



Hacettepe University Graduate School of Social Sciences

Department of Economics

**TIME-VARYING EXCHANGE RATE PASS-THROUGH IN  
TURKEY: A DCC GARCH ANALYSIS**

Kübra ERŞİN

Master's Thesis

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## ÖZET

ERŞİN, Kübra. Türkiye’de *Zaman-Değişen Döviz Kuru Fiyat Geçişenliği: Bir DCC-GARCH Analizi*, Yüksek Lisans Tezi, Ankara, 2021.

Fiyat istikrarını sağlamak bir piyasa ekonomisinin etkinliği için temel koşullardan biridir ve fiyatlar genel düzeyindeki değişimler ekonomiyi farklı kanallardan etkilemektedir. Döviz kuru da yurtiçi fiyatları etkileyerek enflasyona neden olan en önemli faktörlerden biridir. Exchange Rate Pass-Through (ERPT) olarak bilinen kavram, iktisat literatüründe döviz kurlarında meydana gelen değişimlerin ithalat ve ihracat fiyatlarını etkileyerek yurtiçi fiyatlarına yansımaları olarak tanımlanmaktadır. Özellikle dışa açık ve enflasyon hedeflemesi uygulamayı amaçlayan ülkelerde ERPT seviyesi karar alıcılar tarafından göz önünde bulundurulması gereken önemli olgulardan biridir. Literatürde bu konuyu ampirik olarak inceleyen birçok çalışma mevcuttur ve son zamanlarda bazı çalışmalar ERPT’nin zamana göre değişen yapısına da odaklanmıştır. İlgili çalışmaların argümanları ise ekonomilerin parasal durumlarının yani enflasyonun sabit olmaması dolayısıyla ERPT seviyesinin de zaman için de değişebileceği yönündedir.

Bu tezin temel amacı, enflasyon hedeflemesi uygulayan Türkiye ekonomisi için ERPT’nin zaman içinde değişen yapısını analiz etmektir. Bu amaçla, 1990:3 ve 2019:12 dönemlerindeki aylık veriler ile dinamik koşulu korelasyon DCC-GARCH yöntemi kullanılmıştır. Model tahmin sonuçlarına göre, Türkiye’de yüksek enflasyon gözlemlenen 1990’lı yıllarda ERPT seviyesinin yüksek olduğu ve son on yılda nispeten daha düşük enflasyon oranları ile daha düşük seyrettiği gözlemlenmiştir. Bu bağlamda elde edilen sonuçlar Taylor (2000)’in hipotezini destekler nitelikte olup ERPT seviyesinin zamana göre değiştiğini ortaya koymaktadır.

**Anahtar Sözcükler:** Döviz Kuru Geçişkenliği, Döviz Kuru, Enflasyon, DCC-GARCH

## ABSTRACT

ERŞİN, Kübra. *Time-Varying Exchange Rate Pass-Through in Turkey: A DCC-GARCH Analysis*, Master's Thesis, Ankara, 2021.

Ensuring price stability is one of the basic conditions for the effectiveness of a market economy and changes in the overall level of prices affect the economy through different channels. The exchange rate is also one of the most important factors affecting domestic prices and causes inflation. The concept known as Exchange Rate Pass-through (ERPT) is defined in the economic literature as the reflection of changes in exchange rates on domestic prices by affecting import and export prices. Especially in countries that are open and aim to implement inflation targeting policy, the ERPT level is one of the most important phenomena that should be considered by decision-makers. Many studies in the literature examine this topic empirically and recently some studies have also focused on the time-varying nature of ERPT. The arguments of the relevant studies are that the monetary positions of the economies that is, inflation, are not constant, thus the level of ERPT can also change over time.

The main aim of this thesis is to analyze the changing nature of ERPT over time for the Turkish economy, which applies inflation targeting policy. For this purpose, the dynamic conditional correlation DCC-GARCH method was used with monthly data in the periods 1990:3 and 2019:12. According to the results of the model forecast, it was observed that the level of ERPT was high in the 1990s when high inflation was observed in Turkey, and in the last decade, it remained lower with relatively low inflation rates. The results obtained in this context support Taylor (2000)'s hypothesis and show that the level of ERPT varies over time.

### **Keywords**

Exchange Rate Pass-Through (ERPT), Exchange Rate, Inflation, DCC-GARCH

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## **ABBREVIATIONS**

CBRT:	Central Bank of the Republic of Turkey
CPI:	Consumer Price Index
DCC-GARCH:	Dynamic Conditional Correlation GARCH
ERPT:	Exchange Rate Pass-Through
FED:	Federal Reserve
PPP:	Purchasing Power Parity
VAR:	Vector Auto Regression



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## INTRODUCTION

Movements in foreign exchange rates have a considerable impact on important macroeconomic performance indicators of economies. One of the most obvious effects of exchange rate movements on a country's economy can be seen in price stability. Accordingly, the authorities need to measure and consider the exchange rate pass-through phenomenon (ERPT) concerning the extent to which exchange rate movements affect domestic prices and import prices. ERPT must be closely monitored by Central Banks of countries in the choice of the optimal monetary policy and foreign exchange regimes. Thus, many developing countries, adopting a free-floating exchange rate regime along with inflation targeting, have considered the relationship between inflation and exchange rate more in recent decades. Estimating the degree of ERPT gives information to money authorities about how they react against unexpected increase or decrease on the rate of foreign exchange. Especially, in a country such as Turkey in which exchange rate volatility and inflation rate are high, it will be useful to know to what extent the exchange rate affects prices.

The related literature documents that the degree of ERPT is larger (smaller) in countries with high (low) inflation rates, a result that is consistent with the Taylor (2000)'s hypothesis. This might suggest that the ERPT degree is likely to be time-varying as monetary positions of countries and thus inflation rates are not constant over time. There are empirical studies investigating the time-varying structure of ERPT mainly using Kalman Filtering, Split Sample and Rolling Window estimation techniques. One influential study by Özkan and Erden (2015) considers adopting a distinct method, the DCC-GARCH model, to analyze the time-varying degree of ERPT for a panel of 88 countries.

This thesis revisits the phenomenon of time-varying ERPT applying the DCC-GARCH method to an emerging market economy, Turkey, using monthly time series data over the 1990-2019 periods. Focusing on a single country case such as Turkey is expected to reveal some interesting pattern in the time-varying degree of ERPT as the Turkish

