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NONLINEAR DYNAMICS IN EXCHANGE RATE PASS-THROUGH AND INFLATION PERSISTENCE: THE CASE OF TURKISH ECONOMY

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ABSTRACT

As a small open economy, inflation is still largely driven by exchange rate developments in Turkey. Despite the fact that exchange rate pass-through (ERPT) to inflation has declined after the adoption of explicit inflation targeting in 2003, its contribution to the consumer prices and producer prices inflation is still prominent. Furthermore, recent studies show that inflation persistence appears to be another issue preventing from achieving price stability. This paper aims to explore the non-linear dynamics of ERPT and inflation persistence in the case of Turkey by employing Smooth Transition Regression (STR) models. The main motivation of this study is to identify different regimes characterized by the magnitude of exchange rate movements in which ERPT and persistence in inflation indicators differ. Estimation results for the period 2003-2017 shows that inflation persistence and ERPT for Consumer Price Index (CPI) is high in regime with a sizeable import price shock. Additionally, STR estimation results indicate that ERPT and import price pass-through to Producer Price Index (PPI) is more influential in "high depreciation" regime.

Contribution/ Originality: The paper's primary contribution is finding that there exists nonlinearities in exchange rate and import prices pass-through in Turkish economy. To this end, this study utilizes Smooth Transition Regression (STR) methodology.

1. INTRODUCTION

Understanding inflationary dynamics and assessing the relation between local price increases and exchange rate movements have been vital topics in monetary policy formulation, especially in emerging markets. That mainly stems from the cost pressure as well as their effects on the pricing expectations. Countries that are heavily dependent on the import prices for intermediate and final goods are more subject to the exchange rate shocks than those that are not. Considering emerging markets, specifically Turkey, exchange rate is still one of the key drivers of both consumer and producer prices. In this context, although Turkish economy has experienced some sort of transformation resulting a sizeable disinflation, there still remains a big effect of exchange rate on inflation (Kara *et al.*, 2005). In developed economies, exchange rate pass-through (ERPT) can be identified as a transmission mechanism functioning from exchange rate movements to domestic import prices. On the other hand, for small

open emerging economies, any depreciation in local currency whose influence is transmitted to import prices is also manifested in local consumer prices as consumer baskets include traded goods and imported products (Kara *et al.*, 2005).

As suggested by Carriere-Swallow *et al.* (2016) there exists a close relation between ERPT and monetary policy. The variables which represent the success of monetary policy formulation are found to be highly correlated with ERPT. For instance, the level and standard deviation of inflation rate as measures of price stability become more prominent given higher ERPT in emerging as well as developed countries. Furthermore, monetary policy credibility is also relevant to the degree of ERPT. According to empirical results, variability of consensus of inflation forecasts and the disagreement among professional forecasters of inflation are more observed with higher ERPT (Carriere-Swallow *et al.*, 2016). If the inflation expectations are well anchored, then real shocks originated from various channels including ERPT would have less prominent impact on expected and trend inflation (Mishkin, 2008). Hence, understanding the response of consumer prices to shocks coming to exchange rate constitutes the initial step to diagnose the transmission channels through which inflation is affected. Such an analysis is also the first step to achieve price stability and it provides inputs to formulate a sound monetary policy. In particular, this study aims to explore ERPT and inflation persistence behavior from the perspective of nonlinearity.

2. EXCHANGE RATE PASS-THROUGH IN TURKEY AND RELATED FACTORS

In the case of Turkey, since explicit inflation targeting has been applied after 2006, pass-through to consumer prices holds importance as inflation targets are set in terms of Consumer Price Index (CPI) levels. Historical evaluation shows that before the adoption of implicit inflation targeting in 2002, low level of control of Central Bank of Turkey (CBRT) on the longer end of yield curve combined with volatile risk premium resulted sizeable fluctuations in exchange rate. Thus, fast and high ERPT was observed. On the other hand, Kara *et al.* (2005) finds that the exchange rate pass through to consumer prices has declined since 2001, due to the structural break in Turkish economy. Considering cost channel to CPI, Atuk *et al.* (2013) finds that there is a long run relationship between those two concepts, and more importantly, the effect of ERPT to producer prices is faster than to the consumer prices, since producer prices do not include tax and services items. Therefore, the response of producer prices to exchange rate is more volatile than that of consumer prices. The question is whether the response of those price series to exchange rate shocks is the same across time. Many studies in the literature argue that it is not. Doğan (2013) uses a threshold autoregressive model on manufacturing prices in Turkey and finds that depending on the aggregate demand conditions the pass through can be varied. Arbalı (2003) and Dedeoğlu and Kaya (2014) too, find results supporting the fact that response of prices to exchange rate shocks does not stay the same across time.

