# ARE INFLATION EXPECTATIONS IRRATIONAL IN TURKEY? EXCHANGE RATE PASS-THROUGH ANALYSIS

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*Gönderim tarihi: 23.05.2023* *Kabul tarihi: 31.08.2023*

**Abstract**

This study investigates the rationality of inflation expectations in Turkey over 2011-2019 via exchange rate pass-through (ERPT) analysis. Relying on the assumption that the inflation rate and inflation expectations are going to change equally if the economic agents form rational expectations, we utilize the vector autoregression model with inflation expectations to quantify the ERPT to inflation and to inflation expectations. The results show that exchange rate shocks do not have the same impact on the inflation rate and inflation expectations over different horizons. In the short term, the inflation rate rises faster than the inflation expectations following unexpected exchange rate swings; however, they move in tandem after six months. With the time-varying analysis, we trace the evolution of the ERPT coefficients to characterize the nature of agents' expectations. The findings document that the discrepancy between ERPT coefficients is persistent, inclining to chronic irrationality of expectations, with decaying degrees in the longer horizon, rendering adaptive formation of expectations over time.

**Keywords:** emerging markets, exchange rate pass-through, inflation expectations, Turkey, VAR.

**JEL Codes:** E31, E42, E58.

**Öz**

Bu çalışma, 2011-2019 yılları arasında Türkiye'de enflasyon beklentilerinin rasyonalitesini döviz kuru geçişkenliği (DKG) analizi ile incelemektedir. Ekonomik birimlerin rasyonel beklentiler oluşturması durumunda, enflasyon oranının ve enflasyon beklentilerinin eşit olarak değişeceği varsayımına dayanarak enflasyona ve enflasyon beklentilerine DKG'ni ölçmek için enflasyon beklentilerini içeren vektör otoregresyon modelini kullanmaktayız. Sonuçlar, döviz kuru şoklarının, farklı dönemlerde, enflasyon oranı ve enflasyon beklentileri üzerinde aynı etkiye sahip olmadığını göstermektedir. Kısa vadede, beklenmeyen kur dalgalanmaları sonrasında enflasyon oranı, enflasyon beklentilerinden daha hızlı yükselmekte; ancak altı ay sonra birlikte hareket etmektedir. Zamanla değişen analizle, ekonomik ajanların beklentilerinin doğasını karakterize etmek için DKG katsayılarının gelişimini izlemekteyiz. Bulgular, DKG katsayıları arasındaki farklılığın kalıcı olduğunu, dolayısıyla, beklentilerin kronik irrasyonelliğine meyilli olduğunu; ancak daha uzun dönemlerde azalan derecelerde olması, beklentilerin zaman içinde uyumlu oluşumu sağladığını belgelemektedir.

**Anahtar Kelimeler:** döviz kuru geçişkenliği, enflasyon beklentileri, gelişen piyasalar, Türkiye, VAR.

**JEL Codes:** E31, E42, E58.

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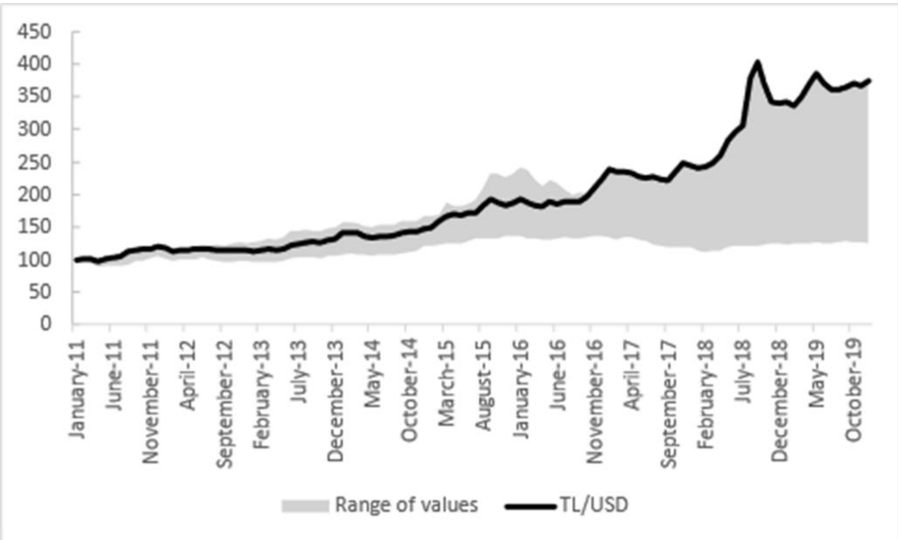
## 1. Introduction

The effect of exchange rate movements on domestic prices is measured by the exchange rate pass-through (ERPT). This metric quantifies the percentage change in the consumer price index (CPI) as a response to a one percent shock in the exchange rate. Smets and Wouters (2002), Monacelli (2005) and many others suggest that the size and the duration of the transmission from exchange rate to inflation are critical for the design of the monetary regime as it characterizes where the central bank (CB) should direct its efforts. For instance, this knowledge would be informative in keeping inflation on track; in setting the exchange rate as a nominal anchor and limiting entirely or partially its swings (i.e. exchange rate pegging), or in determining the inflation target for the end-of-year to anchor the inflation expectations accordingly (i.e. inflation targeting (IT)), all of which serve to greater freedom for CB to follow an independent policy. Under any monetary policy regime, ERPT to inflation and to inflation expectations should be stabilized at the same level for the success of the monetary policy. In other words, if the impact of ERPT is not the same upon inflation and inflation expectations, it would cause a deviation from the optimal policy interest rate setting in IT and a non-sustainable depreciation rate in the exchange rate pegging regime. Furthermore, if such a wedge exists, a detailed analysis on its extent and duration would provide valuable information regarding the nature of the inflation expectations as to whether they are adaptive or not, and thereby for the choice and design of the monetary regime.

The related literature focuses on ERPT through the determination of its main factors, namely the exchange rate volatility and uncertainty regarding aggregate demand (Mann 1986); the degree of price rigidity (Taylor 2000); the substitutability of imported goods with low-quality local products (Burstein et al. 2002); switching to inflation targeting in monetary policy (Saiki 2004); long-run inflation volatility (Frankel et al. 2012); and in return, leaving the role of inflation expectations as an unexplored avenue. We fill this gap by introducing the inflation expectations into the ERPT analysis and explore whether ERPT to inflation expectations evolves in parallel with that to inflation over different horizons because the possible discrepancy between ERPT to inflation and that to expectations affects the policy design. If the ERPT to inflation expectations is lower (higher) than that of inflation, *ceteris paribus*, inflation expectations rise less (more) than the inflation rate as a response to exchange rate shocks. In that case, CBs which aim to contain the inflationary pressures from the innovations in the exchange rates may set a policy rate that is lower (higher) than the optimal one. To decide on the deviations from the optimal policy rate, it may be convenient to use the ERPT to inflation expectations. In this respect, our paper answers whether ERPT to inflation and inflation expectations are equal in Turkey over the 2011-19 period.

