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Loom of Symmetric Pass-Through

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Abstract: This paper analyzes the effects of the real policy interest rate on the banking sector lending rate, the deposit rate, real stock prices, and the real exchange rate using the Engle Granger cointegration method (EG), the vector error-correction model (VECM), and the nonlinear vector error-correction model (NVECM) with monthly Turkish data over the period January 2002–April 2018. (1) EG results indicate bivariate cointegration relationships between the real interest rate, lending rates, and the deposit rate. The real interest rate increases all lending rates, mainly the housing rate. However, the long-run coefficient for the real exchange rate is not statistically significant. The pass-through is higher for the deposit rate than for lending rates. Moreoever, real stock prices shrink substantially where the finance sector has been affected the most. (2) VECM results indicate a cointegration relationship between all the variables except for the real exchange rate, which has a statistically non-significant pass-through coefficient. The real interest rate has a noteworthy long-run positive effect on the housing loans lending rate compared to others. The affirmative effect on real stock prices is the highest for the technology sector. The short-run effect of the real interest rate on lending rates, real stock prices and the real exchange rate are statistically non-significant except for the overall stock price index, and the vehicle loans lending rate which has a higher coefficient than the deposit rate. (3) NVECM results allow testing of eleven hypotheses and highlight the symmetric relationship and the valid pass-through effect, and reject the strong exogeneity assumption for all variables.

Keywords: real interest rate; symmetry; pass-through; NVECM

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1. Introduction

Empirical economics indicates that the real policy interest rate has a substantial influence on macro-financial variables in emerging markets. Hikes increase the velocity of money (Sahin 2018), lower demand for cash (Sahin 2013), bind and snag investment, increase savings (Aliravci 2017), appreciate the domestic currency and lead to a wide deduction in net exports (Endut et al. 2018; Bekaert and Hodrick 2014, p. 341).

This paper analyzes the effects of the real policy interest rate on the banking lending rate, deposit rate, real stock prices, and the real exchange rate for Turkey in the period 2001:01–2018:04 by the Engle and Granger (1987) two step cointegration (EG) method, the vector error-correction (VECM) model, and the nonlinear vector error-correction (NVECM) model. The nonlinear model has several advantages over the others. For example, it allows the analysis of the symmetry property of adjustment coefficients for financial and real variables.[1] Another advantage of this model is about an exogeneity assumption

[1] Guney et al. (2015) find nonlinear behavior of real interest rates by Terasvirta (1994)'s linearity test and nonlinear Kopetanios, Shin and Shell (KSS) unit root test and a Smooth Transition Autoregressive (STAR) model, and claim that they are stationary for transition economies.

where some empirical macro-finance models require it for bouncing estimates. For instance, a vector smooth transition regression (VSTR) model is useful in the case of stationary variables and a vector smooth transition error correction (VSMTEC) model for non-stationary variables, which are simply explained by Terasvirta (2017) and necessitate an exogeneity assumption, whilst the NVECM model plausibly makes it possible to test these assumptions within the model. Third, the nonlinear adjustment function has a logistic specification that determines the speed of adjustment and allows for asymmetry. Therefore, by employing the NVECM model, symmetry, completeness and exogeneity hypotheses can be tested for the Turkish economy.

Section 2 provides a literature review. Section 3 presents the data and methodology. Section 4 is devoted to results, and Section 5 contains a discussion. The last section summarizes, emphasizes limitations and presents implications of the paper and suggestions for future research.

2. Literature Review

This section briefly deals with previous empirical studies that have been examined and which concern the effects of the real interest rate on the lending rate, the deposit rate, stock prices, and the real exchange rate. Mora (2014) points out that the effect of the policy rate on the consumer loan lending rate has diminished following the global economic crisis, blaming unconventional monetary policy tools. Sweiden (2011) finds by the asymmetric error correction (AECM) model that there is a complete pass through in Jordan and banks adjust their lending and deposit rates symmetrically where the lending rate adjusts faster. Leroy and Lucotte (2016) consider the policy rate as an endogenous variable, benefit from the panel interacted vector autoregressive (PIVAR) method and find that the competition in banking sector spurs the pass-through to the lending rate and the effect is non-homogenous for European Union (EU) countries. Grigoli and Mota (2017) benefit from asymmetric cointegration methods and explore the asymmetric cointegration between the policy rate and the loan rate by the momentum threshold autoregressive (MTAR) model and the threshold autoregressive (TAR) model when the threshold level is endogenously determined, and explore a higher pass-through coefficient for the lending rate compared to the deposit rate. Yildirim (2014) uses MTAR and TAR methods and finds that an increase in the policy rate also pushes the lending rate up, but a fall in the policy rate drags down it less. Yuksel and Ozcan (2013) find non-stationary results for the policy rate and the lending rates with the augmented Dickey Fuller (ADF) trend and intercept specification and investigate an interest rate pass-through effect using the asymmetric threshold cointegration method. They find a symmetric adjustment for cash, vehicle and commercial loans and asymmetric adjustment for housing loans for Turkey but could not find any for deposit rates. Matemilola et al. (2015) make use of MTAR and TAR models and suggest that the policy rate and the lending rate are cointegrated and adjust asymmetrically, and the adjustment rate is slower during tight monetary policy conditions. Borstel et al. (2016) benefit from the factor-augmented vector autoregressive (FAVAR) model and apply it for EU countries. Stanislawska (2015) explores a long-run pass-through effect of the policy rate on deposit and lending rates for Poland.

Montagnoli et al. (2016) state that banks increase their deposit rates faster when the policy rate shifts upwards compared to a reduction by the nonlinear error correction model (NECM) model for Italy. Becker et al. (2012) assume a weak exogeneity of the policy rate to the market rate that is exogenous to the loan rate and use the nonlinear threshold error correction model (NTECM) for the UK to explore an asymmetry depending on the level of policy rate. Belke et al. (2013) utilize the NECM model and attain heterogeneous results for European countries. Doojav and Kalirajan (2016) explore a long-run pass-through of the policy rate on the lending rate and the deposit rate, and asymmetric linkage by the nonlinear autoregressive distributed lag (NARDL) model for Mongolia. Andries and Billon (2016) provide a substantial symmetry literature review as well as asymmetry for the interest rate pass-through from the policy rate to banking sector rates. As they specify, the competition level of the banking industry is one of influential factors determining the adjustment of deposit and lending rates where low competition creates more stickiness. Apergis and Cooray (2015), after reviewing and reporting the asymmetric interest rate pass-through literature run the NARDL model and reveal a positive asymmetry for the lending rate but a negative asymmetry for the deposit rate for the US, the UK, and Australia. Mustafa and Rahman (1995) detect no long-run relationship between short and long-run rates in research of the US using the EG model. Sarno and Thornton (2003) apply the NVECM model to investigate effects of the policy rate on the three-month Treasury bill rate. Mark and Moh (2005) take nonlinearities into account and find a stronger relationship between the real interest rate differential and the real interest rate in the short-run compared to the long-run. Egorov (2018) uses the ECM model and determines an asymmetric effect of the policy rate on the deposit rate for Russia. Zhang et al. (2017) use the NARDL model for Taiwan and obtain symmetric pass-through to lending rates and fail to find an asymmetric adjustment in the long-run but an adjustment in the short-run for deposit rates. Zulkhibri (2012) benefits from the NECM model and shows that the adjustment of the lending rate is slower than the deposit rate, and the interest rate adjusts faster during monetary easing. Eggertsson et al. (2017) emphasize that negative interest rates are not expansionary and claim that there is a low level of pass-through from the policy rate to lending and deposit rates. Fadiran (2014) uses the EG model to investigate a long-run relationship between the bank deposit rate and the discount rate. Later the author uses the NECM model and obtains mixed results for Brazil, Russia, India, China and South Africa (BRICS) countries. Mora (2014) claims that banks are reluctant to pass market rates to deposit rates when the policy rate is shooting up, but the reverse is true for the loans market. Rocha (2012) makes use of the NECM model and demonstrates that a decrease in the policy rate reduces the deposit rate more compared to an increase for Portugal and reports evidence of an asymmetric adjustment for lending rates.