Considering the dynamic effects of exchange rate on inflation, Kara *et al.* (2017) investigate the drivers of consumer inflation in Turkey during 2006-2016 by employing reduced form time varying parameter (TVP) Phillips curve and find that average contribution of exchange rate developments to average inflation rate in sample period (8.2%) is around 1.3%. This impact is also found to be more prominent after 2011 when average contribution to CPI inflation increased to 2% (Figure 1). It is claimed that, weaker capital flows during this period has exerted upside inflationary pressures through ERPT, especially after Federal Reserve's (Fed) tapering signal in May 2013.

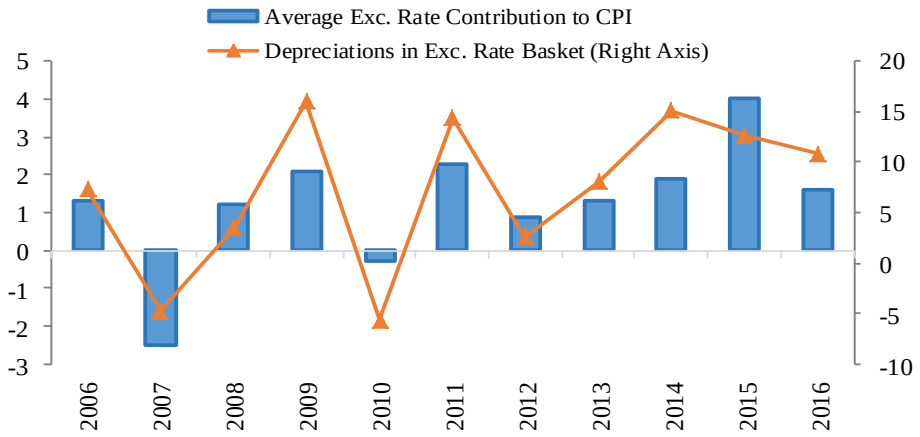

Figure-1. Exchange Rate Movements and Its Contribution to CPI in Turkey (percentage)
Source: Kara *et al.* (2017)

When we examine the factors behind effective ERPT to consumer prices in Turkish economy, we can mention about three important phenomena which are related to the patterns of pricing behavior and structure of production. Firstly, Turkish economy is highly dependent on imported intermediate goods and inputs for production. Considering the fact that import prices in local currency is determined by import prices in foreign currency and respective nominal exchange rate, any sizeable depreciation in currency would be manifested in import prices. As Goldberg and Campa (2010) argue, it is highly likely that CPI would be sensitive to import prices (hence exchange rate depreciations) due to the use of imported components in domestic production and direct household consumption of imported products. According to Turkish Statistical Institute (TurkStat), as of 2012, almost 15% of all inputs used in production are imported. This dependence is further supported by the foreign trade statistics. According to Broad Economic Classification (BEC) 70% of imports in Turkey are classified as intermediate goods. Such a production structure results in significant upward pressure in Producer Price Index (PPI) inflation caused by intermediate goods category.

The second factor behind ERPT in Turkey is related to the composition of CPI. When we examine the content of CPI basket, we observe that some items are subject to tradability and commercial activities, especially the main categories of energy, food and non-alcoholic beverages, clothing and footwear etc. Hence depreciation of TL might influence the TL value of imported goods as well as the CPI itself. Lastly, indexation channel constitutes the third factor which is a determinant of ERPT in Turkey. As stated in Kara *et al.* (2005) exchange rate depreciations might put upward pressure on inflation rate in the form of higher expectations. Since some firms base their pricing decisions on the course of exchange rate movements, this might induce persistence in inflation dynamics. Considering the fact that there is causal relation between inflation level and inflation expectations, role of inflation persistence in Turkey still holds importance.

The abovementioned non-linear dynamics of exchange rate is regarded as key determinant in setting up an effective monetary policy in Turkey. This effect would require the optimal policy to be different depending on the exchange rate shocks. In this respect, understanding the nonlinear dynamics in the ERPT to consumer and producer prices would be of greater use in applying an effective monetary policy to help stabilizing the economy.