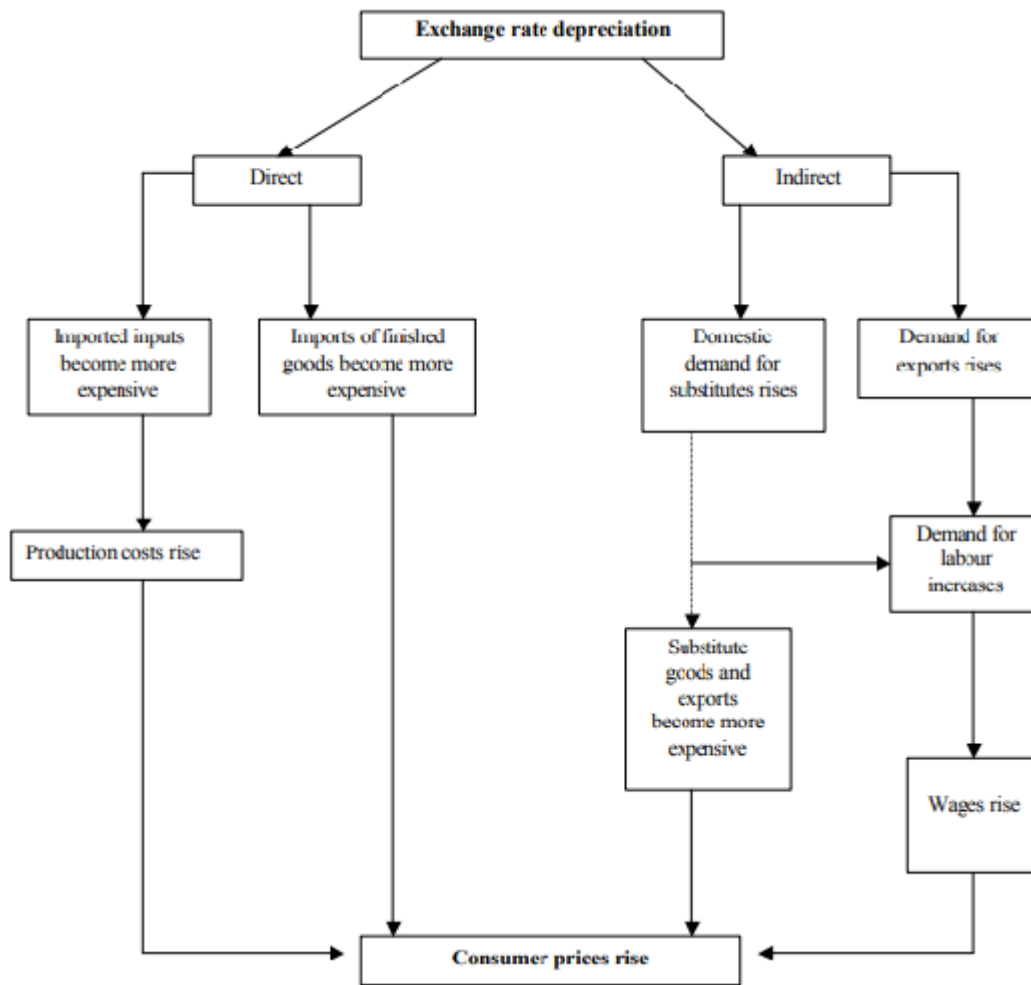
economy experienced regime shifts in the exchange rate and inflation rate over the sample period. Employing the DCC-GARCH method provides some advantages in terms of considering conditional correlations over time, overcoming the heteroskedasticity (time-varying volatilities in exchange rate and inflation rate) by using generalized residuals and supporting unbiased estimates (Chiang, Jeon, & Li, 2007; Cho & Parhizgari, 2008; Özkan and Erden, 2015).

This thesis is organized as follows. In the first chapter, the theoretical background of pass-through is provided. The second chapter consists of a literature review of the studies on ERPT. Third chapter summarizes foreign exchange policies implemented in Turkey for the analysis period. Fourth chapter explains the sources of the obtained data, and implications of the model, and how to apply the DCC-GARCH process to estimate coefficients of ERPT. Besides, the empirical results are interpreted with the scope of policy implications and the thesis is concluded with evaluating as a whole.

## **CHAPTER I - THEORETICAL BACKGROUND ON EXCHANGE RATE PASS-THROUGH**

The pass-through effect from exchange rate to consumer prices is defined as an affection of the movements in foreign exchange to import prices and to consumer prices. The response of consumer prices to the movements in foreign exchange rates accrues in two stages. In an open economy, an increase in the rate of foreign exchange is assumed, this rise depreciates the local currency, and then the value of imports increase and the value of exports decreases in this country. Such a mechanism is described as the primary level of ERPT. Then, an increase in the price of imported goods increases the value of consumer and producer goods by the channel of ERPT; this is also described as the second stage of ERPT. Moreover, in terms of the size of pass-through, there are four possible cases such as no ERPT, incomplete ERPT, high ERPT, and complete ERPT (one-to-one increase).

As common results of the studies regarding the mechanism and the evolution of ERPT, the fluctuations in foreign currency spread throughout the production chain, affecting prices not completely but partially. The changes in exchange rates affect domestic prices directly and indirectly. The first-hand effect is concerned with imported inputs and final goods. If there is a depreciation of the domestic currency, imports will become more expensive, the cost of production will increase, it will reflect on the prices of consumer goods in the country. Hence the step of ERPT is influenced by the import share of consumption and imported goods' share of total production cost. The more directly imported goods or imported input-intensive sectors have a large share in the economy, the more pass-through effect is expected (CBRT, 2017). The indirect effect is related to ineffective demand. When the rate of foreign exchange rises, in other words, the value of domestic goods falls, the demand for domestic goods will increase with creating an inflationist effect. In Figure 1, a demonstration of the direct and indirect mechanism of ERPT is showed.



**Figure 1: The Direct and Indirect Mechanism of ERPT**

Source: McFarlene (2002)

When one dives into the theoretical history, it can be expressed that ERPT proceeds from surveys on Purchasing Power Parity (PPP) and The Law of One Price. PPP divides into two types of parities as the absolute and the relative PPP. Absolute PPP assumes that countries will use identical levels of price concerning identical monetary units. Such a definition brings into mind The Law of One Price which asserts that the nominal exchange rate is equivalent to the price ratio of countries when the real exchange rate is equal to one. Thus, the exchange rate variance is expressed in prices to the extent that PPP holds, known as complete pass-through. However, to achieve this, the goods must be homogeneous, prices must be determined from the manufacturer's currency and costs

such as transportation must be ignored. The state of non-validity of this law supports the existence of incomplete pass-through in reality.

Literature on ERPT has some theoretical frameworks related to incomplete ERPT. The idea that the fall in the degree of ERPT results from low inflation conditions achieved by many countries is contended by Taylor (2000). Taylor (2000) inferred the view that the low inflationary environment that many countries have recently achieved has resulted in a decline in the level of pass-through or pricing power. ERPT is experienced with lower degrees if a country implements the regime of low inflation (Özkan&Erden, 2015). Lower levels of inflation and reliable monetary policy may cause incomplete ERPT. According to Frankel et al. (2005), mobility in per capita income level, transport costs, customs duties, inflation rate, and exchange rates influence the degree of pass-through effect. Firms can change prices in an amount to compensate for the increase in the exchange rate to avoid losing their share in the market due to the competitive nature of their markets or they can adjust their profit margins while not making any changes in their prices. (Krugman & Obstfeld, 2009:449, Aldemir, 2007:57). According to Burstein, Eichenbaum and Rebelo (2002), a rise in the value of imports leads to consumption of other goods of lower quality rather than imported goods, suggesting that (substitution effect) reduces the pass-through effect. Golberg (2006:7) claimed that if there is high elasticity in the demand curve for exporters, it means that exchange rates will reduce the transition effect on prices (Kaygısız, 2018).

Recently, the changing degree of ERPT overtime is one of the literature's stylized facts. As literature shows, a general decline in the increase of price levels after the 1970s, especially in industrialized countries can be observed. Hypotheses have therefore begun efforts to explain the fall in inflation and empirical experiments have also been carried out to shed light on the matter. The causes of these falls were examined in the literature by scholars both on a macro scale and a micro-scale. Some surveys have stood out with their macroeconomic approach to explore the variation of ERPT between countries and explain the reasons. Micro-based approaches bring several reasons for declining the level of ERPT such as the role of pricing to market conditions (Krugman, 1986; Knetter, 1992; Menon, 1995), the substitution of goods in markets (Dornbusch, 1987;

Fischer, 1989) and local currency pricing (Devereux and Engel,2001). On the other hand, macro-based approaches also discussed the reasons as monetary policy strategies (Eichengreen,2002; Kara&Öğünç,2008; Boukez&Rebei,2008; Bailliu,2010), flexible exchange rate regime (Menon,1995; Campa&Goldberg,2002), the size of a country or its degree of openness (Damars,2010; Alper,2003; McCarthy,1999; Ball,1999; Svensson,1998; Ha, Stocker & Yilmazkuday,2019) and price stickiness (Devereux and Yetman,2002b). However, the most notable one of macro-based approaches is Taylor's claim. Taylor (2000) emphasized that a country that has high inflation experience also has a higher level of ERPT. If a country has a low average inflation level for a long time, firms cannot reflect the increase in the rate of foreign exchange into the prices of their goods. However, provided that a country has a relatively higher average inflation rate, firms can reflect these changes to their prices easily. In Taylor's words "inflation is positively correlated with persistence of inflation suggesting that the low inflation itself has caused the low pass-through" (Taylor, 2000). A high inflationary environment offers an appropriate framework for perceiving persistent cost increases arising from exchange rate fluctuations since firms can easily tend to reflect increasing costs on prices (Özkan and Erden, 2015). Many studies after Taylor also support Taylor's hypothesis which ERPT is expected to be above in high inflationary states so they provide empirical support in recent decades.



