Exchange-rate pass-through in Ukraine

Victor Shevchuk[1]

Abstract

The paper provides estimates of the exchange rate pass-through (ERPT) to consumer prices for Ukraine. Using a five-variable VECM (vector error correction model), including the nominal effective exchange rate, consumer prices, terms of trade, the central bank reference rate and output) for the quarterly data of 2002-2019, it has been shown that the long-term ERPT to consumer prices is likely to decrease since the switch to a floating exchange rate regime in 2014. However, it seems to be just the opposite for the short-term estimates of ERPT. As suggested by the forecast error variance decomposition (FEVD), the fraction of exchange rate in the changes of consumer prices is dependent on the ordering of impulse responses, being within the range of 10 to 40%. Regardless of the ordering scheme and data sample used, it is found that the depreciation of a nominal exchange rate has a contractionary effect on output, being in line with the guidelines of a simple AD-AS model with rational expectations. Among other results, the central bank reference rate is increased in response to an exchange rate depreciation, thus offsetting a currency shock. Somewhat surprisingly, the estimates for a shorter 2010-2019 sample reveal that improvement of terms of trade leads to exchange rate depreciation on impact.

Keywords: inflation, exchange rate pass-through, central bank reference rate, Ukraine

JEL Classification: C54, E52, F31

1. Introduction

Since the beginning of 2018, deceleration of consumer price inflation (CPI) in Ukraine from 14 to 4% at the end of 2019 has coincided with a significant appreciation of the exchange rate by 15% over the same period (Fig. 1). As found for the Central and Eastern European (CEE) countries with a flexible exchange rate regime, a high degree of exchange rate pass-through (ERPT) allows to lower inflationary pressure due to nominal exchange rate appreciations (Beirne and Bijsterbosch, 2011). Stronger ERPT can explain the price puzzle when there is an increase in the inflation rate when the interest rate increases (Ali and Anwar, 2016). Among many factors of the ERPT, the degree of price flexibility, the shipping costs, the share of non-traded goods in consumer prices, or the differences in the rate of inflation or monetary policy accommodation are mentioned (Beirne and Bijsterbosch, 2011).

[1] Corresponding author: Cracow University of Technology, Council of Social Sciences, Warszawska 24, 31-155 Cracow, Poland, victorshevchuk@netscape.net.

As there is a limited number of studies that focus on monetary policy issues in the Commonwealth of Independent States (CIS) economies, the main motivation of this study is to measure the magnitude of the ERPT in Ukraine, in the presence of relied macroeconomic developments. We implement vector autoregressive error-correction model (VECM) approach for modeling the ERPT. In the broader context, the knowledge of the link between exchange rate and consumer prices is important for forecasting inflation and monetary policy decision-making, especially in an inflation-targeting framework.

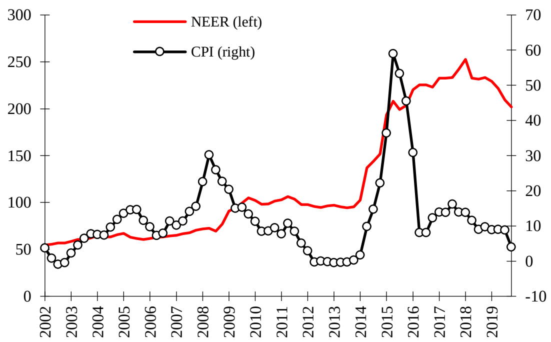


Figure 1. Nominal effective exchange rate (index, 2010=100) and CPI (%), 2002-2019

Note: An increase in the NEER reflects depreciation of the exchange rate.
Source: IMF *International Financial Statistics* (www.imf.org).

The rest of the paper is organized as follows. Section 2 provides a brief outline of analytical issues. Section 3 describes data and outlines statistical methodology. Section 4 discusses empirical results and Section 5 offers some concluding remarks.

2. Analytical framework

The analyses of the ERPT often apply models based on aggregate demand and money demand equations, interest parity equation, import price setting process etc., as in the cases of Boug *et al.* (1994), Barhoumi (2006) or Ali and Anwar (2016). For economies with the financial constraint in real sector, it is reasonable to account for the aggregate supply relationships as well, thus expanding the list of exchange rate transmission mechanisms.

