NATIONAL BANK OF UKRAINE

Working Paper Series

No. 01/2016

Nonlinear Exchange Rate Pass-Through to Domestic Prices in Ukraine

Oleksandr Faryna

National Bank of Ukraine Working Paper Series:

The Working Paper Series of the National Bank of Ukraine (NBU) presents the independent research of the staff of the NBU or outside contributors on topics relevant to central banks. The purpose of the Working Papers is to provide the platform for discussion and critical comments. The Working Papers are reviewed internationally to ensure the high quality of the content. The opinions and conclusions in the papers are strictly those of author(s) and do not necessarily reflect the views of the National Bank of Ukraine or of the Board members.

This publication is available on the NBU website at **http://www.bank.gov.ua**.

Address:

9 Instytutska Street,
01601, Kyiv, Ukraine
email: **research@bank.gov.ua**

NONLINEAR EXCHANGE RATE PASS-THROUGH TO DOMESTIC PRICES IN UKRAINE

Oleksandr Faryna*

December 2016

Abstract

This paper aims to estimate the degree of exchange rate pass-through (ERPT) to domestic prices in Ukraine considering nonlinearities with respect to the size and direction of exchange rate movements, inflation environment, and business cycles. We use disaggregated consumer price data and employ a panel autoregressive distributed lag model including threshold parameters to account for nonlinearities in the ERPT mechanism. Estimation results suggest that the pass-through effect is higher from currency depreciation than in the case of appreciation for most price groups. We also find that price responsiveness to small, medium, and large exchange rate changes is nonlinear. In particular, we provide evidence that prices are sensitive to small changes, but the pass-through effect is insignificant if exchange rate movements are moderate. Furthermore, the degree of ERPT is higher in periods of extremely large depreciations, high inflationary environment, and economic slumps.

JEL Codes: E31, E52, E58, F31.

Keywords: exchange rate pass-through, inflation, Ukraine, nonlinear ERPT, Autoregressive Distributed Lag model

---

* leading expert of the Research Division, Department of Monetary Policy and Economic Analysis, National Bank of Ukraine; senior lecturer at the National University of “Kyiv-Mohyla Academy”; email: **oleksandr.faryna@bank.gov.ua**

NON-TECHNICAL SUMMARY

Understanding the mechanism of exchange rate shocks transmission into domestic inflation is of particular importance for the monetary authority in order to react efficiently to such shocks and maintain price stability. Recent developments in the literature provide strong evidence that the pass-through effect of exchange rate changes is nonlinear. In particular, domestic prices may respond asymmetrically to appreciations and depreciations of different magnitude. In addition, the degree of exchange rate pass-through (ERPT) may have other macroeconomic determinants, such as inflation environment and economic activity.

In 2014, the National Bank of Ukraine (NBU) adopted a flexible exchange rate regime required for the implementation of its inflation targeting (IT) policy. Nevertheless, the adoption of IT and transition to a flexible exchange rate in a small open economy may be problematic if the risks associated with exchange rate volatility remain high. Hence, the ability of the NBU to attain its inflation targets requires a thorough understanding of the extent to which consumer prices respond to exchange rate movements. Existing empirical studies on Ukraine avoid, or include partially, analysis of ERPT asymmetry and nonlinearity. Therefore, in our paper we attempt to fill the gap in the literature and provide thorough evidence on the nonlinear pass-through effect to consumer prices in Ukraine with respect to different macroeconomic determinants. In particular, we focus on several sources of potential nonlinearities such as size and direction of exchange rate variations, inflation environment, and business cycles.

We follow a very recognizable *"pricing to market"* framework that examines the ERPT mechanism from the perspective of a foreign exporting firm and its price-setting behavior in the climate of monopolistic competition. In this type of framework, a foreign producer has a market power on the importing country's market and sets prices to maximize profits by adjusting its mark-up which, in turn, depends on demand conditions. We use monthly data from January 2007 to April 2016 and incorporate theoretical arguments in the empirical model in order to estimate the pass-through coefficients to consumer prices in Ukraine. We use 258 consumer price indices, nominal effective exchange rate (NEER), fuel price index, and industrial production gap. Furthermore, we include nonlinear parameters in order to reflect periods of depreciations and appreciations, small and large exchange rate changes, low and high inflation rates, recessions and expansions. The choice of threshold values is based on statistical properties of the data.

Our results suggest that consumer prices in Ukraine are more sensitive to depreciations than to appreciations. Following the *"pricing to market"* theory, appreciation of domestic currency has a positive effect on a foreign exporter's mark-up and, thus, the absorption of exchange rate fluctuations is more desirable. Furthermore, in a climate of imperfect competition, a foreign producer has a high market share in the destination market and, thus, has no incentive to absorb exchange rate depreciation. In this case, ERPT is higher in the case of depreciation, which is in line with our estimates for Ukraine.

We also find that the effect from small and large exchange rate movements is nonlinear. In particular, the pass-through effect is higher in periods of small exchange rate changes. Moderate (i.e., relatively larger) exchange rate changes, in turn, have an insignificant effect on consumer prices. Given that foreign firms most often follow a producer currency pricing strategy while exporting goods to Ukraine, our results indicate the presence of menu costs for foreign producers. More specifically, changing the invoice price might be costly for a foreign firm and, hence, prices expressed in an importer's currency respond to small exchange rate changes. However, our results indicate that extremely large exchange rate depreciations have a considerable effect on the price development. Episodes of dramatic depreciation in Ukraine were experienced in 2008, 2014, and 2015 during substantial economic slumps, unfavorable inflationary environments, and confidence crises which can explain a higher degree of the pass-through effect. These arguments are in line with our estimates of the pass-through effect considering nonlinearities with respect to the inflation environment and economic activity.

To sum up, the pass-through effect in Ukraine rises in periods of small and extremely large depreciations, which aggravates the vulnerability of the economy to external shocks. On the contrary, in periods of appreciations and moderate depreciations in the climate of a stable macroeconomic environment, consumer price responsiveness is lower. This, in turn, gives the floor for the NBU to conduct credible monetary policy and maintain price stability.

1. Introduction

ERPT is traditionally defined as the percentage change in the price of an imported good in local currency resulting from a one percent change in the nominal exchange rate.[2] The puzzle of incomplete ERPT to import prices has become a trending research topic in theoretical and empirical literature since the breakdown of the Bretton Woods system. Furthermore, its importance from a monetary policy perspective extended the focus of such interest to capture the effect of exchange rate movements to all domestic price indices. Understanding the mechanism of exchange rate shocks transmission into domestic inflation might be a useful instrument for inflation forecasting, thus allowing the monetary authority to react efficiently to such shocks and maintain price stability.

Given the particular importance of the ERPT mechanism for emerging small open economies, the literature on ERPT in Ukraine is scarce. To our knowledge, few studies provide empirical estimates of ERPT for Ukraine (see Table 1). Korhonen & Wachtel (2005) study ERPT to consumer prices in CIS countries. Authors use the VAR approach and impulse response analysis and estimate ERPT to consumer prices in Ukraine at a level of 0.63-0.64. Compared to other CIS countries, results for Ukraine are relatively high. Following a similar approach, Beckmann & Fidrmuc (2013) provide ERPT estimates for seven CIS countries and confirm results for a high pass-through in Ukraine. They extend their analysis to measure US dollar and Euro ERPT separately and find that Ukrainian prices are much more sensitive to US dollar exchange rate changes (0.45) than to Euro (0.25). Novikova & Volkov (2012) employ a VEC framework and find that long-run ERPT to core inflation in Ukraine amounts to a level of 0.35-0.47.

Empirical literature indicates a relatively high degree of ERPT in Ukraine. However, all of these studies avoid, or include partially, analysis of ERPT asymmetry and nonlinearity. Therefore, in our paper we attempt to fill the gap in the literature and provide thorough evidence on the nonlinear ERPT to consumer prices in Ukraine with respect to macroeconomic conditions. In particular, we focus on several sources of potential nonlinearities such as size and direction of exchange rate variations, the inflation environment, and business cycles. Following a highly recognizable micro-founded mark-up approach, we first employ a linear Autoregressive Distributed Lag (ARDL) model and then extend the linear set-up by inclusion of nonlinear dummy parameters in order to capture asymmetries between appreciation and depreciation, as

[2] Goldberg & Knetter (1997) provide the definition

well as nonlinearities between small and large exchange rate changes, low and high inflation environments, and low and high economic activity.

The rest of the paper proceeds as follows: a brief overview of the literature on ERPT and analytical framework of our analysis are presented in **Section 2** and **Section 3**, respectively; **Section 4** provides an estimation approach and data description; estimation results can be found in **Section 5**; the robustness of our results is examined in **Section 6**; and then followed by conclusions in **Section 7**.

2. Brief Literature Overview

Traditional macroeconomic open-economy models assume that markets are characterized by perfect competition where purchasing power parity holds, implying that market participants taking advantage of their arbitrage opportunities equalize prices of tradable goods, expressed in the same currency, across countries. Hence, exchange rate changes should be completely reflected in prices. However, a large stand of empirical literature finds that ERPT to domestic prices is far from complete even in the long run.[3]

Most of these studies analyze price responsiveness from the industrial-organization perspective in the climate of imperfect competition. Starting from Dornbusch (1987) and Krugman (1987), the relationship between prices and exchange rates has been represented within a *"pricing to market"* theory which implies that foreign exporting firms tend to adjust their mark-ups in response to exchange rate fluctuations. More recently, a class of New Open Economy Models (NOEM) has incorporated microeconomic evidence of incomplete ERPT into the macroeconomic framework. Betts & Devereux (1996) introduced the general equilibrium model with nominal rigidities and market imperfections allowing for pricing to market and, thus, incomplete pass-through. In their theoretical set-up the degree of ERPT to domestic prices depends on the pricing strategy of firms which are able to choose between producer currency pricing (PCP) and local currency pricing (LCP) strategies.

Furthermore, recent developments in the literature show that a common assumption of symmetric and linear relationships between prices and exchange rates is too restrictive and unrealistic. There is growing evidence that a foreign firm's decisions whether to absorb or pass through exchange rate variations have macroeconomic determinants. In particular, domestic prices may respond asymmetrically to national

[3] Menon (1995) provides an overview of 43 empirical studies.

currency depreciation and appreciation episodes of different size and frequency. In addition, price responsiveness to exchange rate fluctuations may depend on the inflation environment and economic activity of the importing country. Omitting those nonlinearities may result in biased estimates and misinterpretation of the pass-through mechanism.

2.1 Nonlinear pass-through with respect to exchange rate variations

The literature on ERPT nonlinearity suggests that the degree of a pass-through effect depends on the direction and size of exchange rate variations. In particular, price responsiveness to appreciations and depreciations of different sizes may be nonlinear.

ERPT asymmetry with respect to the direction of exchange rate changes is generally explained within a micro-founded *"pricing to market"* theory. Under this framework, the mark-up responsiveness from depreciation and appreciation has an opposite nature. More specifically, appreciation of an importing country's currency has a positive effect on a foreign exporter's mark-up and, thus, the absorption of exchange rate fluctuations (i.e., raising the mark-up and keeping constant prices expressed in an importing country's currency) is more desirable. In the case of depreciation of an importer's currency, a foreign exporter has an incentive to pass through exchange rate changes and raise prices in order to maintain stable profits.

However, as discussed in Pollard & Coughlin (2004) and Marston (1990), assuming that foreign producers care about their market share, exporting firms are likely to pass-through exchange rate appreciation and decrease prices, expressed in the currency of the importer, in order to gain market share. Depreciation, in turn, will not be reflected in domestic prices given that foreign firms may never raise prices above the price of a substitute good in the importing country's market in order to hold on to market share. Hence, in a competitive environment, the response of domestic prices to exchange rate appreciation is higher than in cases of depreciation.

On the contrary, in a climate of imperfect competition, a foreign producer has a high market share in the destination market and, thus, has substantial pricing power. Bussiere (2007) and Delatte & Lopez-Villavicencio (2012) argue that the higher the market share, the lower the incentive of an exporter to absorb exchange rate depreciation (i.e., to keep constant prices in an importer's currency and decrease profits) and to pass-through appreciation (i.e., decrease prices and keep fixed profits). In this case, imperfect competition implies that prices are more sensitive to depreciations than to appreciations.

The effect from small and large exchange rate movements might also be nonlinear. Pollard & Coughlin (2004) explain such nonlinearities by the presence of menu costs. Assuming that the change of the invoice price is costly for an exporting firm, ERPT from small and large changes may differ. In this case, the type of pricing strategy matters (i.e., local currency pricing vs. producer currency pricing). The invoice price changes if the exchange rate change is above a certain threshold level.

Under the producer currency pricing strategy, the invoice price is set in the exporter's currency. A foreign firm may not adjust its invoice prices due to a small exchange rate change, which implies that prices expressed in an importer's currency will fully reflect exchange rate movements. In this case, ERPT is complete. However, in order to react on demand conditions and maintain a market share, exporters may absorb a part of the exchange rate pressure from large changes and adjust prices in their currency, thus reducing the degree of pass-through to prices in an importing country's currency.

On the contrary, under the local currency pricing strategy, the invoice price is set in the importer's currency. In this case, import prices in domestic currency do not respond to small exchange rate changes. If the change is large, a foreign firm may adjust the price and increase the level of pass-through. Hence, LCP strategy implies that ERPT is higher when exchange rate changes are larger than when they are small.

Theoretical literature is not straightforward in explaining the direction of ERPT asymmetry from depreciation and appreciation of different sizes. Moreover, empirical studies are not conclusive either. There is vast literature that confirms the presence of nonlinearities on the industry level and finds that the direction of asymmetry varies across industries. Campa et al. (2005) use disaggregated data from EU countries and find that the extent to which import prices in manufacturing industries respond to appreciation episodes is higher than in the case of depreciation. In contrast, a symmetric response of prices for agriculture and commodity imports cannot be rejected. Pollard & Coughlin (2004), in turn, provide ERPT estimates for 30 manufacturing industries and find that the degree of pass-through is positively related to the size of the exchange rate change. However, they also show that prices respond asymmetrically to appreciation and depreciation only in a few industries and the direction of asymmetry varies. Bussiere (2007) also supports the presence of nonlinearities in ERPT. The author analyzes aggregate import prices in G7 counties and finds strong evidence of asymmetric ERPT, although the direction of asymmetries varies across countries. Nogueira & Leon-Ledesma (2008) use aggregate consumer price data for six countries under IT regimes and provide evidence that the magnitude of exchange rate variations is a driving factor of nonlinearities for some countries. Delatte & López-Villavicencio

(2012) also find that CPI response to exchange rate depreciation is higher than to appreciation in four developed countries.

For the direction of exchange rate changes, the pass-through effect can be examined in empirical analysis by taking into account demand conditions in an importing country. For the magnitude of exchange rate variations, different price-setting behaviors of exporting firms can be captured by examining ERPT to prices set in producer and local currencies separately. This, however, requires a highly disaggregated and informative data range that is usually unavailable. In our analysis, we assume that producer currency pricing is prevalent in the case of Ukraine and, thus, following theoretical arguments, one can expect that aggregate domestic prices in Ukraine should be more sensitive to smaller rather than to larger exchange rate changes. In addition, given that Ukraine can be characterized by a monopolistic competition market structure, the pass-through from exchange rate depreciation should be higher than in the case of appreciation.