## CHAPTER II -LITERATURE REVIEW

There are many studies on the determinants and evolution of ERPT in the literature. Some of the studies are applied to a single country, while some are to a group of countries. Since this study will be done for a single country, these studies will focus more on it. In accordance with the scope of this section, studies in literature will be examined in terms of different point of view by groupings such as studies which establish the degree of linear ERPT in Turkey with mostly using VAR analysis and studies which focus the nonlinear and time-varying structure of ERPT in line with this thesis.

In the literature, although there are many studies on the linear structure and evolution of ERPT, most of them have similar analyses and results. They aren't solely limited to the relationship between foreign exchange rate and price level, besides it is associated with other macro-magnitudes such as imports, exports, growth, and unemployment. The Vector Auto Regression Model (VAR) which McCarthy has proposed in 2000 performs tremendously well in estimating the degree and the timing of ERPT. Hence, VAR is the most commonly used method for calculating the pass-through effect in the literature. As a leading study for the Turkish economy, Leigh and Rossi (2002) examined the effects of foreign exchange rate movements between 1994 and 2002. They found that the impact of ERPT lasted around 1 year and a significant portion of the total impact occurred in the first 4-months period. The study reports that towards the end of the year, a shock in the exchange rate has a 60% effect on the wholesale price index and 45% on the CPI. Moreover, the study indicates that Turkey's transition to prices is both faster and greater when compared to other emerging economies. Arat (2003) also models the effect of ERPT from 1994 to 2002 by using sequential VAR. The estimators show that Turkey's degree of ERPT was upper contrast to developed countries' economies and this effect decreased after the implementation of the "floating exchange rate regime". Kara and Ögünç (2012) conducted a VAR analysis on Turkey's degree of ERPT from 2002 to 2011. They point out that transitivity is approximately 15 percent over a year and the relationship continues to decline. Dedeoğlu and Kaya (2015) examined the ERPT with consideration uncertainty modeling. Their analysis is from 2003 to 2013 and

was carried out within the framework of the VAR system. The ERPT estimators are around 4-8 percent implying an uncertain model in ERPT estimation. They used Bayesian VAR to take process uncertainty into account and they found that the pass-through coefficient is 7.5 percent. Alptekin, Yılmaz and Taş (2016) analyzed ERPT for consuming and producing aspects for Turkey from 2005 to 2015 by using the VAR model. They concluded that ERPT tends to decrease and against a one-agent increase or a shock in the exchange rate, the response value of consumer goods is smaller in contrast to producing goods' values. Durgun and Kaygısız (2018) tested ERPT for Turkey by using VAR model. According to their results, the response of the price level against the shocks appears to cut down after 16 periods. 20 percent of the adjustment in ERPT is caused by the change in the exchange rate, it is achieved that ERPT doesn't change from beginning to end, meaning that the rate of foreign exchange is affected at the same rate as consumer prices in the short-term and the long-term. Alper (2003) analyzed ERPT for Turkey for 1987-2003 by using Error Correction Model. The results demonstrated that the level of ERPT is high and this process is rather quick and the major determinants causing an upper level of ERPT are foreign exchange rate crisis experiments and the level of international trade.

Another important issue of the analysis of ERPT on the Turkish economy is the study of dynamics between pre and post-transition periods to new foreign exchange policy. The key implications of the surveys show that the level of ERPT is decreasing over time. This situation is explained by factors such as the competitive environment, the mid-2001 fluctuating policy, implicit targeted inflation policy and low inflation process (Karamollaoğlu, 2018). The studies of Kara ve Ögünç (2005, 2008) are some of the most important studies that examined ERPT in two stages as fixed and free-floating (flexible) policies. After the transition to the free-floating regime, the degree of ERPT lessened and completion of the pass-through effect slowed down. Long-term cumulative reflection on CPI was reported to have fallen from 45 percent levels to 30 percent during the floating exchange rate regime. The completion of the pass-through effect before the fluctuation exchange rate lasted about 6 months, while it lasted above 12 months under the floating regime.

Taylor's hypothesis that high ERPT is observed in countries with high inflation drew attention to the fact that the time-varying nature of ERPT must also be considered. Since inflation is not constant and changes over time, then it has also changed the level of ERPT. The changes in the inflation structures of the countries have pushed some researchers to make time-varying estimates of ERPT. Instead of linear ERPT, time-varying ERPT began to be measured and studied. Now we will focus on the empirical literature on the time-varying ERPT.

In literature, the followings are the most used methods to examine the time-varying effect of ERPT: Rolling Regressions, Split Sample Estimations, Kalman Filtering, or Stochastic Volatility (time-varying parameter) Model. As with the VAR analysis, these models are applied to a single country or country group. Sekine (2006) estimates the ERPT of 6 big industries' economies by the Stochastic Volatility model and finds that there is a gradual decline in ERPT of every sample country, but the timing of fall is not similar for everyone. Choudhri and Hakura (2006) get time-varying ERPT levels of 71 economies from 1979 to 2000 by using a split sampling model and splitting period in terms of the level of inflation. As a result of their analysis, they came to the following conclusion; during periods of low inflation, the degree of ERPT was also measured as low. Kabundi and Mlebu (2018) examined the change in the ERPT in South Africa from 1994 to 2014 by using Rolling regression. Also, Rincon and Rodriguez (2016) analyzed the structure of ERPT and estimated short and long-run impacts using monthly data over 2002-2015 in Columbia by Bayesian Methods. According to results, "ERPT is incomplete, endogenous and then changes over time." Ghosh and Rajan (2009) estimate the extent of exchange ERPT on values of imports in Singapore from 1980 to 2005 using the Kalman Filtering technique and find that level of ERPT differs depend on the short-term or long-term. Kara et.al (2007), McFarlane (2009), Albuquerque and Portugal (2005), Darvas (2001), Sestorad (2016) and Patra et. al.(2018)also examined the time-varying nature of ERPT using the Kalman filtering method. Kara et al. (2007), examined the nature of exchange rate pass-through to consumer prices on the period between 1995 and 2004, showed a variance of this (if exists) and specified determinants of this variation. Two types of analysis were applied as (TVP) Time-Varying Parameter and (SUR) Seemingly Unrelated Regression. According to obtained results, there is a

change in ERPT in the Turkish economy. The degree of ERPT is high in the pre float period and one of the main determinants of the ERPT mechanism in Turkey might be monetary and exchange-rate regimes. A significant decline exists on the level of ERPT after the implementation of a free-floating exchange rate system.

Kal and Arslaner (2015) analyzed the sources of asymmetry and nonlinearity of ERPT in Turkey for the years between 2003 and 2014 by Markov Switching Regression. According to results, during appreciation of TL and low volatile nominal exchange rate period, the magnitude of ERPT is lower. Similarly, Akkoç and Yücel (2017) studied ERPT in the Turkish economy over 2002-2017 with the Markov method, which is a nonlinear model. According to the basic findings of the nonlinear model, there are two regimes and exchange rate transitivity varies considerably depending on the regimes. Exchange rate transitivity, which is 3% in a stable regime, is 21% in periods of the unstable regime.

Arbatlı (2003) employed the VAR model to analyze the nature and extent of pass-through to prices in Turkey and TVAR models to estimate asymmetries in pass-through. The study implies that in periods with higher exchange rate depreciation and lower inflation, the ERPT level is lower. Çatık, Karaçuka and Gök (2016) employed a nonlinear VAR model with time-varying parameters to estimate the magnitude of ERPT on Turkey in the period 1985-2015. According to estimation results, the ERPT level has reached its maximum level after the 1994 crisis, with the implementation of the inflation targeting regime the magnitude of ERPT has started to decline.