King (2016, p. 30) remarks that during the saving glut period of the US economy, real interest rates decreased, asset prices revived, house prices increased, the debt level accelerated, and the imbalance in the economy created the recent global crisis. Kohlscheen et al. (2018) benefit from the banking sector data of several emerging economies and explore that an increase in short-term interest rates tends to plunge the return on bank assets but the 10-year bond yield increases it. Rapach et al. (2016) mention that the interest rate is an essential variable for stock price returns. Martinez et al. (2015) determine a negative relationship between interest rates and stock returns using the wavelet method for the Spanish economy. According to Apergis and Eleftheriou (2002), a decrease in interest rate stimulates stock prices. Alam and Uddin (2009) use the method of ordinary least squares (OLS) and find a negative effect of the interest rate on stock prices. Sahin et al. (2009) use the biplot approach and investigate a restricted relationship between stock price returns and the deposit interest rate, but a negative relationship for USD/TRY exchange rate. Sahin (2014) benefits from the quantile regression method and finds the negative symmetric effect of the policy rate on real stock price returns for Turkey. Rizwan et al. (2017b) show a long-run relationship between stock prices, aggregate prices and oil prices by the Johansen cointegration method for Pakistan. Oskooee-bahmani and Saha (2016) prefer the nonlinear autoregressive distributed lag (NARDL) model and explain that an appreciation of the US dollar and a depreciation of the US dollar do not have a same influence on stock prices both in the short-run and long-run. They claim that a strong dollar stimulates stock prices both in the short-run and long-run, but not vice versa. Toraman and Basarir (2014) obtain nonstationary results for the interest rate and stock market capitalization for Turkey and explore a cointegration relationship by the Johansen methodology. Taufeeq et al. (2017) benefit from the NARDL model and detect a nonlinear negative effect of domestic currency depreciation and the interest rate on stock market returns. Stoica et al. (2014) use the VECM model and estimate a negative effect of the policy rate on stock prices for Bulgaria and Latvia. Assefa et al. (2017) state that the effect of interest rate changes on stock price returns is higher for developing countries than for developed countries by the panel generalized method of moments method (GMM). Ferrando et al. (2017) use the quantile regression method for Spain and find a negative effect of 10-year government bond yields on stock price returns and make sectoral comparisons. Jain et al. (2011) detect the negative effect of the policy rate on stock returns for Australia using the exponential generalized conditional heteroscedasticity (EGARCH) model.

Mcdonald and Nagayasu (2000) deduce a cointegration relationship between the real interest rate differential and the real exchange rate using Johansen's and panel cointegration methods for a set of countries.[2] Hyde (2007) estimates the effects of the real exchange rate and the real interest rate on stock price returns. Kim (2003) benefits from Johansen methodology and finds a positive long-run relationship between stock prices and output but a negative relationship between the real exchange rate, the interest rate and the inflation. Andries et al. (2017) benefit from the wavelet based analysis for Romania and obtain a negative accordance in the short-run but this turns out to be positive in the long-run for the policy interest rate and the exchange rate. Narayan and Smyth (2006) detect a long-run relationship for China using the autoregressive distributed lag (ARDL) cointegration test for the real exchange rate, foreign exchange reserves and the real interest rate differential between China and the US. In addition, in the short-run, the real interest rate differential has a negative effect on the real exchange rate. The effect of the policy rate on the expected nominal exchange rate is positive according to results of the VECM model of Sahin et al. (2010). Huang et al. (2016) benefit from the vector autoregressive (VAR) model, which consists of the oil price, the exchange rate, the real interest rate and stock prices where their first differences are taken. The effect of the real interest rate on stock prices is negative. Huang et al. (2017) use daily US data and benefit from the VAR model and find that an increase in the interest rate decreases oil and copper prices and strengthens the US dollar and detect a negative relationship by the dynamic conditional correlation generalized autoregressive conditional heteroscedasticity (DCC-GARCH) model. Sollis and Wohar (2006) investigate a nonlinear relationship between the real exchange rate and the real interest rate differential measured by the difference between the domestic and the US real interest rate for several developed countries. For most of the countries, they find no cointegration and the long-run effect of the real interest rate differential on the real exchange rate is negative. However, nonlinear tests reveal the rejection of no cointegration for most of the countries. Li and Wong (2011) use the VAR model for thirteen countries and find a negative effect of the real interest rate differential on the real exchange rate. Chakrabarti (2006) uses panel data of developed countries and identifies no long-run relationship between real interest rates and real exchange rates. According to Arora and Tanner (2013), an increase in the real interest rate reduces real oil prices by using the VAR model for the US and they obtain a positive response of the real exchange rate to the real interest rate. Rizwan et al. (2017a) benefit from the Johansen cointegration method and investigate a long-run relationship between the interest rate, the exchange rate, stock returns and inflation for the Pakistan economy. Shastri and Shastri (2016) find a long-run relationship between the interest rate, the exchange rate, the money supply, output, and trade and capital flows, and stress the role of structural breaks. Sarac and Karagoz (2016) take the logarithmic first difference of the interest rate and the US dollar exchange rate to ensure stationarity for Turkey and reject the causality from the interest rate to the exchange rate, but not vice versa. Wu (1999) uses the Johansen cointegration method for Japan and acquires a long-run relationship between the real interest rate differential, the real exchange rate and cumulative current accounts. Bonser-Neal et al. (2000) construct a theoretical model for the US and explore a negative effect of the interest rate on the policy rate. Dekle et al. (2001) use data for Korea to realize a negative effect of the interest rate on the exchange rate in the long-run. Hnatkovska et al. (2013) determine a threshold for the exchange rate and find that small changes in the policy rate decrease the exchange rate but high changes increase it (See the parameter estimates for some of these papers mentioned in Table 1).

[2] According to the asset market approach to exchange rate determination, the exchange rate is a function of the foreign interest rate minus the domestic interest rate differential plus expected stock prices (Bekaert and Hodrick 2014, p. 341).

Table 1. Previous selected literature results on the pass-through effect of the policy rate on loan and deposit rates, stock prices and the exchange rate.