2.2 Exchange rate pass-through and inflation environment

In addition to nonlinearities in the pass-through mechanism with respect to variations of the exchange rate, recent developments in the literature suggest that the extent to which aggregated domestic prices respond to exchange rate changes may also depend on other macroeconomic factors. In particular, Taylor (2000) argues that the declining pass-through to aggregate prices is a result of a low inflation environment that has recently been achieved in many countries. The author first uses a micro-founded price-setting framework to show that lower perceived persistence of cost changes causes lower ERPT. A foreign exporting firm may associate low inflation with less persistent changes in costs. Therefore, the shift to a low-inflationary environment with lower persistence of inflation reduces the pricing power of firms and, hence, lowers the pass-through of exchange rate changes. In this respect, the pass-through becomes endogenous to monetary policy stance and, hence, a credible and stable monetary policy can lead to a lower ERPT.

This famous argument of J. Taylor has become a trending topic in international economics. A large volume of literature attempts to develop and verify Taylor's hypothesis using data on exchange rates and inflation in different countries. In particular, Bailliu & Fujii (2004) use a panel dataset of 11 industrialized countries and find that ERPT declines with a shift to a low-inflation environment induced by a shift in the monetary policy regime. Choudhri & Hakura (2006) test Taylor's hypothesis on a large dataset for 71 countries and find strong evidence of a positive and significant correlation between the average inflation rate and the degree of ERPT. Following a similar idea, Devereux & Yetman (2010) develop a simple theoretical model and argue that sticky prices represent a key determinant of ERPT. Using data for 144 countries, authors show that average inflation tends to increase the rate of ERPT.

The relationship between ERPT and the inflation environment is usually associated with the adoption of an IT regime by many countries, which is characterized by more stable and low average inflation rates. Since 2014, the NBU has initiated the transition from a de-facto exchange rate peg towards an IT regime. Although the new direction of monetary policy has already proved its credibility as the annual inflation rate has been reduced substantially, the overall period is relatively short to provide reliable conclusions regarding the effect of an IT regime on the degree of ERPT. Nevertheless, for the recent decade, Ukraine has experienced several inflationary episodes which, following existing literature, could influence the pass-through effect from exchange rate changes.

2.3 Exchange rate pass-through and business cycles

The business cycle is also often considered as an important source of nonlinearities in the pass-through mechanism. The intuition behind this idea is closely related to the pricing behavior of a foreign firm under monopolistic competition. In particular, exporting firms tend to pass-through cost changes associated with exchange rate shocks when the economy of an importing country is growing. In contrast, a foreign exporter is likely to adjust its markup and absorb exchange rate fluctuations in order to hold on to its market share in periods of recession.

Goldfajn & Werlang (2000) use the data from 71 countries and find that the pass-through effect is higher when an economy is booming. Correa & Minella (2010), in turn, examines the pass-through mechanism in Brazil and confirms the hypothesis of a positive relationship between economic activity and the degree of ERPT.

Cheikh (2013) also provides strong evidence of nonlinearity in 6 out of 12 countries in the euro area with respect to economic activity. However, there is no clear evidence on the direction of nonlinearity. In particular, for some countries the degree of ERPT is higher in periods of high economic activity and lower during recessions, which is in line with a pricing-to-market theory. However, for other countries the relationship between business cycle and ERPT is inverse. If low economic activity in an importing country is associated with an economic slump or macroeconomic instability, foreign producers may shift from a LPC to a PCP strategy, which increases the pass-through effect. Moreover, as argued in Nogueira & Leon-Ledesma (2011), ERPT can be higher in periods of financial or confidence crises, when foreign exporters have no incentive to absorb cost increases in their margins.

3. Analytical Framework

Empirical literature provides strong evidence showing that nonlinearities in the pass-through mechanism cannot be neglected both for import prices as well as for consumer prices. Given this fact, we attempt to relax the assumption of symmetric and linear ERPT to consumer prices in the case of Ukraine. We employ a standard micro-founded mark-up approach, commonly utilized in literature, as a starting point for our analysis.[4] We then adapt it to estimate ERPT to consumer prices taking into account potential nonlinearities with respect to macroeconomic conditions. In particular, we consider in our analysis size and direction of exchange rate changes, low and high average inflation rates, and low and high economic activity along the business cycle.

A standard mark-up approach implies that a single Foreign firm sells a specific product to Home country and has pricing power in the importing country's market. The pricing behavior of a firm may be expressed by a simple profit-maximization problem:

$$\max_{P^H} \pi = \frac{P^H Q}{E} - C(Q), \qquad (1)$$

where π is the exporting firm's profit in Foreign currency; E is the exchange rate of Home currency per unit of the exporting firm's currency, P^H is the price in Home currency, $C(Q)$ is the cost function in the Foreign currency, and Q is the quantity demanded.

The first-order condition of equation (1) yields to the following form:

$$P_t^H = E_t \mu_t C_t^F, \qquad (2)$$

where C_t^F is the marginal cost of the exporting firm and μ_t is the mark-up over marginal cost. Equation (2) implies that the price of a product in Home currency may vary due to independent changes in the nominal exchange rate, Foreign firm's marginal cost, and mark-up, which, in turn, is assumed to depend on the demand conditions in the Home market. The mark-up, in turn, is defined as $\mu_t = \eta/(1-\eta) = \mu(Y)$, where η is the price elasticity for demand of the imported product and Y states for the demand conditions in the destination country.

In addition, we test in our analysis the hypothesis that mark-up responsiveness is nonlinear with respect to macroeconomic environment. In particular, a foreign firm's decision whether to absorb or pass-through exchange rate depreciation may be different

[4] For example, as in Goldberg & Knetter (1997).

from the case of appreciation. Similarly, nonlinearities in price-setting behaviors can be related to the size of exchange rate variations, the inflation environment, and economic activity. Incorporating these arguments, we consider the transition function $\gamma(D)$ representing the nonlinear channel of a pass-through, where D is the transition variable indicating macroeconomic conditions (e.g., the direction and size of exchange rate variations, average inflation rate, or cyclical component of output). Thus, a foreign firm's mark-up can be expressed in the following functional form:

$$\mu_t = \mu\left(Y, E^{\gamma(D)}\right). \tag{3}$$

Consequently, according to equation (2) and (3), a simple log-linear reduced-form ERPT equation would be:[5]

$$p_t^H = \alpha + \beta e_t + \gamma(D) e_t + \delta c_t^F + \rho y_t^H + \varepsilon_t. \tag{4}$$

Assuming that there is a threshold value D^*, which divides extreme cases of macroeconomic conditions into *"low"* and *"high"* regimes, the function $\gamma(D)$ may be further defined in the following way:

$$\gamma(D) = \begin{cases} 0, & if \;\; D > D^* \\ \varphi, & otherwise \end{cases}. \tag{5}$$

Inclusion of the transition function to our model enables the estimation of two different ERPT coefficients. From equation (4), the joint ERPT coefficient is measured as $(\beta + \gamma(D))$. Hence, for high regime (i.e., $D > D^*$), the degree of pass-through is $(\beta + 0 = \beta)$. However, in the case of low regime (i.e., $D \leq D^*$), ERPT is $(\beta + \varphi)$. The φ sign indicates the direction of nonlinearity, i.e., whether the transmission of exchange rate changes to prices is higher or lower under different regimes.

Following this approach, we consider nonlinearities in the pass-through mechanism with respect to the direction and size of exchange rate movements. In this case, a transition variable can be represented as the percentage change of exchange rate over some period of time, namely, $D = \Delta e_{t-i}$. For the direction of exchange rate changes, a threshold value $D^* = 0$ divides extreme cases into periods of appreciations (i.e., $D \leq D^*$) and depreciations (i.e., $D > D^*$). For the size of exchange rate variations, D^* represents some threshold value below and above which exchange rate variations are assumed to be small and large, respectively. In addition, we attempt to test the

[5] Equation (4) is similar to one in Cheikh (2013) and Nogueira & Leon-Ledesma (2008), where component $\gamma(D)$ was used to represent the business cycle and macroeconomic stability conditions in the destination country.

hypothesis that prices respond nonlinearly to exchange rate changes in the climate of low and high inflation environments and economic activity.

The framework presented above describes the process of price adjustment from a microeconomic perspective and is usually used in literature to estimate ERPT to import prices of tradables in specific industries. Nevertheless, we use it as a starting point and extend the model so that it is suitable to estimate ERPT to consumer prices. As argued in Bailliu & Fujii (2004), a common assumption in empirical literature is that the aggregate price level and exchange rate follow non-stationary processes. Differentiation of variables expressed in logarithms results in the estimation of an inflation equation. In addition, following literature on inflation and ERPT to aggregate consumer prices, we also include inflation persistence to account for adaptive expectations.[6] Furthermore, lagged values of other independent variables should be considered in order to capture the relationship in dynamics. Incorporating these arguments, equation (4) can be re-written as follows:

$$\Delta p_t^H = \alpha + \sum_{i=1}^{n} \theta_i \Delta p_{t-i}^H + \sum_{i=0}^{k} \big(\beta_i + \gamma(D)\big) e_{t-i} + \sum_{i=0}^{q} \delta_i c_{t-i}^F + \sum_{i=0}^{r} \rho_i y_{t-i}^H + \varepsilon_t. \qquad (6)$$

Equation (6) represents the extension of the theoretical mark-up model for the case of consumer prices including inflation persistence and an output gap to match Phillips curve. In addition, this type of equation allows for nonlinearities in the pass-through mechanism for aggregate consumer prices. In the next step of our analysis, we use an extended theoretical inflation equation in order to set up an empirical model and estimate the degree to which consumer prices in Ukraine respond to exchange rate changes with respect to different macroeconomic determinants.

4. Estimation Approach and Data Description

Considering a theoretical inflation equation (6) described in the previous section, we employ an ARDL model in our econometric set-up. A simple reduced-form ARDL(n, k) model can be presented as follows:

$$Y_t = a_0 + \sum_{i=1}^{n} a_{1,i} Y_{t-i} + \sum_{i=0}^{k} a_{2,i} X_{t-i} + \varepsilon_t, \qquad (7)$$

[6] For example, as in Nogueira & Miguel (2008).

where Y_t is the dependent variable, X_t represents an independent variable, $a_{1,i}$ and $a_{2,i}$ are parameters of the model, a_0 is a constant, and ε_t is white noise.

An ARDL model can be easily estimated by ordinary least squares using lag selection criterions (e.g., Akaike, Shwarz, Hannan-Quinn information criteria). Interpretation of the coefficients in equation (7), where all variables are in first differences and in logarithms, is straightforward, indicating a percentage change of a dependent variable resulting from a 1% change of each regressor. In the case of ERPT estimation (i.e., when the dependent variable is inflation, and the independent is the exchange rate change), in order to account for the dynamic effect, we compute dynamic multiplier coefficients considering inflation persistence and past exchange rate movements. We first calculate lag coefficients, which represent the relationship at each point in time, and then derive cumulative ERPT dynamic multipliers.

Lag coefficient:

0. $\beta_0 = a_{20}$
1. $\beta_1 = a_{11}\beta_0 + a_{21}$
2. $\beta_2 = a_{11}\beta_1 + a_{12}\beta_0 + a_{22}$

...

jth $\beta_j = \sum_{i=1}^{n} a_{1,i}\beta_{j-i}$;

Cumulative coefficient:

$$\beta_{full} = \sum_{j=0}^{\infty} \beta_j = \frac{\sum_{i=1}^{n} a_{2,i}}{1 - \sum_{i=0}^{q} a_{1,i}}. \quad (8)$$

Following analytical framework, we also add nonlinear elements to a linear baseline model to estimate nonlinear effects. We consider two dummy variables which divide a data set into low and high regimes:

$$R^{+} = \begin{cases} 1, \ if \ \ TV > \gamma \\ 0, \ if \ \ TV \le \gamma \end{cases}; \qquad \mathrm{R}^{-} = \begin{cases} 0, \ if \ \ TV > \gamma \\ 1, \ if \ \ TV \le \gamma \end{cases}, \quad (9)$$

where R^{+} and R^{-} are dummy variables that represent high and low regimes, TV states for the transition variable, and γ is a threshold value. Addition of dummy variables results in the following Nonlinear ARDL (NARDL) representation:

$$Y_t = a_0 + \sum_{i=1}^{n} a_{1,i} Y_{t-i} + \mathrm{R}^{+} \sum_{i=0}^{k} a_{2,i} X_{t-i} + \mathrm{R}^{-} \sum_{i=0}^{k} a_{3,i} X_{t-i} + \varepsilon_t. \quad (10)$$

Equation (10) allows the estimation of two types of coefficients for low and high regimes. In particular, asymmetries with respect to the direction of exchange rate movements are captured when the transition function represents the change of exchange rate and γ is zero. On the contrary, a certain threshold value can be also used to calculate ERPT coefficients from small and large changes separately. Similarly, R^{+}

and R^{-} can be used to represent low and high regimes of the inflation environment and economic activity.

Our analysis is based on monthly frequency data and captures the period from January 2007 to April 2016.[7] The data choice is based on the consideration of the theoretical framework hypothesis described in previous sections. Following a mark-up approach, we use disaggregated data of consumer prices (i.e., 258 indices) in Ukraine and estimate the nonlinear effect of exchange rate changes for the set of price groups separately, including:

- all consumer prices;
- raw food prices;
- core nonfood (narrow) prices;
- prices of import tradables.
- core consumer prices;
- core food prices;
- prices of tradables; and

We use several price groups in our analysis in order to capture peculiarities of different consumer price indices. In particular, the group of *"all consumer prices"* includes prices of all goods and services. *"Core consumer prices"* excludes raw food prices, administratively regulated prices and services, and fuel prices. Moreover, following the analytical framework of our analysis, which aims to explain the pass-through effect to prices of goods, we also estimate the response of core food and nonfood prices excluding services. Finally, the *"pricing-to-market"* theory assumes that an exporting firm's mark-up responsiveness may depend on demand conditions in the importing country and prices of domestically produced substitutes. Hence, we narrow the analysis to study the pass-through effect to prices of tradable goods. In addition, we also examine import tradables, which may be particularly sensitive to exchange rate movements. **Table 2** represents the detailed structure of each group. All price indices are normalized (December 2006 = 100) and seasonally adjusted using an X-12 additive monthly seasonal adjustment method.

Korhonen & Wachtel (2005) argue that the US dollar exchange rate is one of the most important relative prices in most CIS countries, including Ukraine. In addition, Coibion & Gorodnichenko (2015) highlight the importance of the USD to UAH exchange rate for households' expectations. However, as a result of the exchange rate peg to the US dollar, a USD/UAH time series includes only several appreciation episodes and three stages of rapid depreciation in 2008, 2014, and 2015, which makes the estimation of nonlinearities problematic. On the contrary, the NEER is more volatile as it includes

[7] Data source: NBU Statistics and State Statistics Service of Ukraine.

trade-weighted exchange rates of other countries. Thus, in our empirical analysis, the exchange rate variable is an inverted normalized NEER of domestic currency per unit of weighted foreign currencies (December 2006 = 100). A positive change in NEER indicates depreciation, while negative changes represent episodes of appreciation.