This paper investigates ERPT and inflation persistence in the case of Turkey with non-linear methodologies, in particular Smooth Transition Regressions (STR). Next section covers related literature while Section 4 and 5 describe the data and methodologies, respectively. Section 6 presents the empirical results, Section 7 conducts robustness tests of the respective model, and lastly final part concludes the paper.

3. EMPIRICAL LITERATURE REVIEW

Most common methodology to assess the ERPT is the model of McCarthy (2007) where a VAR model is established incorporating oil prices, nominal exchange rate, industrial production, import prices, producer prices and consumer prices. ERPT in different horizons are measured through impulse response functions and forecast error-variance decompositions. In the case of Turkey, Kara and Öğünç (2005) apply this model to inflation data for the period 1995-2004. Firstly, they diagnose the existence of pass-through with Granger causality analysis. They also find that ERPT to consumer prices has weakened after the adaptation of floating exchange rate regime. Their results show that pass-through to private manufacturing prices are higher than that of consumer prices. As examples of more recent studies, Dedeoğlu and Kaya (2014) use rolling VAR to assess the change in ERPT to consumer prices over time. Their results are also in line with the studies above. Özmen and Topaloğlu (2017) investigate the ERPT to 152 subcomponents of CPI basket for the sample period of 2005-2015 through VAR models. Their results highlight the fact that ERPT is more prominent in core goods and energy groups as well as food and services. In terms of the inflation persistence, empirical evidence is less comprehensive. Kara *et al.* (2017) use TVP approach to identify the contributions of main categories to CPI inflation. In their model, time varying constant term is interpreted as a representation of trend inflation which is related to the inflation persistence embedded in pricing behavior associated with inflation expectations. They calculated average contribution of this constant term to headline inflation as 4% for the period 2006-2016.

Taking dynamics of Turkish economy into consideration, majority of price movements in PPI in Turkey is expected to reflect the fluctuations in exchange rate and import prices. Empirical works show that ERPT to producer (wholesale) prices in Turkey is more pronounced compared to ERPT to consumer prices Leigh and Rossi (2002). PPI is not only affected heavily by exchange rate depreciations but it is also closely related to CPI inflation. Similar to that, Yüncüler (2011) prove the higher ERPT to producer prices in Turkey by using VAR models. Considering this close relation between the two, some studies aim to examine the pass-through from PPI to CPI. Atuk *et al.* (2013) use VECM model for the period 2003-2013 to show the impact of PPI on CPI. Since producer prices do not include tax and services (whose prices are sticky) in terms of the composition, ERPT appears to be faster for PPI. Here, changes in taxes may overshadow the role of exchange rate movements, ultimately leading to non-linear dynamics in pass-through.

Empirical works conducted for Turkey are mostly employing linear models. Few examples of non-linear models applied to inflation dynamics include (Arbalı, 2003) in which threshold VAR models are constructed to assess ERPT over different regimes depending on the economic activity, size of exchange rate movements and whether economy experiences high inflationary period. Selecting different threshold variables, it is found that ERPT is higher during the expansion phase of the economic activity and when exchange rate movements are small in size. Arslaner *et al.* (2014) employ Markov switching regression model to test nonlinearities in ERPT in Turkey for the period 1986-2013. Switching regressors are specified as the lag values of exchange rate. In short, they found that the coefficients on exchange rate are statistically significant and have different signs in two states. In terms of the nonlinearities in ERPT to PPI, Doğan (2013) analyze the ERPT to manufacturing prices in Turkey with Threshold Autoregressive (TAR) models to understand whether the reaction of prices to the exchange rate varies depending on the demand conditions, size of exchange rate changes, exchange rate volatility, and inflation level. The results indicate that when the economy is growing, exchange rate changes are transmitted to prices to a larger extent than otherwise.

In contrast to Turkish case, many studies are conducted to assess nonlinearities in ERPT and inflation dynamics for other countries. Especially, cross-country studies and works done with developed countries' data are widely using TAR and Smooth Transition Autoregressive (STAR) type models. Mihaljek and Klau (2008) prove the nonlinearities in ERPT and inflation persistence by employing Ordinary Least Squares (OLS) regressions and tests for threshold effects. Furthermore, Shintani *et al.* (2013) describe a theoretical model of importing firms in which

ERPT is found to be affected by lagged inflation reflecting the role of inflation persistence. Using the dynamic Phillips curve, they assert that nonlinear behavior in ERPT can be best modeled by U-shaped STAR model. Their findings show that low ERPT is likely to be associated with the low inflation.

