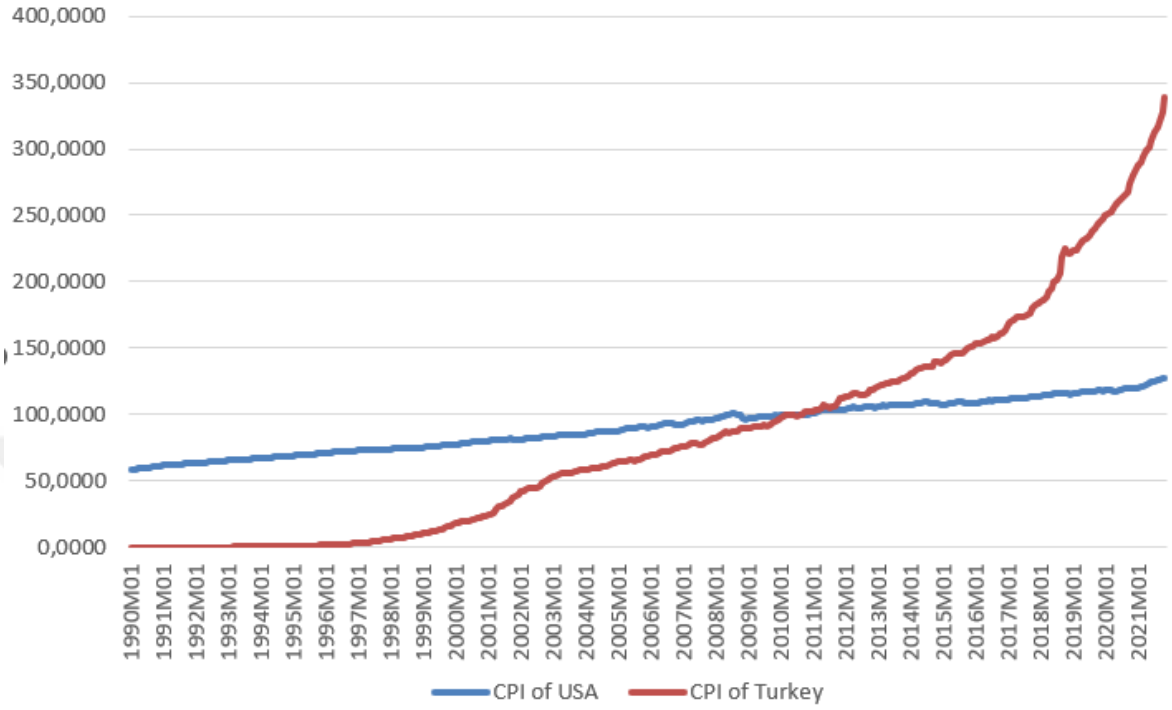

Figure 4: CPI of USA and CPI of Turkey

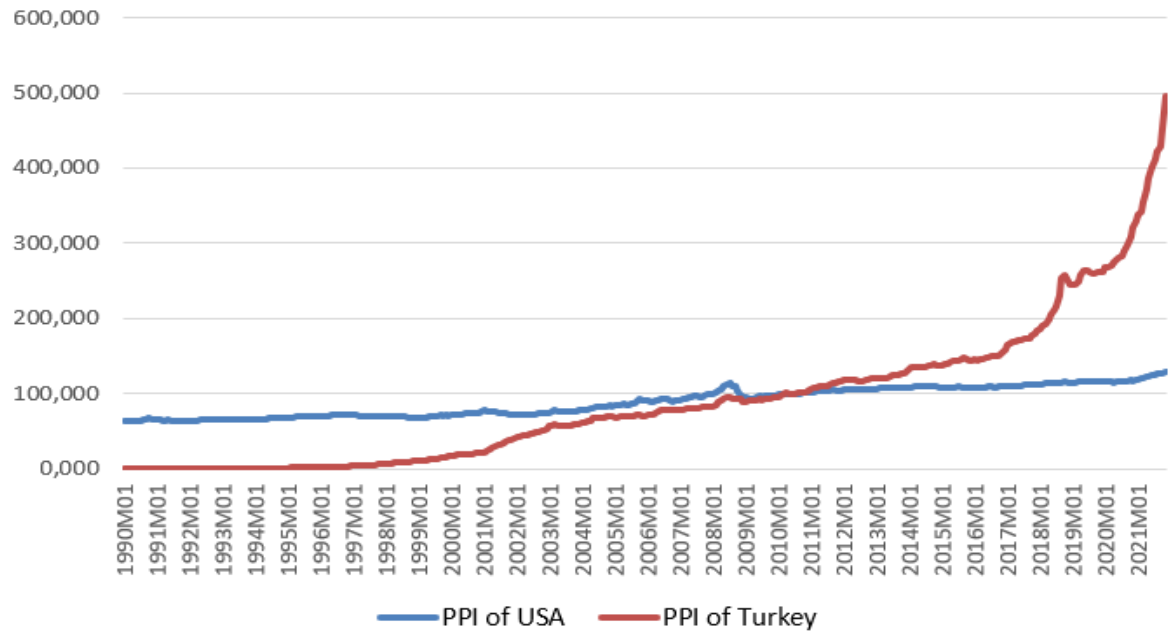

Figure 5: PPI of USA and PPI of Turkey

We measure the prices of tradable and nontradables using PPI and CPI, following the relevant literature. The Producer Price Index (PPI) is widely regarded as the primary and frequently utilized indicator for representing the prices of traded goods **(Engel, 1999; Battendorf and Chen, 2013)** as it mostly covers tradable commodities**.** Accordingly, the relative prices of PPIs are used as a proxy for the relative tradable prices as a component of fundamental factors**.**

$f_t^T = \ln (PPI_t) - \ln (PPI_t^*)$

Since CPI mostly includes the tradable and nontradable basket of goods and services, the differences of CPI from PPI may represent the prices of nontradables. Accordingly, the proxy for the relative prices of nontradables as a component of fundamental factors can be obtained as following:

$f_t^N = \ln (CPI_t) - \ln (PPI_t) - (\ln(CPI_t^*) - \ln(PPI_t^*))$

4.2. EMPIRICAL RESULTS

This study employs the GSADF test methodology to detect bubble patterns in the USD/TRY exchange rate. Initially, we implemented the GSADF test to USD/TRY nominal exchange rate. Then, the test is utilized to analyze the deviations of the nominal exchange rate from its fundamental components, specifically the relative prices of non-traded and traded goods.

4.2.1. GSADF Test Results for Nominal Exchange Rate (s_t)

Variable (1990 M1-2021 M11)	**GSADF**	**Episodes**
s_t	*2.596451****	*1994, 2000-2001, 2003-2010, 2018*

1 % Critical Value	*1.772854*
5 % Critical Value	*1.354152*
10 % Critical Value	*1.145489*

Table 1: GSADF Test Results for Nominal USD/TRY Exchange Rate

Note: The table above shows the GSADF test statistics for the natural logarithm of nominal exchange rates, s_t. Critical values are derived through Monte Carlo simulations comprising 2000 iterations. The test statistic considers a minimum window size of 39.

**** denotes significance level at 1%*

Table 1 summarizes the results of GSADF test application to the nominal exchange rate series. The null hypothesis suggests the absence of explosive tendencies in the nominal exchange rate. Given the rejection of the null hypothesis at a 1% significance level, it can be inferred that the nominal exchange rate presents an explosive behavior over the sample period. In order to date excessive movements in the series, the backward sequences of the test statistics and 95% critical values are obtained and depicted in Figure 1. The log of exchange rate is a green line, backward sequences of test statistics are a blue line and critical values are a red line.

