PANOECONOMICUS, 2016, Vol. 63, Issue 5, pp. 563-579
Received: 07 March 2014; Accepted: 09 January 2016.

UDC 339.743:330.101.51 (560)
DOI: 10.2298/PAN140307005C
Original scientific paper

Abdurrahman Nazif Çatık
Corresponding Author

Department of Economics,
Ege University,
Turkey
a.nazif.catik@ege.edu.tr

Mehmet Karaçuka

Department of Economics,
Ege University,
Turkey
mehmet.karacuka@ege.edu.tr

Barış Gök

Department of Economics,
Ege University,
Turkey
baris.gok@ege.edu.tr

A Time-Varying Parameter VAR Investigation of the Exchange Rate Pass-Through in Turkey

Summary: The effects of exchange rate movements on price levels have important implications to macroeconomic policies through the impacts on trade balance and inflation. In contrast to previous studies, we employ a VAR model with time-varying parameters to measure the magnitude of exchange rate pass-through (ERPT). The findings confirm the time-varying pattern in the ERPT, as the magnitude of ERPT has reached its maximum value during the 1994 financial crisis. The decline in the magnitude of ERPT has become more pronounced after the 2001 financial crisis as a result of the implementation of inflation targeting, which has shifted Turkey's economy from a long lasting high inflationary phase to a low inflationary economic environment.

Key words: Exchange rate pass-through, Wholesale prices, Consumer prices,Time-varying parameter VAR, Turkey.

JEL: C32, E31, E42, E58.

Since the 1980's, Turkey's economy has witnessed different monetary policies and exchange rate mechanisms. Until the last decade, chronically high inflation, financial crisis and currency devaluation had been the main macroeconomic patterns. However, following the November 2000- February 2001 crisis, Turkey has moved from a high- to a low-inflation regime as a result of the implemented stabilization program and this has led to changes in the estimated parameters in modeling inflation (see A. Özlem Önder 2009, for details). From this viewpoint, one may expect to see a structural change after 2001 in the relationship between inflation and exchange rate for Turkey similar to the one observed in other emerging countries.

This paper aims to investigate the evolution of exchange rate pass-through (ERPT) in Turkey. In contrast to previous studies on Turkey, we employed a time-varying parameter vector autoregression (TVP-VAR) model to account for the time-varying structure of exchange rate pass-through. Based on this model, we computed time-varying variance decompositions and impulse responses to assess the impact of different monetary policy applications on the responsiveness of consumer prices to the movements in exchange rate under different regimes. The findings of this study provide an empirical support for the time-varying pattern in the ERPT, suggesting that the pass-through has declined substantially after the implementation of inflation targeting policy.

The rest of the paper is structured as follows. The brief overview of the literature on exchange rate pass-through is included in the section that follows. The data and methodology are described in Section 2. The empirical results of the study are presented in Section 3. Finally, the paper ends with concluding remarks.

1. Literature Review

The degree to which exchange rate shocks are passed through into domestic prices, known as the exchange rate pass-through, has important implications on the conduct of monetary policy as well as exchange rate regime (Joseph E. Gagnon and Jane Ihrig 2004; Douglas Steel and Alan King 2004). First, the sensitivity of domestic prices to external shocks as a result of fluctuations in the prices of imported commodities, such as gas and oil, is a crucial factor that central banks should consider for their inflation targeting policies and predictions. Second, ERPT is important for the expenditure-switching effect, which presumes an adjustment of trade imbalances *via* changes in the relative prices as a result of fluctuations in the nominal exchange rates, which in turn lead consumers to substitute domestically produced goods to imported goods. This effect depends on the magnitude of ERPT, which will change the relative prices for final consumers, if it is sufficiently strong. In case of a complete pass-through, currency devaluation will result with no improvements in trade balance but only a higher level of inflation.

In the literature, various studies on the importance of ERPT have been conducted. For example, Guillermo A. Calvo and Carmen Reinhart (2000) and Michele Ca'Zorzi, Elke Hahn, and Marcelo Sanchez (2007) found that the pass-through effect is higher in emerging markets than in developed countries whereas Matthieu Bussiere and Tuomas Peltonen (2008) did not find any evidence for such a significant difference. Jonathan McCarthy (2007) investigated the ERPT for industrialized economies using various recursive linear VAR models, and observed that pass-through effect tends to be larger in countries with a larger import share.

Recent studies on developed countries also indicated the existence of a significant decline in the exchange rate pass-through after the 1990s. John B. Taylor (2000) analyzed the reasons for the structural change in the dynamics of this relationship by employing a microeconometric model based on staggered price setting behavior and found that the low inflationary regime, as a result of the credible macroeconomic policies, can play an important role in the absorption of exchange rate shocks. Therefore, the low and stable inflationary environment itself can lead to a low exchange rate pass-through by anchoring expectations of the economic agents.

The validity of the hypothesis of Taylor (2000) has been empirically tested by numerous studies. These studies generally confirm that the pass-through has been declining in recent years with the adoption of inflation targeting and flexible exchange rate regimes. For instance, using the data for 71 countries, Ehsan U. Choudhri and Dalia S. Hakura (2001) found a positive and significant connection between the pass-through and low inflation. They also observed that inflation rate is superior to the other macroeconomic variables in explaining cross-regime differences in the pass-through. They also emphasized that policymakers may not benefit from a low pass-through environment without establishing the credibility of the low inflation regime. This result is also confirmed by Gagnon and Ihrig (2004) for 20 industrialized countries between 1971 and 2003. They found that the economic agents are less prone to a change in prices as a response to a given exchange rate shock when they expect the monetary authority to act strongly to stabilize the domestic inflation rate. They also realized that the credible monetary policy aiming at stabilizing inflation plays an important role in the achievement of low pass-through rates in economy.