In order to account for demand conditions in an importing country, we use the Industrial Production Index gap (IPI),[8] which is available on a monthly basis. Foreign producer costs, which, in turn, reflect supply conditions, are commonly expressed by inclusion of energy prices (e.g., oil prices), as in Koichi (2013), Delatte & López-Villavicencio (2012), and McCarthy (2000, 2007). Thus, we use the Fuel Price Index (FPI)[9] from the IMF Commodity Price Statistics in our analysis.

All time series are in logarithms and first differences.[10] **Figure 1** represents the data used for the analysis.

Following the above-mentioned analytical framework and estimation approach, we start with estimation of the baseline linear ARDL model to measure ERPT to consumer price indices. The lag length of each variable in the equation was selected using a *"general to specific"* approach and AIC statistics, resulting in the following ARDL specification:

$$CPI_t = a_0 + \sum_{i=1}^{3} a_{1,i} CPI_{t-i} + \sum_{i=0}^{3} a_{2,i} NEER_{t-i} + \sum_{i=1}^{2} a_{3,i} IPI_{t-i} + \sum_{i=0}^{2} a_{4,i} FPI_{t-i} + \varepsilon_t. \qquad (11)$$

We then use a baseline linear setup and add nonlinear elements to account for asymmetry with respect to direction and size of exchange rate movements, the inflation environment, and business cycles. First, we include two dummy variables R^+ and R^-, which reflect periods of depreciation and appreciation, and estimate ERPT coefficients for different regimes separately. Then we repeat this procedure with dummy variables that reflect periods of small and large exchange rate changes, low and high past annual inflation, and low and high economic activity along the business cycle. In order to test for a linearity hypothesis, we use the Wald-test imposing coefficient restrictions $\beta_{R^+} = \beta_{R^-}$.

[8] The IPI gap is computed by taking the difference of seasonally adjusted IPI and HP-filtered IPI in logarithms.

[9] FPI includes Brent oil, natural gas, and coal prices.

[10] Except of the output gap, which is manually stationarized by HP-filtering.

5. Estimation Results

Estimated coefficients from the linear ARDL model were used to calculate the dynamic multiplier measuring the cumulative ERPT effect. Estimation output and cumulative ERPT coefficients with corresponding standard errors are represented in **Table 3**.

Figure 2 shows the response of core consumer prices to a 1% NEER change where the left graph represents the effect on the price change (i.e., inflation) at each point in time, while the right graph shows the accumulated response of prices. ERPT for the group of all consumer prices is estimated at a level of 0.172, which is in line with existing empirical studies for Ukraine. The response of core prices, prices of tradables, and import tradables is 0.181-0.189. For core food prices, the ERPT coefficient is somewhat higher at 0.268, while prices of core nonfood goods have the lowest pass-through of 0.154. Interestingly, in the short-run, the degree of ERPT for raw food prices rises to 0.24, which is the highest compared to other price groups, and subsequently stabilizes at a level of 0.183. All ERPT coefficients are statistically significant at a 1% confidence level.

In the next step of our analysis, we estimate several nonlinear models considering different directions and sizes of exchange rate changes, the inflation environment, and economic activity.

5.1. Size and direction of exchange rate movements

Before discussing estimation results from the nonlinear ARDL models, an important issue on the choice of a transition variable and the threshold value should be raised. In this case, a transition variable is used to divide the exchange rate time series on several regimes (e.g., depreciation and appreciation; small and large exchange rate changes). Empirical literature on ERPT asymmetry (e.g., as in Pollard & Coughlin, 2004) commonly use a percentage change of the exchange rate variable utilized in the regression equation as a transition variable. More specifically, within a monthly-based analysis, the sign of a monthly exchange rate change is used to divide a dataset into regimes of depreciation and appreciation (i.e., $\Delta e_{t-1} > 0$ and $\Delta e_{t-1} < 0$). However, one would argue that a transition variable should reflect exchange rate movements over some longer period in the past. In particular, the transition from one regime to another may not be instant. In our analysis, we choose a transition variable which covers all lagged values of the exchange rate variable in the inflation equation. In particular, the inclusion of three lags of exchange rate implies that the transition variable is the NEER quarterly percentage change ($\Delta neer_{t-3}$). Depreciation and appreciation periods are simply split by a threshold value which equals zero. This results in the division of the total number of observations into episodes of 61% depreciation and 39% appreciation.

While for the direction of exchange rate movements the choice of a threshold value is intuitive, a measurement of the size of exchange rate changes requires additional assumptions. Pollard & Coughlin (2004) use an arbitrarily chosen threshold value of 3% in their analysis. In contrast, a set of empirical ERPT studies use Threshold Autoregressive models (TAR) or Smooth Transition Regressions (STR) in order to determine a threshold value endogenously.[11] We use several alternative threshold values in order to measure asymmetries and nonlinearities in the ERPT mechanism for Ukraine with respect to the size of exchange rate movements. We first use a median of the absolute values of the quarterly NEER change, which approximately equals 3% (i.e., MED. = 0.0325). Using the median allows for the division of the data set into two equal periods. In the alternative model specification, we use two standard deviations as a threshold value, which approximately equals 16% (i.e., S.D. = 0.0794). This helps to capture extremely large depreciation episodes in 2008, 2014, and 2015. Although the fraction of extreme cases is 9%, the panel dimension enables the estimation of the ERPT coefficient with a relatively low number of observations. Transition variables and threshold values are graphically represented in Figure 3. Table 4 shows the cumulative price responsiveness to a one percent NEER change considering direction and size of exchange rate variations.

Results suggest that ERPT is asymmetric with respect to the direction of NEER change for most of price groups.[12] In particular, depreciation passes through to a larger extent than appreciation in the case of all consumer prices, core consumer prices, core nonfood prices, and prices of tradables and import tradables. Compared to the linear ARDL model, the degree of ERPT from depreciation is larger and varies from 0.221 for all consumer prices to 0.299 for the group of import tradables. In the case of raw food prices, ERPT asymmetry has an opposite direction. We find that a one percent NEER appreciation results in a 0.728 percent decline in prices of raw foods. Following theoretical assumptions, these results indicate much better competition conditions for such type of goods. Although the ERPT coefficient is statistically significant at a 99% confidence level, raw foods are usually sensitive to other external factors (e.g., crop yielding capacity) that are not considered in our analysis and may bias results. For the

[11] For example, Shintani (2009) uses a grid search approach to determine a threshold value.

[12] See Figure 4 for graphical representation of ERPT with respect to the direction of exchange rate changes.

group of core food prices, the linearity hypothesis cannot be rejected, indicating no asymmetry in the ERPT mechanism.

Estimation of nonlinear ERPT considering the magnitude of exchange rate movements using alternative threshold values provide controversial results. When a threshold value is set to 3%, small NEER changes pass through to consumer prices to a larger extent than in the case of large changes. However, we find the opposite direction of price responsiveness in the alternative NARDL specification if a threshold value is set to a 16% NEER change. In particular, ERPT from extremely large NEER changes is larger. These results indicate that ERPT nonlinearities with respect to the size of exchange rate changes may include more than one threshold value. Thus, we estimate the model allowing for small, medium, and large NEER changes. We use both threshold values of 3% and 16% to divide time series of the quarterly NEER change to periods of small changes (i.e., $abs(\Delta neer_{t-3}) < 3\%$), large changes (i.e., $abs(\Delta neer_{t-3}) > 16\%$), and medium changes (i.e., $3\% < abs(\Delta neer_{t-3}) < 16\%$). Results show that for most price groups, extremely large as well as small NEER changes have a considerable effect on consumer prices.[13] Moreover, the linearity hypothesis cannot be rejected for core consumer prices, core food and nonfood prices, and prices of import tradables. On the contrary, medium NEER changes are statistically insignificant in all cases.

Finally, we estimate alternative NARDL specification taking into account both size and direction of exchange rate variations. In particular, the linear model is extended by four dummy variables that represent periods of appreciations as well as small, medium, and large depreciations. **Table 5** provides ERPT estimates for different sizes and directions of exchange rate changes.[14] Results confirm our previous findings and suggest that for most price groups ERPT from small and extremely large depreciation is higher, while medium depreciation has a statistically insignificant effect. Appreciations, in turn, have a statistically insignificant effect for the group of all consumer prices. However, for raw food prices and core food prices, ERPT from appreciation is positive, while ERPT is negative for core narrow prices, prices of tradables, and import tradables.

Our results are in line with the *"pricing-to-market"* theory in a climate of imperfect competition. In this respect, foreign exporting firms have market power over importing countries' market and tend to adjust their mark-ups in response to appreciations, thus

[13] See **Figure 5** for graphical representation of ERPT with respect to the magnitude of exchange rate changes.

[14] See **Figure 6** for graphical representation of ERPT with respect to the direction and size of exchange rate changes.

keeping fixed prices and rising profits. On the contrary, following depreciation of an importing country's currency, foreign producers have an incentive to raise prices and keep stable profits. Interestingly, ERPT from appreciations in some cases has a negative sign (i.e., currency appreciation increases domestic prices). As argued in Faryna (2016), this can be a result of sufficient cross-country spillovers in the ERPT mechanism. In particular, the pass-through effect from appreciation may be compensated by allowing for higher order transmission channels between several countries.

In addition, considering theoretical arguments on ERPT nonlinearity, our results indicate the presence of menu costs, which implies that foreign exporting firms following a producer currency pricing strategy may not adjust their prices in response to small exchange rate changes. On the contrary, foreign producers may absorb the pressure from relatively larger exchange rate movements in their mark-ups in order to keep maintain the market share in the case of depreciation of the destination country's currency. However, extremely large exchange rate depreciation episodes in Ukraine were experienced during substantial economic slumps, an unfavorable inflationary environment, and confidence crises which can explain a higher degree of the pass-through effect. To support this argument, we also provide estimates of the pass-through effect considering nonlinearities with respect to the inflation environment and economic activity in following sections.

5.2. Inflation environment

In order to examine other macroeconomic sources of nonlinearities in the ERPT mechanism (e.g., inflation environment), we need a suitable transition variable that can be used to divide the overall time span into periods of low and high macroeconomic regimes. This allows the estimation of ERPT coefficients that correspond to a specific regime. To study the relationship of the degree of ERPT and the inflation environment, we use an aggregate Headline Consumer Price Index (HCPI) and compute the annual rate of inflation. In addition, following the idea that inflation represents the perceived cost changes for an exporting firm, we use past values of annual HCPI change.[15] Thereafter, the transition variable can be divided to periods of low and high inflation using a certain threshold value. The choice of a reliable threshold value, however, requires additional assumptions. For our analysis, we use several threshold values and estimate alternative NARDL specifications. We compute cumulative ERPT coefficients corresponding to low and high inflationary environments for each model and then we

[15] Namely, if the price index π is used in logarithms, the past annual inflation is computed as $(\Delta\pi_{t-12})_{t-1}$.

test for the linearity hypothesis using Wald statistics. This procedure can be useful to identify potential nonlinearities and find a reliable threshold value. Given that the mean inflation rate in Ukraine for the entire period of our analysis exceeds 13%, we estimate three NARDL models with a threshold value of 10%, 15%, and 20%.

Table 6 shows cumulative ERPT coefficients for low and high inflation regimes.[16] Results suggest that the linearity hypothesis cannot be rejected if the threshold value is 10% and 15%. However, it is strongly rejected if the threshold value is set to 20% for most price groups. In particular, we find that ERPT is higher if past annual inflation exceeds 20%, while the effect is statistically lower for a relatively low inflation regime. Although these results are consistent with J. Taylor's hypothesis, our results may capture nonlinearities with respect to the magnitude of exchange rate variations given that high inflation episodes in Ukraine were mainly experienced in periods of large exchange rate variations.

5.3. Business cycles

Finally, we explore potential nonlinearities in the pass-through mechanism with respect to economic activity. We extend the linear ARDL model with dummy variables that represent periods of expansion and recession. For this purpose, we use a cyclical component of the Industrial Production Index, namely the IPI gap which is used as a control variable in the ARDL model. The time span of the analysis is then divided to periods of expansion (e.g., IPI gap > 0) and recession (e.g., IPI gap ≤ 0).

Summary results are presented in Table 7.[17] We find that the pass-through effect is lower when the economy is in expansion. In particular, if actual output (i.e., industrial production) is higher than potential, ERPT coefficients are statistically insignificant for most price groups. On the contrary, during economic slowdowns, the pass-through varies from 0.26 to 0.41. Although our results might look controversial to the intuition behind the price-setting behavior of exporting firms, the negative output gap reflects periods of economic and financial crises in 2008 and 2014, which, following Cheikh (2013), can explain the inverse relationship between ERPT and economic activity.

[16] See Figure 7 for graphical representation of ERPT with respect to inflation environment.

[17] See Figure 8 for graphical representation of ERPT with respect to economic activity.

6. Robustness Check

In order to verify our results, we provide a set of robustness checks. In particular, additional attention is focused to several assumptions of our analysis which might affect overall conclusions.

First, we check whether the results obtained on ERPT nonlinearity with respect to exchange rate variations depend on the choice of a transition variable and threshold values. More specifically, we use quarterly exchange rate change in the baseline ARDL model as a transition variable in order to cover the length of lagged exchange rate values in the inflation equation. Therefore, we estimate nonlinear ERPT coefficients from depreciation and appreciation using threshold values representing the change of NEER over different periods. Results presented in **Table 8** suggest that the choice of transition variable does not change the general conclusion and confirms the presence of nonlinearities in the ERPT mechanism.

In addition, important nonlinearities with respect to the magnitude of exchange rate changes may depend on the choice of a relevant threshold value. In order to verify our results, we use different threshold values to determine small and large exchange rate changes.[18] Results suggest that the direction of nonlinearity shifts if a threshold value changes from small to relatively larger value, hence, indicating the importance of medium exchange rate movements. To examine this issue, we use two threshold values of 6% and 9%, which determine bounds for medium exchange rate changes. Thereafter, we gradually extend these bounds to 2% and 13%. **Table 10** provides results. We find that important nonlinearities become more evident when bounds are extended, which gives support to general conclusions in the paper.

In order to check for the stability of our results, we also estimate a time-varying ERPT using a linear ARDL model. More specifically, we estimate the average ERPT in a rolling window of two years (i.e., 24 months) and then plot cumulative coefficients (± 2S.D.) on the graph.[19] Results suggest that the pass-through effect is volatile for the period of our analysis and varies from 0 to 0.4 for most price groups. This may be a result of important nonlinearities in the pass-through mechanism as the highest ERPT is estimated for periods of extreme depreciation, economic slumps, and intensified inflationary environments. It is noteworthy that since the adoption of a flexible exchange rate regime in 2014 and transition to IT, the pass-through effect seems to

[18] See **Table 9** for estimation results.

[19] See **Figure 9** for results.

follow a downward trend. Although this tendency is not yet permanent and can be associated with smaller exchange rate fluctuations compared to periods of crisis, the declining ERPT might be also a result of effective implementation of the IT policy.