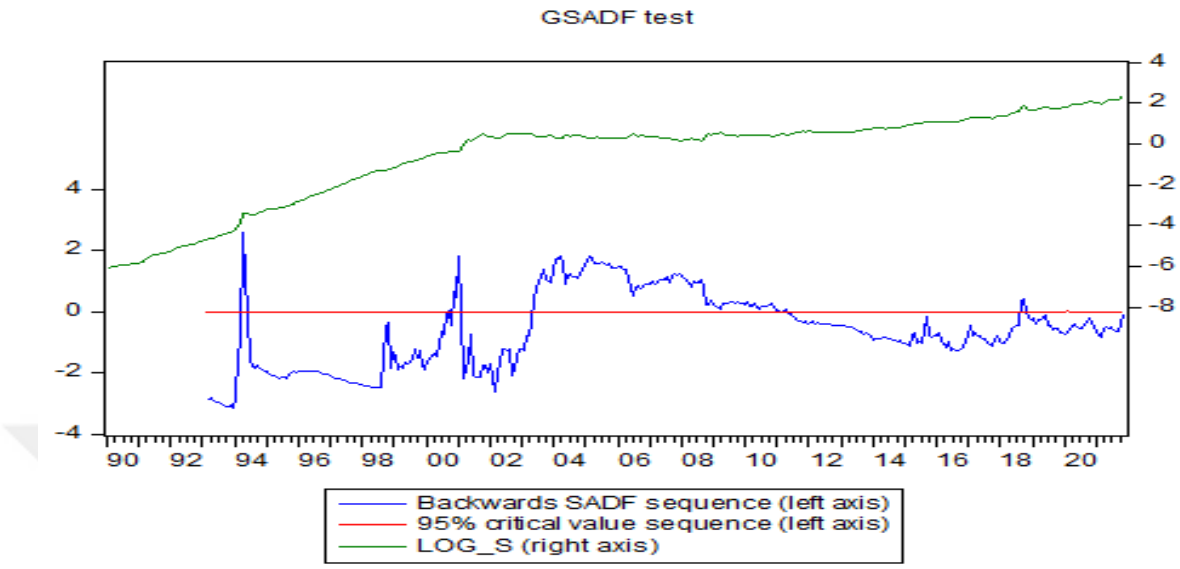

Figure 6: Backward Sequences of Test Statistics for Nominal USD/TRY Exchange Rate

Note: The graphical representation illustrates the GSADF test statistics for the natural logarithm of the nominal USD/TRY exchange rate, denoted by the highest curve on the right axis. It also displays the accompanying backward SADF sequence and 5% critical values of GSADF test statistics.

As seen in *Figure 6*, there are four explosive periods over the sample, three of which can be classified as short-lived explosiveness in 1994, 2000-2001, and 2018 while the other is longed lived beginning in 2003 and ending in 2010. Although the majority of those periods coincide with several crisis periods in the Turkish economy, the one in 2018 corresponds to the political conflict between Turkey and the United States of America.

In 1994, Turkey experienced a debt and currency crisis which resulted in a 6% reduction in output and a dramatic rise in inflation rate. During this period, the Central Bank of the Republic of Turkey (CBRT) experienced a depletion of half of its reserves, and the Turkish lira experienced a depreciation of over 50% against the US dollar during the initial quarter of this year. **(Özatay, 2000)**.

The second explosive period is linked to a severe banking crisis that Turkey experienced between the years 2000 and 2001. This crisis has inflicted substantial harm upon the Turkish banking system and has led to a reduction in overall economic productivity. In November 2000, banks decided to close their credit lines to Turkish banks, citing their assessment of the banks' operations as excessively vulnerable. These apprehensions about the Turkish banking system caused investors to withdraw their funds from Turkish financial markets, thus initiating the crisis. Subsequently, certain banks were obligated to sell government security portfolios, resulting in a substantial decrease in their value and a surge in interest rates in the secondary market. These events further compounded the doubts regarding the permanence of public debts and the crawling peg interest rate regime. The interbank interest rates escalated to 873%, leading to a liquidity crisis. This crisis caused a decline in the Turkish economy and an escalation in the level of inflation to 70%. The 2001 banking crisis is widely known to have been precipitated by political conflicts, resulting in a period of immense financial hardship for Turkey. The crisis began in February 2001, and the stock market plummeted by 18% overnight, with interest rates skyrocketing to 7500%. To avert the collapse of the Turkish banking system, the floating exchange rate regime was implemented, resulting in a substantial 40% devaluation of the Turkish Lira and the subsequent closure of numerous banks **Aysan & Ceyhan (2010).**