Choudhri, Hamid Faruqee, and Hakura (2005) investigated the performance of open economy's macroeconomic models in explaining the exchange rate pass-through for a wide range of prices that include domestic and international prices. They used impulse response functions derived from VAR models for G-7 countries for the period 1979:01 to 2001:03. The endogenous variables are the interest rate, the exchange rate, the import price index, the export price index, the producer price index, the consumer price index and the wage rate. Two exogenous variables are foreign interest rate and the foreign consumer price index. They found that models based on local currency pricing are able to predict the responses of domestic prices and wages well. A model that gives equal weights to local currency pricing and producer currency pricing yields better results for tracking of international price responses.

Faruqee (2006) focused on euro area prices and the exchange rate with monthly data from 1990 to 2002 using the VAR methodology. This study found that short-run pass-through is low in the euro area similar to the United States. However, pass-through has been rising over time in the euro area although this effect is small in wage and consumer price pass-through which is relatively small. The highest degree of pass-through is found in euro area import prices. A difference in pricing behavior of domestic and foreign firms in the euro area exists, as the pattern of pass-through in trade prices suggests asymmetry. The model in this study suggests that a depreciation in the exchange rate improves trade balance. Dubravko Mihaljek and Marc Klau (2000) analyzed the ERPT for 14 emerging market countries (India, Korea, Malaysia, the Philippines and Thailand from Asia; Brazil, Chile, Mexico and Peru from Latin America; the Czech Republic, Hungary, Poland and Turkey from central and eastern Europe; and South Africa) with quarterly data covering the period from 1994 to 2006. They asserted that since the mid-1990s, the degree of pass-through has declined in the emerging economies including Turkey. Reginaldo P. Nogueira Jr. (2007) analyzed the inflationary impact of exchange rate for developed (Canada, United Kingdom and Sweden) and emerging markets (Brazil, Czech Republic, Mexico, South Africa and South Korea). The analysis, based on the estimation of single equation autoregressive distributed lag (ARDL) model, indicated that the ERPT has decreased substantially after the adoption of inflation targeting for all countries under consideration. However, the estimated long-run ERPT parameters also implied that the pass-through has not disappeared completely and seems to be a significant variable driving inflation over the long-run. Xiaowen Jin (2012) estimated the exchange rate pass-through in China and investigated its relationship with monetary policy covering the period 1996 and April 2010. The results indicate the existence of a very low consumer price pass-through compared to the producer price. It was also found that fixed exchange rate regime leads to higher Consumer Price Index (CPI) pass-through, but does not have any significant impact on Producer Price Index (PPI).

Although the studies above highlight the declining pattern in the relationship in recent years, they are mainly based on linear time series applications where changes in the parameters are captured through the estimations of the model based on different subsamples. However, as the empirical evidence suggests, the magnitude of ERPT changes substantially over time due to the policy changes of central banks and governments, as well as surrounding economic indicators. The attempts to cover nonlinearities to analyze ERPT emerged recently by employing a VAR model with time-varying parameters (Toshikata Sekine 2006; Haroon Mumtaz and Laura Sunder-Plassmann 2013).

Regarding Turkey, we found various studies on the inflationary effects of exchange rates. However, they are also mainly based on the estimation of linear VAR models. Daniel Leigh and Marco Rossi (2002) used a VAR model similar to McCarthy (2007) covering the period 1994-2002 and found that the impact of exchange rate on prices is over after about a year, but mostly passes through in the first four months. They also observed that the pass-through is larger and completed in a shorter time in contrast to other emerging markets. The estimated pass-through coefficients obtained from accumulated responses are found to be less than one, that is, incomplete, 60 and 45 percent of the depreciation shocks are passed through to wholesale and consumer prices, respectively. Hakan Kara and Fethi Öğünç (2008)analyzed the difference between pass-through for before and after the adoption of inflation targeting in Turkey using a linear VAR model covering the period 1995-2004. The pass-through coefficients obtained from subsample VAR estimates indicate that the pass-through to domestic prices has been weakened and slowed down substantially after the implementation of inflation targeting strategy. The accumulated response of private manufacturing inflation to a shock to import price inflation shows that 74 percent of changes in imported prices passed through manufacturing inflation within six months in the pre-targeting subsample. In the post-targeting subsample, it declined to 50 percent and completed in fifteen months after the shock. For the core CPI, the figure declined to 30 percent in the post-targeting period from 45 percent of the pre-targeting period.

The nonlinear applications of ERPT for Turkey have remained limited compared to the linear applications. Elif Arbatlı (2003) employed a threshold VAR model covering the period 1994:01 and 2004:05 and found that the ERPT is asymmetric, that is, lower during the significant economic contraction, higher exchange rate depreciation and lower inflation periods. Kara et al. (2007) estimated a single equation time-varying parameter model where inflation is only explained by the change in the nominal exchange rate. They reported a significant decline in the ERPT after the adoption of floating exchange rate system.