Lastly, we test whether the choice of the exchange rate variable for our analysis affect obtained results on the degree of ERPT. While for the baseline ARDL specification we utilize NEER due to its volatility, the bilateral exchange rate of the US dollar with respect to Ukrainian hryvnia can have an additional effect on price developments in Ukraine. Hence, we use interbank USD/UAH exchange rate for the robustness check and estimate ERPT taking into account the direction, size, and both direction and size of exchange rate variations. Summary results are presented in **Table 11**.

We find that US dollar ERPT is somewhat higher compared to NEER and varies from 0.24 to 0.42. These results indicate that price-setting decisions are much more sensitive to perceived cost changes associated particularly with US dollar exchange rate variations. In addition, our results confirm that the pass-through effect from depreciations is higher than in the case of appreciations. In order to identify nonlinearities with respect to the size of exchange rate changes, we estimate several alternative NARDL models using different threshold values. In this case, there is no evidence for several threshold values and, hence, there is no need to distinguish between small and medium exchange rate variations. We find that price responsiveness is considerable if quarterly US dollar exchange rate depreciation exceeds 9%, while for small exchange rate changes the pass-through effect is statistically insignificant.

7. CONCLUSIONS

From the beginning of 2014, Ukraine has experienced a rapid depreciation of the hryvnia caused by dramatic shifts in the risk premium, adjustments to balance of payment mismatches, and unfavorable terms of trade, all of which aggravated macroeconomic turbulences and, eventually, resulted in peek inflation up to 60%. Since 2015, the NBU has declared a new direction for its monetary policy on IT. In a climate of gradual economic stabilization and a floating exchange rate regime, the hryvnia depreciated by around 20%. In contrast to past periods, it was mainly due to a drop in world commodity prices and imposed trade restrictions with Russia. In this case, the decrease of commodity prices had both a positive and negative effect on the aggregate price level. This, eventually, resulted in a relatively modest price adjustment.

Nevertheless, the adoption of IT and transition to a flexible exchange rate in a small open economy may be problematic if the risks associated with exchange rate volatility remain high. Hence, the ability of the NBU to attain its inflation targets requires a thorough understanding of the extent to which consumer prices respond to exchange rate movements.

Given the particular importance of exchange rate pass-through, literature that explores this issue in Ukraine is scarce. Although there are several comprehensive studies that provide empirical estimates for Ukraine, the time span of their analysis can be characterized by the period of the exchange rate peg to the US dollar, which was used to provide a nominal anchor for the economy. In this paper, we fill the gap in the literature by examining ERPT issues in Ukraine. In particular, we attempt to answer the question of what extent consumer prices in Ukraine respond to exchange rate changes taking into account nonlinearities with respect to the direction and size of exchange rate variations, the inflation environment, and economic activity.

Following a standard mark-up approach, we find that for most price groups the pass-through effect from depreciation is higher than from appreciation, indicating weak competition in Ukraine. Additionally, we find that small depreciations have a considerable effect on price adjustments in Ukraine, while moderate changes are statistically insignificant. Given that foreign firms most often follow a PCP strategy while exporting goods to Ukraine, our results indicate the presence of menu costs for foreign producers. In addition, we find that the pass-through effect rises considerably in periods of extremely large exchange rate depreciations, high annual inflation rates, and economic slumps. To sum up, the NBU, while attaining its inflation targets, should be aware that consumer prices in Ukraine are sensitive to small and extremely large NEER changes, while the pass-through effect is statistically insignificant in the case of moderate NEER fluctuations.

REFERENCES

Bailliu, J., and E. Fujii (2004). Exchange Rate Pass-through and the Inflation Environment in Industrialized Countries: An Empirical Investigation. Bank of Canada Working Paper, 2004-21.

Beckmann, E., and J. Fidrmuc (2013). Exchange Rate Pass-Through in CIS Countries. Comparative Economic Studies, Vol.55(4), pp. 705-720.

Ben Cheikh, N. (2013). Nonlinear Mechanism of the Exchange Rate Pass-Through: Does Business Cycle Matter? CREM UMR CNRS 6211, WP 2013-06.

Betts, C. and M. Devereux (1996). The Exchange Rate in a Model of Pricing-to-Market. European Economic Review, 40, 1007-21.

Bussiere, M. (2007). Exchange Rate Pass-Through to Trade Prices: The Role of Nonlinearities and Asymmetries. ECB Working paper, No. 822.

Campa, J. M., L. S. Goldberg, and J.M. González-Mínguez (2005). Exchange-Rate Pass-Through to Import Prices in The Euro Area. NBER Working Paper, No. 11632, pp. 9-36.

Choudhri, E. U., and D. S. Hakura (2006). Exchange Rate Pass-through to Domestic Prices: Does the Inflationary Environment Matter? Journal of International Money and Finance, 25(4), 614-639.

Correa, A., and A. Minella (2006). Nonlinear Mechanisms of Exchange Rate Pass-Through: A Phillips Curve Model with Threshold for Brazil. Central Bank of Brazil Working Paper No. 122.

Delatte, A.-L., and A. López-Villavicencio (2012). Asymmetric Exchange Rate Pass-Through: Evidence from Major Countries. Journal of Macroeconomics, Vol.34, pp. 833–844.

Devereux, M., and J. Yetman. (2010). Price Adjustment and Exchange Rate Pass-Through. Journal of International Money and Finance, 20(2010), 181-200.

Dornbusch, R. (1987). Exchange Rates and Prices. American Economic Review, 77, 93-106.

Faryna, O. (2016). Exchange Rate Pass-Through and Cross-Country Spillovers: Evidence from Ukraine and Russia. BOFIT Discussion paper, 14/2016.

Goldberg, P., & Knetter, M. (1997). Goods Prices and Exchange Rates: What Have We Learned? Journal of Economic Literature, 35, pp. 1243-1292.

Goldfajn, I., and S.R.C. Werlang (2000). The Pass-Through from Depreciation to Inflation: A Panel Study. Banco Central Do Brasil Working Paper No. 423.

Koichi, M. (2013). Asymmetric Effects of The Exchange Rate on Domestic Corporate Goods Prices. Japan and the World Economy, Vol.25-26, pp. 80-89.

Korhonen, I., and P. Wachtel (2006). A Note on Exchange Rate Pass-Through and Its Asymmetry in CIS Countries. Research in International Business and Finance, Volume 20(Issue 2), pp. 215–226.

Krugman, P. R. (1986). Pricing to Market When the Exchange Rate Changes. National Bureau of Economic Research Working Paper, 1926.

Marston, R. C. (1990). Pricing to Market in Japanese Manufacturing. Journal of International Economics 29(3-4), pp. 217-236.

McCarthy, J. (2000). Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies. BIS Working Papers, No.79, p. 48.

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

Menon, J. (1995). Exchange Rate Pass-Through. Journal of Economic Surveys, 9(2), 197-231.

Nogueira Jr., R. P., and M. Leon-Ledesma (2008). Exchange Rate Pass-Through Into Inflation: The Role of Asymmetries and Nonlinearities. Studies in Economics, No. 0801, Department of Economics, University of Kent, p. 44.

Nogueira Jr., R. P., and M. Leon-Ledesma (2011). Does Exchange Rate Pass-Through Respond to Measures of Macroeconomic Instability? Journal of Applied Economics, Vol XIV, No. 1, pp. 167-180.

Novikova, N., and D. Volkov (2012). Modelling Core Inflation in Ukraine in 2003-2012. Economics Education and Research Consortium Working paper, 12/12E.

Coibion, O., and Y. Gorodnichenko (2015). Inflation Expectations in Ukraine: a Long Path to Anchoring. Visnyk of the National Bank of Ukraine, No.233, pp. 6-23.

Pollard, P. S., and C.C. Coughlin (2004). Size Matters: Asymmetric Exchange Rate Pass-Through at The Industry Level. Federal Reserve Bank of St. Louis, Working Paper 2003-029C, p. 38.

Shintani, M., A. Terada-Hagiwara, and T. Yabu (2013). Exchange Rate Pass-Through and Inflation: A Nonlinear Time Series Analysis. Journal of International Money and Finance, Vol. 32, pp. 512–527.

Taylor, J. B. (2000). Low Inflation, Pass-through, and the Pricing Power of Firms. European Economic Review, 44(7), 1389-1408.

FIGURES AND TABLES

Table 1. ERPT for Ukraine in empirical literature

Source	Price index	Data set	Exchange rate	Time period	ERPT
Korhonen & Wachtel (2005)	CPI	1999-2004	USD	12 month 24 month	0.63 0.64
			EUR	12 month 24 month	0.24 0.28
Beckmann & Fidrmuc (2013)	CPI	1999-2010	USD EUR	12 month	0.45 0.25
Novikova & Volkov (2012)	Core CPI	2003-2012	NEER	long-run (cointegration)	0.35-0.47
Faryna (2016)	Core CPI	2001-2015	USD EUR NEER RUB	12 month	0.40-0.42 0.20-0.21 0.27-0.28 0.09-0.10

Table 2. CPI Components

Component	Headline CPI	Core CPI	Raw food	Core food	Core narrow	Tradebales	Imp. Tradables	Component	Headline CPI	Core CPI	Raw food	Core food	Core narrow	Tradebales	Imp. Tradables
Rice	•	•		•				Women's underwear	•	•			•	•	•
White bread (extra class)	•							Women's bra	•	•			•	•	•
White bread (first class)	•							Women's tights	•	•			•	•	•
Black bread	•							Women's furs	•	•			•	•	•
Loaf	•							Kids jackets	•	•			•	•	•
Baguette	•	•		•				Kids overalls	•	•			•	•	•
Pasta (durum wheat)	•	•		•		•		Kids suits	•	•			•	•	•
Pasta (common wheat)	•	•		•		•		Kids dresses	•	•			•	•	•
Perogies, potstickers	•	•		•				Kids pants	•	•			•	•	•
Waffles	•	•		•		•		Kids jeans	•	•			•	•	•
Cookies	•	•		•		•		Kids sweaters	•	•			•	•	•
Cakes	•	•		•		•		Kids sportswear	•	•			•	•	•
Wheat flour	•		•					Kids t-shirts	•	•			•	•	•
Semolina	•		•					Kids underwear	•	•			•	•	•
Buckwheat	•		•					Kids tights	•	•			•	•	•
Oat flakes	•	•		•				Headwear	•	•			•	•	•
Peeled and pearl barley	•		•					Dry-cleaning	•	•					
Millet	•		•					Men's warm boots	•	•			•	•	•
Beef	•		•					Men's shoes	•	•			•	•	•
Beef tenderloin	•		•					Men's sneakers	•	•			•	•	•
Pork	•		•					Men's home footwear	•	•			•	•	•
Pork tenderloin	•		•					Women's warm boots	•	•			•	•	•
Poultry (chicken carcass)	•		•					Women's boots	•	•			•	•	•
Other chicken parts	•		•					Women's brand shoes	•	•			•	•	•
Cooked sausage (extra class)	•	•		•				Women's summer footwear	•	•			•	•	•
Sausages, wieners (extra class)	•	•		•				Women's sneakers	•	•			•	•	•
Cooked smoked sausage	•	•		•				Women's home footwear	•	•			•	•	•
Uncooked smoked sausage	•	•		•				Kids warm boots	•	•			•	•	•
Cooked smoked meat	•	•		•				Kids shoes	•	•			•	•	•
Best quality meat	•	•		•				Kids summer footwear	•	•			•	•	•
Beef byproducts	•		•					Kids sneakers	•	•			•	•	•
Pork byproducts	•		•					Kids home footwear	•	•			•	•	•
Chicken byproducts	•		•					Footwear repair	•	•					
Chopped meat	•		•					Housing rental	•						
Live fish (chilled)	•	•		•		•	•	Housing utilities	•					•	
Frozen fish	•	•		•		•	•	Details and designs	•	•			•	•	•
Fillet of frozen fish	•	•		•		•	•	Paints	•	•			•	•	•
Seafood	•	•		•		•	•	Sanitation equipment	•	•			•	•	•
Salt anchovy	•	•		•		•	•	Paving-tile	•	•			•	•	•
Smoked mackerel	•	•		•		•	•	Wallpapers	•	•			•	•	•
Herring	•	•		•		•	•	Cold water	•						
Canned fish in oil	•	•		•		•	•	Sewerage	•						
Red caviar	•	•		•		•	•	Liquefied gas for domestic use	•					•	
Crab sticks	•	•		•		•	•	Coal	•					•	
Pasteurized milk (low-fat)	•		•					Heating	•						
Pasteurized milk (high-fat)	•		•					Hot water	•						
Kefir	•		•					Kitchen furniture	•	•			•	•	•
Yoghurt	•		•					Wardrobes	•	•			•	•	•
Edam-type cheese	•	•		•				Upholstered furniture	•	•			•	•	•
Brine cheese	•	•		•				Carpeting	•	•			•	•	•
Low-fat soft cheese	•		•					Linoleum	•	•			•	•	•
Curd	•		•					Blankets	•	•			•	•	•
Sour cream (low-fat)	•		•					Linens	•	•			•	•	•
Sour cream (high-fat)	•		•					Refrigerators	•	•			•	•	•
Eggs	•		•					Washing machines	•	•			•	•	•
Butter	•		•					Microwaves	•	•			•	•	•
Margarine	•	•		•				Heaters	•	•			•	•	•
Sunflower oil	•		•					Vacuum cleaners	•	•			•	•	•
Salo (bacon)	•		•					Irons	•	•			•	•	•
Oranges, tangerines	•		•			•	•	Repair of electrical goods	•	•					
Bananas	•		•			•	•	Porcelain-faience housewares	•	•			•	•	•
Apples	•		•					Metal housewares	•	•			•	•	•
Drupaceous fruits	•		•					Synthetic detergents	•	•			•	•	•
Series	•		•					Antibiotics (domestic)	•	•			•	•	•
Grapes	•		•					Vitamins (domestic)	•	•			•	•	•
Watermelons	•		•					Vasodilators (domestic)	•	•			•	•	•
Dried fruits	•	•		•		•		Hormones	•	•			•	•	•
Cabbage	•		•					Antipyretics, analgesics (domestic)	•	•			•	•	•
Cucumbers	•		•					Ointments (domestic)	•	•			•	•	•
Tomatoes	•		•					Adhesive tapes	•	•			•	•	•
Zucchini, eggplant, pumpkins	•		•					Advisory medical services	•	•					