4. METHODOLOGY

To capture non-linearities in the ERPT and inflation persistence, we utilize multivariate version of class of STAR models, which is STR model. STAR models can be defined as a general class of reduced form regime switching non-linear models that accommodate different dynamic responses depending on the states. Hence, such models are particularly practical to examine the asymmetric behavior of economic series. Specification, testing and estimation procedures of this model are widely covered in Luukkonen *et al.* (1988) and Teräsvirta (1994). As surveyed by van Dijk *et al.* (2002) such models have been increasingly used in empirical works. STAR for a univariate time series of order p can be defined as follows:

$$Y_t = \pi_{10} + \sum_{i=1}^{p} \pi_{1i} Y_{t-i} + \left[\theta_{20} + \sum_{i=1}^{p} \theta_{2i} Y_{t-i}\right] F(y) + e_t$$

$F(y)=(1+\exp[-\gamma(y_{t-d}-c)])^{-1}$

$F(y)=1-\exp(-\gamma(y_{t-d}-c)^2)$

In the STAR model, there exists a smooth change between respective regimes. Transition function can be logistic or exponential in the STAR model as specified by Teräsvirta (1994). *F(y)* is bounded between 0 and 1, while it realizes the smooth transition between regimes in a dynamic manner rather than a sudden jump from one regime to another as in the TAR model. In the above specification, c is the threshold value, y_{t-d} stands for the transition variable and γ is the smoothness parameter which determines the speed of the transition. When smoothness parameter increases in value, the regime change becomes much quicker.

The first step in STAR framework is determining appropriate lag length[1] and testing nonlinearity as mentioned by Teräsvirta (1994). In order to derive a Lagrange-Multiplier (LM) type test for nonlinearity, Luukkonen *et al.* (1988) suggest replacing the transition function with third-order Taylor expansion around $\gamma=0$. Then, an auxiliary regression is set up as follows:

$$y_t = \beta_0 + \beta_1' w_t + \sum_{j=1}^{p} \beta_{2j} y_{t-j} y_{t-d} + \sum_{j=1}^{p} \beta_{3j} y_{t-j} y_{t-d}^2 + \sum_{j=1}^{p} \beta_{4j} y_{t-j} y_{t-d}^3 + e_t$$

$H_0: \beta_{2j} = \beta_{3j} = \beta_{4j} = 0$

$H_{01}: \beta_{4j} = 0$

$H_{02}: \beta_{3j} = 0 \mid \beta_{4j} = 0$

$H_{03}: \beta_{2j} = 0 \mid \beta_{3j} = \beta_{4j} = 0$

[1] In our study, AIC, BIC, general-to-specific and specific-to-general methods are used to determine lag length in linear models.

Linearity test is conducted based on the test statistic $LM=T(SSR_0-SSR_1)/SSR_0$ that follows a Chi-squared distribution. In this context, SSR_0 is the sum of squared residuals obtained from linear model while SSR_1 is based on auxiliary regression. To determine the optimal delay parameter, linearity test is carried out for different lag values. If the null hypothesis is rejected for more than one delay parameter the decision can be made depending on the p-value. Smallest p-value (giving greatest power for the test) should be chosen. Teräsvirta (1994) further explain a sequence of nested tests for the choice between logistic (LSTAR) and exponential smooth transition models (ESTAR) (Anderson and Terasvirta, 1992). If we fail to reject H_{01} and H_{03} and reject H_{03}, then appropriate model is ESTAR. In other cases, LSTAR is used to analyze the nonlinearities.

After the model is set up, non-linearity tests are conducted and the form of transition function is chosen; second stage is to estimate the parameters of the model by nonlinear least squares (NLS) method that provides asymptotically normal and consistent estimators. In this context, literature suggests to perform a grid search for the estimation of threshold value (c) and smoothness parameter (γ). For each values of γ (from 1 to 100) and c (across all ranked values of the transition variable), residual sum of squares are computed and stored. Initial values for NLS are taken such that they minimize the residual sum of squares. Last stage in the methodology is related to the several misspecification tests; test of no autocorrelation in residuals, Jarque-Bera test for normality and parameter constancy test (Eitrheim and Teräsvirta, 1996).