The third explosive period includes the subprime mortgage crisis in the US; however, we can observe that the excessive behavior started in 2003 and continued until the end of the global crisis. During these periods, domestic and global economies have undergone substantial changes. The Fed increased the rates dramatically until May 2006 and then reduced them. Flexible exchange rate regime and inflation targeting strategies have been adopted in Turkey. The subprime crisis started in 2008-09 **(Cömert & Çolak, 2016).**

The last explosive period coincides with the rising political tension between Turkey and the US over a cleric named Brunson. Beginning in April 2018, the declaration

of economic sanctions on the Turkish economy by the United States, the USD/TRY exchange rate first jumped to 5 TRY in August and quickly reached 7.2 TRY levels **(Şanlı, 2021).**

4.2.2. GSADF Test Results for Deviations of Exchange Rate from Relative Prices of Non-Traded Goods ($s_t - f_t^N$)

In order to see if any of those explosive periods can be associated with fundamental factors such as the relative prices of tradables and nontradables, we apply the GSADF tests firstly using the deviations of the exchange rate from the relative prices of nontradables. The test results are depicted in *Table 2* and Figure 6. One might expect the movements in the relative prices of the nontradables as a result of relative productivity shocks as posited by the Balassa-Samuelson hypothesis could be responsible for excessive movements in the exchange rate. Nevertheless, as observed, the results remain identical to those before, indicating that the relative prices of nontradables do not contribute to explaining explosiveness in the exchange rate.

Table 2: GSADF Test Results for ***($s_t - f_t^N$)***

Variable (1990 M1-2021 M11)	**GSADF**	**Episodes**
$s_t - f_t^N$	*2.161565****	*1994, 2000-2001, 2003-2009, 2018*
1 % Critical Value	*1.772854*	
5 % Critical Value	*1.354152*	
10 % Critical Value	*1.145489*	

Note: Critical values are derived from Monte Carlo simulations with 2000 replications in this test statistic. The smallest window size considered is 39.