In this study, we extended the previous literature on the analysis of ERPT for Turkey. The time-varying parameter VAR model based on Giorgio E. Primiceri (2005) was applied in the modeling of time-varying structure of ERPT. Impulse responses and the pass-through coefficients computed from this model were used to evaluate the validity of the hypothesis of Taylor (2000) suggesting that low inflationary environment leads to a low exchange rate pass-through.

2. Data and Methodology

We used monthly data covering the period 1985:01-2015:04 obtained from the International Monetary Fund (2016) International Financial Statistics (IFS) Database[1]and the Turkish Statistical Institute (2016)[2]. The start date of the estimation period was determined by the availability of industrial production series obtained from the IFS Database. All variables were seasonally adjusted by using the Census X12 method. The definitions of the variables are in line with the work of McCarthy (2007). The vector of endogenous variables, Y_t, is given by:

$$y'_t = [s_t d_t er_t m_t wpi_t cpi_t], \tag{1}$$

where s_t is the log of imported oil prices. As a measure of economic activity, we used output gap (d_t) calculated as the gap between the actual and potential industrial production. In the calculation of the potential output, we used the Hodrick-Prescott filter by setting the smoothness parameter to 14400. er_t is the log of the nominal TL/US dollar exchange rate. To consider the impact of first-stage pass-through, the log of import price index, m_t, is also included. Finally, wpi_t and cpi_t represent the wholesale and consumer price indices, respectively, with 1987 as the base year.

Before the estimation of the TVP-VAR, the unit root properties of the variables were investigated with ADF and Phillips-Perron tests. The results suggest that all variables, except for the output gap are found to be nonstationary (see Table 2 in the Appendix B). The unit root test of George Kapetanios (2005) was also conducted to account for the impact of possible structural breaks on the integration level of the variables. In contrast to Robin Lumsdaine and David Papell (1997) and Junsoo Lee and Mark C. Strazicich (2003), this test allows checking for the stationarity of the time series up to m unknown structural breaks. The results of the tests reported in Table 1 are in line with the previously reported unit root without break tests suggesting that all variables excluding d_t can be treated as I(1) because the null hypothesis of a unit root with breaks is rejected for all variables. Hence, the variables, except for the output gap, were entered to the model in the log's first difference form. The timing of the breaks for the exchange rate and prices calculated through the break fractions seemed to be associated with the 1994 and 2001 financial crises. This implied that linear and constant parameter specifications may not be a suitable tool for the analysis of the ERPT in Turkey.

[1] **International Monetary Fund.** 2016. International Financial Statistics Database. http://data.imf.org/ (accessed January 04, 2016).

[2] **Turkish Statistical Institute.** 2016. Turkish Statistical Institute Databases. http://www.turkstat.gov.tr/ (accessed January 06, 2016).

Table 1 Kapetanios' Unit Root Test with Structural Breaks

Series		Breaking dates	Test statistic $t_{\hat{a}}$	Result
s_t	Levels	1990:07, 2002:07	-5.037	I(1)
	First differences	2004:03, 2009:01, 2010:08, 2013:08	-13.789***	
d_t	Levels	1994:02, 2008:09	-7.240***	I(0)
	First differences	-	-	
e_t	Levels	2001:10	-4.050	I(1)
	First differences	2001:09, 2008:07, 2013:03	-12.974***	
m_t	Levels	2003:11	-4.408	I(1)
	First differences	2008:06	-9.908***	
w_t	Levels	1994:04	-4.517	I(1)
	First differences	2001:11	-12.034***	
c_t	Levels	1994:03	-4.762	I(1)
	First differences	2001:12	-12.905***	

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. The model allows breaks in the intercept and the slope. Critical values were obtained from Kapetanios (2005).

Source: Authors' estimations.

After checking for the integration of the variables, we estimated the VAR model with time-varying parameter and stochastic volatility by using Bayesian estimation methodology based on Primiceri (2005). The model has a state-space form and the measurement equation is written as:

$$y_t = c_t + B_{1,t}y_{t-1} + \ldots + B_{p,t}y_{t-p} + u_t = \mathrm{X}_t\Theta_t + \varepsilon_t, \quad (2)$$

where c_t represents the time-varying intercept coefficients. $B_{1,t \ldots p,t}$ are the vectors of time-varying coefficients written as a matrix Θ_t. X_t is the matrix of time-varying parameters including a constant and the lags of endogenous variables. The disturbance term u_t is assumed to be heteroskedastic and normally distributed with a zero mean and a time-varying covariance matrix, Ω_t. The time-varying variance covariance matrix of disturbances illustrating the dynamic interactions among the variables is decomposed as:

$$\Omega_t = A_t^{-1}H_t(\mathrm{A}_t^{-1})', \quad (3)$$

$$A_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 & 0 & 0 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 & 0 & 0 & 0 \\ \alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 & 0 & 0 \\ \alpha_{51,t} & \alpha_{52,t} & \alpha_{53,t} & \alpha_{54,t} & 1 & 0 \\ \alpha_{61,t} & \alpha_{62,t} & \alpha_{63,t} & \alpha_{64,t} & \alpha_{65,t} & 1 \end{bmatrix},$$

$$H_t = \begin{bmatrix} h_{1,t} & 0 & 0 & 0 & 0 & 0 \\ 0 & h_{2,t} & 0 & 0 & 0 & 0 \\ 0 & 0 & h_{3,t} & 0 & 0 & 0 \\ 0 & 0 & 0 & h_{4,t} & 0 & 0 \\ 0 & 0 & 0 & 0 & h_{5,t} & 0 \\ 0 & 0 & 0 & 0 & 0 & h_{6,t} \end{bmatrix}, \tag{4}$$

where A_t is the lower triangular matrix illustrating the contemporaneous relationships among the variables and H_t is a matrix including the stochastic volatilities on the diagonal elements.