Following Shevchuk (2017), a simple AS-AD model is presented below:

$$y_t = s_1(m_t - E_{t-1}p_t) - s_2E_{t-1}(e_t + p_t^* - p_t) + u_t, \quad (1)$$

$$y_t = a_1(m_t - E_ti_{t+1}) + a_2E_t(e_{t+1} + p_{t+1}^* - p_{t+1}) - a_3r_t + v_t, \quad (2)$$

$$i_t = \gamma p_t + (1-\gamma)(e_t + p_t^*), \quad (3)$$

$$r_t = r_t^* + E_te_{t+1} - e_t - (E_ti_{t+1} - i_t), \quad (4)$$

$$e_t = \rho e_t + \varepsilon_t, \quad (5)$$

where y_t is the is real output, m_t is the money supply, p_t and p_t^*, r_t and r_t^* are domestic and foreign prices and real interest rates, respectively, e_t is the nominal exchange rate (the domestic currency price of foreign currency), ε_t is the transitory component of the exchange rate, i_t is the consumer price index, u_t and v_t are stochastic supply and demand shocks, respectively. All variables, except for r_t and r_t^*, are expressed in logarithms. E_t and E_{t-1} are the expectation operators, denoting expectations made in the periods t and t-1, respectively.

Equation (1) describes the aggregate supply function, with output responding to the amount of real credit (*the financial effect*), and it is negatively related to the relative price (*the price effect*). The decisions made by producers are based on last period's expectations of relative prices. Equation (2) describes aggregate demand for the domestic good as a function of the real money supply (*the wealth effect*), expectations of the relative price (*the price effect*), and the real interest rate. A rise in the foreign price increases aggregate demand, as do the real value of money supply and a decline in the real interest rate. The productivity and demand shocks, u_t and v_t, respectively, are assumed to be expansionary.

Equation (3) defines the consumer price index as a weighted average of the price of domestic goods and the domestic price of foreign goods. In equation (4) the interest rate is specified in real terms as the foreign interest rate plus the expected depreciation of the domestic currency, subtracting the expected rate of inflation. Finally, in equation (5) the exchange rate is modelled as a composite of permanent and transitory components. If the changes in exchange rate are transitory, ρ=0; if they are permanent, ρ=1.

As our focus is on the response of consumer prices to changes in exchange rate, the reduced-form solutions to the system (1)–(5) for the values of output and domestic price level contain only exchange rate variables and stochastic shocks as follows:

$$y_t = \bar{y} - \left(1/_{\Delta_1}\right)[\rho s_1 a_2 + (\gamma - (1-\gamma)\rho))s_2 a_1]e_{t-1} + u_t, \tag{6}$$

$$p_t = \bar{p} + \left(1/_{\Delta_1}\right)[s_2 + \rho a_1 - \rho(1-\gamma)a_1]e_{t-1}$$
$$+ \left(1/_{\Delta_2}\right)\left[(a_2 - \gamma a_3)\frac{s_2 + \rho a_s - (1-\gamma)\rho a_1}{\Delta_1} + \gamma a_3 + (1-\gamma)a_1\right]\varepsilon_t$$
$$+ \left(1/_{\Delta_2}\right)(v_t - u_t), \tag{7}$$

where $\Delta_1 = \gamma a_1 + \rho a_2 + (1-\rho)\gamma a_3 + s_2 - s_1$, $\Delta_2 = \gamma a_1 + \gamma a_3$, $\bar{y}$ and $\bar{p}$ are the equilibrium values of output and domestic price level, respectively.

A temporary depreciation of the exchange rate, ε_t, has no effect on output, but causes changes in the domestic price level. Assuming a permanent depreciation of the exchange rate

$(\rho = 1)$, the magnitude of domestic price effects of e_{t-1} depends on the relative strength of the price effects and the wealth effect in comparison to the financial effect, as well as on the share of domestic goods in the consumer prices. For higher values of γ, an increase in the domestic prices tends to be stronger. If we account for the consumer prices (equation (3)), the condition of a relatively stronger financial effect, i.e. $s_1 > a_1$, in combination with a low share of imported goods in the consumer price index $(\gamma = 1)$ and low price elasticities of both aggregate demand and aggregate supply might bring about the value of ERPT above 1. If imported goods prevail in the consumer prices $(\gamma = 0)$, the degree of the ERPT potentially becomes even larger if the price effects are strong enough. Regardless of the structural features, a permanent depreciation of the exchange rate brings about a decline in output. The intuition behind this result is rather clear. The price effect in the aggregate demand is not sufficient to offset contractionary supply effects. However, the ERPT can be weakened by foreign firms that tend not to increase their prices because of the market share concerns and thus leading to incomplete ERPT (Ali and Anwar, 2016). On the other hand, as the domestic currency appreciates, the foreign firms are likely to reduce their prices.