Authors	Country	Method	Major Results	L	D	S	E
Mora (2014)	US	Panel OLS	Pass-through effect was weakened for the post 2008 period.	0.58 (a) 0.01 (b)			
Sweiden (2011)	Jordan	AECM	Deposit rates adjust faster than loan rates. Both exhibit symmetric adjustment to the long-run equilibrium. There is a case for a complete pass-through in the long-run.	1.21 (c)	1.09 (c)		
Leroy and Lucotte (2016)	EU	ARDL-ECM IVAR	There is a heterogeneity among EU countries concerning pass-through coefficients explained by several economic and structural factors. Increasing competition in banking sector stimulates the pass-through effect.	0.73 (d) 0.79 (e)			
Grigoli and Mota (2017)	Dominican Republic	MTAR TAR	Complete pass-through to the lending rate and asymmetric adjustment to the long-run equilibrium. Deposit rate and lending rates responds faster to decreases and increases respectively.	0.60–1.20 (f)	0.50–0.70 (f)		
Yildirim (2014)	Turkey	MTAR TAR	Asymmetry in lending rates. The effect of policy rate on loan rates are not the same and there is a downward rigidity.	0.75 (f,g) 1.01 (c,g) −0.04 (f,b) 0.86 (c,h) 0.36 (f,a) 0.94 (c,a) 0.06 (f,i) 0.94 (c,a)			
Yuksel and Ozcan (2013)	Turkey	TAR MTAR	Mixed results for the loan rate adjustment but it is faster than the deposit rate. There is no effect of the policy rate on the deposit rate.	na	na		
Stanislawska (2015)	Poland	DOLS	Complete pass-through. Analyze the topic by the panel data and explores a long-run relationship.	0.99 (a,d) 0.78 (a,e) 0.32 (a,d) 0.66 (f,e)	0.92 (d) 0.96 (e) 0.52 (f,a) 0.53 (f,e)		
Apergis and Eleftheriou (2002)	Athens	IV	It is claimed that stock prices are affected more from the inflation rate than interest rates where both of them decrease stock prices.			0.003 (f)	

Table 1. *Cont.*

Authors	Country	Method	Major Results	L	D	S	E
Alam and Uddin (2009)	South Africa	OLS	Explores a negative effect of interest rate on stock prices.			5.32 (f)	
Narayan and Smyth (2006)	China	ARDL	There is a long-run relationship between the real interest rate and the real exchange rate when foreign exchange rate reserves are included.				0.00 (f)
Shastri and Shastri (2016)	India	Granger	Interest rate has no effect on the exchange rate.				0.177 (o)
Dekle et al. (2001)	Korea	Johansen	Explores a bivariate causal relation between the interest rate and the exchange rate. An increase in interest rate appreciates nominal exchange rate.				−0.43 (c) −0.28 (f)

Notes: L, D is for the loan rate, deposit rate coefficients respectively. S: stock prices. E: exchange rate. na: not available. (a) Housing. (b) Auto. (c) Long-run coefficient. (d) Household. (e) Firms. (f) Short-run coefficient. (g) Cash. (h) Automobile. (i) Commercial. (j) Trace statistics. (k) Positive long-run. (l) Negative long-run. (m) Positive short-run. (n) Negative short-run. (o) Chi-squared statistic. OLS: ordinary least squares. AECM: asymmetric error correction model. IVAR: interacted vector autoregressive model. MTAR: momentum threshold autoregressive model. TAR: Threshodl autoregressive model. DOLS: Dynamic ordinary least squares. IV: Intervention variable model. ARDL: Autoregressive distributed lag model. Granger: Granger causality. Johansen: Johansen cointegration test.

3. Data and Methodology

Monthly seasonally unadjusted Turkish data spanning 2002:01-2018:04 were used for the analyses in this study. Table 2 provides details of the data and its sources. The frequency of the data was chosen as monthly because the interest rate pass-through to other financial variables are not simultaneous and it needs some considerable time for banks to re-allocate their cost structure and implement new rates. Moreover, it is usually assumed that monetary policy does not have a contemporaneous effect on output and inflation as mentioned by papers such as Romer and Romer (2004) and Sahin and Dogan (2017). Therefore, the timing of monetary policy is essential to be considered in academic writing. This lag is high for developing countries since there are substantial imperfections and financial frictions within markets. As mentioned in the previous literature section, the adjustment speed of deposit and credit interest rates is considered as a degree of efficiency and development for financial markets.

The autocorrelation function (ACF) of a nonstationary variable tends to persist with higher time lags (Patterson 2011, p. 26) and consistent with this fact, ACFs are ebbing. *Q*-statistics also reject the null that all autocorrelation coefficients are zero up to certain lags. The augmented Dickey-Fuller (ADF) unit root test results are provided in Table 3 for specifications for the intercept, intercept and deterministic trend, and neither. Lag selection for the ADF test was conducted using the Schwarz information criteria. If the ADF test statistics is less than the critical values in absolute terms then the variable will be called as non-stationary because of failing to reject the unit root hypothesis.[3] It is concluded that, by using graphs of variables, the ADF unit root tests (see Enders 2015, p. 218) and Kwiatkowski et al. (1992)[4] stationarity tests, the cointegration analysis can be implemented.[5]

The EG model was applied to begin the study and see the long-run effect of the real interest rate (*RINT)* on other variables. For this purpose, Equation (1) was initially estimated where all variables are integrated in order one.

$$X_t = Constant + \beta_1 RINT_t + \varepsilon_t \tag{1}$$

In this bivariate specification, if there is a long-run effect of the *RINT* on dependent variables, one should be able to reject the unit root for residuals: see Neusser (2016, pp. 159–60). The Eviews 10.0 program was used for the EG method that employs the ADF test with neither specification for error terms.

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[3] One can see Neusser (2016, pp. 145–48) for a discussion of several specifications of the ADF unit root test. The specification in the ADF test is essential because, as mentioned by Patterson (2011, p. 40), if the data is trend stationary and one takes its first difference to obtain stationarity there may be a negative unit root problem in error terms. Therefore, first differencing may not solve the unit root problem for trend stationary variables. There is also one unique insight on the topic. For instance, according to Popiel (2016), if the unit root is rejected but stationarity is not rejected then the variable is trend stationary. However, if the unit root not rejected but the stationarity is rejected than the variable is a random walk with drift. Financial variables are usually considered to be a random walk process, and are also non-stationary and their first difference should be taken for a difference or covariance stationary process.

[4] The null of this test is stationarity. See Table 4 for results.

[5] Non-stationarity of the interest rate implies that the policy action of a central bank has permanent effects over an interest rate as mentioned by Apergis et al. (2015). Thus, this pre-assumption may have important economic interpretations.

Table 2. Description of the variables.