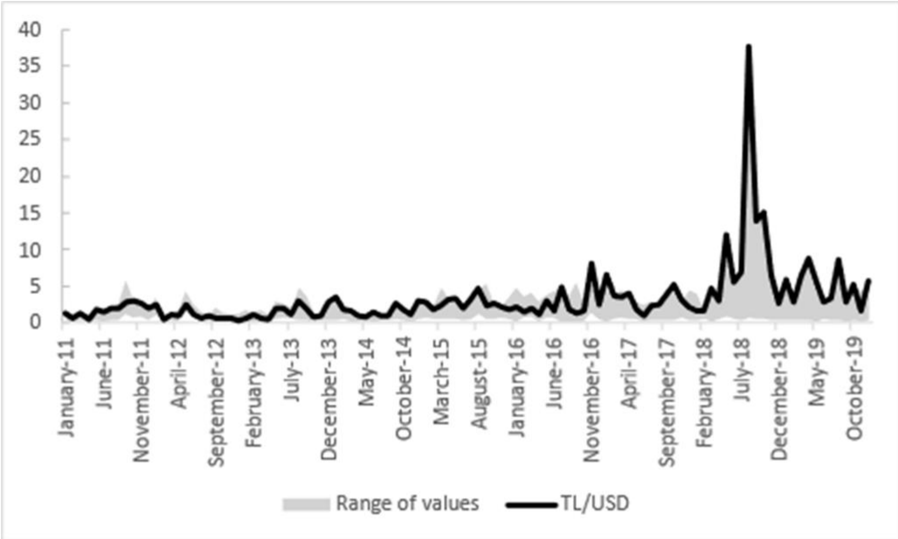
The risk of a policy failure is greater in developing economies and emerging markets as the exchange rate volatility is higher in these countries if ERPT to inflation cannot be adequately assessed (Calvo and Reinhart 2002). Predicting the movements in the exchange rate is troublesome, causing difficulty for monetary authorities in forming accurate forecasts of inflation in countries with high ERPT. As a small open developing economy with floating exchange rate regime and high inflation history, Turkey, where the Central Bank of the Republic of Turkey (CBRT) mainly adopts IT, both inflation and inflation expectations are prone to be immensely affected by the exchange rate changes. As it is shown in Figures 1 and 2 below, the monthly average value and the monthly volatility of the Turkish Lira have been above those of major developing economies, namely, Brazilian Real, Colombian Peso, Czech Koruna, Hungarian Forint, Indian Rupee, Mexican Peso, and South African Rand. Therefore, for a better understanding of ERPT on inflation and its expectations both in terms of size and duration, Turkey presents a genuine outlet for this study. With this paper, we shed light on the role of exchange rate movements, which is and has been one of the major problems of the Turkish economy, and therefore one of the current debates, on inflation and inflation expectations.

**Figure 1. The monthly average value of the currencies vis-a-vis the US Dollar (January 1, 2011=100)**




**Source**: Turkey Data Monitor, authors' calculation

**Figure 2. The monthly standard deviation of the daily values of the currencies vis-a-vis the US Dollar**




**Source:** Turkey Data Monitor, authors' calculation

The financial crisis in 2008 increased the uncertainty in the global markets by rising volatility in capital flows toward developing countries. In countries with high and sustained current account deficits, such volatilities cause vulnerability in economic activities. In other words, the global financial crisis highlights that CBs should also mind the risks accumulating in financial markets while maintaining the price stability (Kara 2012). Consequently, CBRT changed its monetary policy objectives in 2011 to become more flexible and to respond faster to macroeconomic shocks. The financial stability objective relied mainly on capital flow management. The goal was to prevent the sudden stops, which were accompanied by the majority of the crises in Turkey, and the capital reversal which could destabilize the economic activity. By restricting excessive real appreciation of the domestic currency, it is thought that the current account deficit could be controlled, and external financing could be balanced. This policy, however, led to deviations from the inflation target; and affected the degree of flexibility in the exchange rate regime, which makes Turkey an even more interesting case study as the results also relate to the literature on monetary and exchange rate regimes. In other words, Turkey's establishment of an unconventional monetary policy regime since 2011, where it is more accommodative than solely IT, forms the second reason for studying Turkey in ERPT analysis.

Empirical studies on ERPT, first, have analyzed developed economies and recently, developing countries have attracted attention. In this line of research, papers concentrate mainly on the duration and the magnitude of the pass-through. For instance, McCarthy (2007) examines a Vector Autoregressive (VAR) model for nine industrialized countries using oil prices, output gap, import price, exchange rate, producer price index (PPI) and consumer price (CPI). ERPT is found to be low on CPI and high in countries where foreign trade has a high share of imports. Choudhri and Hakura (2001) explore 71 developing and industrial countries over 1979-2000 based on a theoretical framework. Estimation results from weighted least squares show that there is a positive and significant relation between ERPT and the average inflation rate, even when macroeconomic factors are controlled for. Campa et al. (2005) estimate ERPT to import prices in a single equation framework via Ordinary Least Square (OLS) for the period January, 1989 to May, 2004 in euro area countries. Their results indicate that ERPT in the short-run is incomplete (i.e., between zero and one) and that ERPT changes depending on the countries and industries. In the long run, ERPT is found to be higher and close to one (i.e., complete).

Ito and Sato (2008) use a VAR model for East Asian countries over 1993–2005 including oil price, output gap, money supply, nominal exchange rate (NERT), and domestic prices. Results imply that ERPT to import prices is quite high in the economies experienced crisis. By estimating factor-augmented and structural VAR (SVAR) models for 47 countries including emerging market and developing economies, Ha et al. (2019) find that ERPT to consumer price in emerging market and developing economies is higher than in advanced economies. The magnitude of ERPT depends on the country's characteristics and the shock that is accounted for, with monetary policy shocks having the highest effect among domestic shocks while global shocks having different effects. Lower ERPT is observed in countries with credible IT and more flexible exchange rate regimes. Ghosh and Rajan (2007) examine ERPT to export prices in Thailand, Korea, and Singapore with data from 1980-2006. They conclude that the degree of transition to export prices varies from country to country. They attribute these different transition effect sizes to not reflecting the rapid changes in the exchange rate to prices in order to avoid loss of reputation in trade. Bhattacharya et al. (2011) use a structural Vector Error Correction model (VECM) from 1997 to 2009 for India accounting for WPI, industrial production index (IPI), interest rate, world tradable inflation, monetary policy stance of the rest of the world and exchange rate. They observe a low, but significant ERPT while policy rate can affect prices via ERPT. Conducting an SVAR model, Jiang and Kim (2013) investigate China over 1999-2009. According to their findings, ERPT to the retail price index is lower than ERPT to PPI. Using data from January, 1992 to April, 2011 for Peru, Winkelried (2014) employs an SVAR model introducing foreign inflation, economic activity, nominal depreciation, import, producer, and consumer inflation as the variables. Results indicate that ERPT gradually reduces, which is attributed to a credible regime of low inflation. Helmy et al. (2019) conduct a VAR analysis with food price index, NERT, IPI, PPI, CPI, and import prices over 2003–2015 in Egypt. Although ERPT is found to be incomplete for all price indices, it is relatively lower in CPI. As it can be deduced from the existing literature, results are contingent on the periods covered, countries considered, the variables and estimation methods used in these studies.