Many recent empirical studies for the CEE countries, including Beckmann and Fidrmuc (2013), Hajek and Horvath (2015), Jimborean (2013), Kurtovic (2019), are in favour of the incomplete ERPT. However, the ERPT is found to be relatively high and rapid for CIS countries in the case of the nominal effective exchange rate (Comunale and Simola, 2018).

For Ukraine, Faryna (2016) obtained the ERPT at 20–40% for the Ukrainian CPI. In a wider context, a direct link between exchange rate depreciation and prices combined with a contractionary output effect has been found by Shevchuk (2017), even though in a one-equation estimation. However, the reduced form approach is criticized on the basis that it provides very little insight into the way in which the ERPT depends on the supply and demand shocks (Barhoumi, 2006), with a two-way causation between the exchange rate and policy instruments to be of special interest.

3. Data and statistical model

The quarterly series used in the estimates of ERPT are the consumer price index (2010=100, cpi_t, terms of trade (index, 2015=1), tot_t, the National Bank of Ukraine (NBU) reference rate (%), rcb_t, the gross domestic product (in 1994 prices), y_t. The terms of trade index is calculated as the ratio between export prices approximated by the world price indices for metals and agricultural raw materials, with weights based on the share of both subgroups in the Ukraine's exports, and crude oil prices as a proxy for import prices. The data set for the sample period of 2002Q1:2019Q3 has been collected from the IMF International Financial Statistics (IFS) and Ukraine's State Committee of Statistics databases. All data were seasonally adjusted using the Census X12 procedure, except for the CPI.

Both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationarity tests indicate that all the macroeconomic variables are non-stationary in levels and stationary in first differences at the 5% significance level (not reported and available on request). As the variables are best characterized as I(1) process, it is necessary to study for cointegration. According to the Johansen test (Table 1), the null hypothesis of no cointegration is rejected for both the trace test and maximum eigenvalue test, with a cointegration rank of one identified.

Table 1. Johansen Cointegration Test

H_0	Trace Statistic	Critical values (5%)	*p*-value	Max-Eigen Statistic	Critical values (5%)	*p*-value
0	121.30*	88.80	0.00	66.26*	38.33	0.00
1	59.03	63.88	0.22	19.26	32.11	0.71
2	35.78	42.91	0.21	14.17	25.82	0.71
3	21.61	25.87	0.15	12.51	19.38	0.36
4	9.09	12.51	0.17	9.09	12.51	0.17

Note: * denotes rejection of the null hypothesis at the 10% level.

Since all of the variables are I(1) and some of the variables are cointegrated, it is preferable to use the VEC representation of the process instead of the vector autoregressive (VAR) representation. Our reduced form VECM with a cointegration of rank $\boldsymbol{r} < \boldsymbol{k}$ is set up in the form:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-1} + \Phi D_t + \varepsilon_t, \tag{8}$$

where $y_t = (tot_t, cpi_t, rcb_t, e_t, y_t)$ is a $k \times 1$ vector of a time series, α is a $k \times r$ matrix of loading coefficients, β is a $k \times r$ cointegration matrix, Γ_i is a $k \times k$ short-run coefficient matrix, D_t is a vector of independent variables, ε_t is a $k \times 1$ vector of reduced-form disturbances which are assumed to be normally distributed white noise $\mathrm{E}[\varepsilon_t] = 0$ with a constant covariance matrix $\mathrm{E}[\varepsilon_t \varepsilon_t'] = \Sigma_\varepsilon$ and $\mathrm{E}[\varepsilon_t \varepsilon_s'] = 0$ for a $s \neq t$, and Δ is the operator of the first differences.

As mentioned by Beirne and Bijsterbosch (2009), that main drawback of both single equation models and structural autoregression models (SVARs) is that they fail to recognize cointegration, which should be taken into account due to the theoretical co-movement of prices and exchange rates in the long-run. Information contained in levels is particularly relevant for the catching-up economies that experience trend appreciation of their currencies.