****Denotes significance level at 1%*

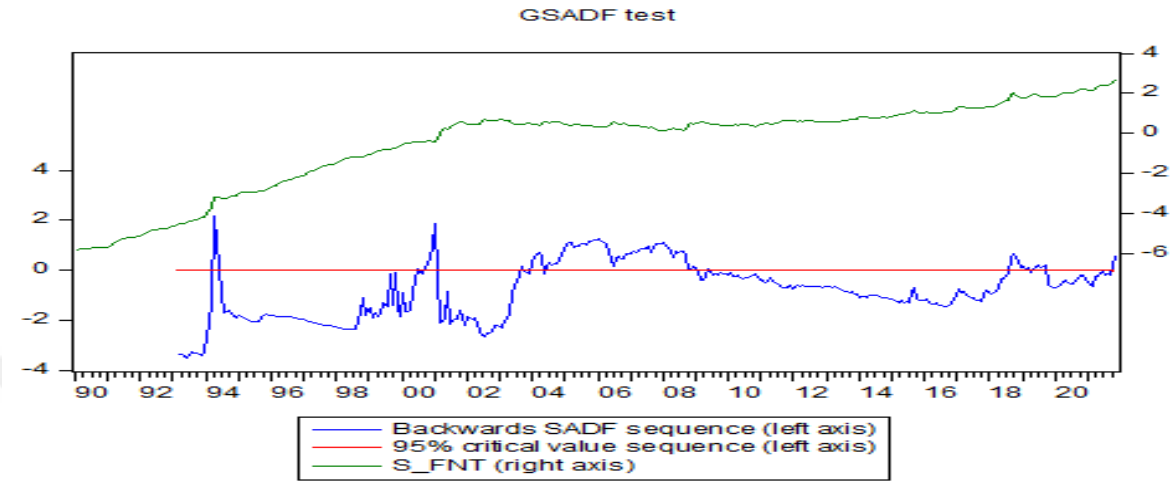

Figure 7: Backward Sequences of Test Statistics for $(s_t - f_t^N)$

Note: The graphical representation above shows the GSADF tests statistics of the natural logarithm of the nominal USD/TRY exchange rate to the fundamentals of the non-traded goods which is represented by the highest curve, right axis. The graph also represents the corresponding backward SADF sequence and 5% critical values of GSADF test statistics.

4.2.3. GSADF Test Results for Deviations of Exchange Rate from Relative Prices of Traded Goods ($s_t - f_t^T$)

We finally apply the GSADF tests using the deviations of the exchange rate from the relative prices of tradables. The test results demonstrated in *Table 3* show the explosiveness is evident in the series. However, looking at the details over time with the backward sequences, there remain only the episodes of excessive behaviors in 2001 and 2006 while the relative prices of tradable goods can explain the other episodes in 1994, some periods of long-lived excessiveness during 2003-2009 and in 2018. PPI increased by 117% and 42% in Turkey compared to 2% and 3% in US respectively in 1994 and 2018. Thus, the widening gap in the relative prices of tradable goods seems to be responsible for excessive movements in exchange rates during those years. When considering excessive periods of 2001

and 2006, it is observed that the PPI of Turkey increased by 31% and 9% compared to the respective rise of 7% and 1% in the US. This indicates that there is negligible gap of relative prices believed to be responsible for these periods. Thus, the results suggest the USD/TRY exchange rate experienced only two rational speculative bubbles in 2001 and 2006 during the observed time frame as represented in *Figure 8*. During the crisis period 2001, Turkey experienced a sharp devaluation of the Turkish Lira against US dollar. Further contributing to the exchange rate of USD/TRY was the Federal Reserve's decision to raise interest rates until May 2006.

Table 3: GSADF Test Results for $(s_t - f_t^T)$

Note: Critical Values are obtained from Monte-Carlo simulations with 2000 iterations. The smallest window size is 39 in this test statistic.

Variable (1990 M1-2021 M11)	**GSADF**	**Episodes**
$s_t - f_t^T$	*1.411940***	*2001, 2006*
1 % Critical Value	*1.772854*	
5 % Critical Value	*1.354152*	
10 % Critical Value	*1.145489*	