In this setting, the parameters of the TVP-VAR model are evolved in accordance with the following equations:

$$\begin{aligned} \Theta_t &= \Theta_{t-1} + v_t \\ \alpha_t &= \alpha_{t-1} + \zeta_t \\ \ln h_{i,t} &= \ln h_{i,t-1} + \eta_t \end{aligned} \qquad \begin{bmatrix} \varepsilon_t \\ v_t \\ \zeta_t \\ \eta_t \end{bmatrix} \sim N \left[0, \begin{bmatrix} \Omega_t & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & Z \end{bmatrix} \right]. \tag{5}$$

Equation (5) implies that the disturbances of the parameter equations follow the normal distribution. The first two equations indicate that the time-varying parameters, Θ_t and α_t, are assumed to follow random walk without a drift process. Because the random walk model is non-stationary, the stability constraint is imposed on the evolution of the time-varying parameters following Timothy Cogley and Thomas J. Sargent (2005). The vector of stochastic volatilities, h_t, is assumed to follow geometric random walk as with the financial literature. In this state-space model, the disturbances of the measurement equation and three transition equations are assumed to be independent of each other. As noted by Primiceri (2005), this assumption simplifies the inference and increases the efficiency of the estimation algorithm.

3. Empirical Results

The model described above is estimated with a Markov Chain Monte Carlo (MCMC) algorithm based on Metropolis-within-Gibbs posterior sampler. To this aim, a modified version of the RATS code of Todd E. Clark and Stephen E. Terry (2010) has been used in the estimation. The estimation of the TVP-VAR consists of the following steps (Clark and Terry 2010; Sohrab Rafiq 2010; Mumtaz and Sunder-Plassmann 2013):

1. The linear VAR model covering the period from 1985:02 to 1991:12 is estimated to determine the starting values of the time-varying parameters. Hence, the

first impulse responses computed from the TVP-VAR model are available from 1992:01.

2. Then the VAR coefficient, Θ_i, and the off-diagonal elements of the covariance matrix, A_t, are simulated by using the backward smoother method by Christopher K. Carter and Robert Kohn (2004).

3. The stochastic volatilities H_t are drawn using the date-by-date blocking scheme of Eric Jacquier, Nicholas G. Polson, and Peter E. Rossi (1994).

4. The priors for the Q and S are obtained from an inverse Wishart distribution, the priors for G are derived from an inverse Gamma distribution. A detailed explanation about the determination of the priors is presented in Appendix A.

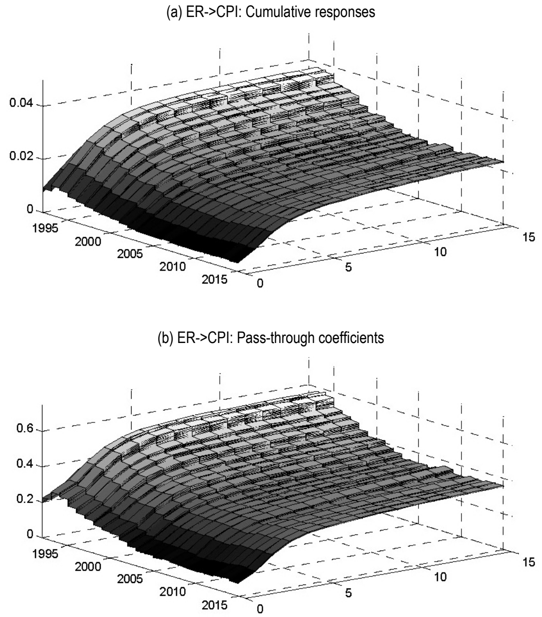
To reduce the frequency of the explosive draws of the VAR parameters, this paper employed an informative prior on the training parameters as suggested by Marco del Negro (2003) and Clark and Troy Davig (2009). The posterior sampler excludes the explosive draws of time-varying parameter, Θ_t, the model backcasts to achieve parameter stability in case of explosive draws. In the estimation of the posterior distribution 50,000 burn-in sample performed, followed by 50,000 draws, by keeping every 10th draw following Cogley and Sargent (2005) and Primiceri (2005).

Having estimated the TVP-VAR model, we conducted an impulse response analysis based on Equation (3). We first computed the time-varying responses with their standard error bands at five dates (1992:01, 1994:04, 2001:04, 2008:10 and 2015:04) to illustrate the significance of the responses over the investigation period. The results of the time-varying impulse responses with the standard error bands are presented in Appendix B. The impact of exchange rate shocks on the import prices, that is, the first stage pass-through, is found to be insignificant and low in terms of magnitude; and the cumulative impact obtained of the shocks on the import prices is slightly above 1 percent over the investigation period (see Figure 4). The pass-through from the exchange rate to the wholesale and consumer prices is found to be both positive and significant, but has a declining trend over time. The impact of exchange rate innovations on the consumer prices is found to be lower than that of wholesale prices as expected (see Figure 5). The results also suggest that the response of cpi_t to wpi_t is high, significant and follows a stable pattern over time (see Figure 6).