In addition to the lagged values of the endogenous variables, the VECM includes a crisis dummy (1 for 2008Q3-2009Q4, 2013Q4-2016Q2 and 0 otherwise) and both current account and financial account balances. The most appropriate model appears to be the one that which permits the intercept (no trend) to enter both the cointegration space and the VAR. Similar to Hajek and Horvath (2015), we use two lags of each endogenous variable, as implied by the Schwarz Information Criterion (SIC) as the most accurate for small samples in conjunction with ensuring lack of any residual problems in the unrestricted VAR. In addition, we impose restrictions on the short-term coefficients for tot_t. It is assumed that short-term dynamics of terms of trade is independent of the long-term factors.

The analysis of impulse response functions (IRFs) at various time horizons allows us to check robustness of the cointegration results as well as identify potential differences (if any) between alternative ordering schemes. Similar to other studies, for example Beirne and Bijsterbosch (2011), McCarthy (2007) or Hajek and Horvath (2015), our VECM-I is based on the following variable ordering: $tot_t \Rightarrow rcb_t \Rightarrow e_t \Rightarrow y_t \Rightarrow cpi_t$. Also, it is possible to argue that this type of ordering reflects the logic of the AD-AS model, as both output and prices result from more exogenous shocks such as changes in terms of trade, interest rate or exchange rate. As found by Comunale and Simola (2018), accounting for commodity prices is important in the ERPT studies for the CIS countries. However, in the spirit of the IS-MP-IA model it seems reasonable that the central bank reference rate becomes more endogenous as compared to inflation and affects the exchange rate on impact, which in turn becomes the factor behind output developments. All said, it provides rationale for such a variable ordering: $tot_t \Rightarrow cpi_t \Rightarrow rcb_t \Rightarrow e_t \Rightarrow y_t$ (VECM-II). Among other considerations, an alternative ordering scheme can be viewed as a form of robustness check for the estimated relationships.

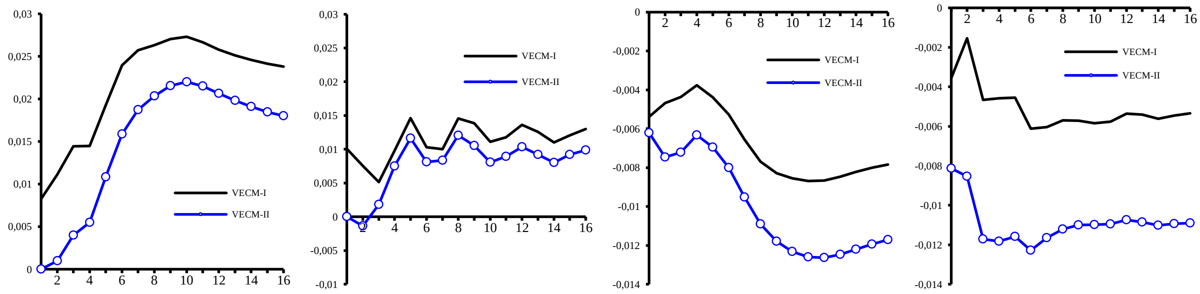
4. Estimation results

The long-run parameters for both 2002-2019 and 2010-2019 samples are presented in Table 2 (in order to determine the ERPT, the results are normalised with respect to consumer prices). The degree of the ERPT seems to be in excess of 1, albeit somewhat weakening over time. Similar to Beirne and Bijsterbosch (2011), our results seem to confirm that the ERPT to domestic consumer prices is higher when some sort of fixed exchange rate is in place. At this point, it is worth mentioning that despite the declaration of a floating exchange regime in 2000 there had been a *de facto* pegging of the Ukrainian hryvnia do the U.S. dollar until 2013. The signs of other parameters are also in accordance with the logic of mainstream economic theory, not only the AD-AS model. Specifically, a positive coefficient on output is consistent with the IS-MP-IA model (Romer, 2000). However, there is no evidence of a stable inverse long-term relationship between the central bank reference rate and consumer prices.

Table 2. Long-term estimates of the ERPT coefficients

Sample	cpi_t	tot_t	rcb_t	e_t	y_t
2002–2019	1.00	–0.71 (0.17)	–0.21 (0.07)	1.44 (0.06)	0.70 (0.20)
2010–2019	1.00	–0.32 (0.17)	0.07 (0.03)	1.11 (0.03)	0.98 (0.31)

Note: Standard errors in parentheses; the sign of the coefficients on tot_t, rcb_t, e_t, and y_t is changed to make interpretation of the results easier.



a) consumer prices ($e_t \Rightarrow cpi_t$) b) output ($e_t \Rightarrow y_t$)

Figure 2. Response of selected variables to exchange rate shock

Note: Hereafter IRFs for the 2002-2019 estimates are on the left panel/side and IRFs for the 2010-2019 estimates are on the right panel/side.