*** Denotes significance level at 5%*

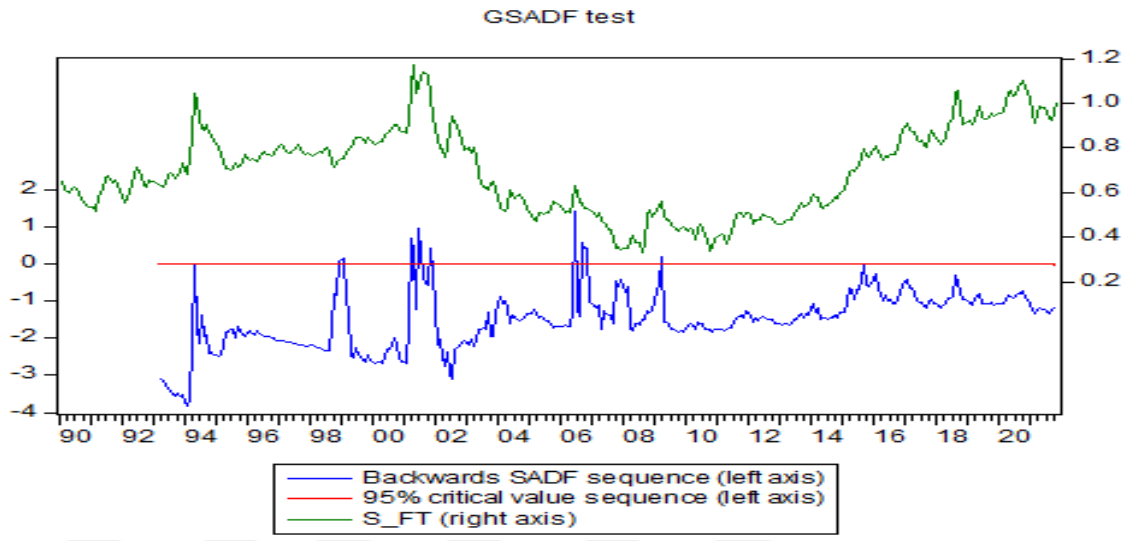

Figure 8: Backward Sequences of Test Statistics for $(s_t - f_t^T)$

Note: The graphical representation above shows the GSADF tests statistics of the natural logarithm of the nominal USD/TRY exchange rate to the fundamentals of the traded goods which is represented by the highest curve, right axis. The graph also represents the corresponding backward SADF sequence and 5% critical values of GSADF test statistics.

CONCLUSION

In recent times, there has been an increased focus from both economists and policymakers on the investigation of exchange rate bubbles and their subsequent analysis. This study was conducted with the aim of analyzing the bubbles in the USD/TRY exchange rate for the period between 1990 and 2021. To this end, the GSADF test, which allows the examination of multiple bubbles, is applied to the nominal USD/TRY exchange rate and the deviations of the exchange rate from its fundamentals represented by the relative prices of tradable and nontradable commodities.

Initially, the GSADF test is employed on the nominal USD/TRY exchange rates, leading to the rejection of the null hypothesis which represents no explosiveness in a dataset. This confirms the presence of explosive movements in the nominal

exchange rate of US Dollar and Turkish Lira. Looking at the backward sequences of the test statistics over time, the episodes of explosive movements in 1994, 2001, 2003-2009, and 2018 are identified. It is noteworthy that these episodes coincide with currency, and banking crises, global financial crises, and political conflict periods that Turkey has been affected.

Secondly, the GSADF test is applied to the difference between the nominal exchange rate and the relative prices of goods that are not traded. As Balassa-Samuelson hypothesis suggests, exchange rates might fluctuate due to prices of non-tradables resulting from productivity shocks in the tradable goods sector. However, the results of the test showed the episodes of explosive behavior remained the same as before. This means that the relative productivity shocks are not the major reason why the nominal exchange rate exhibited explosiveness in 1994, 2001, 2003-2009, and 2018.

GSADF test is finally implemented to the deviations of the exchange rate from the relative prices of tradables. The results of the tests demonstrate the presence of explosiveness in the series. However, upon examination of the details over time with the use of backward sequences, it is observed that only the episodes of excessive behaviors in 2001 and 2006 remain present, while the relative prices of tradables can account for the remaining episodes in 1994 and in 2018, as well as certain periods of prolonged excessiveness during 2003-2009. These findings suggest that the USD/TRY exchange rate underwent two rational speculative bubbles within the observed period, in 2001 and 2006. Upon analyzing the economic climate during these specific time periods, it is evident that there was a significant depreciation of the Turkish Lira against the US Dollar due to the crisis that occurred in Turkey. Additionally, up until the year of 2006, the Federal Reserve consistently raised interest rates, resulting in an increase in exchange rates.

It has been established that the presence of a bubble in exchange rates can have several effects on an economy. Especially, it should be noted that the existence of a bubble can result in a redistribution of wealth among the various agents of an economy (**Jimenez, 2011**). This study shows USD/TRY exchange rate experienced exuberant episodes in 1994, 2001, 2003-2009, and 2018. However, it is interesting to note that the explosive episodes in 1994 and 2018 can be attributable to the movements in relative prices of tradables while those in 2001 and 2006 seem to be driven by rational bubble.

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