In this paper, we adopt a VAR framework for two reasons. First, it allows for dynamic feedbacks so that the endogeneity issue is accounted for. Second, VAR enables separate estimation of ERPT over different horizons, which gives hints about the nature of the economic agents' expectations. In fact, it becomes possible to see if, ever, the ERPT coefficients of inflation and its expectations differ or not i.e., when agents accurately estimate the ERPT to inflation rate. If those coefficients are equal, it is possible to say that the agents form rational inflation expectations regarding the exchange rate.

It is well established by the empirical evidence that actual inflation is driven by supply and cost shocks, fiscal and monetary policy stance, aggregate demand, labor market outlook, past inflation, and inflation expectations on top of the exchange rate. Since the relationship between inflation and its expectations has shown to have a strong significance (Phelps 1967; Friedman 1968), it is reasonable to assume that inflation expectations are also influenced by the drivers of inflation. In this respect, the ordering of variables in ERPT literature differs depending on the characteristics of the country under consideration and the problem explored. For example, Kim and Roubini (2000) analyze a model for industrialized countries by ordering variables as follows: policy rate, money demand, CPI, IPI, world oil price, U.S. Federal Funds Rate and the exchange rate. Such a model demonstrates the features of a large open economy with fully floating exchange rate regime where CB has independence over monetary policy. The presence of the world variables in the model indicates that they are not contemporaneously influenced by the shocks to the home country variables, rather influenced by a lag. However, for a small open economy, developing country where domestic factors cannot affect the world market prices, considering the world variables as exogenous is more appropriate. Accordingly, McCarthy (2007) orders the variables as oil price inflation, output gap, exchange rate, import price inflation, wholesale, and consumer price inflation. This model again encapsulates the floating exchange rate regime, which instantly reacts to demand and supply side shocks. In this regard, we use the following Cholesky orthogonalization: oil price, output, exchange rate, producer price index, consumer price index or inflation expectations. In doing so, we assume that oil price is the most exogenous indicator, and it affects all the remaining variables for Turkey as it is a small, open, non-oil-producing, developing country. On the other hand, inflation expectations are the most endogenous variable, affected by all the previous variables.

Turkey has also been a subject for ERPT analysis in the existing literature. Leigh and Rossi (2002) study Turkey over the period 1994-2002 via VAR analysis including oil prices, real output, NERT, wholesale prices and consumer prices. They find that ERPT to CPI is lower than that to PPI; and the effect peaks in the first four months and lasts for 11 months. Kara and Öğünç (2008) assess a VAR model in Turkey including output gap, import prices, private manufacturing prices and core CPI. ERPT was high and rapid, but it diminished substantially after the adoption of IT in 2001. According to the analysis of Kara and Öğünç (2012) for the period 2002-2011 using VAR, pass-through from import prices to core inflation is as important as ERPT to core inflation, both being 15 percent for a year. As the underlying reasons behind the declining ERPT, they propose decreasing inflation rates and the adoption of the floating exchange rate regime after the crisis in 2001. Using a VAR analysis including output gap, NERT, import unit value index, PPI and CPI for the January, 2005 – April 2015 period, Alptekin et al. (2016) find incomplete ERPT in Turkey where ERPT to CPI is lower than that to PPI. The declining trend of ERPT is explained by firms' adjusting their profit margins rather than making price adjustments to avoid losing market shares, the substitution away from imported products to lower quality final products and from imported intermediate goods to alternative cheaper intermediate goods to reduce production costs. Emek et al. (2021) use an ARDL method with CPI/PPI, exchange rate, IPI, and import unit value indices for January, 2005 – April, 2020 period and ERPT to PPI is found to be greater than that to CPI. Recently, Gürkaynak et al. (2022) stress the importance of expectations regarding lower steady-state inflation in the success of neo-Fisherian disinflation policies. Hence, our paper contributes to this debate by augmenting the inflation expectations to the ERPT analysis so that depending on rational (irrational) expectations of economic agents, optimal (suboptimal) policies of CBRT can also be identified. In this regard, our findings signal a suboptimal policy rule by CBRT due to the irrational expectations of agents, even under the neo-Fisherian perspective.

The estimation of our six-variable VAR models for Turkey quantifies the ERPT to inflation and to inflation expectations. Our findings show that the transmission from exchange rate to inflation expectations remains lower than that to inflation at every time horizon in an economy where the monetary policy shifts its focus to financial stability and growth-enhanced strategy rather than IT. More specifically, ERPT coefficients of 1-, 3-, 6-, and 12-month inflation are 8.7 percent, 19.9 percent, 20.2 percent, and 19.9 percent, respectively whereas ERPT coefficients of 12-month-ahead inflation expectations over 1-, 3-, 6-, and 12-months are 4.3 percent, 12 percent, 18.7 percent, and 19.2 percent, respectively. Next, we conduct the time-varying analysis, and the results reveal that there has been a chronic discrepancy between ERPT to inflation rate and inflation expectations, more so in shorter horizons. Finally, with robustness checks, we investigate whether our findings are valid when we (i) extend the model by introducing both domestic and foreign monetary policies (henceforth, extended model), (ii) consider different ordering of the shocks in the baseline and the extended models. According to our results, ERPT coefficients to inflation and to inflation expectations remain the same with the baseline model. Specifically, ERPT to inflation expectations in the first months are formed significantly below the ERPT to inflation; and exhibits fast convergence thereafter, whilst remaining slightly below at every horizon.

The contribution of this paper to the existing literature is three-fold. First, to the best of our knowledge, this is the first study that compares the impact of exchange rate on both inflation and inflation expectations; and despite many analyses regarding Turkey, this is the first paper that investigates ERPT in Turkey considering the interaction of inflation expectations. The second contribution is the provision of a policy recommendation. The wedge between ERPT to inflation and that to inflation expectations is crucial for policy design as it designates which variable to take into account by CBRT for optimal policy. Since the wedge decays over time, CBRT should take into account the inflation expectations of the longer horizons in its policy rules. Lastly, this paper analyzes the evolution of the ERPT coefficients with time-varying analysis, which serves for the characterization of the nature of agents' expectations. The importance of the coefficients is that they are the indicators of irrationality. The difference of the coefficients under varying horizons may suggest chronic irrationality of expectations by agents whereas the convergence to the same level of the coefficients of expectations and inflation itself implies the adaptive formation of expectations over time. On the account of this, CRBT should focus more on this feature to forward-guide the expectations.

The rest of the paper is organized as follows. Section 2 explains the data collection and methodology. Section 3 describes the findings of the regression analysis and checks the robustness. Section 4 concludes.

## 2. Model and Data

The aim of this paper is to evaluate the rationality of inflation expectations regarding the exchange rate. To assess the rationality, the equivalence of ERPT to inflation and ERPT to inflation expectations at different horizons is checked. We base our analysis on the assumption that if the economic agents are rational, they can form correct priors on the future inflation rate. In other words, by employing all the information available up to and including time $t$, rational agents can predict how the inflation rate will evolve in the future. Hence, they will adjust their expectations at the same rate as inflation. Specifically, for the rational agents, the ERPT coefficients, which measures the impact of exchange rate shocks, of both inflation and its expectations, should be equal. Otherwise, there is a wedge between the ERPT coefficient of inflation and inflation expectations at the corresponding horizon. Therefore, if we model both inflation and inflation expectations by using the same explanatory variables, we should find the same ERPT coefficients.