After checking for the significance of the responses, we plotted the accumulated time-varying responses at different time horizons $t = 0, 1, 2, \dots, 15$ in a three-dimensional space to evaluate the impact of exchange rates on prices. Based on the accumulated time-varying responses, we also computed the pass-through coefficients to measure the extent of ERPT over time. Following Leigh and Rossi (2002) and Kara et al. (2007), the pass-through coefficients are calculated with the following formula:

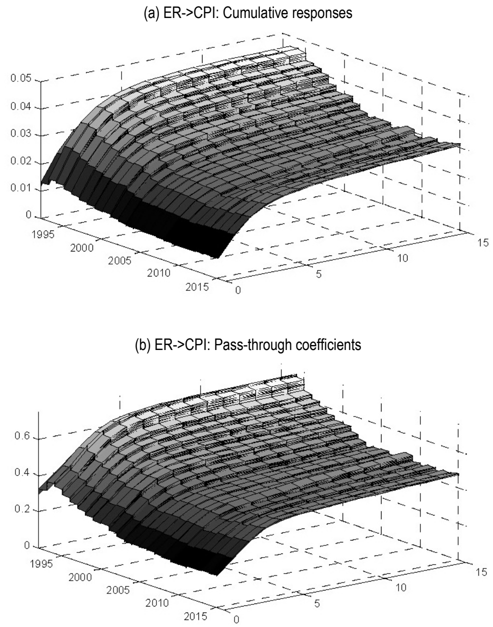
$$PT_{t,t+j} = \frac{P_{t,t+j}}{E_{t,t+j}}. \tag{6}$$

Time-varying accumulated responses for the wholesale and consumer prices and their corresponding pass-through coefficients are presented in Figures 1 and 2. Note that the pass-through coefficients for both prices are varying over time but the



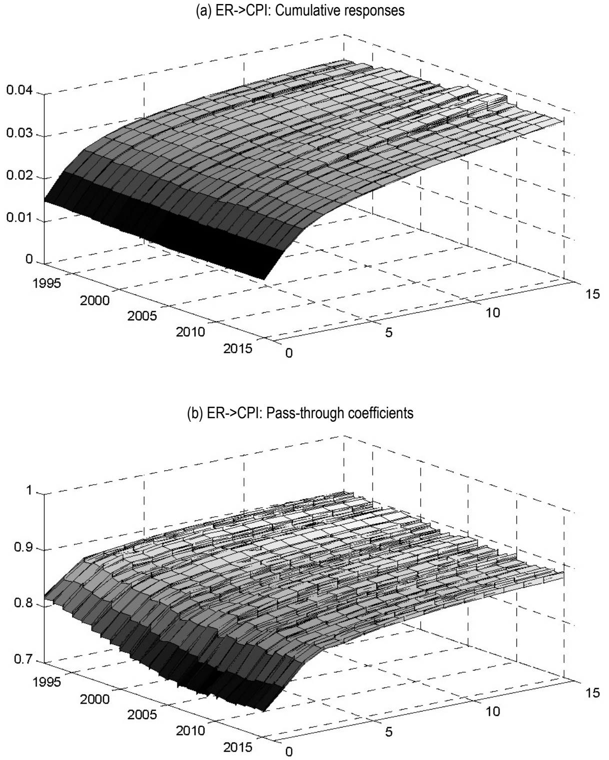
Source: Authors' estimations.

Figure 1 Time-Varying Responses of CPI to the Exchange Rate Shocks



Source: Authors' estimations.

Figure 2 Time-Varying Responses of WPI to the Exchange Rate Shocks



Source: Authors' estimations.

Figure 3 Time-Varying Responses of WPI to CPI

value obtained was less than one for the whole investigation period. Therefore, one unit change in exchange rate leads to a less than one unit change in both wholesale and consumer prices. This finding is consistent with the results of Leigh and Rossi (2002) and Kara and Öğünç (2008) based on the linear VAR estimates. In the beginning of the investigation period, ERPT coefficients for the wholesale and consumer prices are computed as 58.24 and 45.13, respectively. The highest impact of exchange rate shocks has been reported on April 1994 coinciding with the 1994 financial crisis (72.23 percent for wpi_t and 58.67 for cpi_t). During that time, Turkey's currency crashed as a result of the financing of the huge budget deficits through monetization and unsustainability of trade deficits. In the first quarter of 1994, the Turkish Lira (TL) has been devalued more than 50 percent against the US dollar; the Central Bank lost half of its reserves; interest rates and the inflation rates have reached three-digit figures (Oya Celasun 1998). After the crisis, the pass-through coefficients for wpi_t and cpi_t followed a relatively stable pattern and did not fall below 50 percent and 40 percent up to the 2001 crisis. The lowest impact of exchange rate has been observed by the end of 2007 as 45.59 and 33.65 percent for wpi_t and cpi_t, respectively. The pass-through coefficients increased slightly (48.85

percent for wholesale and 36.58 percent for consumer prices) after that time due to the possible impact of the 2008 global financial crisis. This also led to a slight increase in consumer price inflation from 8.75 percent in 2007 to 10.44 percent in 2008. At the end of the analysis period, the ERPT coefficients for wpi_t and cpi_t have been realized as 47.02 and 36.02 percent. The responses in Figure 3 also indicate that the impact of wholesale prices on the consumer prices is very high. Unlike the responses to exchange rate shocks, the cumulative response of cpi_t to wpi_t follows a stable pattern and the pass-through coefficients obtained are very close to 90 percent as far as the whole investigation period is considered.