Variable	Code	Description	Data Span	Source
INTON	TP.PY.P06.ON	Nominal Interest Rate, (ON) Simple Interest Rate Weighted Average (%) (Overnight)-Level	1990M01–2018M04	CBRT, EVDS
INTWAC	TP.APIFON4	Weighted, Average, Cost of Funding, Average cost of funding, Weighted Average, Cost of the CBRT Funding	2011M01–2018M04	CBRT, EVDS
INT	Self-Calculation	INTON + for the *post*-January 2011, INTWAC is used.	1990M01–2018M04	CBRT, EVDS
EINF	TP.BEK.S01.D.A	Arithmetic Mean, Expected Annual CPI Inflation Rate By The End of the Year (%)	2001M08–2018M04	CBRT, EVDS
RINT	Self-Calculation	Exante Real Interest Rate is the wedge between INT and EINF.	1990M01–2018M04	Own Calc.
PERSONAL	TP.KTF1	Personal Loan Lending Rate (TRY, %)-Level	2002M01–2018M04	CBRT, EVDS
VEHICLE	TP.KTF11	Vehicle Loan Lending Rate (TRY, %)-Level	2002M01–2018M04	CBRT, EVDS
HOUSING	TP.KTF12	Housing Loan Lending Rate (TRY, %)-Level	2002M01–2018M04	CBRT, EVDS
COMMERCIAL	TP.KTF17	Commercial Loan Lending Rate (TRY, %)-Level	2002M01–2018M04	CBRT, EVDS
CONSUMER	TP.KTFTUK	Consumer Loan Lending Rate (TRY) (Personal + Vehicle + Housing)-Level	2002M01–2018M04	CBRT, EVDS
RER	TP.RK.T1.Y	CPI Based Real Effective Exchange Rate (2003 = 100)-Level	2002M01–2018M04	CBRT, EVDS
BIST100	TP.MK.F.BILESIK	(Price Indices) BIST-100, According to Closing Price (January, 1986 = 1)-Level	1986M02–2018M04	CBRT, EVDS
BISTSER	TP.MK.F.HIZMET	(Price Indices) BIST-Services According to Closing Price (27-12-1996 = 1046)-Level	1997M01–2018M04	CBRT, EVDS
BISTFIN	TP.MK.F.MALI	(Price Indices) BIST-Financial, According to Closing Price (31-12-1990 = 33)-Level	1991M01–2018M04	CBRT, EVDS
BISTIND	TP.MK.F.SINAI	(Price Indices) BIST-Industrials, According to Closing Price (31-12-1990 = 33)-Level	1991M01–2008M04	CBRT, EVDS
BISTTEC	TP.MK.F.TEKNOLOJI	(Price Indices) BIST-Technology, According to Closing Price (30-06-2000 = 14466.12)-Level	2000M06–2018M04	CBRT, EVDS
DEPS	TP.MT210AGS.TRY.MT03	Up to 6 Months (TRY Deposits)-Level	2000M06–2018M04	CBRT, EVDS
DEPT	TP.MT210AGS.TRY.MT04	Up to 1 Year (TRY Deposits)-Level	2000M06–2018M04	CBRT, EVDS

Notes: The data span provided here gives the maximum available interval. However, in the cointegration analysis of the paper it is restricted to 2002:01–2018:04. Exante *RINT* seems more plausible in the analysis since one does not know the future inflation rate and forms an expectation accordingly. However, the rate of nominal interest is well-known before the transaction for the future release. So *RINT* inherits substantial behavior aspect. The Central Bank of the Republic of Turkey (CBRT) has adopted the overnight interest rate as the short-term interest rate indicator but for the post 2011 period, the weighted average cost of funding is used as the primary monetary policy tool. Thus, the CBRT had used three interest rates to obtain flexibility for adjusting the liquidity in the market. In addition, it can change its interest rate depending on whether the shock is persistent or temporary. The weighted average interest rate is higher than the overnight rates during the post 2011 period so the interest rate variable (*INT*) is compiled by merging these two variables. Otherwise, since the CBRT does not use *INTON* as the monetary policy tool actively, it would not be meaningful to utilize it solely for the post 2011 period.

Table 3. Augmented Dickey-Fuller (ADF) unit root test results.

	Level			First Difference			
Variables	**Intercept**	**Trend and Intercept**	**None**	**Intercept**	**Trend and Intercept**	**None**	**Result**
RINT	−2.0137	−2.6107	−2.6107	−14.6313 ***	−14.5995 ***	−14.6599 ***	I(1)
PERSONAL	−4.4751 ***	−3.4543 **	−3.4403 ***	−9.1038 ***	−9.9335 ***	−8.9488 ***	I(0)
VEHICLE	−3.0553 **	−2.3806	−2.2656 **	−6.8809 ***	−10.8232 ***	−6.8116 ***	I(1)
HOUSING	−3.7495 ***	−2.9446	−3.2554 ***	−9.9387 ***	−10.3186 ***	−9.7774 ***	I(1)
COMMERCIAL	−3.0505 **	−2.3517	−2.1195 **	−4.2238 ***	−4.6356 ***	−4.1626 ***	I(1)
CONSUMER	−4.2642 ***	−4.1203 ***	−3.2327 ***	−8.9886 ***	−9.4375 ***	−8.8493 ***	I(0)
RER	−1.9686	−2.2643	−0.5013	−10.1790 ***	−10.2197 ***	−10.1982 ***	I(1)
BIST100	−0.4509	−3.1440	1.4105	−11.5569 ***	−11.5417 ***	−11.3424 ***	I(1)
BISTSER	0.3560	−2.7679	2.2206 **	−11.3962 ***	−11.4402 ***	−11.0196 ***	I(1)
BISTFIN	−1.3295	−3.3118 *	0.5739	−11.5988 ***	−11.5664 ***	−11.5090 ***	I(1)
BISTIND	1.9803	−0.9606	3.8868 ***	−11.3894 ***	−11.5741 ***	−10.9023 ***	I(1)
BISTTEC	−1.2735	−2.6529	−0.3956	−3.6935 ***	−3.6391 **	−3.6205 ***	I(1)
DEPS	−3.5082 ***	−2.3742	−3.0872 ***	−5.4255 ***	−6.0517 ***	−5.2630 ***	I(1)

Notes: ***, ** and * represent the significance at 1%, 5% and 10% levels respectively.

Table 4. Kwiatkowski et al. (1992) stationarity test results.

	Level		First Difference	
Variable	**Intercept**	**Trend and Intercept**	**Intercept**	**Trend and Intercept**
RINT	1.2933 ***	0.2999 ***	0.1030	0.0480
PERSONAL	1.1324 ***	0.3660 ***	0.8778 ***	0.1433 *
VEHICLE	1.0810 ***	0.3478 ***	0.6732 **	0.0753
HOUSING	1.1315 ***	0.3178 ***	0.5252 **	0.0519
COMMERCIAL	1.0469 ***	0.3827 ***	0.8649 ***	0.1168
CONSUMER	1.1704 ***	0.3486 ***	0.7885 ***	0.1227 *
RER	0.5169 **	0.3807 ***	0.1485	0.0255
BIST100	1.6395 ***	0.0471	0.1485	0.0255
BISTSER	1.7061 **	0.0431	0.1777	0.0573
BISTFIN	1.5641 ***	0.1005	0.0289	0.0287
BISTIND	1.6168 ***	0.2559 ***	0.3979 *	0.0940
BISTTEC	1.1962 ***	0.3325 ***	0.5243 **	0.0849
DEPS	1.0900 ***	0.3168 ***	0.9311 ***	0.1671 **
DEPT	1.1082 ***	0.3169 ***	0.9462 ***	0.1630 **

Notes. ***, ** and * represent the significance at 1%, 5% and 10% levels respectively.