5. DATA

Seasonally adjusted monthly data used in this study covers the period between January 2003 and July 2017. Beginning of the sample period is chosen as corresponding to the start of inflation targeting period. Moreover, sample period excludes disinflation period when inflation rate in Turkey decreased from 60% to single digits in couple of years before the 2003. CPI and PPI are obtained from TurkStat and used in seasonally adjusted terms. The D Index is used as the core CPI inflation. D Index is calculated from CPI basket by excluding unprocessed food, alcoholic beverages and tobacco which are more volatile and influenced greatly by administered prices. Therefore it gives a chance to focus on main trend of consumer price levels purified from the impact of administered price developments. On the other hand, buying rate of exchange is obtained for TL/USD from Central Bank of Turkey (CBRT) Electronic Data Dissemination System.

As described in Carriere-Swallow *et al.* (2016) ERPT can be decomposed into two parts which are first and second round effects. First round involves the adjustment occurred in the local currency price of imported goods measured at the border resulted from exchange rate movements, while second round effects include the adjustment of other prices in the economy which are retail margins, distributional costs, prices of non-tradable goods and wages. Hence, import prices are included in the model to capture the first round effects. Import prices are also assumed to be important component of the impact of exchange rate on aggregate demand (Gagnon and Ihrig, 2004). The unit value index of imports from TurkStat are used as a proxy for import prices.

Monthly inflation, import price movements and exchange rate changes are calculated as logarithmic differences. Summary statistics are provided in Table 1 and series are scattered in Figure 2. It is seen that in sample period, exchange rate movements are sizeable as seen in the standard deviation of changes in TL/USD rate. Monthly depreciation in TL against hard currencies such as USD even reached to 18% in sample period.

In order to ensure that series do not contain unit root (stochastic trend), ADF and PP unit root tests are applied before the estimation. According to the test results presented in Table 2, logarithmic first differences of the data are stationary.

Table-1. Summary Statistics (percentage)

	CPI Inflation	PPI Inflation	TL/USD	Import Prices
Mean	0.637	0.660	0.439	0.203
Median	0.630	0.573	0.000	0.196
Maximum	1.929	4.399	18.076	4.690
Minimum	-0.328	-3.606	-8.783	-0.328
Std. Dev.	0.367	1.168	3.359	0.367
Observations	174	174	174	174

Source: Authors' calculations, CBRT, TurkStat

Table-2. Unit Root Test Results

	ADF		PP	
	No Trend	With Trend	No Trend	With Trend
CPI Inflation	-7.64***	-7.60***	-7.65***	-7.61***
PPI Inflation	-8.79***	-8.76***	-7.69***	-7.64***
TL/USD Exc. Rate	-9.43***	-9.88***	-8.97***	-9.07***
Import Prices	-7.42***	-7.65***	-7.90***	-8.11***