Dinççağ (2009) analyzed Turkey's ERPT applying Johansen's (1988) and Engle-Granger's (1987) two-part analysis. The obtained estimators indicate that the connection among the rate of foreign exchange and CPI is co-integrating and however, asymmetries are evaluated in the model and depreciation is shown to result in an upper level of ERPT corresponding with appreciations. Özkan and Erden (2015) employed a DCC-GARCH and panel threshold regression analysis on a sample of 88 countries over the period of 1980-2013. As a result, it is found that ERPT is indeed time-varying and has been declining substantially beginning from 1997. Şıklar, Kocaman and Kapkara (2016)

examined ERPT on CPI and PPI by VAR Model for Turkey from 2002 to 2014. It is concluded that despite the existence of pass-through from exchange rate to consumer and producer prices, but its magnitude isn't as effective as the pre-2001 period. Çiftçi and Yılmaz (2017) examined the nonlinear dynamics in ERPT and inflation persistence in Turkey with the STR model. STR results show that in a regime with sizeable import price shock, ERPT on CPI and inflation persistence is high. Koç (2018) examined ERPT for Turkey applying the nonlinear time series models. Harvey and KSS unit root tests were used for this analysis. There is no co-integration according to the results of this study.

As a common result of studies on the nonlinear and time-varying nature of ERPT in Turkey, they all support Taylor's hypothesis. In high inflation years such as the 1990s, the ERPT level was higher, and in low inflation years such as after 2001, the ERPT level was lower. Table 1 presents the results on the magnitude of ERPT degree from the previous empirical studies for Turkish economy. As seen, there are quite diversified degrees of ERPT documented in the empirical studies. Especially, it is clear that there is a time-shift in the ERPT degree, which also suggests we look at the issue using time-varying techniques.

**Table 1: Magnitude of ERPT degree from the previous empirical studies for Turkish Economy**

The Author	Sample Period	Frequency	Estimation Technique	Result
Leigh and Rossi (2002)	1994:01 - 2002:04	Monthly	VAR	ERPT on CPI is estimated as <b>45%</b> .
Kara et. Al. (2007)	1995: 01- 2004:12	Monthly	TVP and SUR	ERPT on CPI is <b>55%</b> until 2001 crisis, after crisis it declines to 17%.
Kara and Öğünç (2012)	2002 :03 – 2011:06	Monthly	VAR	The average annual ERPT on import prices and on core CPI is about 15%.
Dedeoğlu and Kaya (2015)	1990:2012	Monthly	Bayesian Model Averaging VAR	The ERPT is 7.5%.

Alptekin et.al. (2016)	2005:01 – 2015:04	Monthly	VAR	The response of consumer price to a one-unit shock at the exchange rate is as low as 4% and the impact is ending for the ninth month.
Tümtürk (2017)	1994:01- 2016:12	Monthly	OLS	While ERPT coefficient is 0.64 in the pre-inflation targeting period, this declines to 0.28 in post-period.
Akkoç and Yücel (2017)	2002:3- 2017:6	Monthly	MarkovRegime Switching	While ERPT is 3% in (macroeconomic) stable regime, it is 21% in the unstable regime.

## **CHAPTER III–A REVIEW ON FOREIGN EXCHANGE POLICIES IN TURKEY**

As this thesis focuses on the ERPT degree for the Turkish economy which may be dependent on the choice of exchange rate regime, it will be useful to review exchange rate regimes adopted in Turkey over the last three decades. Foreign exchange policy is a method in which government will determine how it relates its currency to foreign currencies in terms of value. The difficulty of achieving an optimal exchange rate policy has been a long issue for decision-makers. Turkey also has had a long experience in setting foreign exchange regimes in history.

Before the beginning of the analysis period, it would be useful to look at the economic situations experienced before 1990. Considering foreign exchange policies implemented from the past to present in the Turkish economy, clearly, the conclusion can be said that the longest implemented policy is fixed foreign exchange rate policy (Arat,2003). From a historical perspective, the 1980s is known in the literature as years of liberalization in Turkey's economy. Until the 1980s, a fixing exchange rate policy was implemented and the value of TL was determined by the government in accordance with the economic conditions of the country. In 1981, The Central Bank of the Republic of Turkey (CBRT) started to declare foreign exchange rates daily and single exchange rate implementation started (Kepenek, 2010). After the liberalization process in the 1980s, considerable developments have been experienced in capital mobility. With the implementation of “decree No. 32 on the protection of the value of Turkish currency” economic units have become free to trade with foreign economic units by foreign currency in 1989 (Kepenek, 2010). The foreign exchange rate could be set in the conditions of the market. TL could be easily converted to foreign currencies without any restrictions and foreign capital could make portfolio investments. Forex and foreign currency markets were established and daily sessions with representatives from banks and private financial institutions were held by the CBRT (Dinççağ, 2009). So this was an improvement higher level of liberalization in financial markets. However, in practice, this policy has not been fully implemented. In the years in which the frequency of devaluations increased, the fixed exchange rate regime was used to combat inflationary

pleasures. Even so, there have been large amounts of capital inflow in Turkey and TL appreciated against other currencies (Kepenek, 2010).

Although the effect of market conditions has increased in determining the exchange rates since 1990, it can be said that the controlled flexible exchange rate regime is still valid (Özçam,2004). Monetary targets have been tried to be achieved with monetary programs implemented by the CBRT. However, due to the Gulf War and increasing public deficits, there was a serious financial crisis in April 1994. Before the crisis, some measures were implemented on January 26, the value of the Turkish lira was reduced by 14% (Özçam,2004). Later, a number of economic measures were subsequently put into effect by the 5 April resolutions. Through the use of policy regimes, CBRT might interfere exchange rate system. Since April 5, 1994, CBRT has announced that the exchange rates to be applied for foreign exchange and foreign exchange transactions were freely set by banks, authorized institutions, private financial institutions and PTT within the market rules (Arat,2003). Besides, The Central Bank has begun to announce “indicative” exchange rates reflecting the exchange rates generated in the marketplace. The main objective of the foreign exchange rate is to act as a “nominal anchor” to lower the level of inflation. After the signing of Stand-By Agreement with IMF, with the purpose of minimizing the movements of the real exchange rate, exchange rates are arranged to increase at the same rate as monthly inflation rates. In a way, the Central Bank's use of exchange rate policies while ensuring financial stability has helped banks reduce exchange rate risks at a time when foreign exchange obligations are beginning to increase (Arat, 2003).In addition, this policy made it easier for the Treasury to pay its large domestic debts by borrowing money from the Central Bank.

In 2000, a new deal was negotiated with the IMF and the programs that will last three years were attempted to be implemented. The new programs aimed to determine the exchange rate regime for inflation and exchange rate arrangements were determined on the basis of inflation forecasts between 1995 and 2000. According to Arat(2003), “After 2000, instead of the arrangements, it was the exchange rate itself that was adjusted to the expected inflation.” In 2000, one might argue that the CBRT has switched its inactive status with an active status.



As a part of the program performed in 2000, a line of two-part applications have been enhanced on foreign exchange policy. The rate of increase in the first eighteen months was implemented in the pre-announced exchange rate regime, known as a “crawling peg regime”. In the second 18 months period “a crawling band regime” was aimed to be implemented. It’s specified that the central bank won’t interfere with the band rate of foreign exchange movements. This must be noted that the framework for band exchange rates to be implemented in the program’s second half is an exit strategy from the current fixed rate of exchange policy (Arat,2003).

The crawling peg regime has been practiced for some time; but, as the February 2001 liquidity crisis broke out, the crawling peg regime could never be implemented. Due to the 2001 depression and reliability deficiency of policy, there was unexpectedly a demand surplus of foreign currencies, which resulted in exchange rate upward pressure. As a consequence, no longer could the CBRT follow a crawling peg regime and moved a freely floating exchange-rate regime. “Besides, the policy of moving to band regime was declared in July 2001, i.e. exit from the fixed exchange rate regime, but this aim was not achieved.” (Arat, 2003).