Following unit root tests and the single equation based cointegration method the Johansen (1995) multivariate linear cointegration test based on the vector error correction (VECM) model was applied to see if there is a linear long-run bivariate relationship between variables.[6] It is assumed according to unit root test results that variables were integrated in order one and the VECM analysis can be conducted. Estimations were implemented using the Eviews 10.0 program. Below, the VECM model was written following econometric sources such as Brooks (2014, p. 386), Enders (2015, pp. 373–83) and Pesaran (2015, pp. 523–62). The VECM model[7] is primarily derived from the vector autoregression (VAR) model: The VAR model in Equation (2) is for the specification without trend and constant. Rearranging it yields Equation (3), and for a one period lagged specification, Equation (4) can be written for no intercept or trend in the cointegrating equation (CE) or the VAR model.[8]

$$\text{VAR}: \; y_t = \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} + \ldots + \Gamma_p y_{t-p} + u_t;\; u_t : IID(0, \sigma^2); y_t = [X_t, RINT_t]' \tag{2}$$

$$\Delta y_t + y_{t-1} = \Gamma_1 y_{t-1} + \Gamma_2 (y_{t-1} - \Delta y_{t-1}) + \ldots + \Gamma_p (y_{t-1} - \Delta y_{t-1} - \ldots - \Delta y_{t-p+1}) + u_t \tag{3}$$

$$\text{VECM}: \; \Delta y_t = -\pi y_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + u_t \tag{4}$$

where $\varphi_j = -\sum\limits_{i=j+1}^{p} \Gamma_i$. Note that $\pi = \alpha\beta' = I_m - \Gamma_1 - \Gamma_2 - \ldots - \Gamma_p$ provides the error correction representation where β stands for cointegrating vectors and α is for adjustment parameters. If the rank of the matrix is one (r = 1), that is the number of eigenvalues determining the cointegration relationship, which will be zero otherwise since the eigenvalues will be zero. By the VECM model, one tries to identify stationary linear combinations known as cointegration vectors (Antonucci and Girardi 2006, p. 83). If there is a no cointegration vector, then the linear combination of variables will be non-stationary and the VAR model will be decided on instead. The VECM model with no intercept and no trend specification was represented above but the cointegrating equation or the model may include an intercept or a trend term. Hence, there are five types of VECM[9] specifications and, as mentioned by Johansen and Juselius (1990), the distribution and estimation of the statistics are affected from the type of specification. The number of lags for the Johansen cointegration test specification was chosen by the Schwarz information criterion. This lag is also used in the nonlinear model as suggested by Popiel (2017).

Last, following Popiel (2017), the NVECM model was applied to see if there is a long-run pass-through, an asymmetric adjustment and short-run dynamics. Its advantage over the VECM model is that it considers the potential nonlinearity and asymmetry by a logistic smooth transaction function and it allows the testing of 11 hypotheses within the model. One may also benefit from the exponential version of the transaction function but the logistic version allows one to test the nonlinearity by observing whether the real interest rate is above or below its threshold value. Thus, an

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6 If there is a no cointegration relationship among the variables, Tarak et al. (2014) suggest to using the Granger (1969) test for a short-run analysis. Concerning cointegrated variables, the VECM model may be applied to assess both short- and long-run dynamics. According to Gupta and Singh (2016), if variables are cointegrated, the VECM model's short-run coefficients may be used to test for causality.

7 Khata (2018) suggests using the VECM model if the variables in the VAR model are cointegrated with the EG cointegration test.

8 Since we difference the VAR model to obtain the VECM model, the lag order would be p-1 lags for the latter.

9 The Johansen (1995) cointegration method can only be used if most of the variables are integrated in order one. However, the variables may be fractionally integrated and in this palpable case, the fractionally cointegrated vector autoregressive model (FCVAR) of Johansen (2008) and Johansen and Nielsen (2010, 2012, 2014) can be used instead. An application of this model to the political economy can be found in Jones, Nielsen and Popiel (2016). If Kwiatkowski Phillips Schmidt Shin (KPSS) and ADF unit root tests are both rejected, then there will be a case of fractional time series according to Jones et al. (2014, p. 16). A Geweke Porter Hudak (GPH) test can be applied if there is a case of fractional integration. The results can be obtained using the computer program that is provided by Nielsen and Popiel (2016). ACFs decay hyperbolically for the fractional process but for stationary process ACFs decay geometrically (see also Jones et al. 2014, pp. 14–15).

asymmetric behavior between an increase in the real interest rate changes compared to a threshold can be resolved. If the threshold is zero, then the asymmetry will be interpreted by using a positive or negative terminology because there is no square exponent unlike the exponential version. Since the effect of the policy rate on financial indicators may differ depending on the sign of the change, there may be potential adjustment costs and an increase may have different effect than the decrease. Another advantage of the model relates to the exogeneity of the policy rate, which the NVECM model allows to be tested. Equation (5) is used for the NVECM model where linear and nonlinear combinations are provided as follows:

$$\Delta y_t = \alpha(X_t + \beta RINT_t + Constant) + \delta \frac{1}{\left[1+e^{\psi(X_t+\beta RINT_t+Constant)}\right]}(X_t + \beta RINT_t + Constant) + \sum_{i=1}^{k} \Gamma_i \Delta y_{t-i} + \varepsilon_t \quad (5)$$

where, again $y_t = [X_t, RINT_t]'$ and ε_t is independently and identically distributed with zero mean and constant variance covariance matrix. $\alpha = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$ $\delta = \begin{bmatrix} \delta_1 \\ \delta_2 \end{bmatrix}$ $\Gamma = \begin{bmatrix} \Gamma_1 \\ \Gamma_2 \end{bmatrix}$ where α is the linear adjustment coefficient; δ is the nonlinear adjustment coefficient; the first subscript is for the policy rate; the second subscript is for the other variable concerned; and the parameter ψ determines the behavior of the logistic function.

4. Results

Table 5 provides EG results and we may claim that there is a cointegration relationship between *VEHICLE-RINT*, *HOUSING-RINT*, *COMMERCIAL-RINT* and *DEPS-RINT*. According to the EG first step specification, the real interest rate increases all lending rates, chiefly the housing loan rate, as was expected. The pass-through is higher for deposit rates than for lending rates, while it decreased financial share prices the most. However, the long-run coefficient for the real exchange rate is not statistically significant.

Trace statistics are used for testing the null of no cointegration (H_0: rank (π) = 0). The results of the VECM model with intercept, no trend in the cointegrated equation and no intercept in the VAR specification, which has the lowest Shwartz bayesian criteria (SBC) compared to the other specifications, and trace statistics are provided in Table 6. The detailed results for the other specifications will be provided by the author upon request. Table 7 summarizes results for all five specifications. It is concluded that, except for the real exchange rate, there is a cointegration relationship among variables that is detected with the trace statistics.