4. Conclusions

In this paper, we analyzed the pass-through from exchange rate to domestic inflation for Turkey covering the period 1985:01-2015:04. In contrast to previous studies on Turkey, we employed the TVP-VAR model as a nonlinear estimation framework to account for the time-varying relationship between exchange rate and domestic prices over time. Based on this model, we conducted a time-varying impulse response analysis and calculated the time-varying pass-through coefficients.

Our analyses reveal that the exchange rate pass-through is not constant and follows a time-varying pattern over the investigation period. Findings of the decline in the time-varying exchange rate pass-through coefficients support the proposition of Taylor (2000) that the low inflationary environment leads to the low exchange rate pass-through. The decline in the pass-through has become more apparent with the adoption of the stabilization program after the crisis in 2001. Our results present a more concrete measurement of the exchange rate pass-through because the TVP-VAR model accounts for time variation in the parameters by allowing us to capture the gradual declining trend in the exchange rate pass-through. Our pass-through coefficients are not directly comparable with the previous studies because they are time-varying; however, the evidence on the decline in the ERPT coefficients is consistent with Kara and Öğünç (2008) estimating the similar recursive linear VAR model of McCarthy (2007).

Our findings on the decline of ERPT can be explained by the following reasons leading to low inflationary environment in Turkey. First, the switching of a flexible exchange rate system, legislation of the new central bank law and the prohibition of the use of short-term advances to finance government budget deficits contribute positively to the independence and credibility of the Central Bank of the Republic of Turkey. Second, inflation targeting strategy, adopted after the 2001 financial crisis,has proven to be successful in breaking down the strong correlation between exchange rate and inflation by anchoring the expectations of the economic agents about the future price level (Kara and Öğünç 2008).

Our results also highlight the need for a further analysis to explain the underlying reasons behind the observed decline in exchange rate pass-through. To this aim, the TVP-VAR model employed in this study can be extended by the introduction of the subcomponents of the wholesale and consumer prices to examine the impact of exchange rate shocks at the disaggregated level.

References

Arbatlı, Elif. 2003. "Exchange Rate Pass-Through in Turkey: Looking for Asymmetries." *Central Bank Review*, 3(2): 85-124.

Bussiere, Matthieu, and Tuomas Peltonen. 2008. "Exchange Rate Pass-Through in the Global Economy: The Role of Emerging Market Economies." European Central Bank Working Paper 951.

Calvo, Guillermo A., and Carmen Reinhart. 2000. "Fixing for Your Life." National Bureau of Economic Research Working Paper 8006.

Carter, Christopher K., and Robert Kohn. 2004. "On Gibbs Sampling for State Space Models." *Biometrika*, 81(3): 541-553.

Ca'Zorzi, Michele, Elke Hahn, and Marcelo Sanchez. 2007. "Exchange Rate Pass-Through in Emerging Markets." European Central Bank Working Paper 739.

Celasun, Oya. 1998. "The 1994 Currency Crisis in Turkey." World Bank Development Research Group, Policy Research Working Paper 1913.

Choudhri, Ehsan U., and Dalia S. Hakura. 2001. "Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter?" International Monetary Fund Working Paper 194.

Choudhri, Ehsan U., Hamid Faruqee, and Dalia S. Hakura. 2005. "Explaining the Exchange Rate Pass-Through in Different Prices." *Journal of International Economics*, 65(2): 349-374.

Clark, Todd E., and Troy Davig. 2009. "An Empirical Assessment of the Relationships among Inflation and Short- and Long-Term Expectations." Federal Reserve Bank of Kansas City Working Paper 08-095.

Clark, Todd E., and Stephen E. Terry. 2010. "Time Variation in the Inflation Pass-Through of Energy Prices." *Journal of Money, Credit and Banking*, 42(7): 1419-1433.

Cogley, Timothy, and Thomas J. Sargent. 2005. "Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII US." *Review of Economic Dynamics*, 8(2): 262-302.

Del Negro, Marco. 2003. "Discussion of Cogley and Sargent's Drifts and Volatilities: Monetary Policy and Outcomes in the Post WWII US." Federal Reserve Bank of Atlanta Working Paper 2003-26.

Faruqee, Hamid. 2006. "Exchange Rate Pass-Through in the Euro Area." *IMF Staff Papers*, 53(1): 63-88.

Gagnon, Joseph E., and Jane Ihrig. 2004. "Monetary Policy and Exchange Rate Pass-Through." *International Journal of Finance and Economics*, 9(4): 315-338.

Jacquier, Eric, Nicholas G. Polson, and Peter E. Rossi. 1994. "Bayesian Analysis of Stochastic Volatility Models." *Journal of Business and Economic Statistics*, 12(4): 371-417.

Jin, Xiaowen. 2012. "An Empirical Study of Exchange Rate Pass-Through in China." *Panoeconomicus*, 59(Special Issue): 135-156.

Kapetanios, George. 2005. "Unit-Root Testing against the Alternative Hypothesis of up to m Structural Breaks." *Journal of Time Series Analysis*, 26(1): 123-133.