Table 2. (cont.) CPI Components

Component	Headline CPI	Core CPI	Raw food	Core food	Core narrow	Tradebales	Imp. Tradables	Component	Headline CPI	Core CPI	Raw food	Core food	Core narrow	Tradebales	Imp. Tradables
Sweet pepper	•		•					Dental services	•	•					
Onions	•		•					Diagnostic services	•	•					
Beetroot	•		•			•		Services of sanatoriums	•	•					
Carrot	•		•			•		Cars made in Ukraine	•	•			•	•	•
Mushrooms	•		•			•		Bicycles for adults	•	•			•	•	•
Beans	•		•			•	•	Gasoline A-95	•					•	•
Canned vegetables	•	•		•		•	•	Parking for personal transport	•						
Canned mushrooms	•	•		•		•	•	Suburban train	•						
Tomato paste	•	•		•		•		Intercity train	•						
Potatoes	•		•					Suburban bus	•						
Sugar	•		•					Intercity bus	•						
Pure honey	•	•		•		•		Public transport	•						
Chocolate	•	•		•		•	•	Taxi	•	•					
Chocolate sweets	•	•		•		•	•	Airfare	•						
Caramel	•	•		•		•	•	Telephones	•	•			•	•	•
Jelly, marshmallow, halva	•	•		•		•		Mobile Phones	•	•			•	•	•
Ice-cream	•	•		•				Mobile Communication	•	•					
Tomato ketchup	•	•		•				Internet	•	•					
Mayonnaise	•	•		•				MP3 players	•	•			•	•	•
Salt	•	•		•				Televisions	•	•			•	•	•
Garlic	•		•					DVD players	•	•			•	•	•
Spices	•	•		•		•	•	Photo cameras	•	•			•	•	•
Soups, bouillon cubes	•	•		•				Toys	•	•			•	•	•
Infant milk formula	•	•		•				Natural flowers	•	•			•	•	•
Ground coffee	•	•		•		•	•	Pet food	•	•			•	•	•
Instant coffee	•	•		•		•	•	Sports services	•	•					
Tea	•	•		•		•	•	Cinemas	•	•					
Mineral water	•	•		•		•		Cable TV	•	•					
Beverages	•	•		•		•		Photography	•	•					
Fruit and berry juice	•	•		•		•	•	Books	•	•			•	•	
Vodka	•					•		Newspapers	•	•			•	•	
Brandy	•					•	•	Notebooks	•	•			•	•	
Table wine	•					•	•	Pens	•	•			•	•	•
Fortified wine	•					•	•	Tourist and excursion services	•	•					
Sparkling wine	•					•	•	Kindergartens	•						
Beer	•					•		Secondary schools	•	•					
Cigarettes with filter	•							Universities	•	•					
Cigarettes with no filter	•							Courses	•	•					
Men's jackets	•	•			•	•	•	Restaurants	•	•					
Men's suits	•	•			•	•	•	Cafe	•	•					
Men's pants	•	•			•	•	•	Bars	•	•					
Men's jeans	•	•			•	•	•	Fast Food	•	•					
Men's shirts	•	•			•	•	•	Hotels	•	•					
Men's sweaters	•	•			•	•	•	Pensions	•	•					
Men's sportswear	•	•			•	•	•	Services of hairdressers	•	•					
Men's t-shirts	•	•			•	•	•	Toilet soap	•	•			•	•	•
Men's underwear	•	•			•	•	•	Shampoos	•	•			•	•	•
Men's socks	•	•			•	•	•	Toothpastes	•	•			•	•	•
Women's coats	•	•			•	•	•	Creams	•	•			•	•	•
Women's thickened coats	•	•			•	•	•	Deodorants	•	•			•	•	•
Women's jackets	•	•			•	•	•	Makeup	•	•			•	•	•
Women's pants	•	•			•	•	•	Toilet paper	•	•			•	•	•
Women's jeans	•	•			•	•	•	Feminine Hygiene	•	•			•	•	•
Women's blouses	•	•			•	•	•	Gold jewelry	•	•			•	•	•
Women's skirts	•	•			•	•	•	Bags	•	•			•	•	•
Women's sweaters	•	•			•	•	•	Financial services	•	•					
Women's sportswear	•	•			•	•	•	Notary services	•	•					
Women's t-shirts	•	•			•	•	•	Funeral services	•	•					

Figure 1. Data: exchange rate, output, energy prices, consumer prices

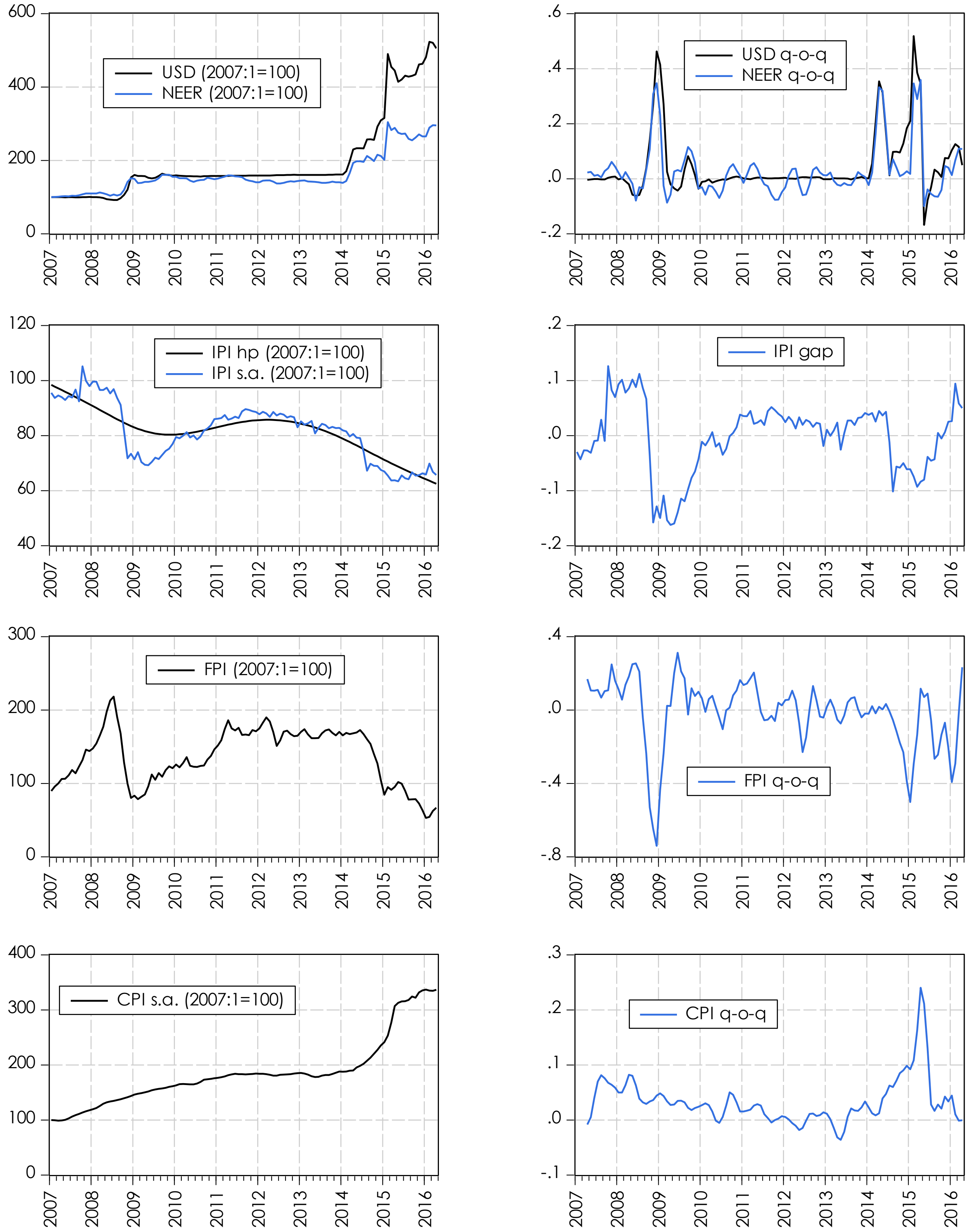


Table 3. ARDL estimation output

Model: ARDL (fixed effects)
Estimation method: Pooled Least Squares
Sample (adjusted): 2007M05 2016M04
Observations after adjustment: 108

Variables	Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Cross-sections included	258	182	47	50	104	151	129
Total pool observations	27864	19656	5076	5400	11232	16308	13932
Constant	0.005 [0.000]	0.004 [0.000]	0.005 [0.001]	0.003 [0.000]	0.004 [0.000]	0.005 [0.000]	0.004 [0.000]
CPI(-1)	0.339 [0.006]	0.392 [0.007]	0.327 [0.014]	0.795 [0.014]	0.285 [0.009]	0.357 [0.008]	0.365 [0.008]
CPI(-2)	0.005 [0.006]	0.004 [0.008]	0.002 [0.015]	-0.147 [0.017]	-0.033 [0.01]	-0.093 [0.008]	-0.019 [0.009]
CPI(-3)	-0.015 [0.006]	0.056 [0.007]	-0.037 [0.014]	0.058 [0.013]	0.026 [0.009]	0.013 [0.008]	0.047 [0.008]
NEER	0.021 [0.004]	0.012 [0.002]	0.040 [0.019]	-0.002 [0.003]	0.015 [0.003]	0.020 [0.004]	0.013 [0.003]
NEER(-1)	0.112 [0.004]	0.101 [0.002]	0.185 [0.02]	0.124 [0.003]	0.108 [0.003]	0.115 [0.004]	0.117 [0.003]
NEER(-2)	-0.021 [0.004]	-0.011 [0.002]	-0.088 [0.018]	-0.039 [0.004]	-0.009 [0.003]	-0.010 [0.004]	-0.011 [0.003]
NEER(-3)	0.004 [0.004]	-0.004 [0.002]	-0.007 [0.018]	-0.003 [0.004]	-0.003 [0.003]	0.008 [0.004]	-0.004 [0.003]
GAP(-1)	0.018 [0.007]	0.012 [0.004]	0.057 [0.035]	0.034 [0.006]	-0.004 [0.006]	0.008 [0.007]	0.006 [0.005]
GAP(-2)	-0.044 [0.007]	-0.027 [0.004]	-0.111 [0.035]	-0.036 [0.006]	-0.032 [0.006]	-0.044 [0.007]	-0.031 [0.005]
FPI	0.010 [0.003]	0.015 [0.002]	0.008 [0.015]	0.005 [0.003]	0.021 [0.003]	0.011 [0.003]	0.018 [0.002]
FPI(-1)	-0.012 [0.004]	-0.020 [0.002]	0.006 [0.017]	-0.010 [0.003]	-0.025 [0.003]	-0.017 [0.003]	-0.023 [0.003]
FPI(-2)	-0.018 [0.003]	-0.025 [0.002]	0.002 [0.016]	-0.011 [0.003]	-0.042 [0.003]	-0.031 [0.003]	-0.035 [0.002]
R-squared	**0.177**	**0.346**	**0.142**	**0.621**	**0.313**	**0.245**	**0.365**
AIC	**-3.997**	**-5.415**	**-2.564**	**-5.972**	**-5.253**	**-4.627**	**-5.337**
DW	**2.007**	**2.006**	**2.007**	**2.023**	**2.014**	**2.014**	**2.010**
ERPT (cumulative)	**0.172 [0.012]**	**0.181 [0.009]**	**0.183 [0.054]**	**0.268 [0.024]**	**0.154 [0.009]**	**0.183 [0.011]**	**0.189 [0.009]**