In the analysis, first, we test whether there is such a discrepancy. Next, we evaluate whether the wedge varies in time. To conduct these analyses, we extend the five-variable VAR in the seminal study of McCarthy (2007) to cover inflation expectations. The model is specified in (1) as follows

$$\mathbf{Y_t} = \mathbf{c} + \sum_{\mathbf{i=1}}^{\mathbf{p}} \boldsymbol{\beta}_\mathbf{i}\, \mathbf{Y_{t-i}} + \boldsymbol{\varepsilon}_\mathbf{t} \tag{1}$$

where $Y_t$ is the vector of endogenous variables, $c$ is the vector of constants, $p$ denotes the order of the system, $\beta_i$ represents the matrix of the autoregressive coefficients, and $\varepsilon_t$ is the vector of white noise process. In the system, the endogenous variables vector contains oil price, economic activity indicator, exchange rate, producer and consumer inflation, and inflation expectations measures for different horizons. In monthly frequency, we use the logarithmic differences in the price of the barrel of Brent oil in Turkish Lira (TL), TL/US Dollar (USD) as the exchange rate, seasonally and working day adjusted IPI for economic activity, PPI for producer's inflation, CPI for consumer inflation, and the change in 12-month-ahead for inflation expectations. To test for unit root, we conduct Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests[4]. Table 1 and Table 2 report ADF and PP test results, respectively. Since the null hypothesis of having a unit root is rejected for each variable for each tests, all the variables are stationary.

[4] Throughout the analysis, Eviews 8 is used as a software.

**Table 1.** Augmented Dickey-Fuller test results

| | None | Intercept | Trend and Intercept |
|---|---|---|---|
| Brent oil (logarithmic difference) | -11.13 | -11.13 | -11.25 |
| | (0.00) | (0.00) | (0.00) |
| WDSA IPI (logarithmic difference) | -17.00 | -17.74 | -17.75 |
| | (0.00) | (0.00) | (0.00) |
| TL/USD (logarithmic difference) | -10.46 | -10.83 | -11.10 |
| | (0.00) | (0.00) | (0.00) |
| PPI (logarithmic difference) | -7.13 | -9.00 | -8.97 |
| | (0.00) | (0.00) | (0.00) |
| CPI (logarithmic difference) | -2.38 | -9.16 | -9.14 |
| | (0.02) | (0.00) | (0.00) |
| Inflation expectations (difference) | -5.76 | -5.87 | -6.27 |
| | (0.00) | (0.00) | (0.00) |

**Notes:** Unit root tests are conducted based on Schwarz Information Criteria where up to 14 lags are considered. t-statistics are shown next to the variable. p-values are in parentheses.

**Table 2.** Phillips Perron test results

| | None | Intercept | Trend and Intercept |
|---|---|---|---|
| Brent oil (logarithmic difference) | -10.79 | -10.89 | -10.86 |
| | (0.00) | (0.00) | (0.00) |
| WDSA IPI (logarithmic difference) | -16.85 | -17.75 | -17.77 |
| | (0.00) | (0.00) | (0.00) |
| TL/USD (logarithmic difference) | -9.73 | -9.75 | -9.79 |
| | (0.00) | (0.00) | (0.00) |
| PPI (logarithmic difference) | -7.15 | -8.02 | -7.99 |
| | (0.00) | (0.00) | (0.00) |
| CPI (logarithmic difference) | -8.00 | -10.92 | -10.90 |
| | (0.00) | (0.00) | (0.00) |
| Inflation expectations (difference) | -5.83 | -5.98 | -6.06 |
| | (0.00) | (0.00) | (0.00) |

**Notes:** Unit root tests are conducted based on automatic bandwidth selection using Newey-West Bandwidth method. t-statistics are shown next to the variable. p-values are in parentheses.

Brent oil price, IPI, exchange rate, PPI, CPI, and Istanbul Stock Exchange (ISE) repo rate are gathered from Turkey Data Monitor (TDM)[5]. Inflation expectations data are obtained from Electronic Data Delivery System[6] of CBRT. Ten-year US government bond yield is collected from FRED[7].

Time span for the analysis is between January, 2011 and December, 2019. The single objective of CBRT was the price stability with IT between 2006-2010 whereas, since 2011, it has extended its objectives to maintain the financial and macroeconomic stabilities while keeping price stability as the primary objective. This switch in monetary policy, which can be described as a regime change, affects macroeconomic variables and the nature of the relationship between these variables. Additionally, we rule out the period after 2020 due to our reservations arising from the Covid-19 pandemic in 2020 and the possible deterioration of the stationarity in the series in the subsequent period. Consequently, our study proposes an analytical structure of how ERPT evolves over time in the recent (i.e., as from 2011), single-type (i.e., weak policy) monetary regime, that has financial stability and growth-enhanced focus rather than IT; in an exchange rate regime that is not purely free-floating; and in an environment without a world-wide unexpected negative shock.

We calculate ERPT coefficients in these inflation metrics by using the impulse-response analysis of these systems. Specifically, we compute the ERPT coefficients of inflation and inflation expectations by using

$$\mathrm{ERPT}_t^i = \frac{the\ cumulative\ response\ of\ i\ to\ the\ exchange\ rate\ shock_t}{the\ cumulative\ response\ of\ exchange\ rate\ to\ the\ exchange\ rate\ shock_t}$$

where $i$ is either inflation rate or inflation expectations.

In the baseline analysis, we obtain the structural shocks from the VAR, where we order the variables as listed above, following Leigh and Rossi (2002), using the Cholesky decomposition. Under this recursive identification scheme, we assume that the identified shocks affect their contemporaneous corresponding variables and the variables in the later stages, but they do not affect the shocks in the earlier stages. Therefore, the first variable in the

[5] Data are available from the authors on request.

[6] The data that support the findings of this study are available at https://evds2.tcmb.gov.tr/index.php?/evds/DataGroupLink/9/bie_urbek/tr, reference number TP.BEK.S01.B.A.

[7] The data that support the findings of this study are available at https://fred.stlouisfed.org/series/IRLTLT01USM156N, reference number IRLTLT01USM156N.

system is the most exogenous indicator, and it is not affected by the other variables. On the other hand, the last variable is the most endogenous variable, and it is affected by all the other variables prior to it. In our model, oil price shocks affect all the variables in the system; however, they are not affected by any of the other shocks. Next, there are the output, and the exchange rate shocks. Following these, we include the producer price variable. Finally, we have CPI and inflation expectations variables. This identification scheme enables tracing out the impact of the exchange rate shocks in various stages of the supply chain. However, note that this ordering is one alternative among several possible orderings and variables.