After the effects of the 2001 crisis, with the transition to a free-floating exchange rate regime as a solution, the CBRT doesn’t set any nominal or real exchange rate target. Because of that in the floating exchange rate regime, the exchange rate is not used as a policy instrument. However, the CBRT usually takes action against the excessive appreciation or depression of the Turkish lira to reduce the risks of financial stability. In addition to exchange rate policies, another turning point that should be mentioned in the Turkish economy is the transition to the open inflation targeting strategy as of 2006. Recently, Turkey has been implementing a free-floating exchange rate regime along with inflation targeting.

## CHAPTER IV – DCC-GARCH ANALYSIS

### 4.1 METHODOLOGY AND EMPIRICAL MODEL

In order to measure Turkey's time-varying nature of ERPT, the dynamic conditional correlation GARCH (DCC-GARCH) model in which conditional correlations depend on time was used. Engle and Sheppard introduced DCC-GARCH Model in 2001. The DCC-GARCH method is well adapted to circumstances where adjusting the correlation over time has an effect on parameter estimation. Since DCC-GARCH Model provides grounds for the conditional correlations to change over time, it is more credible than constant conditional correlation models and it supports an advantageous application to compute parameters. It provides that the number of parameters to be estimated in the correlation process is not related to the number of series to be correlated. Hence too large correlation matrixes are possible to be estimated and the conditional correlation matrix is designed to vary over time.

In DCC- GARCH model, conditional correlation is not constant, and the model in which correlations can change over time means that the averages of the relevant variables will be distributed normally with '0' and variance  $H_t$  (Atmaca, 2018). One of the main ideas of this model is that covariance matrix,  $H_t$ , can be separated into two parts as standard deviations  $D_t$  and time-varying correlation matrix  $R_t$ . Both  $D_t$  and  $R_t$  change over time. As also mentioned in Özkan and Erden (2015)'s study, the DCC-GARCH model is defined as follows;

A multivariate series,  $r_t$ , is given as<sup>1</sup>

$$r_t | \Omega_{t-1} \sim N(0, H_t) \text{ where } H_t = D_t R_t D_t \quad (1)$$

$$h_{i,t} = w_i + \sum_{p=1}^{P_i} \alpha_{ip} r_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it} - q \quad (2)$$

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<sup>1</sup> $r_t$  is a vector of bivariate series: inflation rate and percentage change in the exchange rate in our application

Then a positive matrix  $Q_t$  can be used to define DCC-Garch Model and

$$R_t = \text{diag}\{Q_t\}^{-\frac{1}{2}} Q_t \text{diag}\{Q_t\}^{-\frac{1}{2}} \quad (3)$$

According to Engel (2002), simply maximizing the log-likelihood function is the way of obtaining the parameters of the model ( $\beta$ ) where the error term  $\varepsilon_t \sim N(0, R_t)$ .

$$\begin{aligned} L(\beta) &= -\frac{1}{2} \sum_{t=1}^T (n \log(2\pi) + \log |H_t| + r' H_t^{-1} r_t) \quad (4) \\ &= -\frac{1}{2} \sum_{t=1}^T (n \log(2\pi) + \log |D_t R_t D_t| + r' D_t^{-1} R_t^{-1} D_t^{-1} r_t) \\ &= -\frac{1}{2} \sum_{t=1}^T n \log(2\pi) + 2 \log |D_t| + \log |R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t \\ &= -\frac{1}{2} \sum_{t=1}^T n \log(2\pi) + 2 \log |D_t| + r_t' D_t^{-1} D_t^{-1} r_t - \varepsilon_t' \varepsilon_t + \log |R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t \end{aligned}$$

At this point, a regression equation that relates the exchange rate to the inflation rate can be defined as follows.<sup>2</sup>

$$\Delta CPI_t = \beta_1 + \beta_2 \Delta E_{t-1} + \varepsilon \quad (5)^3$$

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<sup>2</sup>In this study, we carry out a bivariate DCC-GARCH model to analyze the ERPT degree. It is important to note that, however, there are other internal and external factors (demand and supply shocks) affecting CPI inflation, which are disregarded from the analysis. Of course, one can easily extend the analysis to a multivariate DCC-GARCH by including the other regressors to study ERPT degrees. Furthermore, this study assumes that the linkage between the two variable runs from exchange rate to inflation rate,

Where  $\Delta CPI$  is the percentage change in CPI (inflation rate),  $\Delta E$  is the percentage change in the exchange rate and  $\varepsilon$  is the error term. We consider the lagged exchange rate in this regression specification to account for the potential delayed responses of the inflation rate to the changes in the exchange rate. The slope coefficient  $\beta_2$  shows the degree of ERPT.

Following studies of Marshall, Maulana, and Tang (2009) and Ozkan and Erden(2015) the time-varying ERPT can be easily obtained by using LS estimator for the slope parameter as

$$\beta_{2t} = \frac{Q_t \sqrt{h_{it}} \sqrt{h_{jt}}}{h_{jt}} = \frac{Q_t \sqrt{h_{it}}}{\sqrt{h_{jt}}} \quad (6)$$

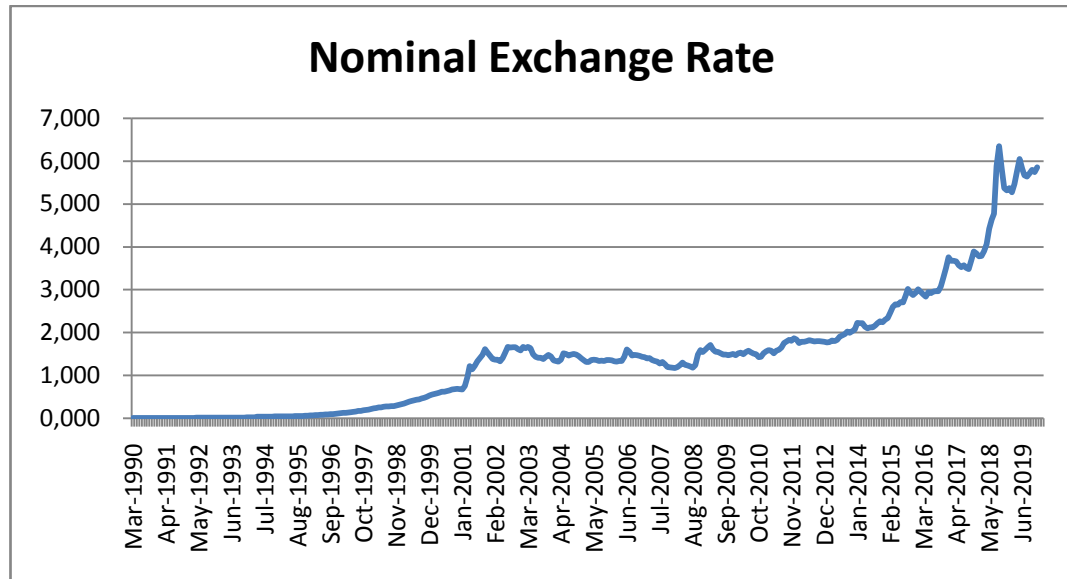
Where  $h_i$  and  $h_j$  show respectively the conditional variances of the inflation rate and the percentage change in the exchange rate and  $Q$  is the conditional correlations that are obtained from DCC-GARCH estimation by maximizing the log-likelihood function in equation (4).

## 4.2 DATA AND EMPIRICAL FINDINGS

Monthly data over the period of 1990:03-2019:12 are used to perform this empirical analysis. The data for nominal exchange rates (defined as Turkish Lira per US dollar) and consumer prices (CPI) are taken from OECD Stat(2020). 2010 was used as the base year of CPI. Monthly data were preferred to better capture the time-varying nature of ERPT degree.