Source: Authors' calculations

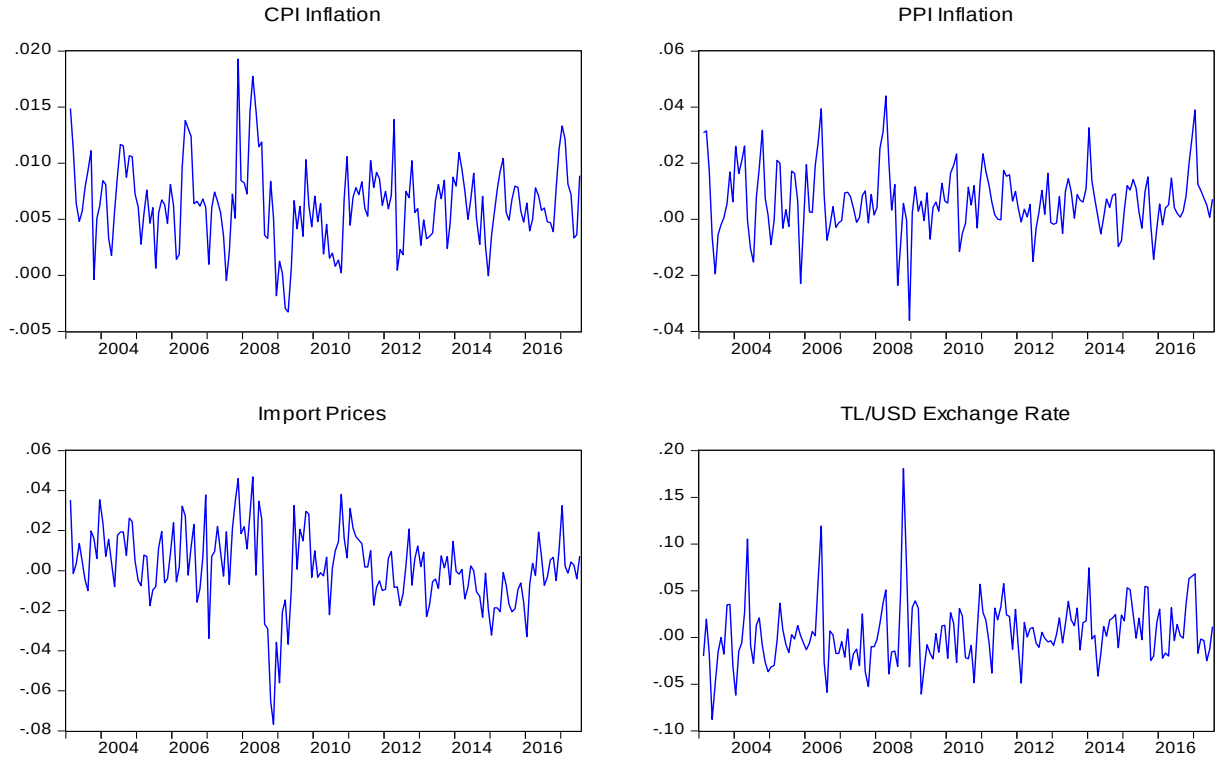

Figure-2. Inflation, Import Prices and Exchange Rate Movements

Source: Authors' calculations, CBRT, TurkStat

6. EMPIRICAL RESULTS

a. Consumer Prices

As a first empirical attempt, lag length of linear specifications are determined. As a result of the AIC, BIC, general-to-specific and specific-to-general methods, optimal lag length is found to be 1 for CPI inflation and 2 for the exchange rate and import prices. Hence, following model is considered.

$$CPI_t = \pi_{10} + \sum_{i=1}^{1} \pi_{1i}\, CPI_{t-i} + \sum_{j=0}^{2} \delta_{1j}\, USD_{t-j} + \sum_{j=0}^{2} \gamma_{1j}\, Import_{t-j}$$

$$+ \left[\pi_{20} + \sum_{i=1}^{1} \pi_{2i}\, CPI_{t-i} + \sum_{j=0}^{2} \delta_{2j}\, USD_{t-j} + \sum_{j=0}^{2} \gamma_{2j}\, Import_{t-j} \right] F(y) + e_t$$

A series of tests are applied for the identification of non-linearity. As a result of the tests considering level, first lag and second lag of exchange rate an import prices as well as the first lag of CPI; LSTAR type nonlinearity is found when contemporaneous value of import price is determined as transition variable. Furthermore, a grid search was conducted to determine the initial values for smoothness parameter and threshold value by minimizing SSR. Grid search reveals that starting value for gamma is 10 and initial value for the threshold is 2.78%. Test results and estimation results are given in Table 3 and Table 4.

Table-3. STR Type Nonlinearity Test for CPI Inflation, Import Prices and USD/TRY Exchange Rate

Transition Variable	Test Results
CPI(t-1)	Linearity
USD(t)	Linearity
USD(t-1)	Linearity
USD(t-2)	Linearity
Import(t)	LSTAR
Import(t-1)	Linearity
Import(t-2)	Linearity

Source: Authors' calculations

Table-4. STR Results for CPI Inflation, Import Prices and USD/TRY Exchange Rate

First Regime				
Variable	**Estimate**	**Std**	**T-stat**	**p-value**
Constant	0.003	0.000	7.478	0.000
CPI_{t-1}	0.372	0.071	5.242	0.000
USD_t	0.023	0.007	3.214	0.001
USD_{t-1}	0.017	0.007	2.243	0.026
USD_{t-2}	0.000	0.007	0.017	0.986
$Import_t$	0.061	0.016	3.852	0.000
$Import_{t-1}$	0.006	0.015	0.421	0.673
$Import_{t-2}$	0.014	0.015	1.010	0.313
Second Regime				
Variable	**Estimate**	**Std**	**T-stat**	**p-value**
Constant	-0.004	0.004	-0.962	0.337
CPI_{t-1}	0.509	0.264	1.928	0.089
USD_t	0.179	0.039	4.571	0.000
USD_{t-1}	0.125	0.033	3.747	0.000
USD_{t-2}	0.069	0.041	1.677	0.095
$Import_t$	0.374	0.147	2.539	0.012
$Import_{t-1}$	0.008	0.070	0.121	0.903
$Import_{t-2}$	0.103	0.048	2.144	0.033
Adjusted R^2	0.540			
Number of Observations	174			