As our primary concern is to estimate the ERPT to consumer prices in line with the output effects, the IRFs to an unexpected increase in the NEER are presented in Fig. 2. For the estimates of the 2002-2019 sample, the exchange rate depreciation increases consumer prices, with the effect strengthening over the period of 4 to 12 quarters time horizon and then starting to somewhat weaken. The estimates for a shorter 2010-2019 sample reveal a similar pattern of the exchange rate effects on consumer prices, regardless of the variable ordering. The same stability of IRFs characterizes the pattern of contractionary exchange rate effects on output as well. Also, it is worth noting that the estimates of the long-run parameters imply an inverse relationship between the exchange rate and output either. Regardless of the ordering scheme and data sample used, our estimates seem to be relevant to the guidelines of the AD-AS model outlined above.

Table 3 provides a summary of the ERPT estimates of the impulse responses at 4, 8, 12, and 16 quarter time horizons. The estimates from the IRFs are much higher for VECM-I, being very close to the cointegration estimates for the 2010-2019 sample. Regardless of the ordering scheme, there is a tendency for the ERPT short-term estimates to increase, which contrasts with an opposite time pattern for the cointegration estimates.

Table 3. Summary of the ERPT short-term estimates

Model	Response of cpi_t to e_t shock				Cointegration
	4 qt	**8 qt**	**12 qt**	**16 qt**	**Long-run**
VECM-I	0.85 (0.73)	0.42 (0.90)	0.32 (0.96)	0.40 (1.04)	1.44 (1.10)
VECM-II	0.16 (0.21)	0.60 (0.44)	0.58 (0.41)	0.30 (0.41)	

Note: Estimates for the 2010-2019 sample in parentheses.

The forecast error variance decomposition (FEVD) confirms that the contribution of the exchange rate shocks to the CPI can be higher during periods of relative exchange rate stability for VECM-I but it is not the case for VECM-II with the inflation shock preceding other macroeconomic developments, including the central bank setting (Table 4). For the latter ordering scheme, a combined share of rcb_t and e_t in the FEVD of cpi_t becomes almost twice as high for a shorter sample of 2010-2019 approaching above 40%. Regardless of the ordering scheme and data sample, the IRFs indicate an increase in the central bank reference rate in response to an exchange rate depreciation (Fig. 3).

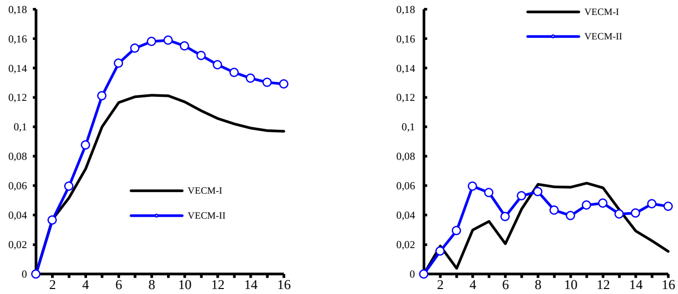


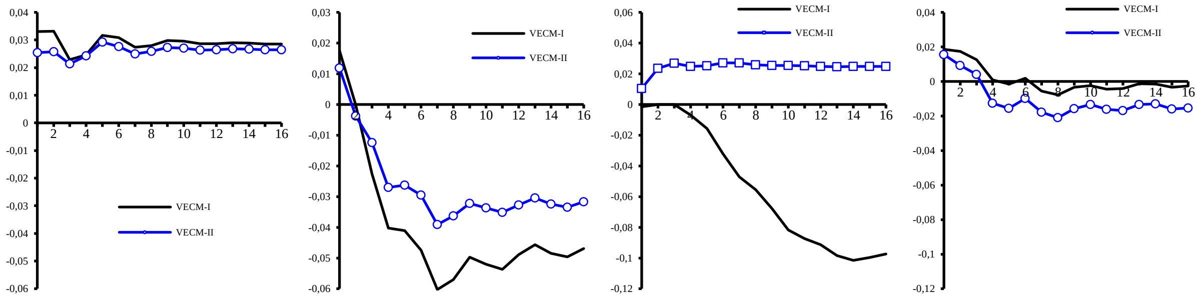
Figure 3. Response of the NBU reference rate to exchange rate shock ($e_t \Rightarrow rcb_t$)