An example for how to interpret results is as follows for *VEHICLE*, the intercept, no trend in the cointegration equation and no intercept in the VAR representation:

$$\Delta Vehicle = -0.06 * (Vehicle_{t-1} - 1.53 * RINT_{t-1} - 11.86) + 0.18 * \Delta Vehicle_{t-1} + 0.14 * \Delta RINT_{t-1}$$

Here in the long-run, the real interest rate has a substantial positive influence on the lending rate. In the short-run, the effect is positive with a coefficient of 0.14. The adjustment coefficient is -0.06 and it is the highest for *VEHICLE* compared to the other loan types and even the deposit rate which is consistent with Sweiden's results (Sweiden 2011). To summarize general findings for this specification the real interest rate has a noteworthy long-run positive effect on the housing lending rate compared to others. The pass-through coefficient is positive for the real exchange rate as expected but it is not significant.[10] However, the effect on real stock prices is the highest for the technology sector and a

[10] There are several puzzles in the empirical macro-finance literature that are perceived to be unusual. Sever and Mizrak (2007) found a positive response of the exchange rate to the interest rate using the VAR, and its explanatory role is very restricted in the decomposition analysis. Karaca (2005) did not find a long-run relationship between the interest rate and the exchange rate using the ARDL model for Turkey. However, in the short-run, the effect of the interest rate is not clear but is positive for the floating regime period.

statistically significant positive result as expected in terms of the economic theory was obtained. For short run coefficients, the effect of the real interest rate on the lending rate is positive as expected for all loan types but only significant for the vehicle lending rate. Even this is higher than the result for the deposit rate. The effects on the real exchange rate and stock prices are all non-significant except for the overall index.[11]

As a next step, the following 11 hypotheses were tested within the NVECM model for the same specification with the intercept, no trend in the cointegration equation and no intercept in the VAR model. The test statistics of the hypothesis was generated by a wild bootstrap method with 5000 bootstrap samples using the MATLAB R2017b computer program following Popiel (2017)[12]. The results are provided in Tables 8 and 9.[13]

Hypothesis 1 (Symmetry). $H^{\delta}_{1,2} : \delta_1 = \delta_2 = 0$ *tests the asymmetric adjustment in the error-correction. Note that if the adjustment parameter for the nonlinear part of the NECM model is zero, then we conclude that the model is linear. If the symmetry hypothesis is rejected, then the adjustment to the long-run equilibrium following a policy shock is asymmetric. Adjustment is symmetric for all variables and it is evident that the response of variables to the real interest rate does not depend on the sign of the shock. This symmetry finding is consistent with the results by Yuksel and Ozcan (2013) and Zhang et al. (2017). Moreover, adjustment parameters are nearly zero.*

Hypothesis 2 (Completeness). $H^{\beta} : \beta = -1$ *tests the complete pass-through. This hypothesis concentrates on the long-run equation and tests the long-run effect of the policy rate on financial variables. Null of completeness is failed to be rejected for all variables. Note that coefficients are all 1.000, as is provided in Table 9. However, pass-through coefficients obtained from the EG method were higher than one.*

Hypothesis 3 (Weak Exogeneity for the Market Rate). $H^{\alpha,\delta}_1 : \alpha_1 = \delta_1 = 0$ *is for the weak exogeneity of the market rate. Here if the null hypothesis cannot be rejected, it is assumed that the policy rate does not have a long-run effect on financial variables. This hypothesis is rejected for housing, commercial loans, service sector stock prices and the deposit rate.*

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[11] Also considering the no-cointegration relationship results from three out of five specifications and the non-significance effect in the short-run and the long-run, there seems to be a weak interaction between the real interest rate and the real exchange rate. This result is also consistent with those of Chakrabarti (2006), Sarac and Karagoz (2016).

[12] I would like to thank Michal Ksawery Popiel for proving me the MATLAB codes of the NVECM model and allowing me to use it in this paper.

[13] One may claim that there may be an omitted variable bias problem since some of the potential explanatory variables are excluded from the model. However, the aim of the paper is to compare impacts and analyze signs assigned by the regression. Embracing the possibility of criticism, bivariate cointegrated equations allow us to do that. Moreover, within the literature there are so many studies conducted with two economic variables, which have a possibility to inherit omitted variable bias since in economics nearly all variables are interact with each other. For instance, variables such as the US interest rate, inflation rate, and uncertainty have a potential to affect both RINT and RER. However, it is assumed that RINT is determined independently by the CBRT. Thus, this explicit exogeneity assumption allows one to conduct analysis by two variables without any need to consider a potential bias. There are also some papers, such as Grigoli and Mota (2017) benefiting from control variables like the reserve requirement ratio, nonperforming loans ratio, EMBI spread and VIX index to account for the other effects rather than the policy rate. Narayan and Smyth (2006) include foreign exchange reserves and find a cointegration using ARDL between the real interest rate and the real exchange rate emphasizing the omitted variable bias on the relationship. This paper follows the thought of Popiel (2017)'s bivariate structure that seems a more robust way to compare effects of explanatory variables. Moreover, following Apergis (2015) and Usman and Elsalih (2018), it is assumed that effects of control variables are captured in stochastic terms and the adjusted R^2 is sufficiently high. For a simple OLS approach, an instrumental variable that is not correlated by error terms but correlated with the real interest rate may be useful (see Wooldridge 2009, pp. 506–10).

Table 5. Engle and Granger (1987) cointegration test results.

	VEHICLE	HOUSING	COMMERCIAL	RER	BIST100	BISTSER	BISTFIN	BISTIND	BISTTEC	DEPS
Constant	12.8026 ***	11.3609 ***	12.2197 ***	107.1207 ***	70,252.88 ***	47,382.33 ***	97,550.41 ***	64,378.19 ***	36,201.33 ***	9.4812 ***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
RINT	1.6443 ***	1.7706 ***	1.7384 ***	−0.2245	−4167.96 ***	−3022.32 ***	−5742.61 ***	−3914.85 ***	−2318.79 ***	1.9618 ***
	[0.0000]	[0.0000]	[0.0000]	[0.1529]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Adjusted R^2	0.6319	0.6361	0.6250	0.0054	0.5476	0.5574	0.6154	0.4088	0.1471	0.6264
F statistics	335.73 ***	341.90 ***	326.04 ***	2.0596	237.05 ***	246.55 ***	313.02 ***	135.81 ***	34.62 ***	328.01 ***
Mean dependent var	19.5458	18.6219	19.3487	106.2001	53,160.70	34,988.24	74,000.86	48,324.00	26,692.30	17.5261
S.D. dependent var	10.1298	10.8715	10.7676	10.7408	27,564.18	19,813.59	35,843.66	29,919.25	29,222.11	12.1372
Schwarz criterion	6.5131	6.6428	6.6536	7.6242	22.5368	21.8547	22.8998	22.9685	23.2878	6.8893
Durbin-Watson stat	0.1605	0.1607	0.1293	0.0912	0.1053	0.0976	0.1531	0.0582	0.0220	0.1120
ADF test	−4.7997 ***	−3.7029 **	−4.5707 ***	−1.9265	−1.4418	−1.0135	−2.4326	−0.0466	−1.4690	−4.4114 ***
Result	Cointeg	Cointeg	Cointeg	No Cointeg	No Cointeg	No Cointeg	No Cointeg	No Cointeg	No Cointeg	Cointeg

Notes: ***, ** and * represent the significance at 1%, 5% and 10% levels. *p*-values are provided within the brackets. ADF test for cointegration: without constant term.

Table 6. Johansen (1995) vector error-correction model (VECM) intercept, no trend in cointegrating equation (CE)—no intercept in vector autoregression (VAR) specification results.