Source: Authors' calculations

Estimation results show that the asymmetric response of CPI inflation to its own lag and exchange rate movements can be modeled significantly with LSTR model which implies two regimes. We define first regime as "low import price pressures" which is observed when transition variable (contemporaneous value of monthly

changes in import prices) stays below 0.278%. On the other hand, second regime is identified as "high import price pressures" when monthly changes exceed threshold value. In terms of the inflation persistence, our findings show that the impact of first lag of CPI on itself is statistically significant in both regimes. However in second regime, the relation gets stronger as coefficient on that variable has higher value when sizeable exchange rate depreciations observed. Moreover, ERPT also displays a nonlinear structure as seen in Table 4. The coefficient on simultaneous changes in exchange rate and first lag of very same variable are statistically significant in both regimes. Coefficients in regime 2 show that ERPT to CPI is more prominent when USD value of import prices increased prominently. The estimation conducted with CPI data has provided evidence in favor of non-linear structure in inflation persistence as well as ERPT in the case of Turkish economy.

b. Producer Prices

As a first step in modeling effort for producer prices, using the AIC, BIC, general-to-specific and specific-to-general methods the optimal lag lengths are obtained. While the optimal lag length is found to be 1 for PPI inflation, 2 lags are taken for the exchange rate and import prices. Therefore, the model specification turns out to be as follows.

$$PPI_t = \pi_{10} + \sum_{i=1}^{1} \pi_{1i} PPI_{t-i} + \sum_{j=0}^{2} \delta_{1j} USD_{t-j} + \sum_{j=0}^{2} \gamma_{1j} Import_{t-j} + \left[\pi_{20} + \sum_{i=1}^{1} \pi_{2i} PPI_{t-i} + \sum_{j=0}^{2} \delta_{2j} USD_{t-j} + \sum_{j=0}^{2} \gamma_{2j} Import_{t-j} \right] F(y) + e_t$$

Similar to the case of CPI, second step of modeling process for producer prices involves testing STAR-type nonlinearities. Letting the exchange rate to govern the regime changes together with the optimal lag lengths, the STAR-type non-linear model specification is found to exist. What is more, to get the initial values for smoothness parameter and threshold value, a grid search was conducted by minimizing SSR. According to the search results, initial values for γ and c are 6.6153 and 0.0233, respectively. Test results and estimation results are given in Table 5 and Table 6.

Estimation results show that the asymmetric response of PPI inflation to import prices and exchange rate movements can be modeled significantly with a LSTR model accompanied by two regimes.

The first regime can be defined as "low depreciation/appreciation" that occurred when monthly changes in USD/TL exchange rate is below 0.02%, while second regime is identified with high level of currency depreciation. According to the results, ERPT displays a non-linear structure as the first lag of exchange rate has higher and significant coefficient in second regime. Furthermore, the pass-through from import prices to producer prices is also non-linear in the sense that the coefficients on the contemporaneous value and first lag of import prices are significant and larger in magnitude when high level of depreciation is observed. Depending on the regime type, the pass through to producer prices is subject to change. This is compatible with the previous studies that concentrated on exchange rate pass through in Turkish economy. On the other hand, no statistically significant non-linear structure in persistence in producer prices is observed.

Table-5. STR Type Nonlinearity Test for CPI Inflation, Import Prices and USD/TRY Exchange Rate

Transition Variable	Test Results
CPI(t-1)	Linearity
USD(t)	Linearity
USD(t-1)	Linearity
USD(t-2)	LSTAR
Import(t)	Linearity
Import(t-1)	Linearity
Import(t-2)	Linearity