Then, we can represent the system as follows:

$$\pi_t^{oil} = E_{t-1}\left[\pi_t^{oil}\right] + \varepsilon_t^{oil} \tag{2}$$

$$y_t = E_{t-1}[y_t] + \alpha_1 \varepsilon_t^{oil} + \varepsilon_t^{y} \tag{3}$$

$$e_t = E_{t-1}[e_t] + \beta_1 \varepsilon_t^{oil} + \beta_2 \varepsilon_t^{y} + \varepsilon_t^{e} \tag{4}$$

$$\pi_t^{PPI} = E_{t-1}[\pi_t^{PPI}] + \gamma_1 \varepsilon_t^{oil} + \gamma_2 \varepsilon_t^{y} + \gamma_3 \varepsilon_t^{e} + \varepsilon_t^{PPI} \tag{5}$$

$$\pi_t^{CPI} = E_{t-1}\left[\pi_t^{CPI}\right] + \delta_1 \varepsilon_t^{oil} + \delta_2 \varepsilon_t^{y} + \delta_3 \varepsilon_t^{e} + \delta_4 \varepsilon_t^{PPI} + \varepsilon_t^{CPI} \tag{6}$$

$$\pi_t^{exp} = E_{t-1}\left[\pi_t^{exp}\right] + \sigma_1 \varepsilon_t^{oil} + \sigma_2 \varepsilon_t^{y} + \sigma_3 \varepsilon_t^{e} + \sigma_4 \varepsilon_t^{PPI} + \sigma_5 \varepsilon_t^{CPI} + \varepsilon_t^{exp} \tag{7}$$

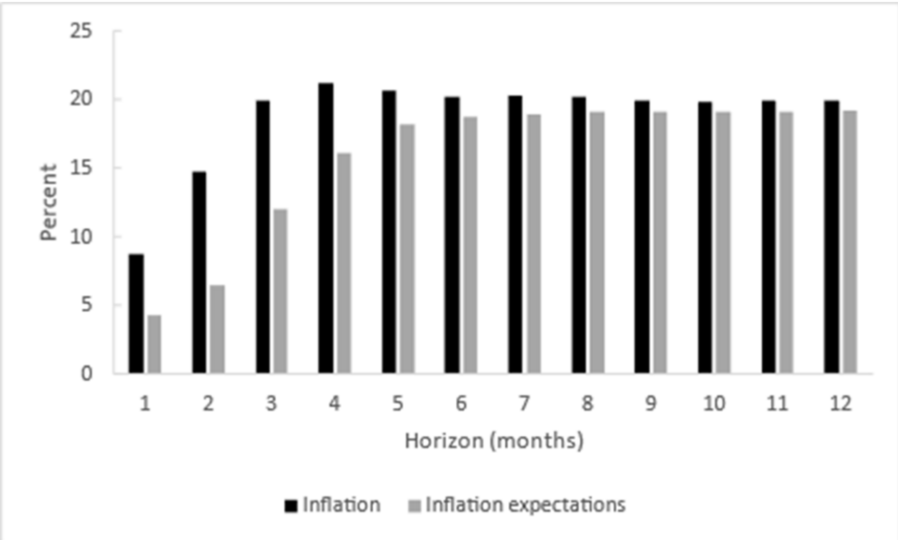
where $\pi_t^{oil}$ is the oil price inflation, $y_t$ is the logarithmic difference of the working day and seasonally adjusted industrial production, $e_t$ is the logarithmic change in the TL/USD, $\pi_t^{PPI}$ is the producer price inflation rate, $\pi_t^{CPI}$ is the consumer price inflation rate, $\pi_t^{exp}$ is the changes in the 12-month-ahead inflation expectations, respectively, at time $t$. $E_{t-1}[.]$ is the expectation of a variable conditional on the information available at time $t-1$. We assume that the conditional expectations of the variables can be obtained by taking the linear combination of the five endogenous variables.

In the estimations, we choose the optimal lag length by considering the number of lags suggested by five statistics: (i) sequential modified LR test statistic, (ii) final prediction error, (iii) Akaike information criterion, (iv) Schwarz information criterion, and (v) Hannan-Quinn information criterion statistics. As each statistic has its own advantage and may point to different lags, we take the average of the number of lags suggested by each of these statistics rather than choosing a specific one. We conduct the lag length selection tests by considering a maximum lag length of four. For the period between January, 2011 and December, 2019, first metric suggests four lags whereas other metrics suggest one lag of the endogenous variables. Taking the average of optimal lag length suggested by these metrics, we estimate the model with two lags.

## 3. Results and Robustness Checks

Figure 3 shows the ERPT to inflation rate (black bars) and inflation expectations (gray bars) for different horizons. The ERPT to both inflation and inflation expectations increase for longer horizons. More specifically, *ceteris paribus*, 1-, 3-, 6-, and 12-month ahead inflation rate increases by 0.87 percent, 1.99 percent, 2.02 percent, and 1.99 percent respectively, if Turkish Lira depreciates by ten percent. On the other hand, as a result of an exchange rate shock of the same size, the 12-month-ahead inflation expectations of the corresponding horizons increase only by 0.43 percent, 1.2 percent, 1.87 percent and 1.92 percent.

**Figure 3. Exchange rate pass-through to inflation rate and inflation expectations**




These findings indicate that economic agents do not accurately evaluate the impact of exchange rate shocks on inflation rate while forming expectations in the short run. Up to six months, ERPT to both inflation and inflation expectations rise; however, ERPT to expectations increase at a slower pace. On the other hand, after six months, ERPT coefficients converge. This observation implies that economic agents do not form rational expectations in the short run. Possibly, first, they follow inflation developments in the short run to grasp the inflation dynamics; then, update their beliefs, which is an indication of adaptive expectation formation, suggesting a rational formation of expectations over time.

Since Figure 3 establishes that there is a wedge between ERPT to inflation and inflation expectations, it is also essential to analyze whether the discrepancy prevails even when we consider any shift in time intervals, where the coefficients of the model are allowed to vary over time. Panels of Figure 4 show the evolution of ERPT to inflation and inflation expectations coefficients of the corresponding horizons. The horizontal axis on these figures shows the end period of the window in each estimation. To conduct the time-varying analysis, we estimate the baseline model in a rolling window framework where the time frame is four years (i.e., 48 observations). Accordingly, the first window ranges from January, 2011 to December, 2014, and the last window spans over the period between January, 2016 and December, 2019. We estimate VAR on 61 rolling windows. The reason behind the use of the rolling VAR methodology is that it is an unstructured way of analyzing parameter changes and instability over time; thereby, without imposing any restriction or assumption on the specification of the model (De Gregorio et al. 2007).