Panel A	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*
$RINT_{t-1}$	1.5388 ***	1.6072 ***	1.2727 ***	−0.1797	−9056 ***	−6537 ***	−10,559 ***	−12,286 ***	−32,133 ***	−0.5033 *
	[−5.7935]	[−6.0709]	[−5.8049]	[0.2406]	[5.6238]	[5.6889]	[5.8047]	[5.2650]	[4.7885]	[1.7208]
Constant	11.8637 ***	10.2932 ***	11.7575 ***	105.33 ***	88,546 ***	60,368 ***	114,689 ***	96,912 ***	17,2084 ***	12.35 ***
	[−7.0607]	[−6.1604]	[−8.6325]	[−22.2142]	[−7.3508]	[−6.9533]	[−8.4868]	[−5.4681]	[−3.3708]	[−5.6394]
Panel B	***AA***	***BB***	***CC***	***DD***	***EE***	***FF***	***GG***	***HH***	***II***	***JJ***
□	−0.0674 ***	−0.0567 ***	−0.0646 ***	−0.0526 **	−0.0043	−0.0028	−0.0075	−0.0018	−0.0013	−0.026 ***
	[−3.9637]	[−4.5927]	[−5.6256]	[−2.4936]	[−1.0280]	[−0.8478]	[−1.2840]	[−0.7196]	[−1.4392]	[−7.4039]
ΔX_{t-1}	0.1847 ***	0.3389 ***	0.1623 **	0.3052 ***	0.1974 ***	0.2257 ***	0.1833 ***	0.2365 ***	0.2844 ***	0.238 ***
	[2.8691]	[5.3936]	[2.4150]	[4.3778]	[2.8120]	[3.2309]	[2.6068]	[3.4044]	[3.8901]	[3.6981]
$\Delta RINT_{t-1}$	0.1443 *	0.1087	0.0286	−0.0831	0.4059 ***	−4.2314	18.7115	−9.8105	6.6384	0.027 ***
	[1.7775]	[1.6279]	[0.4599]	[−0.4590]	[0.0094]	[−0.1728]	[0.2689]	[−0.2833]	[0.1900]	[3.0970]
Adjusted R^2	0.1422	0.2105	0.1779	0.0943	0.0090	0.0014	0.0188	−0.0053	0.0372	0.3598
F statistics	16.9994	26.7270	21.8795	11.0508	1.8963	1.1380	2.8973	0.4756	4.8303	56.6461
SBC	3.5193	3.1290	3.0160	5.1560	19.0304	17.9049	19.9984	18.6086	18.6419	2.2128

Notes: ***, ** and * represent the significance at 1%, 5% and 10% levels. *t* statistics are given in square brackets. Panel A is for the cointegrating equation. Panel B is for the error correction representation: in the form of $\Delta y_t = Constant + □ y_{t-1} + \Sigma \varphi y_{t-j} + u_t$ where *X* is for the other variables rather than *RINT* in the matrix *y*. Lag length is determined according to SBC criteria using a VAR model. For the VECM $p-1$ of the determined lag length is utilized. *A*: $VEHICLE_t$; *B*: $HOUSING_t$; *C*: $COMMERCIAL_t$; *D*: RER_t; *E*: $BIST100_t$; *F*: $BISTSER_t$; *G*: $BISTFIN_t$; *H*: $BISTIND_t$; *I*: $BISTTEC_t$; *J*: $DEPS_t$; *AA*: $\Delta VEHICLE_t$; *BB*: $\Delta HOUSING_t$; CC: $\Delta COMMERCIAL_t$; *DD*: ΔRER_t; *EE*: $\Delta BIST100_t$; *FF*: $\Delta BISTSER_t$; *GG*: $\Delta BISTFIN_t$; *HH*: $\Delta BISTIND_t$; *II*: $\Delta BISTTEC_t$; *JJ*: $\Delta DEPS_t$.

Table 7. Johansen (1995) unrestricted cointegration rank test, trace statistics.

	A		B		C		D		E	
VEHICLE-RINT, None	13.2142	**	25.6616	***	24.0695	***	26.7315	**	22.3681	**
At Most 1	6.2785	***	6.3667		5.3547	***	5.5998		2.7697	*
HOUSING-RINT, None	19.2209	***	32.2163	***	29.6814	***	30.8422	**	25.4239	***
At Most 1	7.5229	***	7.5345		6.1960	**	6.4863		3.3024	*
COMMERCIAL-RINT, None	23.6955	***	45.3370	***	41.8233	***	47.8005	***	36.9373	***
At Most 1	7.6138	***	8.2132	*	7.2919	***	7.7924		4.0771	**
RER-RINT, None	4.7560		12.5088		12.2428		23.8010	*	23.2717	***
At Most 1	0.5923		4.1269		4.0906	**	5.4248		4.9064	**
BIST100-RINT, None	17.4249	***	28.9670	***	25.4044	***	35.8385	***	35.5185	***
At Most 1	2.0476		3.5903		0.1849		10.3452		10.1038	***
BISTSER-RINT, None	20.1182	***	31.3291	***	25.4598	***	33.9946	***	32.9363	***
At Most 1	4.9660	**	5.8539		0.1111		8.5148		7.5342	***
BISTFIN-RINT, None	15.8277	**	29.8844	***	28.1020	***	37.4560	***	37.3499	***
At Most 1	0.3417		3.2116		1.5846		10.9081	*	10.9038	***
BISTIND-RINT, None	24.1072	***	32.3039	***	25.0019	***	30.4133	**	27.3593	***
At Most 1	8.9048	***	8.9733	*	1.7819		3.7285		0.8291	
BISTTEC-RINT, None	22.2851	***	28.7909	***	24.3448	***	32.6805	***	26.9095	***
At Most 1	7.0632	***	7.1117		2.9751	*	5.6513		0.0024	
DEPS-RINT, None	40.3097	***	61.5301	***	66.0163	***	68.6582	***	47.3229	***
At Most 1	8.7830	***	10.2616	**	21.9945	***	24.5906	***	20.7384	***

Notes: Hypothesized number of cointegrating equations are used to test for the long-run relationship. A: No intercept or trend in CE or VAR; B: Intercept (no trend) in CE no intercept in VAR; C: Intercept (no trend) in CE and VAR; D: Intercept and trend in CE no trend in VAR; E: Intercept and trend in CE linear trend in VAR. ***, ** and * represent the significance at 1%, 5% and 10% levels.

Table 8. Likelihood ratio test statistics for the hypotheses.

	1	2	3	4	5	6	7	8	9	10	11
VEHICLE-RINT	11.17 [0.20]	2.22 [0.30]	10.31 [0.12]	1.78 [0.37]	4.82 [0.42]	0.30 [0.70]	0.74 [0.53]	2.52 [0.53]	3.29 [0.54]	0.73 [0.53]	5.55 [0.54]
HOUSING-RINT	10.47 [0.14]	2.78 [0.23]	14.17 * [0.05]	3.40 [0.21]	3.91 [0.42]	1.14 [0.46]	0.52 [0.57]	3.92 [0.39]	1.65 [0.69]	0.52 [0.57]	4.43 [0.56]
COMMER-RINT	8.97 [0.26]	0.96 [0.44]	23.26 * [0.05]	3.90 [0.22]	4.37 [0.39]	2.94 [0.25]	0.00 [0.95]	3.90 [0.37]	3.45 [0.46]	0.00 [0.95]	4.37 [0.54]
RER-RINT	0.69 [0.90]	0.96 [0.61]	3.16 [0.25]	0.95 [0.57]	1.45 [0.72]	0.13 [0.77]	0.14 [0.77]	EXP EXP	0.64 [0.81]	0.14 [0.78]	1.60 [0.85]
BIST100-RINT	7.10 [0.21]	2.52 [0.57]	−0.00 [0.40]	−0.00 [0.99]	0.60 [0.86]	0.16 [0.77]	1.09 [0.39]	2.68 [0.75]	0.90 [0.69]	−0.00 [0.11]	3.64 [0.39]
BISTSER-RINT	7.68 [0.28]	EXP EXP	−0.00 ** [0.03]	−0.00 [0.94]	0.36 [0.82]	EXP EXP	EXP EXP	EXP EXP	0.43 [0.79]	−0.00 [0.15]	0.43 [0.82]
BISTFIN-RINT	1.28 [0.72]	6.10 [0.21]	−0.00 [0.39]	−0.00 [0.99]	3.43 [0.22]	0.34 [0.69]	3.71 [0.10]	6.43 [0.35]	1.03 [0.67]	−0.00 [0.12]	7.14 [0.15]
BISTIND-RINT	9.95 [0.27]	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP
BISTTEC-RINT	16.83 [0.16]	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP	EXP EXP
DEPS-RINT	2.79 [0.49]	0.36 [0.62]	24.72 * [0.09]	4.89 [0.19]	4.42 [0.50]	4.76 [0.18]	0.23 [0.63]	5.13 [0.36]	4.62 [0.46]	0.24 [0.72]	4.66 [0.58]