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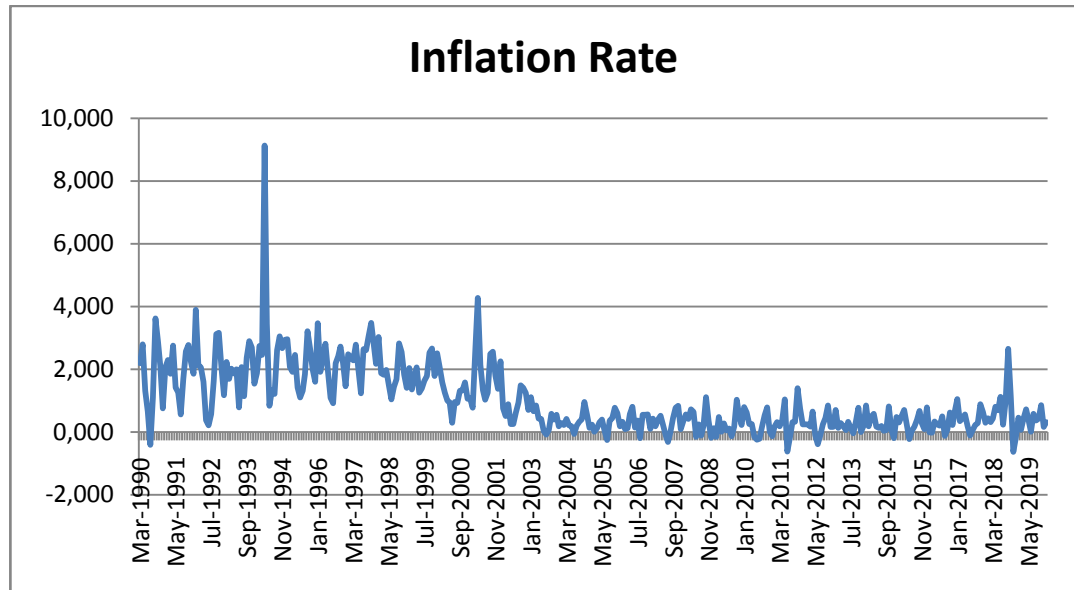
<sup>3</sup>disregarding the possible reverse causality between inflation and exchange rate. Thus the results should not be viewed as causal linkage.



**Figure 2: Monthly Nominal Exchange Rate**

Figure 2 shows the nominal exchange rate series over time. As seen, the nominal exchange rate fluctuates a lot with the dramatic rises in 1994, 2001, 2014 and 2018. These specific years correspond to two currency crises in 1994 and 2001 and as well as dramatic increases in exchange rate starting with the end of the QE(Quantitative Easing) program in 2013-14 and US President Trump's tweets in 2018.

Figure 3 shows monthly percentage changes in CPI(monthly inflation rate) in Turkey. The average monthly inflation rate during the 1990s is much larger than the rest of the periods starting with the year 2002. The regime switch in inflation rate starting with the year 2002 seems to be evident. Clearly, the inflation rate has been rising in the last two years.



**Figure3: CPI**

DCC-GARCH model estimation results are given in Table 2. “ $\alpha$ ” is the ARCH parameter showing the short-run volatility impact (the persistency of standardized residuals from the previous period). ”  $\beta$ ” is the GARCH parameter showing the lingering effect of a shock’s impact on the conditional variances. The significance of  $\alpha$ ’s and  $\beta$ ’s implies that the estimators obtained in the DCC-GARCH are dynamic and time-varying. According to the analysis results, for inflation ( $\Delta CPI_t$ ) since p-values of coefficients  $\alpha_1$  and  $\beta_1$  are less than 5% level of significance, it can be said that  $\alpha_1$  and  $\beta_1$  are significant. For the change in the nominal exchange rate ( $\Delta E_{t-1}$ ),  $\alpha_2$  is significant so the immediate impact of disturbance of conditional volatility exists.  $\beta_2$  is insignificant, so past volatilities are not persistent over time. Also, the sum of  $\alpha$  and  $\beta$  is important for analysis because it shows the stationarity. As seen, the necessary condition  $\alpha + \beta < 1$  is met. It is also important to note that we did not check for the stationarity of each series because we employ the first differences of logs of CPI and E into the DCC-GARCH analysis, which are assumed to become stationary series (I(0)). Further,  $\lambda_1$  and  $\lambda_2$  the parameters of the dynamic conditional correlation model. The fact that both parameters are significant means that conditional correlations are not constant. It is observed that the effect of past shocks on the current correlation ( $\lambda_1$ ) is relatively low compared to the lagged conditional correlation matrix coefficient ( $\lambda_2$ ). In short, it can be concluded that the DCC-GARCH model fits the data quite well.

**Table 2: DCC GARCH Model Results**

		Coefficient	P-values
$\Delta CPI_t$	$\alpha 1$	0.2086893 (0.052894)***	0.000
	$\beta 1$	0.7884871 (0.0481478)***	0.000
$\Delta E_{t-1}$	$\alpha 2$	0.8101879 (0.1318757)***	0.000
	$\beta 2$	0.0463517 (0.668698)	0.488
$\lambda 1$		0.0907877 (0.014238)***	0.000
$\lambda 2$		0.8965511 (0.115177)***	0.000

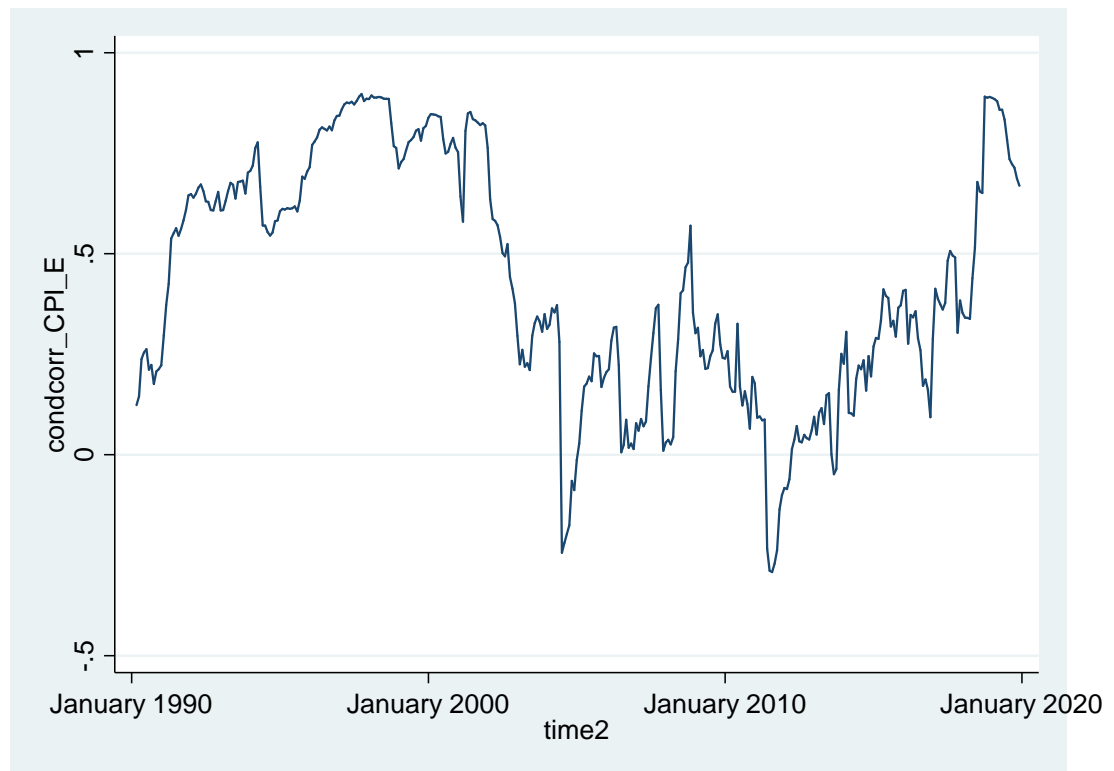
Note:\*\*\* denotes 1 percent significance level.