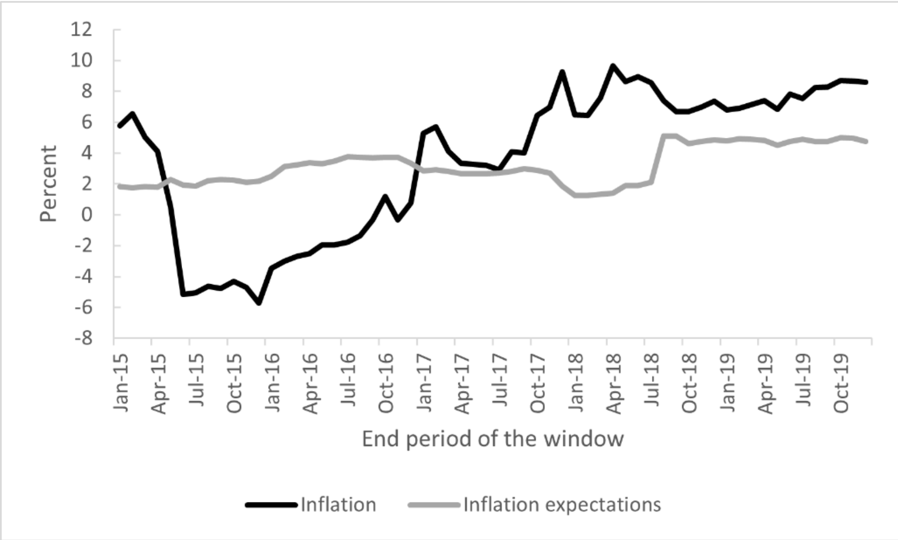
Our time-varying analysis reveals various facts. First, the discrepancy between ERPT to inflation rate and inflation expectations exists at every time horizon, suggesting a chronic discrepancy. This supports our findings in the previous baseline VAR model where the nature of the interaction among the variables is held constant. Second, this gap is much more pronounced in 1- and 3-month ERPT coefficients (Figure 4 Panels a and b) relative to the ones in longer horizons. This illustrates that the fluctuations in exchange rate do not affect agents' short run inflation expectations but rather their longer-run expectations as indicated by 6-month and 12-month ERPT coefficients (Figure 4 Panels c and d), where the gap almost disappears in the latter. In each horizon, while ERPT to inflation rate begins to rise significantly from the third quarter of 2016[8], its impact to inflation expectations increases significantly only after the exchange rate crisis of August 2018[9]. This observation allows us to interpret the formation of economic agents' expectations. If the agents are rational and forward-looking, policy changes should be incorporated into the private sector's forecasts. We can argue that in the case of Turkish economy, the rise in inflation is considered as transitory or the monetary policy communication of CBRT was possibly not clearly perceived by the economic agents; and thus, ERPT to inflation rate and inflation expectations differs in January 2015 – August 2018. This is an episode when irrationality of inflation expectations became severe. There may be two reasons behind this issue. First, economic agents might have perceived that the rise in the exchange rate was temporary. Hence, they did not adjust their expectations accordingly. Second, CBRT's ambiguous monetary policy setting, which emphasized the tightness in its statements while not tightening as necessary, might have perplexed the economic agents.

8 CBRT started to make cuts in its policy interest rate by third quarter of 2016 where annual inflation rate started to accelerate since.

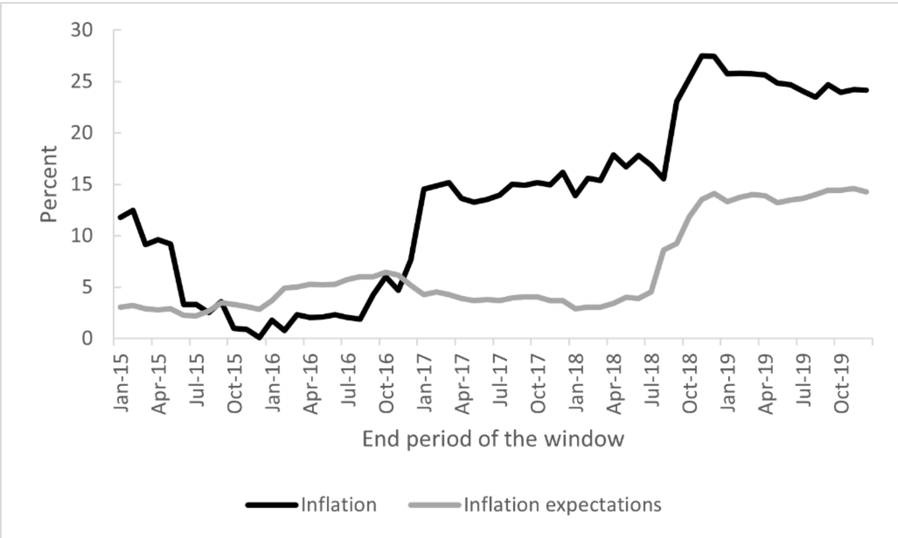
9 In August 2018, Turkish Lira fell up to 7.24 from 3.79 against USD in January 2018.