Notes: numbers are estimated coefficients; numbers in [ ] are standard errors

Figure 2. Linear price responsiveness to 1% NEER change

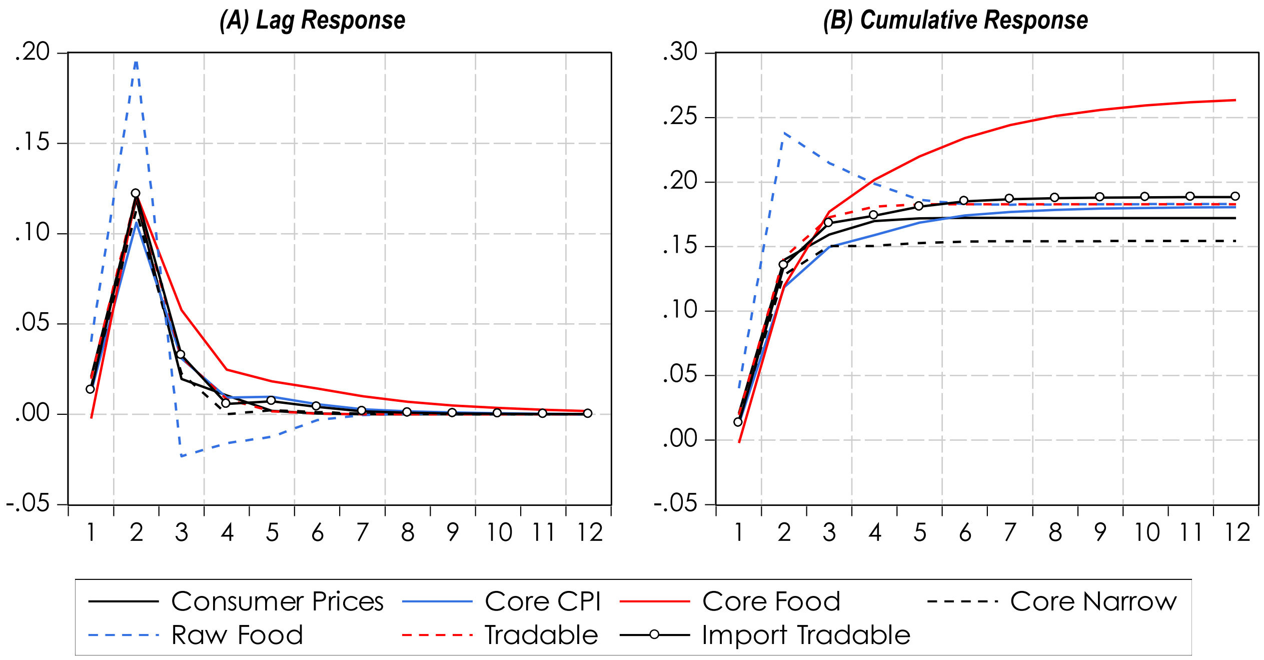


Figure 3. Transition variables and threshold values

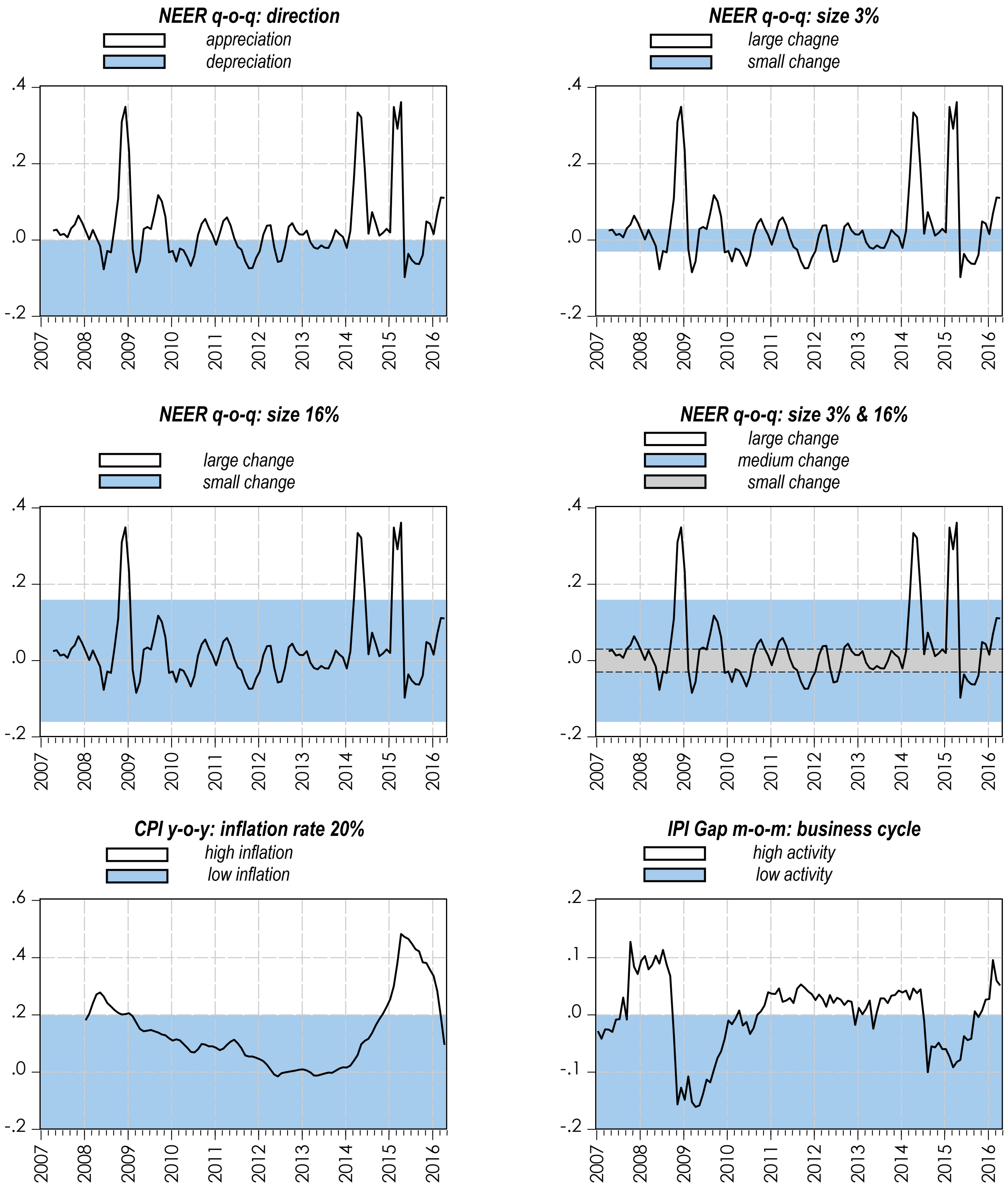
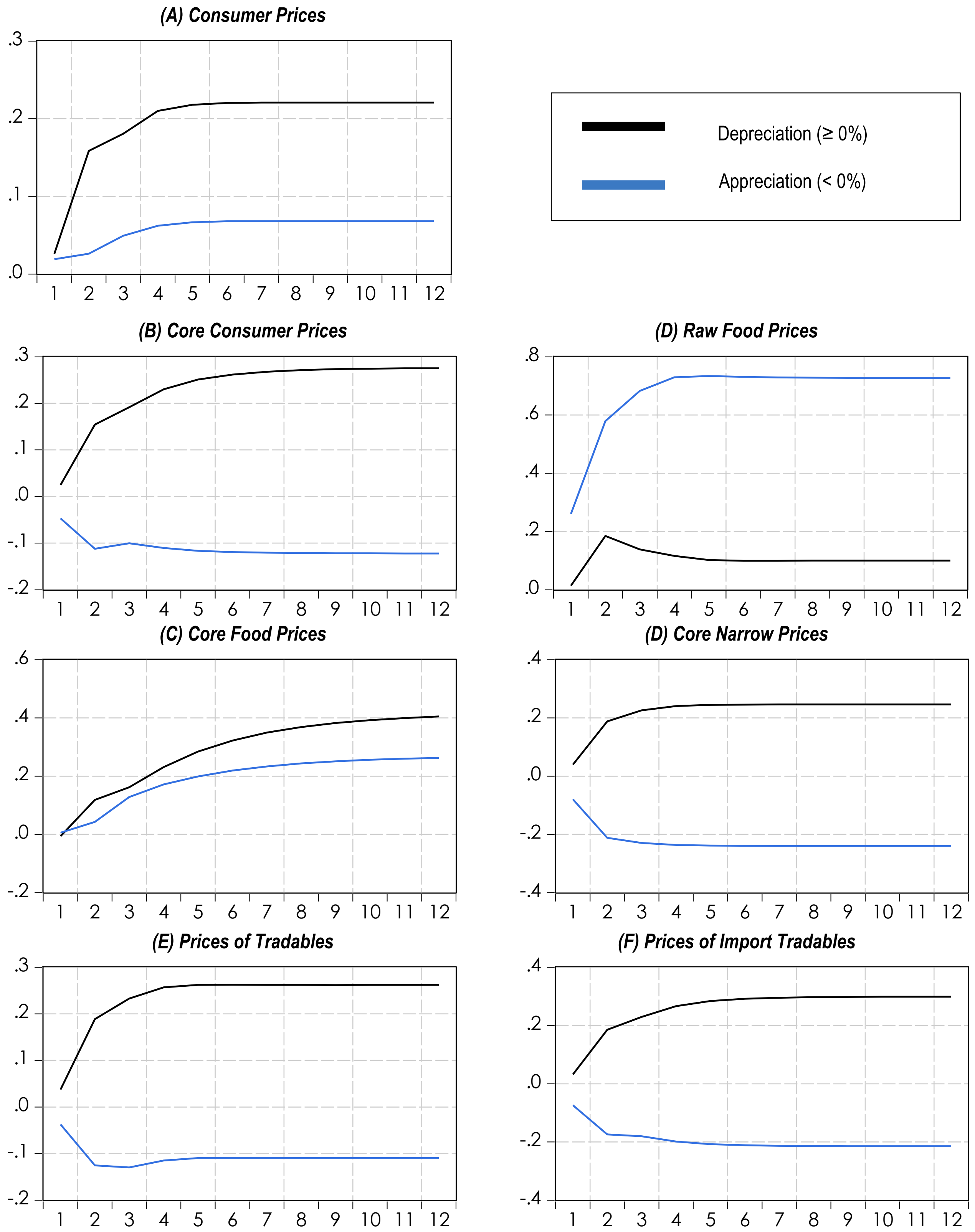


Table 4. ERPT with respect to exchange rate variations

			Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Direction	$\gamma = 0$	Depreciation (61% obs.)	0.221 [0.015]	0.276 [0.011]	0.100 [0.07]	0.417 [0.034]	0.246 [0.012]	0.262 [0.014]	0.299 [0.012]
		Appreciation (39% obs.)	0.068 [0.044]	-0.122 [0.031]	0.728 [0.199]	0.270 [0.093]	-0.24 [0.033]	-0.109 [0.038]	-0.215 [0.034]
		H_0:	###	###	###		###	###	###
Size of exchange rate change	*Median:* $\gamma \approx 0.03$	Large (55% obs.)	0.161 [0.012]	0.169 [0.009]	0.175 [0.055]	0.232 [0.025]	0.148 [0.010]	0.180 [0.011]	0.179 [0.01]
		Small (45% obs.)	0.724 [0.072]	0.351 [0.053]	2.203 [0.326]	0.780 [0.140]	0.209 [0.057]	0.416 [0.064]	0.275 [0.058]
		H_1:	###	###	###	###		###	#
	2 SE: $\gamma \approx 0.16$	Large (9% obs.)	0.231 [0.018]	0.257 [0.013]	0.271 [0.083]	0.616 [0.042]	0.191 [0.014]	0.246 [0.016]	0.266 [0.014]
		Small (91% obs.)	-0.008 [0.024]	0.019 [0.016]	0.144 [0.101]	0.082 [0.045]	-0.014 [0.017]	0.031 [0.019]	-0.002 [0.017]
		H_1:	###	###		###	###	###	###
	$\gamma_2 \approx 0.03$ & $\gamma_2 \approx 0.16$	Large (9% obs.)	0.231 [0.018]	0.258 [0.013]	0.253 [0.082]	0.617 [0.041]	0.188 [0.014]	0.243 [0.016]	0.266 [0.014]
		Medium (46% obs.)	-0.008 [0.024]	-0.031 [0.017]	-0.009 [0.108]	-0.04 [0.048]	-0.043 [0.018]	-0.007 [0.021]	-0.048 [0.018]
		Small (45% obs.)	0.714 [0.073]	0.336 [0.051]	2.287 [0.328]	0.737 [0.145]	0.214 [0.055]	0.420 [0.064]	0.263 [0.056]
		H_1:	###		###			###	
		H_2:	###	###	##	###	###	###	###
		H_3:	###	###	###	###	###	###	###

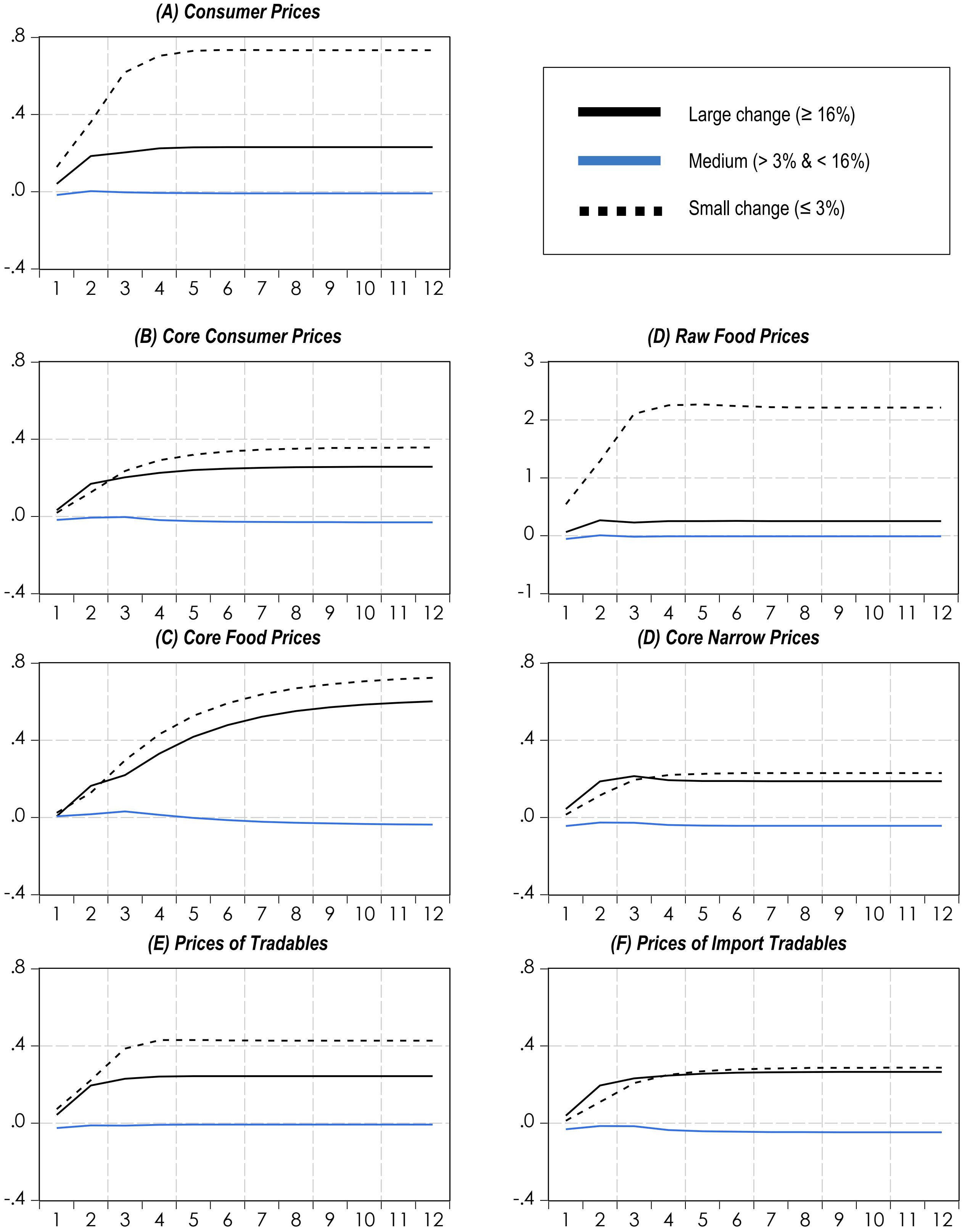
Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses:
H_0: appreciation = depreciation; H_1: large = small; H_2: large = medium; H_3: medium = small

Figure 4. Price responsiveness to 1% NEER change (direction)



Note: figures plot cumulative dynamic exchange rate pass-through coefficients for 12 month

Figure 5. Price responsiveness 1% NEER change (size)



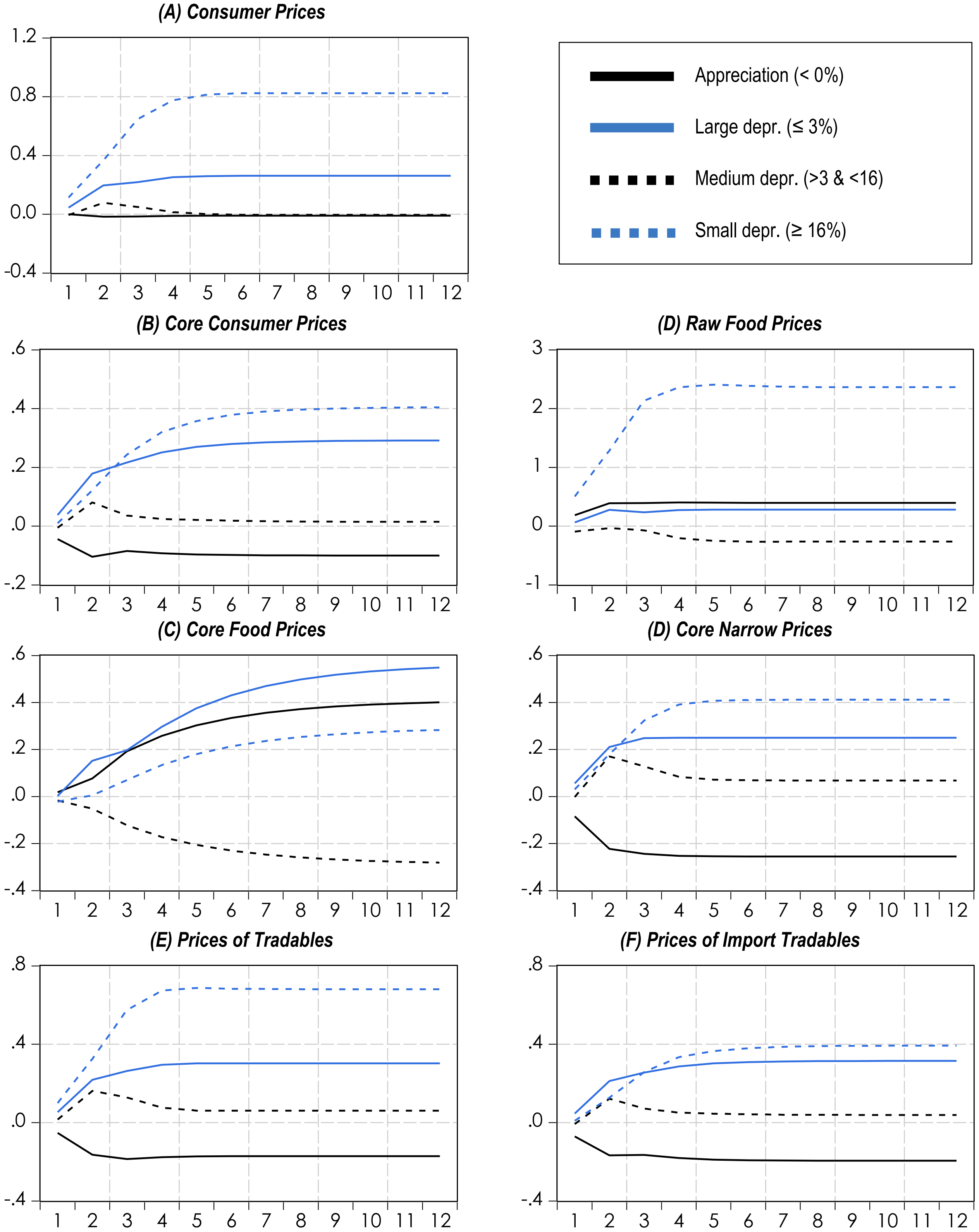
Note: figures plot cumulative dynamic exchange rate pass-through coefficients for 12 month