Table 4. Forecast error variance decomposition of consumer prices

Responses of	Innovations in	Model	Forecast horizons			
			4	**8**	**12**	**16**
cpi_t	tot_t	VECM-I	1 (3)	6 (2)	10 (1)	12 (1)
		VECM-II	0 (24)	6 (27)	10 (25)	12 (25)
	cpi_t	VECM-I	56 (47)	37 (42)	28 (42)	24 (42)
		VECM-II	90 (30)	75 (29)	64 (26)	60 (26)
	rcb_t	VECM-I	29 (15)	29 (9)	26 (11)	26 (10)
		VECM-II	4 (29)	5 (25)	5 (23)	5 (23)
	e_t	VECM-I	12 (6)	26 (9)	34 (10)	37 (10)
		VECM-II	1 (15)	11 (17)	18 (18)	20 (18)
	y_t	VECM-I	2 (29)	1 (38)	1 (37)	1 (36)
		VECM-II	4 (1)	3 (2)	2 (8)	2 (8)

Note: Estimates for the 2010-2019 sample in parentheses.

In contrast to the relationships analyzed above, the response of the NEER to the central bank reference rate is different across data samples (Fig. 4). While the IRFs for a 2002-2019 sample indicate a counterintuitive depreciation of the exchange rate, the outcome is more conventional if more recent time series are used. Somewhat surprisingly, estimates for a shorter 2010-2019 sample reveal that the improvement of terms of trade leads to the exchange rate depreciation on impact.



a) to the NBU reference rate ($rcb_t \Rightarrow e_t$) b) to the terms of trade ($tot_t \Rightarrow e_t$)

Figure 4. Response of the NEER to selected endogenous shocks

5. Conclusions

Our findings have clear implications for monetary policy in Ukraine as regards the merits of the exchange rate appreciation as an anti-inflationary and pro-growth tool. Although the long-term ERPT to consumer prices is likely to decrease slightly over time, it is rather high as compared to similar studies for the CEE and CIS countries. Also, it seems that there is an increase in the short-term ERPT. Regardless of the ordering scheme and data sample used, it has been found that the depreciation of a nominal exchange rate has a contractionary effect on output, being in line with the guidelines of the simple AD-AS model with rational expectations. Anti-inflationary effects of an increase in the central bank reference rate are likely to be strengthened by the exchange rate appreciation to follow.

References

Ali, S.Z., Anwar, S. (2016). Can exchange rate pass-through explain the price puzzle? *Economic Letters, 145*(1), 56-59.

Boug, P., Cappelen, Å., Swensen, A.R. (2017). Inflation dynamics in a small open economy. *Scandinavian Journal of Economics, 119* (4), 1010-1039.

Barhoumi, K. (2006). Exchange Rate Pass-Through and Structural Macroeconomic Shocks in Developing Countries: An Empirical Investigation. *MPRA Paper* (6573).

Beckmann, E., Fidrmuc, J. (2013). Exchange Rate Pass-through in CIS countries. *Comparative Economic Studies*, *55*(4), 705-720.

Beirne, J., Bijsterbosch, M. (2011). Exchange Rate Pass-through in Central and Eastern European Member States. *Journal of Policy Modelling*, *33*(2), 241-254.

Comunale, M., Simola, H. (2018). The pass-through to consumer prices in CIS economies. The role of exchange rates, commodities and other common factors. *Research in International Business and Finance*, *44*(C), 186-217.

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

Jimborean, R. (2013). The Exchange Rate Pass-Through in the New EU Member States. *Eco-nomic Systems*, *37*(2), 302-329.

Kurtovic, S. (2019). Exchange rate pass-through to import prices: Evidence from Serbia. *Economics and Business Letters*, *8*(1), 7-16.

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

Romer, D. (2000). Keynesian Macroeconomics without the LM Curve. *Journal of Economic Perspectives, 14*(2), 149-169.

Shevchuk, V. (2017). The Impact of Anticipated and Unanticipated Exchange Rate Variability in Ukraine. *Visnyk of the National Bank of Ukraine*, *241*, 34-47.