**Figure 4. Rolling window ERPT coefficients over different horizons**

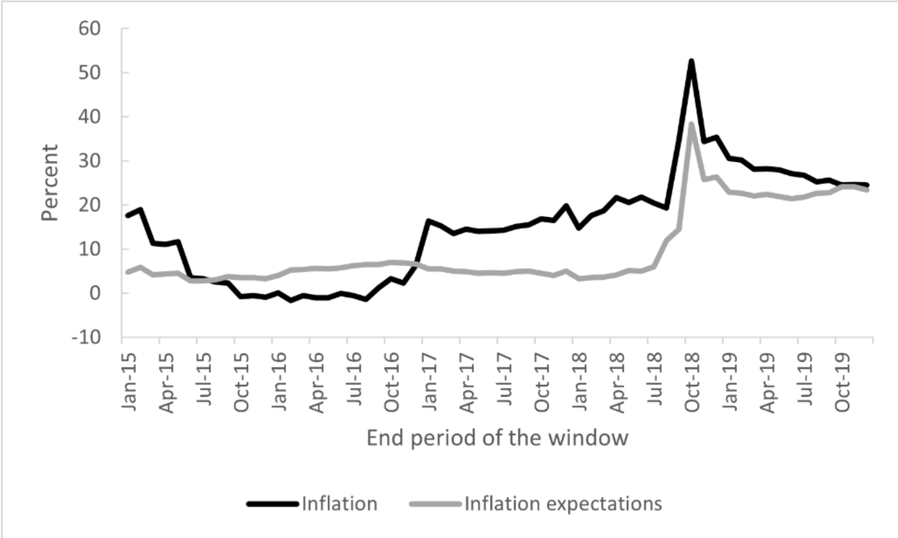
**Panel a**: 1-month horizon



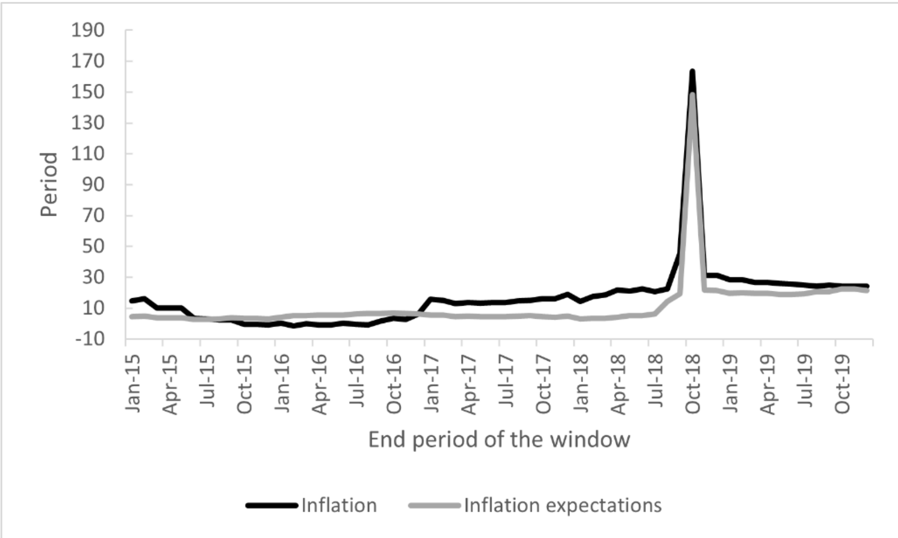

**Panel b**: 3-month horizon



**Panel c**: 6-month horizon




**Panel d**: 12-month horizon




In order to check the reliability of our evidence detailed above, we conduct two robustness checks. In these checks, we investigate whether previous estimates are valid when we (i) extend the model by introducing both domestic and foreign monetary policies (henceforth, it is the extended model), (ii) consider different ordering of the shocks in the baseline and the extended models. Findings reveal that ERPT coefficients to inflation and inflation expectations do not significantly change.

In the first robustness check, we extend the baseline model to cover the foreign and domestic monetary policies. We include the foreign monetary policy to capture the reaction of other CBs to supply shocks, which may have an impact on the value of the domestic currency. In addition, we incorporate the domestic monetary stance into the model to reckon the response of the domestic CB to local inflation rate and inflation expectations. Because the monetary policy may respond to contemporaneous or past exchange rate movements; and affect domestic inflation and exchange rate. In this regard, we include the ten-year US government bond yield and Istanbul Stock Exchange (ISE) repo rate as the foreign and the domestic monetary policy indicators, respectively. We opt for market interest rates because they can reflect the verbal part of the monetary policy in addition to the changes in the policy rates.

In the extended model, we order the foreign monetary measure after the oil price shock, and the domestic monetary measure in the last place. Then, the new identification of the shocks in the model can be represented as follow:

$$\pi_t^{oil} = E_{t-1}\left[\pi_t^{oil}\right] + \varepsilon_t^{oil} \quad (8)$$

$$i_t^f = E_{t-1}\left[i_t^f\right] + \alpha_1\varepsilon_t^{oil} + \varepsilon_t^f \quad (9)$$

$$y_t = E_{t-1}[y_t] + \beta_1\varepsilon_t^{oil} + \beta_2\varepsilon_t^f + \varepsilon_t^y \quad (10)$$

$$e_t = E_{t-1}[e_t] + \gamma_1\varepsilon_t^{oil} + \gamma_2\varepsilon_t^f + \gamma_3\varepsilon_t^y + \varepsilon_t^e \quad (11)$$

$$\pi_t^{PPI} = E_{t-1}\left[\pi_t^{PPI}\right] + \delta_1\varepsilon_t^{oil} + \delta_2\varepsilon_t^f + \delta_3\varepsilon_t^y + \delta_4\varepsilon_t^e + \varepsilon_t^{PPI} \quad (12)$$

$$\pi_t^{CPI} = E_{t-1}\left[\pi_t^{CPI}\right] + \eta_1\varepsilon_t^{oil} + \eta_2\varepsilon_t^f + \eta_3\varepsilon_t^y + \eta_4\varepsilon_t^e + \eta_5\varepsilon_t^{PPI} + \varepsilon_t^{CPI} \quad (13)$$

$$\pi_t^{exp} = E_{t-1}\left[\pi_t^{exp}\right] + \theta_1\varepsilon_t^{oil} + \theta_2\varepsilon_t^f + \theta_3\varepsilon_t^y + \theta_4\varepsilon_t^e + \theta_5\varepsilon_t^{PPI} + \theta_6\varepsilon_t^{CPI} + \varepsilon_t^{exp} \quad (14)$$

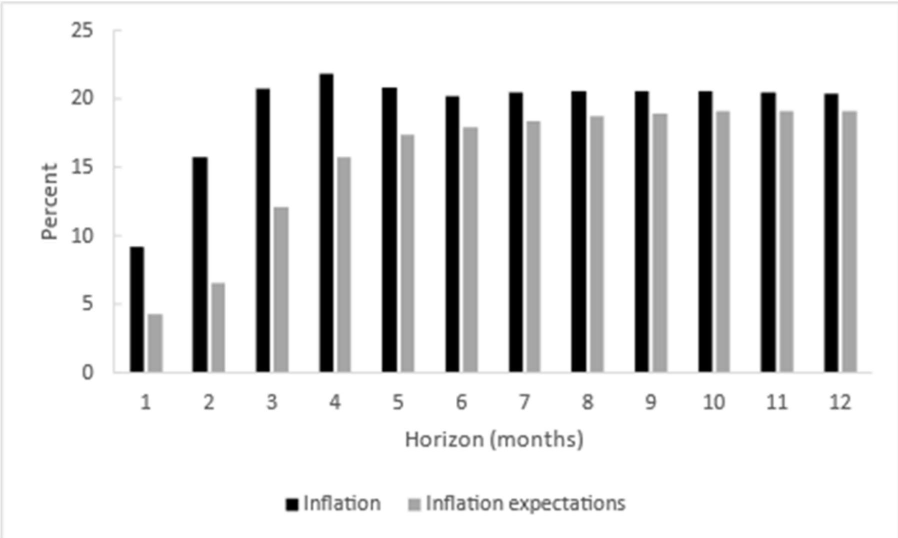
$$i_t^d = E_{t-1}\left[i_t^d\right] + \vartheta_1\varepsilon_t^{oil} + \vartheta_2\varepsilon_t^f + \vartheta_3\varepsilon_t^y + \vartheta_4\varepsilon_t^e + \vartheta_5\varepsilon_t^{PPI} + \vartheta_6\varepsilon_t^{CPI} + \vartheta_7\varepsilon_t^{exp} + \varepsilon_t^d \quad (15)$$

where $\pi_t^{oil}$ is the oil price inflation, $y_t$ is the logarithmic difference of the working day and seasonally adjusted industrial production, $e_t$ is the logarithmic change in the TL/USD, $\pi_t^{PPI}$ is the producer price inflation rate, $\pi_t^{CPI}$ is the consumer price inflation rate, $\pi_t^{exp}$ is the changes in the 12-month-ahead inflation expectations, $i_t^f$ is the change in the ten-year US government bond rate, and $i_t^d$ is the change in the ISE repo rate, respectively, at time $t$. $E_{t-1}[.]$ is the expectation of a variable conditional on the information available at time $t-1$. We assume that the conditional expectations of the variables can be obtained by taking the linear combination of the five endogenous variables.

The new ordering is intuitive for two reasons. First, foreign monetary policy decisions are not affected by domestic developments. Second, the domestic CB makes decisions after the announcement of the inflation rate and the inflation expectations.