Source: Authors' calculations

Table-6. STR Results for PPI Inflation and USD/TRY Exchange Rate

First Regime				
Variable	**Estimate**	**Std**	**T-stat**	**p-value**
Constant	0.002	0.001	2.218	0.028
PPI_{t-1}	0.222	0.088	2.515	0.012
USD_t	0.153	0.026	5.756	0.000
USD_{t-1}	0.078	0.037	2.106	0.036
USD_{t-2}	-0.053	0.044	-1.211	0.227
$Import_t$	0.344	0.050	6.837	0.000
$Import_{t-1}$	-0.030	0.057	-0.526	0.599
$Import_{t-2}$	0.004	0.053	0.094	0.925
Second Regime				
Variable	**Estimate**	**Std**	**T-stat**	**p-value**
Constant	0.008	0.004	2.016	0.045
PPI_{t-1}	0.277	0.218	1.271	0.205
USD_t	0.024	0.059	0.414	0.679
USD_{t-1}	0.153	0.068	2.235	0.026
USD_{t-2}	-0.084	0.067	-1.241	0.216
$Import_t$	0.431	0.126	3.402	0.000
$Import_{t-1}$	0.257	0.118	2.170	0.031
$Import_{t-2}$	-0.088	0.113	-0.783	0.434
Adjusted R^2	0.554			
Number of Observations	174			

Source: Authors' calculations

7. ROBUSTNESS CHECKS

As part of robustness checks, several tests are conducted to if models are correctly specified. Both models of consumer and producer prices show suitable properties in the sense that there is no remaining nonlinear specification behind. Furthermore, there is no autocorrelation in the residuals which makes sure that the shocks coming from previous periods do not feed itself in the model. Both models are passing the parameter constancy tests. These results in turn once again prove that the models are robust against potential model misspecifications. Test results are given at the appendix.

8. CONCLUSION

In a small open and commodity dependent economy, exchange rate can have a big role on inflation developments, mainly due to the fact that intermediate goods and production inputs are heavily imported. As a small open and developing country, the share of imported goods in intermediate ones implies that any depreciation in local currency is first transmitted to the producer prices and then to consumer prices in Turkey. Thus import prices channel constitutes a significant effect on both producer and consumer prices inflation. What is more, the composition of CPI basket, due to the tradable goods and services are also subject to the exchange rate shocks. Lastly, inflation expectations also create significant effects on inflation through indexation channel. Thus, large exchange rate shocks not only pose cost-push effects but also by deteriorating the future expectations, they create

bigger effects than possible cost effects. As a result, depending on the size of the shocks the pass through to inflation might change, in a sense we may observe a non-linear impact in exchange rate dynamics.

To diagnose the potential nonlinear effects of exchange rate in Turkish economy, we use smooth transition models. Since these models benefit from a smooth transition function governing the regime change, the potential effects that could not be captured by single TAR models can be well followed by these models. In other words, we do not see a sudden shift from one regime to another, since we use a smooth transition regime governing function. The results of this study show that the ERPT to CPI is subject to a change depending on the size of import price shocks. When import price shock gets large in magnitude, ERPT becomes more prominent than otherwise. Furthermore, it is found that inflation persistence embedded in CPI is larger in size when "high import price shock" regime is observed. Additionally, we observe that ERPT and import price pass-through to producer prices are more prominent when we are in "high currency depreciation" regime. The results of this study appear to be compatible with previous ones conducted for Turkish economy. As a result, this study once again supports the arguments that there is no one single criteria or level that we can quantify for ERPT for Turkish economy, it is rather a state-dependent one. Finally; in this paper, two regimes have been modelled for ERPT, there might have been more regimes, though. Further research can be built upon this one and output gap (how the demand conditions affect the dynamics of ERPT) in the context of smooth transition regression models.

APPENDIX

Table-7. Test for No Remaining Nonlinearity (CPI model)

Transition Variable	p-value for F-statistics (Null Hypothesis of No Remaining Nonlinearity)
$Import_t$	0.147

Source: Authors' calculations

Table-8. Test for No Remaining Nonlinearity (PPI model)

Transition Variable	p-value for F-statistics (Null Hypothesis of No Remaining Nonlinearity)
USD_{t-2}	0.139

Source: Authors' calculations

Table-9. Parameter Constancy Tests

Model	F-statistic	p-value
CPI	0.564	0.8883
PPI	1.412	0.1029

Source: Authors' calculations

Table-10. Test for No Residual Autocorrelation (CPI model)

Lags	p-value
1	0.1802
2	0.3188

Source: Authors' calculations

Table-11. Test for No Residual Autocorrelation (PPI model)

Lags	p-value
1	0.012
2	0.045

Source: Authors' calculations

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