After DCC-GARCH model estimation on monthly time series data over 1990:3-2019:12 periods for Turkey, I obtained conditional variances of inflation and percentage change in the exchange rate and conditional correlation between the two. Using the obtained conditional correlation and conditional variance series, the coefficient  $\beta_{2t}$ , i.e. the time-varying ERPT degree, was derived.

Before scrutinizing ERPT degrees over time, we look at the dynamic conditional correlations between percentage change in the nominal exchange rate and inflation in Turkey for years between 1990 and 2019. Figure 4 shows the conditional correlations. Overall, the correlation is relatively high in magnitude during the 1990s in contrast to the 2000s, in the early 2000s it dropped to lower levels and after around 2014 it had an increasing trend again. The graph's peaks and dips have occurred with the effects of the 1994, 2001,

2008 and 2018 Andrew Brunson crises. In the period between 1990 and 2001, it is observed that the conditional correlation between inflation and the nominal exchange rate was at high levels, and at some periods dipped and peaked. The effects of the 1994

Mexico-Argentina and Turkey debt crises and the 1997-98 Asian and Russian crises can also be seen. In the period between 2001 and 2014, it can be said that conditional variance fluctuates between a certain band, although there are dip and peak points. In the 2000s, the conditional correlation is observed to have declined and with the low-interest-rate implementation of US between 2001 and 2004, the global crisis of 2008 and the US ‘quantitative expansion policy, the 2000s are notable as low conditional correlation years. After 2014, the conditional correlation increased again and became an increasing trend, especially in 2014, when the United States stopped quantitative expansion and increased its interest rates. With the Trump-Branson (twitter) crisis in August 2018, the surge in exchange rates has pushed the correlation level even higher. In Turkey, it can also be said that the conditional correlation between inflation rate and exchange rate, in general, is of a high magnitude and raising trend and the correlation has a volatile structure as a result of crises, policies and events in global influence.

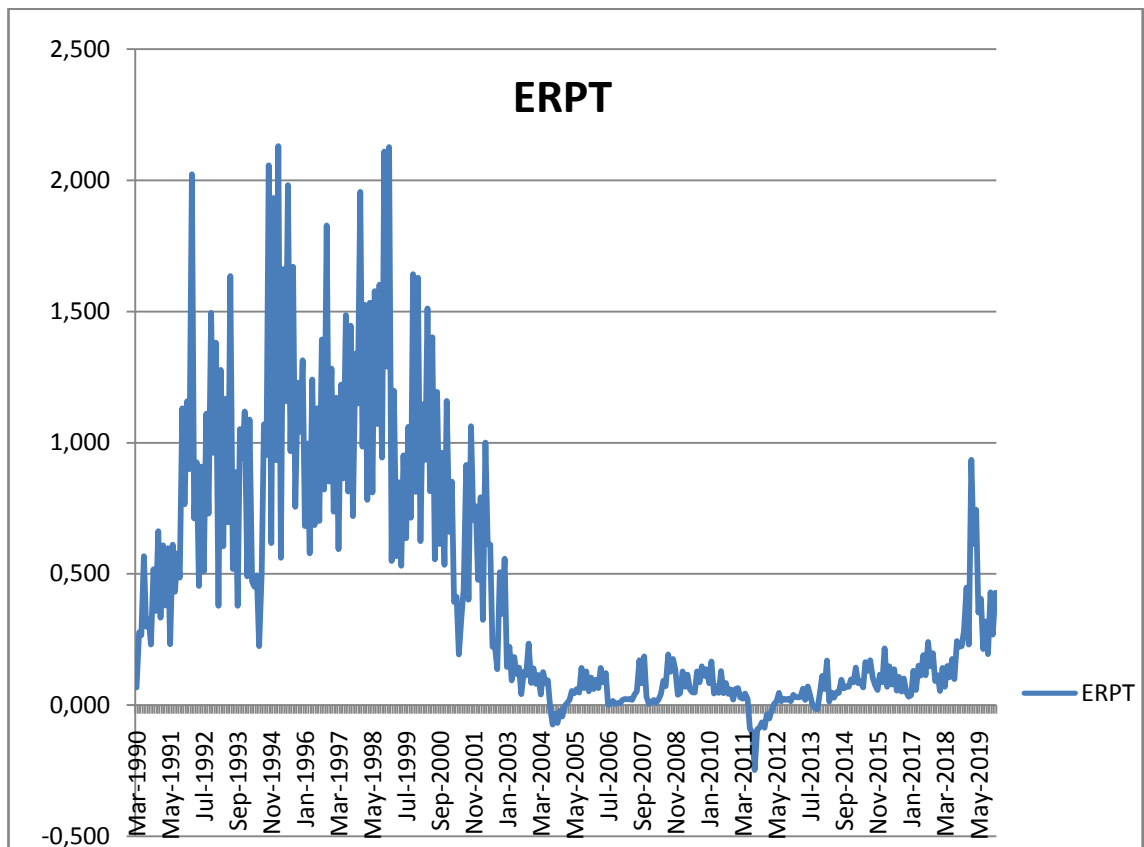


**Figure 4: Conditional Correlation between Inflation Rate and Percentage Change in Exchange Rate**



We now turn our attention to taking a closer look at the ERPT degrees over time. Figure 5 shows the monthly ERPT degrees of Turkey in the specified time period. In the overall spread of the graph, it can be seen that it has almost identical and simultaneous ups and downs as the line of the conditional correlation between nominal exchange rate and inflation. Firstly, it can be said that the 1990s are high ERPT years and the 2000s are low ERPT years. In the 1990s, it seems that ERPT was at high levels and progressed by peaking on the other hand in the 2000s, a more stable and lower ERPT level is observed. ERPT appears to peak many times between 1990 and 2001, however, it experienced a dramatic increase three times; i.e. in the early 1990s, mid-1990s and late 1990s. It had been slowly decreasing after the late-1990s peaked period. In the early 2000s, a dramatic decrease was observed in ERPT; in the years between 2001 and 2014 ERPT fluctuates at a certain level. In 2014 ERPT started to increase and in 2018 it experienced a sudden peak. From 2014 to the end of our observation period, 2019, ERPT has been slowly increasing since its last peak in 2018. According to DCC-GARCH estimation results, the average monthly ERPT was observed as 0,435 for monthly time series data over 1990:3-2019:12. ERPT coefficient shows how a percentage change in the nominal exchange rate is associated with the inflation rate. In high ERPT years, namely the 90s, the average ERPT was about 0.954, while in the early 2000s, namely the low ERPT years, the average was 0.18. It can be said that a one percent increase in nominal exchange rate increases the inflation rate by 0.954 percentage points during the 90s and by 0.18 percentage points during the 2000s. More specifically, the average ERPT in the years between 1990 and 2001 is 0.95, in the years between 2001 and 2014 is 0.13 and after 2014 is 0.17. ERPT peaked in 2018 lastly and reached about 1. Although it has returned to its normal level again after the crisis, it can be said that it has an increasing trend in the last two years.

As mentioned previously in Table 1, there is no unified ERPT degree documented in the empirical literature for Turkey. Nonetheless, depending on the sample period, the studies covering the sample periods of 2000-2015 report around 15% of ERPT. The results from this study for the same periods are quite parallel to the previous studies. However, this study also documents that it started to rise in recent years.