Corresponding ERPT in Figure 5 indicates that 1-, 3-, 6-, and 12-month-ahead inflation rate increases by 0.92 percent, 2.08 percent, 2.02 percent, and 2.04 percent, respectively, if Turkish Lira depreciates by ten percent. On the other hand, as a result of an exchange rate shock of the same size, the 12-month-ahead inflation expectations of the corresponding horizons increase by 0.43 percent, 1.22 percent, 1.79 percent, and 1.91 percent.

**Figure 5. Exchange rate pass-through to inflation rate and inflation expectations (with interest rates)**




In the baseline analysis, we identified the shocks using Cholesky ordering. One caveat of this method is that the impulse response functions are sensitive to the ordering of the variables. To check whether the ordering of the variables matters for the ERPT coefficients, we estimate generalized impulse response functions by following Pesaran and Shin (1998), which calculates mean impulse response values of (i) the baseline and (ii) the extended models.

Figure 6 depicts the new estimates for the ERPT of the baseline model. These findings indicate that 1-, 3-, 6-, and 12-month-ahead inflation rate increases by 0.83 percent, 2.1 percent, 2.24 percent, and 2.21 percent, respectively, if Turkish Lira depreciates by ten percent. On the other hand, as a result of an exchange rate shock of the same size, the 12-month-ahead inflation expectations of the corresponding horizons increase by 0.47 percent, 1.31 percent, 2.09 percent, and 2.12 percent.

**Figure 6. Exchange rate pass-through to inflation rate and inflation expectations (baseline model with generalized impulse-responses)**

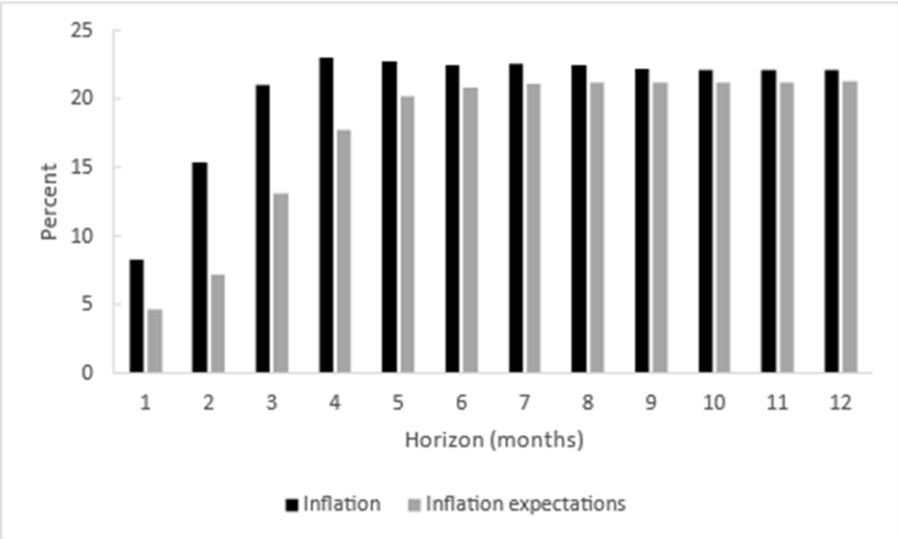
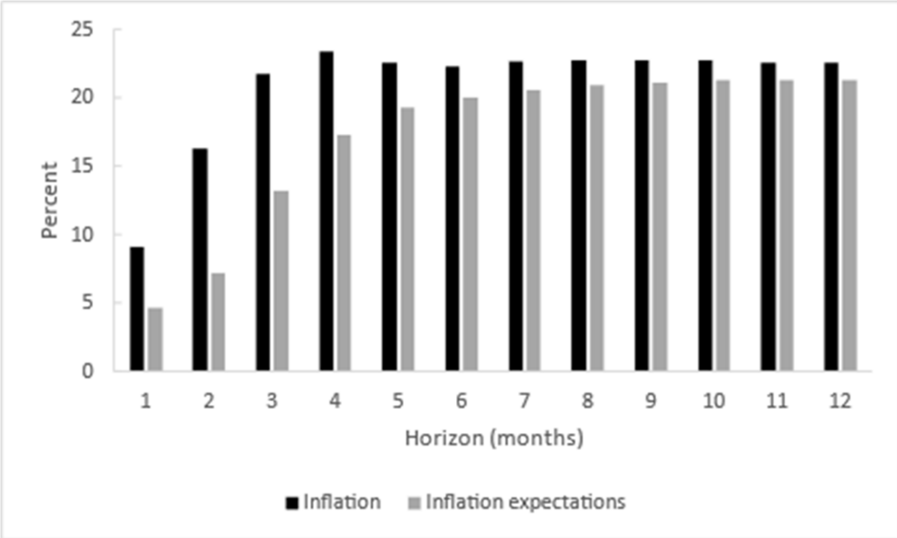



Figure 7 shows the updated estimates for the ERPT of the extended model. These findings indicate that 1-, 3-, 6-, and 12-month-ahead inflation rate increases by 0.91 percent, 2.17 percent, 2.23 percent, and 2.25 percent, respectively, if Turkish Lira depreciates by ten percent. On the other hand, as a result of an exchange rate shock of the same size, the 12-month-ahead inflation expectations of the corresponding horizons increase by 0.47 percent, 1.32 percent, 2 percent, and 2.13 percent.

**Figure 7. Exchange rate pass-through to inflation rate and inflation expectations (extended model with generalized impulse-responses)**




## 4. Conclusion

In this study, we investigate the rationality of inflation expectations regarding the exchange rate in Turkey, which is a small-open developing economy with unexpected changes in exchange rate. Specifically, for the period between 2011 and 2019, we estimate ERPT coefficients to the inflation and inflation expectations for different horizons and examine whether those coefficients differ in different horizons. The analysis reveals that the ERPT coefficients of 1-, 3-, 6-, and 12-month inflation are 8.7 percent, 19.9 percent, 20.2 percent, and 19.9 percent, respectively. On the other hand, ERPT coefficients of 12-month-ahead inflation expectations over 1-, 3-, 6-, and 12-months are 4.3 percent, 12 percent, 18.7 percent, and 19.2 percent, respectively.

The discrepancy between ERPT to inflation and inflation expectations has an important monetary policy implication. If the exchange rate shocks do not propagate to inflation expectations at the same rate as inflation, CBs may adopt a non-optimal policy stance. For instance, they may adopt a looser monetary policy when faced with an unexpected depreciation of the local currency if ERPT to inflation expectations is lower than that to inflation. In that case, inflation rate in that country may stay high for a period. In this regard, policy recommendation to CBs would be to put less weight on the inflation expectations in their policy rules to avoid such an issue.

According to our estimation results, there has been a chronic discrepancy between ERPT to inflation rate and inflation expectations, more so in shorter horizons. Yet, agents in Turkey are using adaptive formation of expectations better in the longer run compared to shorter horizons. In other words, their rationality on inflation expectations is more accurate over longer horizons. Hence, CRBT should focus more on this feature to forward-guide the expectations. Since coefficients of ERPT to inflation in the time-varying analysis are found to be mostly higher than that to inflation expectations with a converging fashion over longer horizons, CBRT is advised to attach less weight on inflation expectations in its policy rules under the current accommodative monetary regime than IT.

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