Table 5. ERPT with respect to the size and direction of exchange rate change

		Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Size & Direction of exchange rate change	Large depreciation (9% obs.)	0.262 [0.020]	0.292 [0.014]	0.280 [0.090]	0.566 [0.044]	0.251 [0.05]	0.302 [0.018]	0.315 [0.016]
	Medium depreciation (46% obs.)	-0.005 [0.046]	0.014 [0.033]	-0.262 [0.208]	-0.289 [0.095]	0.068 [0.034]	0.061 [0.040]	0.039 [0.035]
	Small depreciation (45% obs.)	0.824 [0.141]	0.405 [0.100]	2.364 [0.641]	0.293 [0.287]	0.412 [0.105]	0.681 [0.123]	0.393 [0.107]
	Appreciation (45% obs.)	-0.010 [0.055]	-0.100 [0.039]	0.396 [0.251]	0.410 [0.116]	-0.255 [0.041]	-0.171 [0.048]	-0.195 [0.042]
	H_1:	###	###	###	###	###	###	###
	H_2:	###		###			###	
	H_3:	###	###			###	###	###
	H_4:	###	###	###	##	###	###	###
	H_5:		#	#	###	###	###	###
	H_6:	###	###	##		###	###	###

Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses:
H_1: large depreciation = medium depreciation; H_2: large depreciation = small depreciation;
H_3: large depreciation = appreciation; H_4: medium depreciation = small depreciation;
H_5: medium depreciation = appreciation; H_6: small depreciation = appreciation

Figure 6. Price responsiveness to 1% NEER change (size and direction)



Note: figures plot cumulative dynamic exchange rate pass-through coefficients for 12 month

Table 6. ERPT with respect to inflation environment

			Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Inflation environment	$\gamma = 10\%$	*High inflation (52% obs.)*	0.197 [0.016]	0.212 [0.012]	0.164 [0.070]	0.318 [0.033]	0.179 [0.013]	0.215 [0.015]	0.224 [0.013]
		Low inflation (48% obs.)	0.145 [0.021]	0.179 [0.016]	0.139 [0.093]	0.246 [0.043]	0.169 [0.017]	0.164 [0.019]	0.192 [0.017]
		H_0:	##	#				#	
	$\gamma = 15\%$	*High inflation (34% obs.)*	0.190 [0.017]	0.203 [0.013]	0.172 [0.075]	0.288 [0.035]	0.175 [0.014]	0.219 [0.016]	0.217 [0.014]
		Low inflation (66% obs.)	0.152 [0.017]	0.172 [0.013]	0.160 [0.075]	0.292 [0.036]	0.149 [0.014]	0.155 [0.016]	0.179 [0.014]
		H_0:		#				###	#
	$\gamma = 20\%$	*High inflation (26% obs.)*	0.268 [0.017]	0.288 [0.012]	0.265 [0.077]	0.324 [0.036]	0.277 [0.013]	0.309 [0.015]	0.320 [0.013]
		Low inflation (74% obs.)	0.122 [0.015]	0.137 [0.011]	0.109 [0.066]	0.247 [0.030]	0.108 [0.011]	0.126 [0.013]	0.137 [0.011]
		H_0:	###	###	#	#	###	###	###

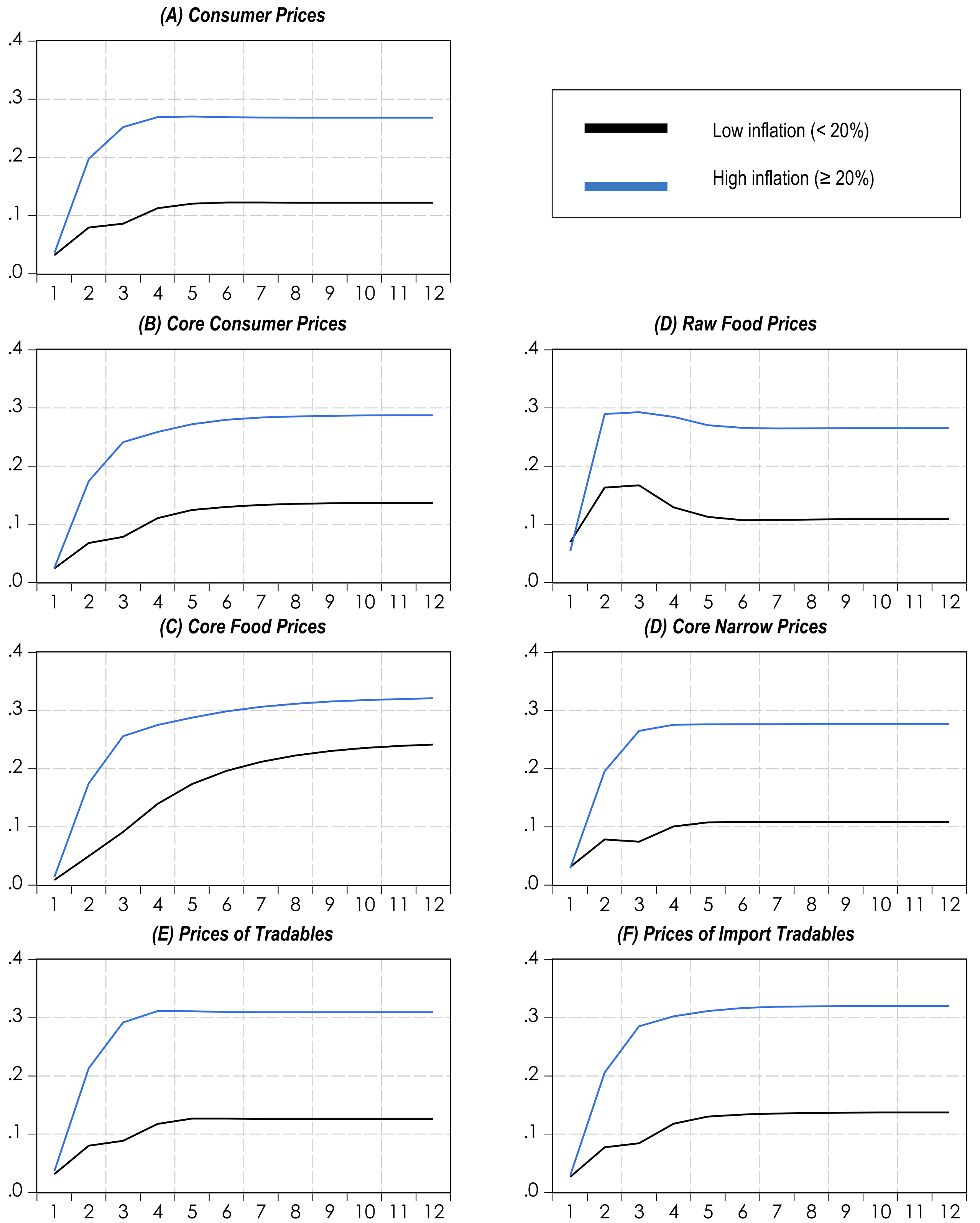
Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses: H_0: high inflation = low inflation

Table 7. ERPT with respect to business cycle

			Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Business cycle	$\gamma = 0$	*Low activity (44% obs.)*	0.281 [0.016]	0.303 [0.011]	0.290 [0.072]	0.413 [0.031]	0.260 [0.012]	0.292 [0.014]	0.317 [0.012]
		High activity (56% obs.)	0.064 [0.020]	0.080 [0.014]	0.046 [0.015]	0.180 [0.037]	0.046 [0.015]	0.060 [0.017]	0.073 [0.015]
		H_0:	###	###	##	###	###	###	###

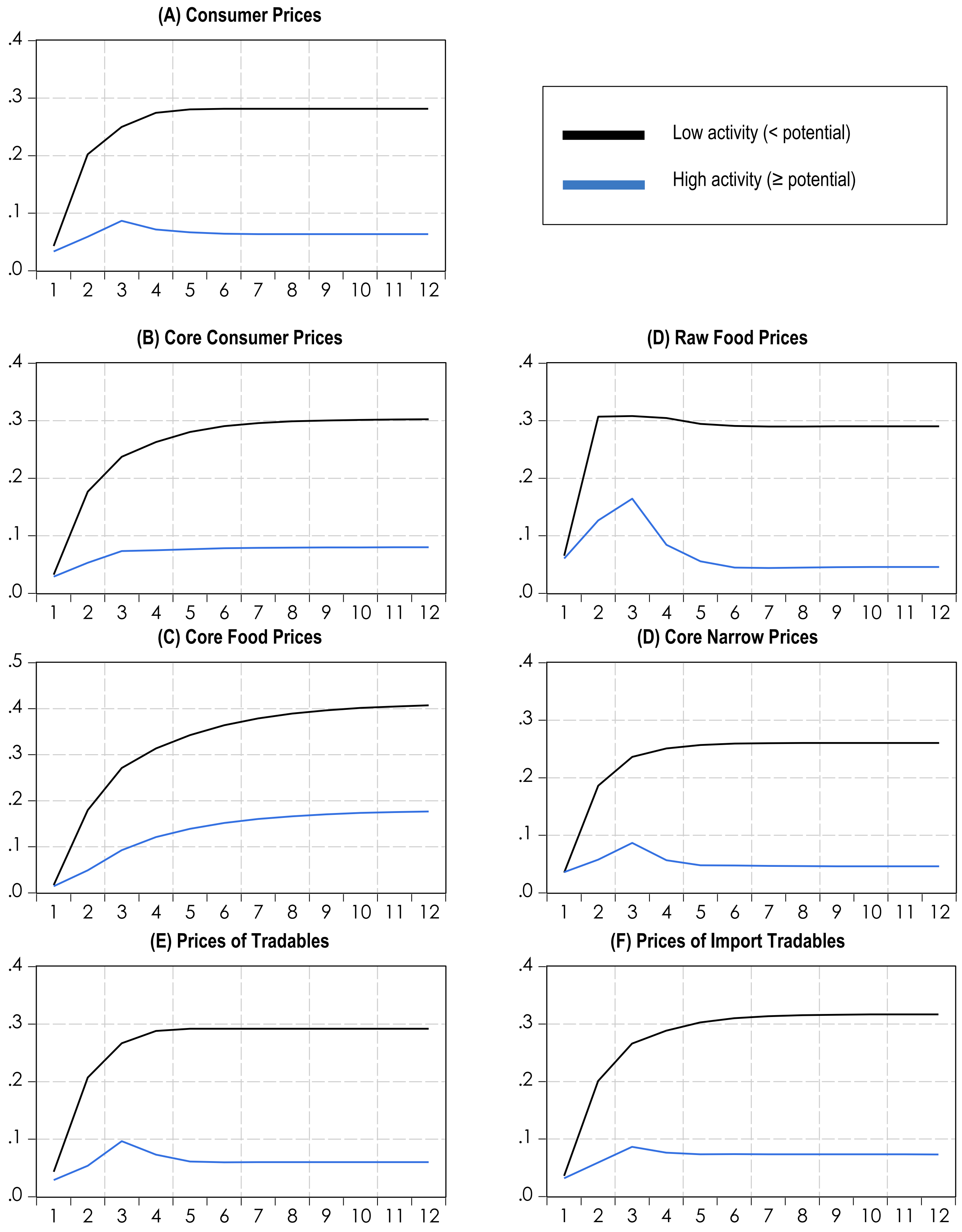
Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses: H_0: high activity = low activity

Figure 7. Price responsiveness to 1% NEER change (inflation environment)



Note: figures plot cumulative dynamic exchange rate pass-through coefficients for 12 month

Figure 8. Price responsiveness to 1% NEER change (business cycle)



Note: figures plot cumulative dynamic exchange rate pass-through coefficients for 12 month

Table 8. ERPT from appreciation and depreciation: different transition functions

		Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
1 M	Appreciation (48% obs.)	-0.035	-0.159	0.271	0.029	-0.207	-0.126	-0.196
		[0.029]	[0.018]	[0.135]	[0.046]	[0.020]	[0.024]	[0.019]
	Depreciation (52% obs.)	0.141	0.183	0.047	0.277	0.152	0.175	0.187
		[0.016]	[0.010]	[0.075]	[0.026]	[0.011]	[0.013]	[0.011]
	H_0:	###	###		###	###	###	###
2 M	Appreciation (41% obs.)	-0.128	-0.309	0.354	-0.460	-0.325	-0.267	-0.350
		[0.033]	[0.022]	[0.155]	[0.060]	[0.023]	[0.028]	[0.023]
	Depreciation (59% obs.)	0.271	0.326	0.172	0.537	0.280	0.313	0.341
		[0.015]	[0.010]	[0.071]	[0.029]	[0.010]	[0.013]	[0.010]
	H_0:	###	###		###	###	###	###
3 M	Appreciation (39% obs.)	0.068	-0.122	0.727	0.269	-0.239	-0.109	-0.214
		[0.043]	[0.031]	[0.198]	[0.093]	[0.033]	[0.038]	[0.033]
	Depreciation (61% obs.)	0.220	0.275	0.100	0.417	0.246	0.261	0.299
		[0.015]	[0.011]	[0.069]	[0.033]	[0.011]	[0.013]	[0.012]
	H_0:	###	###	###		###	###	###
4 M	Appreciation (38% obs.)	0.058	-0.047	0.631	0.365	-0.195	-0.125	-0.144
		[0.045]	[0.032]	[0.206]	[0.093]	[0.034]	[0.039]	[0.034]
	Depreciation (62% obs.)	0.193	0.216	0.088	0.233	0.218	0.243	0.244
		[0.015]	[0.010]	[0.069]	[0.029]	[0.011]	[0.013]	[0.011]
	H_0:	##	###	##		###	###	###
5 M	Appreciation (38% obs.)	-0.043	-0.236	0.432	0.149	-0.351	-0.217	-0.340
		[0.046]	[0.033]	[0.208]	[0.089]	[0.036]	[0.041]	[0.036]
	Depreciation (62% obs.)	0.214	0.256	0.146	0.284	0.249	0.258	0.286
		[0.015]	[0.011]	[0.066]	[0.030]	[0.012]	[0.013]	[0.012]
	H_0:	###	###			###	###	###
6 M	Appreciation (38% obs.)	-0.077	-0.283	0.391	0.144	-0.411	-0.234	-0.388
		[0.044]	[0.032]	[0.199]	[0.087]	[0.036]	[0.040]	[0.035]
	Depreciation (62% obs.)	0.222	0.264	0.174	0.302	0.255	0.260	0.291
		[0.014]	[0.010]	[0.062]	[0.028]	[0.011]	[0.013]	[0.011]
	H_0:	###	###			###	###	###

Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors;
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses: H_0: appreciation = depreciation

Table 9. ERPT from small and large NEER changes: different threshold values

		Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
γ : 3%	Large change (55% obs.)	0.161	0.169	0.175	0.232	0.148	0.180	0.179
		[0.012]	[0.009]	[0.055]	[0.025]	[0.01]	[0.011]	[0.01]
	Small change (45% obs.)	0.724	0.351	2.203	0.780	0.209	0.416	0.275
		[0.072]	[0.053]	[0.326]	[0.14]	[0.057]	[0.064]	[0.058]
	H_0:	###	###	###	###		###	##
γ : 6%	Large change (25% obs.)	0.151	0.152	0.135	0.182	0.142	0.180	0.165
		[0.013]	[0.01]	[0.059]	[0.027]	[0.011]	[0.012]	[0.011]
	Small change (75% obs.)	0.296	0.219	0.796	0.377	0.153	0.197	0.195
		[0.034]	[0.026]	[0.153]	[0.072]	[0.028]	[0.03]	[0.028]
	H_0:	###	##	###	##			
γ : 9%	Large change (15% obs.)	0.185	0.202	0.156	0.229	0.199	0.223	0.224
		[0.014]	[0.01]	[0.062]	[0.028]	[0.011]	[0.012]	[0.011]
	Small change (85% obs.)	0.116	0.046	0.378	0.272	-0.043	0.037	0.001
		[0.026]	[0.019]	[0.117]	[0.053]	[0.02]	[0.023]	[0.021]
	H_0:	##	###	##		###	###	###
γ : 12%	Large change (9% obs.)	0.232	0.257	0.271	0.616	0.191	0.246	0.266
		[0.018]	[0.013]	[0.083]	[0.042]	[0.014]	[0.016]	[0.014]
	Small change (91% obs.)	0.061	0.019	0.144	0.082	-0.014	0.031	-0.002
		[0.022]	[0.016]	[0.101]	[0.045]	[0.017]	[0.019]	[0.017]
	H_0:	###	###		###	###	###	###
γ : 15%	Large change (9% obs.)	0.232	0.257	0.271	0.616	0.191	0.246	0.266
		[0.018]	[0.013]	[0.083]	[0.042]	[0.014]	[0.016]	[0.014]
	Small change (91% obs.)	0.061	0.019	0.144	0.082	-0.014	0.031	-0.002
		[0.022]	[0.016]	[0.101]	[0.045]	[0.017]	[0.019]	[0.017]
	H_0:	###	###		###	###	###	###
γ : 18%	Large change (8% obs.)	0.233	0.254	0.277	0.619	0.186	0.244	0.261
		[0.018]	[0.013]	[0.083]	[0.042]	[0.014]	[0.016]	[0.014]
	Small change (92% obs.)	0.090	0.072	0.156	0.107	0.047	0.071	0.060
		[0.021]	[0.015]	[0.097]	[0.043]	[0.016]	[0.019]	[0.016]
	H_0:	###	###		###	###	###	###

Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses: H_0: large = small

Table 10. ERPT from small, medium, and large NEER changes: different threshold values

		Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
γ : 6% & 9%	Large change (55% obs.)	0.204 [0.014]	0.239 [0.01]	0.151 [0.064]	0.235 [0.029]	0.246 [0.011]	0.259 [0.012]	0.270 [0.011]
	Medium change (45% obs.)	-0.101 [0.076]	-0.422 [0.056]	0.497 [0.342]	0.164 [0.151]	-0.638 [0.06]	-0.364 [0.067]	-0.585 [0.06]
	Small change (45% obs.)	0.294 [0.034]	0.215 [0.025]	0.789 [0.154]	0.377 [0.071]	0.146 [0.026]	0.194 [0.03]	0.189 [0.027]
	H_0:	###	###			###	###	###
	H_1:	##		###	##	###	##	###
	H_2:	###	###			###	###	###
γ : 5% & 10%	Large change (25% obs.)	0.236 [0.018]	0.283 [0.014]	0.230 [0.082]	0.662 [0.047]	0.217 [0.014]	0.264 [0.016]	0.298 [0.015]
	Medium change (75% obs.)	-0.046 [0.033]	-0.128 [0.024]	0.054 [0.148]	-0.073 [0.073]	-0.170 [0.026]	-0.093 [0.029]	-0.176 [0.027]
	Small change (92% obs.)	0.395 [0.043]	0.221 [0.032]	1.205 [0.194]	0.472 [0.097]	0.144 [0.033]	0.261 [0.038]	0.198 [0.034]
	H_0:	###	###		###	###	###	###
	H_1:	###	##	###	##	##		###
	H_2:	###	###	###	###	###	###	###
γ : 4% & 11%	Large change (15% obs.)	0.226 [0.018]	0.257 [0.014]	0.249 [0.083]	0.660 [0.047]	0.183 [0.014]	0.238 [0.016]	0.263 [0.015]
	Medium change (85% obs.)	0.012 [0.026]	-0.040 [0.019]	0.062 [0.119]	-0.072 [0.058]	-0.032 [0.02]	0.020 [0.023]	-0.050 [0.021]
	Medium change (92% obs.)	0.345 [0.053]	0.188 [0.039]	1.069 [0.238]	0.517 [0.119]	0.061 [0.041]	0.157 [0.046]	0.131 [0.042]
	H_0:	###	###		###	###	###	###
	H_1:	##	##	###		###	##	###
	H_2:	###	###	###	###	##	###	###
γ : 3% & 12%	Large change (9% obs.)	0.231 [0.018]	0.258 [0.013]	0.253 [0.082]	0.617 [0.041]	0.188 [0.014]	0.243 [0.016]	0.266 [0.014]
	Medium change (91% obs.)	-0.008 [0.024]	-0.031 [0.017]	-0.009 [0.108]	-0.040 [0.048]	-0.043 [0.018]	-0.007 [0.021]	-0.048 [0.018]
	Small change (92% obs.)	0.733 [0.072]	0.357 [0.051]	2.215 [0.327]	0.740 [0.144]	0.230 [0.055]	0.427 [0.063]	0.288 [0.055]
	H_0:	###	###	##	###	###	###	###
	H_1:	###	##	###			###	
	H_2:	###	###	###	###	###	###	###
γ : 2% & 13%	Large change (9% obs.)	0.231 [0.018]	0.258 [0.013]	0.253 [0.082]	0.617 [0.041]	0.188 [0.014]	0.243 [0.016]	0.266 [0.014]
	Medium change (91% obs.)	-0.008 [0.024]	-0.031 [0.017]	-0.009 [0.108]	-0.040 [0.048]	-0.043 [0.018]	-0.007 [0.021]	-0.048 [0.018]
	Small change (92% obs.)	0.733 [0.072]	0.357 [0.051]	2.215 [0.327]	0.740 [0.144]	0.230 [0.055]	0.427 [0.063]	0.288 [0.055]
	H_0:	###	###	##	###	###	###	###
	H_1:	###	##	###			###	
	H_2:	###	###	###	###	###	###	###

Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses:
H_0: large = medium; H_1: large = small; H_2: medium = small

Figure 9. Time varying linear ERPT (± 2 S.D.)

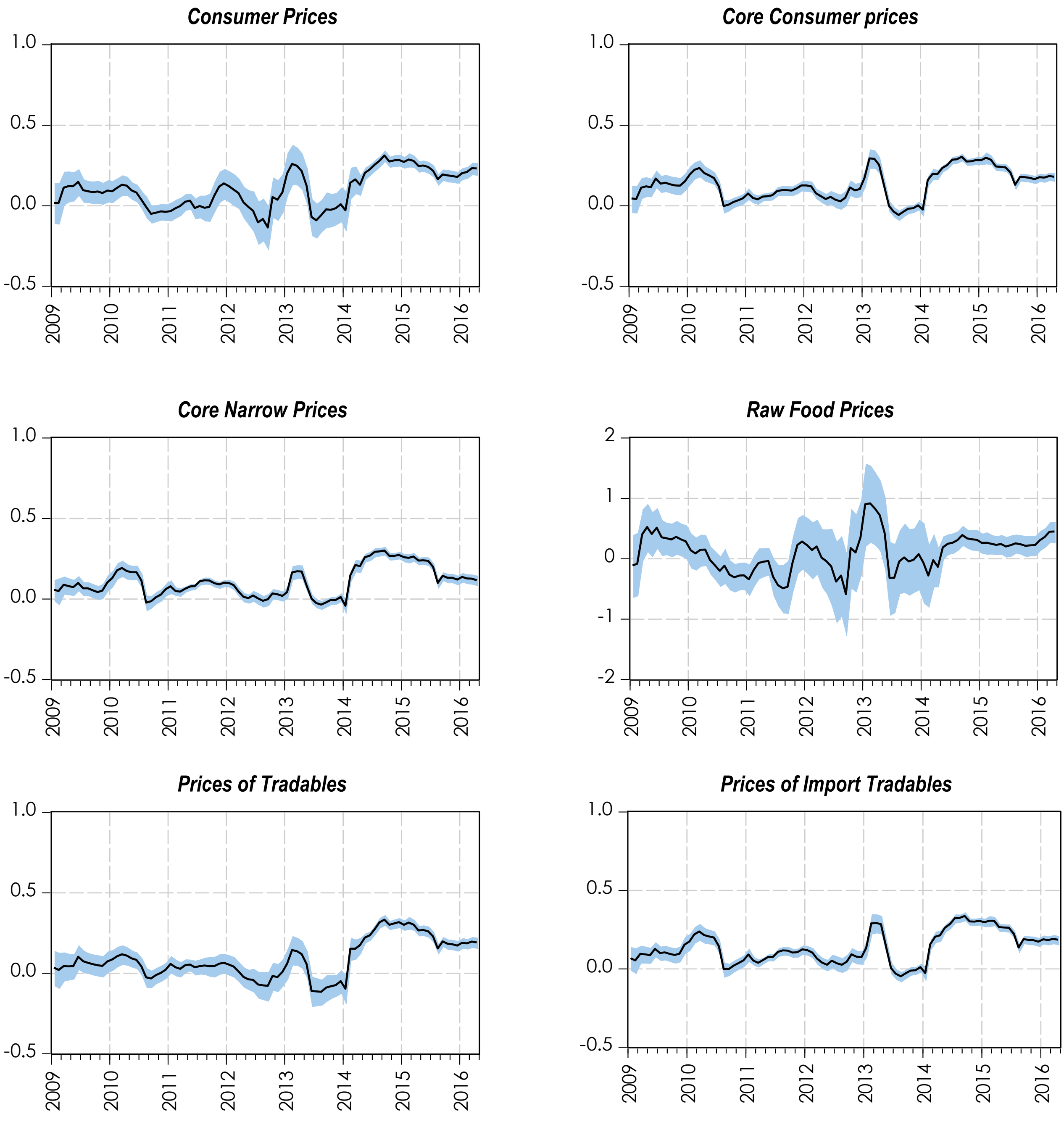


Table 11. US dollar exchange rate pass-through

			Consumer Prices	Core CPI	Raw food	Core food	Core narrow	Tradable	Import Tradable
Linear			0.248 [0.012]	0.275 [0.008]	0.264 [0.054]	0.422 [0.023]	0.243 [0.009]	0.267 [0.01]	0.293 [0.009]
Direction		Appreciation (25% obs.)	0.146 [0.083]	0.011 [0.057]	1.005 [0.381]	0.061 [0.153]	0.151 [0.062]	0.207 [0.073]	0.056 [0.061]
		Depreciation (75% obs.)	0.266 [0.012]	0.294 [0.008]	0.295 [0.053]	0.432 [0.024]	0.266 [0.009]	0.288 [0.01]	0.315 [0.009]
		H_0:		###	##	##	##		###
Size of exchange rate change	γ : 3%	Large change (36% obs.)	0.252 [0.012]	0.279 [0.009]	0.282 [0.054]	0.414 [0.024]	0.252 [0.009]	0.276 [0.01]	0.301 [0.009]
		Small change (64% obs.)	-0.285 [0.161]	0.098 [0.111]	-1.917 [0.74]	-0.077 [0.292]	0.462 [0.119]	0.193 [0.139]	0.343 [0.119]
		H_1:	###		###	##	##		
	γ : 6%	Large change (25% obs.)	0.251 [0.012]	0.277 [0.008]	0.274 [0.055]	0.412 [0.024]	0.249 [0.009]	0.275 [0.01]	0.298 [0.009]
		Small change (75% obs.)	-0.063 [0.06]	-0.085 [0.041]	-0.029 [0.279]	0.060 [0.111]	-0.046 [0.044]	-0.057 [0.052]	-0.061 [0.044]
		H_1:	###	###		###	###	###	###
	γ : 9%	Large change (20% obs.)	0.258 [0.012]	0.278 [0.008]	0.276 [0.055]	0.401 [0.022]	0.253 [0.009]	0.282 [0.01]	0.299 [0.009]
		Small change (80% obs.)	0.058 [0.04]	0.014 [0.027]	0.372 [0.185]	0.054 [0.072]	0.041 [0.028]	0.039 [0.034]	0.026 [0.028]
		H_1:	###	###		###	###	###	###
	γ : 10%	Large change (17% obs.)	0.251 [0.012]	0.277 [0.008]	0.269 [0.056]	0.403 [0.024]	0.249 [0.009]	0.276 [0.01]	0.297 [0.009]
		Small change (83% obs.)	0.267 [0.034]	0.284 [0.024]	0.476 [0.156]	0.347 [0.064]	0.297 [0.025]	0.282 [0.029]	0.316 [0.025]
		H_1:					##		
Size & Direction	γ : 0% & 9%	Large depreciation (19% obs.)	0.256 [0.013]	0.295 [0.009]	0.223 [0.063]	0.538 [0.029]	0.248 [0.01]	0.279 [0.011]	0.311 [0.01]
		Small depreciation (48% obs.)	0.033 [0.058]	0.026 [0.039]	-0.295 [0.27]	-0.010 [0.106]	0.122 [0.041]	0.097 [0.049]	0.058 [0.041]
		Appreciation (33% obs.)	-0.156 [0.079]	-0.217 [0.054]	0.626 [0.371]	-0.188 [0.152]	-0.201 [0.056]	-0.186 [0.067]	-0.205 [0.057]
		H_2:	###	###	##	###	###	###	###
		H_3:	###	###		###	###	###	###
		H_4:	##	###	##		###	###	###

Notes: numbers are ERPT coefficients; numbers in [ ] are standard errors; γ – threshold value.
###, ##, # indicate 1, 5, 10 % significance level to reject linearity hypotheses:
H_0: appreciation = depreciation; H_1: large = small;
H_2: large = small; H_3: large = appreciation; H_4: small = appreciation