Kara, Hakan, Hande Kucuk-Tuger, Ümit Özlale, Burç Tuğer, and Eray Yücel. 2007. "Exchange Rate Regimes and Pass-Through: Evidence from the Turkish Economy." *Contemporary Economic Policy*, 25(2): 206-225.

Kara, Hakan, and Fethi Öğünç. 2008. "Inflation Targeting and Exchange Rate Pass-Through: The Turkish Experience." *Emerging Markets Finance and Trade*, 44(6): 52-56.

Lee, Junsoo, and Mark C. Strazicich. 2003. "Minimum Lagrange Multiplier Unit Root Test with Two Structural Breaks." *Review of Economics and Statistics*, 85(4): 1082-1089.

Leigh, Daniel, and Marco Rossi. 2002. "Exchange Rate Pass-Through in Turkey." International Monetary Fund Working Paper 204.

Lumsdaine, Robin, and David Papell. 1997. "Multiple Trend Breaks and the Unit Root Hypothesis." *Review of Economics and Statistics*, 79(2): 212-218.

McCarthy, Jonathan. 2007. "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies." *Eastern Economic Journal*, 33(4): 511-537.

Mihaljek, Dubravko, and Marc Klau. 2000. "Exchange Rate Pass-Through in Emerging Market Economies: What Has Changed and Why?" Bank for International Settlements Working Paper 35.

Mumtaz, Haroon, and Laura Sunder-Plassmann. 2013. "Time-Varying Dynamics of the Real Exchange Rate: An Empirical Analysis." *Journal of Applied Economics*, 28(3): 498-525.

Nogueira Jr., Reginaldo P. 2007. "Inflation Targeting and Exchange Rate Pass-Through." *Economia Aplicada*, 11(2): 189-208.

Önder, A. Özlem. 2009. "The Stability of the Turkish Phillips Curve and Alternative Regime Shifting Models." *Applied Economics*, 41(20): 2597-2604.

Primiceri, Giorgio E. 2005. "Time-Varying Structural Vector Autoregressions and Monetary Policy." *Review of Economic Studies*, 72(3): 821-852.

Rafiq, Sohrab. 2010. "Fiscal Stance, the Current Account and the Real Exchange Rate: Some Empirical Estimates from a Time-Varying Framework." *Structural Change and Economic Dynamics*, 21(2): 276-290.

Sekine, Toshikata. 2006. "Time-Varying Exchange Rate Pass-Through: Experiences of Some Industrial Countries." Bank for International Settlements Working Paper 202.

Steel, Douglas, and Alan King. 2004. "Exchange Rate Pass-Through: The Role of Regime." *International Review of Applied Economics*, 18(3): 301-322.

Taylor, John B. 2000. "Low Inflation, Pass-Through, and the Pricing Power of Firms." *European Economic Review*, 44(7): 1389-1408.

Appendix A

Determination of Prior Distributions and Initial Values

The priors used for the Bayesian estimation are specified as follows (Primiceri 2005; Mumtaz and Sunder-Plassmann 2013):

1. The prior for the diagonal elements of the variance covariance matrix is assumed to be normally distributed $\ln h_0 \sim N(\ln \delta_0, I_6)$ where δ_0 is the diagonal element of the variance covariance matrix, Σ, obtained from the estimation of the linear VAR model for the training period.

2. The prior for elements of the A_t matrix is also assumed to be normally distributed with $A_0 \sim N(\hat{a}^{OLS}, V(\hat{a}^{OLS}))$ where $\hat{a}^{OLS}$ is the off-diagonal element of Σ with each row scaled by the corresponding element on the diagonal. $V(\hat{a}^{OLS})$ is assumed to be diagonal with the elements set equal to 10 times the absolute value of the corresponding element of $\hat{a}^{OLS}$.

3. The prior on the time-varying parameter Q is assumed to inversely follow the Wishart distribution $Q_0 \backsim IW(\overline{Q}_0, T_0)$ where $\overline{Q}_0$ is assumed to be $\mathrm{Var}(\widehat{\Theta}_{OLS}) \times 10^{-4} \times 3.5$ and T_0 is the length of the training sample.

4. The prior distribution for S inversely follows the Wishart distribution $S_{i,0} \backsim IW(\overline{S}_i, K_i)$ where i = 1. . . 6 represents the blocks of S. The starting values of the diagonal matrix $\overline{S}_i$ are computed by multiplying the relevant elements of $\hat{a}^{OLS}$ with 10^{-3}.

5. Finally, the prior for the elements of the matrix of stochastic volatility, Z, is assumed to follow the inverse-gamma distribution $Z \sim IG\left(\frac{10^{-4}}{2}, \frac{1}{2}\right)$ as in Cogley and Sargent (2005).