**Figure5: Monthly ERPT over 1990:3–2019:12.**

In Figure 5, in the 1990s, it seems that there are many peak points and some spikes; moreover, the magnitude of the ERPT level is higher relative to the 2000s. In the 1990s, it seems that there is a process of globalization in Turkey and in global, and therefore a crisis anywhere in the world affects all other countries. The CBRT aimed to meet the market's liquidity needs without destabilizing exchange rates and interest rates with its monetary program, which is made public for the first time in 1990 (Özçam, 2004). Although the plan was successful at first, economic balances were disrupted due to the Gulf Crisis, which affected the whole world. As seen in Figure 5, the ERPT level peaks because of the economic imbalance and high exchange rate environment that deteriorated with the Gulf crisis in the early 90s. Later, a remarkable spike in the ERPT series was observed in 1994. The Mexican (tequila) crisis, which spilled over some growing economies, was also effective during the same period. On the other hand, the pressure in the period after the Gulf crisis on the financial sector, political instability, fiscal policy and the fragile structure of the banking sector issues such as the lack of

tight enough and the absence of macroeconomic stability has led to a financial crisis in the first quarter of 1994. Public Sector Borrowing Requirement also increased considerably, from 4.1% in 1988 to 12.1% in 1993, therefore in 1994 Turkey experienced a major economic crisis (Kepenek,2010). The average price of the dollar increased about 160% and inflation increased about 120% (Kepenek,2010). The effects of this crisis are seen in ERPT line towards the end of 1994's and first months of 1995 and a jump is observed as one of the highest two peaks and the sudden rise in the exchange rate has greatly affected inflation because of a considerable level of capital outflow. Later, the 1997 Asian crisis and the 1998 Russian crisis also caused exchange rates to be affected due to international uncertainty (Arat,2003). The Turkish economy, which already has a high debt burden, is also highly affected by rising exchange rates. Lastly, ERPT, which fell in the first months of 1999, made a peak again. The reason can be said as a large earthquake in August 1999.

After the high-level and fluctuating ERPT trend in the 1990s, the ERPT level has dropped considerably since the beginning of the 2000s. Due to the increasing public deficits, high debt level, high inflation and interest rates towards the end of the 1990s, a stand-by agreement was signed with IMF in 2000 to reduce inflation (Özçam,2004). Although the targeted inflation rate was not achieved, it supported the Turkish lira to appreciate. It can be said that the ERPT level was quite low at the beginning of the 2000s, which contributed to the fact that the Turkish lira appreciated and lowered the exchange rate. As the failure of the application, the impact of the liquidity crisis in November 2000 is also observed at the peak experienced at the ERPT line. But immediately after that, the impact of the second crisis in February 2001 was observed more and interest rates reached very high levels (Özçam,2004). After the 2001 crisis, the CBRT stopped using the exchange rate as a policy instrument and adapted to a free-floating exchange rate system (Özçam,2004). Especially after the transition to a free-floating exchange rate regime, a low ERPT is observed.

As a result of the low-interest rate application implemented by FED between 2001 and 2004, low inflation, low exchange rate and low ERPT period are observed in Turkey; especially after 2001. In 2004 Turkey experienced a spike in the ERPT level with the

FED's decision to increase interest rates again. ERPT continues again in a stable structure at low magnitude. In 2007, the US, the central economy of the world, experienced a mortgage crisis that affected the whole world. Although the ERPT trend did not have a major impact, in 2007, there was a mortgage crisis in America, the central economy of the world, which affected the whole world. The FED implemented policies to lower interest rates again and began to implement unconventional monetary policies to cope with the negative effects of the crisis. The most known and effective of these FED policies is the quantitative easing implemented between 2009 and 2014. The dramatic decline in the ERPT between 2011 and 2012 stems from the quantitative easing policy implemented by FED leading to real appreciation in TL (Vural, 2013).

In 2014, with FED's decision to end quantitative easing and raise interest rates, ERPT again increased and adopted an increasing trend again with TL starting to depreciate. Finally, there is a peak in ERPT in 2018. The incident, which caused tension between the United States and Turkey, with the US announcing that they would sanctions against Turkey because of political issues, was resolved by the release of an American priest. But the tension between the two countries has led to a jump in exchange rates. The dollar exchange rate, which started at 3.79 Turkish liras in early 2018, was 7.21 Turkish liras in August. The sudden rise of the dollar exchange rate in this way has caused deterioration and a jarring effect in the Turkish economy, especially in the balance sheet structures of companies borrowed in foreign currencies. In mid-November of the same year, the dollar rate fell to 5.23 Turkish liras as the problem between the two countries was resolved.

To summarize, in the high inflation environment of the 1990s, ERPT was at a higher level and had a volatile structure, having peak and spike with the crises experienced. In the period after the 2001 crisis until 2014, a lower and more volatile ERPT was observed than in the 1990s due to the transition to a fluctuating exchange rate regime. During this period, it can be said that there were also consequences of the policies implemented by FED at the level and fluctuations of ERPT. In the relatively lower inflation environment of the 2000s, ERPT was at low levels and more stable. In the post-2014 period, ERPT appears to have entered an upward trend again.

## CONCLUSION

The foreign exchange rate has the power to affect the economies through many channels mainly because capital mobility and globalization between countries are at high levels in the last decades. Therefore, the magnitude of the impact of the exchange rate on interest rates, inflation, and consumer and producer prices is a criterion that should also be taken into account in economic policy. Countries should determine the optimal monetary and exchange rate policy by evaluating the exchange rate movements and thus the ERPT phenomenon. The main objective of this study is to investigate the time-varying ERPT degree in the Turkish economy, which plays an important role in the success of the inflation targeting regime and creates a significant vulnerability resulting from the floating exchange rate regime.

Many studies in the literature examine the pass-through effect of the exchange rate on the inflation rate. In the majority of studies, linear ERPT was measured using mostly VAR analysis. However, as countries' inflation experiences and inflation policies changed, the study of the time-dependent ERPT structure began to attract attention. Hence, this research examines the time-varying structure of ERPT in Turkey. To do so, this study adopts the DCC-GARCH method following the study by Özkan and Erden (2015) for a large sample of countries.

In this study, data on the consumer price index and nominal exchange rate for the period 1990:3 and 2019:12 of the Turkish economy are used. After estimating the DCC GARCH model, conditional variances of the inflation rate and percentage change in exchange rate and conditional correlations between the two variables were obtained, from which the time-varying ERPT degrees are calculated.

In the obtained conditional correlation and ERPT, it is observed that both follow quite a similar pattern over the sample periods, coinciding with almost the same period of years in which they make a dip and peak. There seem to be three distinct phases in the time-varying behavior of ERPT degree: 1990-2001, 2001-2014, and the post-2014 period. It is observed that the period between 1990 and 2001 had a high correlation and therefore

a high ERPT value and their volatilities are high. As a reason for this, both the economic structure and crisis of Turkey and the consequences of global crises under the influence of globalization can be shown. In the period between 2001 and 2014, conditional variance and ERPT were the lowest in the sample period. ERPT has fallen to negative levels in the years when TL appreciated against the US dollar mainly because of prolonged low FED rates. However, it has a more stable ERPT than in the 1990s. After 2014, it is observed that the ERPT level has started to rise again and therefore the effect of exchange rate movements on inflation has started to increase even more. According to estimation results, the average monthly ERPT was observed as 0.435 for monthly time series data over 1990:3-2019:12. So on average, it can be concluded that one percent increase in the nominal exchange rate increases the inflation rate by 0.435percentage point.

To sum up, in high inflation environment of the 1990s, ERPT was at a higher level and had a volatile structure, having peak and spike with the crises experienced, hence the magnitude of ERPT level is higher relative to 2000s. On the other hand, in the relatively lower inflation environment of the 2000s, ERPT was at low levels and more stable. Hence, the nature of ERPT shifted from a high and persistent inflationary environment to a low and stable inflationary environment. (Arslaner et al., 2014). The noticeable reason for a lower ERPT degree is a lower average inflation rate. (Özkan and Erden, 2015). It can be concluded that our results are in parallel with the earlier studies on ERPT.

Overall, this study reinforces some important results of previous studies in the literature, particularly concerning Taylor (2000)'s hypothesis that predicts low ERPT in low inflationary states. It can be concluded that the degree of ERPT is time-varying and it has lower degrees that enjoy relatively lower inflation rates in the recent decade. Besides, after the implementation of the free-floating exchange rate regime the level of ERPT decreased considerably. However, as of 2014, it is observed that the degree of ERPT started to increase. Thus the monetary authorities must be careful about the upward direction in ERPT making it difficult to achieve the inflation target, in order not to lose control over the inflation rate.

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