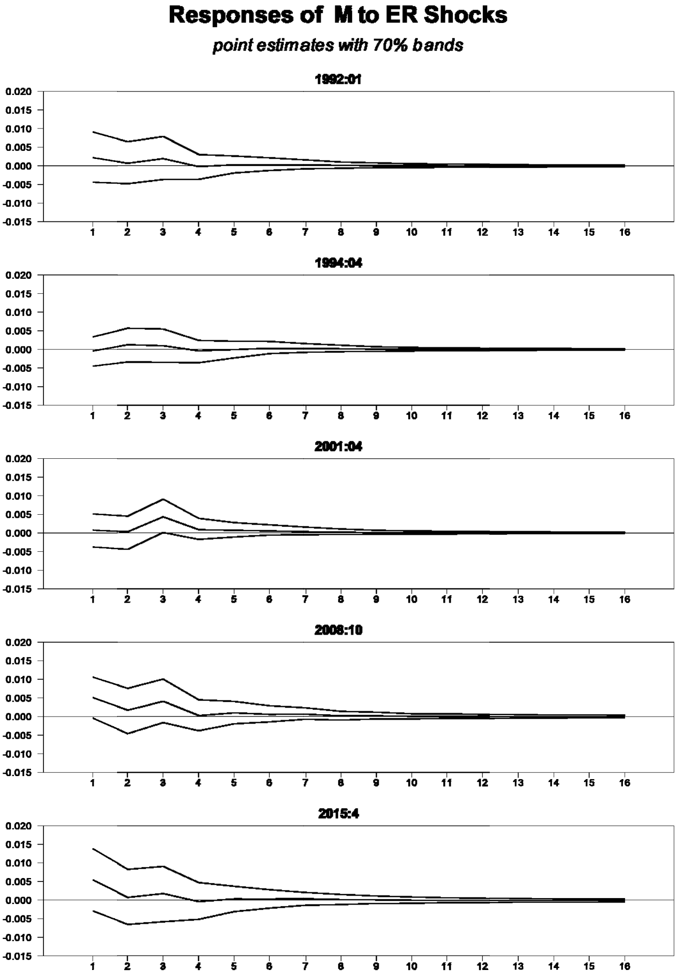
Appendix B

Table 2 Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests

		Levels		First differences	
		***t*-statistics**	***p*-value**	***t*-statistics**	***p*-value**
s_t	ADF	-3.581	0.033	-13.648	0.000
	PP	-3.178	0.091	-13.122	0.000
d_t	ADF	-6.995	0.000	-	-
	PP	-15.228	0.000	-	-
e_t	ADF	0.090	0.997	-12.002	0.000
	PP	0.191	0.998	-12.113	0.000
m_t	ADF	-2.4034	0.3771	-24.054	0.000
	PP	-3.4359	0.0483	-24.054	0.000
w_t	ADF	0.02979	0.9965	-3.5132	0.0395
	PP	0.46529	0.998	-10.135	0.000
c_t	ADF	-0.5091	0.9828	-10.157	0.000
	PP	-0.1414	0.9936	-7.2879	0.000

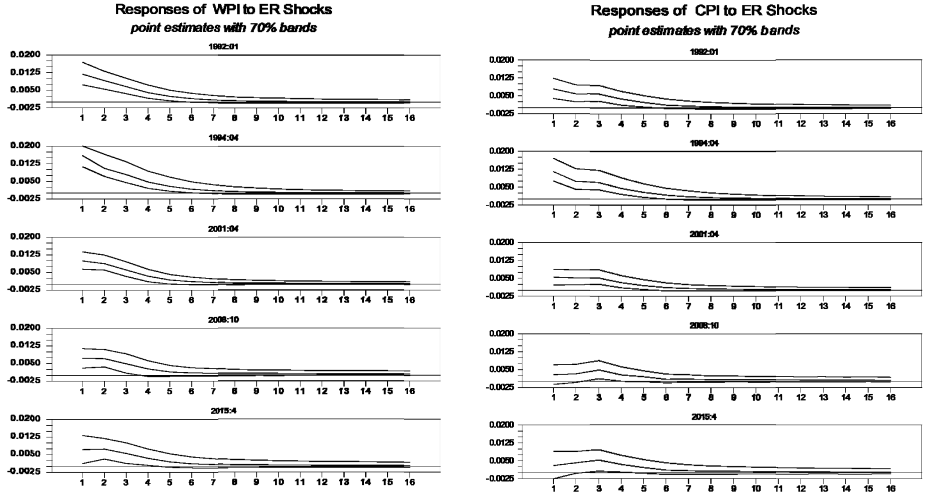
Notes: Trend and intercept specification is employed in the estimation of the ADF (augmented Dickey–Fuller) and PP (Phillips–Perron) tests. The lag length for the ADF test is chosen based on the AIC criterion. Bandwidths in the PP unit root test are determined by the Newey-West statistic using the Barlett-Kernel.

Source: Authors' estimations.



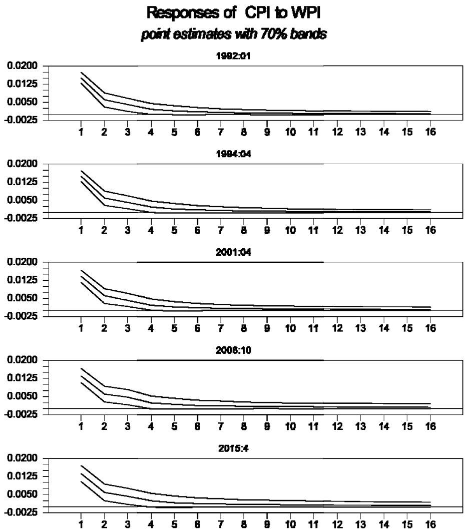
Source: Authors' estimations.

Figure 4 Responses of Import Prices to the Exchange Rate Shock



Source: Authors' estimations.

Figure 5 Responses of WPI and CPI to the Exchange Rate Shocks



Source: Authors' estimations.

Figure 6 Responses of CPI to WPI

THIS PAGE INTENTIONALLY LEFT BLANK