Note: ***, ** and * is for the rejection of null hypothesis at 1%, 5% and 10% levels respectively. *p*-values are reported in brackets. Likelihood ratio statistics are not reported if the characteristic roots are inside the unit circle. EXP indicates that roots are explosive.

Table 9. Coefficient estimates.

Variables	β	*Constant*	α_1	α_2	δ_1	δ_2	Ψ
VEHICLE-RINT	−1.000	−13.277	−0.061	−0.000			
HOUSING-RINT	−1.000	−11.633	−0.048	0.000			
COMMERCIAL-RINT	−1.000	−12.266	−0.062	0.000			
RER-RINT	−1.000	−100.734	−0.049	0.000			
BIST100-RINT	−1.000	−96,408	−0.008	0.000	0.000	−0.000	0.000
BISTSER-RINT	−1.000	−171,100	−0.002	0.000	0.000	0.000	0.000
BISTFIN-RINT	−1.000	−111,801	−0.013	0.000	0.000	0.000	0.000
BISTIND-RINT	−1.000	36,312	0.006	0.000	0.000	0.000	0.000
BISTTEC-RINT	−1.000	40,640	0.007	0.000	0.000	−0.000	0.000
DEPS-RINT	−1.000	−9.244	−0.036	0.000	0.000	−0.000	0.000

Hypothesis 4 (Weak Exogeneity for the other Variables). $H_2^{\alpha,\delta}$: $\alpha_2 = \delta_2 = 0$ *is for the weak exogeneity of the other variables. It is failed to be rejected for all cases. See also Pfaff (2008) which presents the VECM method using a weak exogeneity test for the adjustment coefficients in the cointegrating vector where those should be zero for not being rejected.*

Hypothesis 5 (Strong Exogeneity). $H_i^{\alpha,\delta,T}$: $\alpha_i = \delta_i = \Gamma_{s,i} = 0$*tests the strong exogeneity of the real interest rate for s = 1, . . . , k and $i \in \{1, 2\}$. This hypothesis cannot be rejected for all variables. In a multiple equation context, if the correlation between the dependent variable and the error term, besides the residuals of the autoregressive model of the independent variable are zero it is called strongly exogenous, but weakly exogenous if only the independent variable and error terms are not correlated (Yusupov 2010, p. 27). A review and further debate on the exogeneity in a multiple framework can be found in Johansen (1991) and Urbain (1992). As a result, the exogeneity in NVECM is not based on the exogenous explanatory assumption of OLS, where the correlation between the explanatory variable and the error term is assumed to be zero. The EG approach allows* *interpretation of results as endogenous and exogenous, but in Johansen's method all variables are assumed to be endogenous. Moreover, in the NVECM framework, the exogeneity is different from the exogenous variable in simultaneous equation models (see Wooldridge 2009, p. 548) where exogeneity is not determined within the model. NVECM allows the testing of exogeneity of variables within the model by considering its time structure. If it is in the strong exogeneity form, the variable concerned will not respond to the policy rate in the long-run and short-run. However, for weak exogeneity it only responds in the short-run.*

Hypothesis 6. $H_2^{\alpha} \cap H^{\beta} / H^{\beta}$. *The hypothesis cannot be rejected for all variables.*

Hypothesis 7. $H_2^{\alpha} \cap H^{\beta} / H_2^{\alpha}$. *The hypothesis cannot be rejected for all variables.*

Hypothesis 8. $H_2^{\alpha} \cap H^{\beta}$. *The hypothesis cannot be rejected for all variables.*

Hypothesis 9. $H_2^{\alpha,\delta,\Gamma} \cap H^{\beta} / H^{\beta}$. *The hypothesis tests for strong exogeneity and complete pass-through. The hypothesis cannot be rejected for all variables.*

Hypothesis 10. $H_2^{\alpha,\delta,\Gamma} \cap H^{\beta} / H^{exo}$ *is for complete pass-through conditional on the strong exogeneity of the real interest rate. This hypothesis cannot be rejected for all variables.*

Hypothesis 11. $H_2^{\alpha,\delta,\Gamma} \cap H^{\beta}$ *is for the joint hypothesis of complete pass-through and the strong exogeneity of the real interest rate. This hypothesis cannot be rejected for all variables.*

5. Discussions

Economists usually tend to suggest increasing interest rates substantially, such as Paul Volcker in the US. Paul Volcker increased interest rates from 11.40% to 17.60% during the years 1979–1980 under the capping disinflation program (see Blanchard 2011, pp. 196–97). Central banks such as the Fed tend to increase interest rates above the inflation rate aggressively as in the Volcker reform period (1979–1982), where the average policy rate was 14.36% and consumer inflation was 10.15% (Gavin 2018, Table 1). A similar attempt was made by the Central Bank of the Republic of Turkey (CBRT) by spiking the real interest rate nearly 400 basis points to combat two-digit level inflation. Note that in 2005 the CBRT started targeting inflation and the main policy rate has been the interest rate that is determined by the monetary policy committee of the CBRT. The CBRT follows the shocks keenly and considers their permanent vs. transitory positions before taking an action. In particular, policy agendas of central banks inherit and influence strategy over the exchange rate, which is one of the most important determinants of inflation. However, the results in this study indicate a restricted role for the real interest rate to appreciate the domestic currency.

During times when the US benchmark real interest rate is higher than other major countries' interest rates, the US dollar tends to become stronger (Bekaert and Hodrick 2014, p. 345). Policy makers in Turkey tend to consider this interest rate parity rule and increase interest rates when the real effective exchange rate goes down.[14] This mechanism is especially important for developing countries that have a problem of foreign debt, one of the biggest obstacles for economic development (Sahin 2005). Moreover, an increase in the exchange rate leaks into the domestic currency-denominated foreign debt (Sahin and Sahin 2014). Hence, developing countries are dependent on financing their growth with foreign liquidity. Their saving rates are lower than their investment levels, which maken an inefficient contribution to growth rates (see Sahin 2017) and they have yawning current account

[14] As mentioned in the Monetary and Exchange Rate Policy Report for the year 2017, the CBRT does not allow a depreciation or appreciation of the Turkish lira if the movement is not consistent with the economic basis by referring to financial stability. This statement is also consistent with Gerber (2014, chp. 10) which claims that the exchange rate is determined by financial developments in the short-run but economic fundamentals during longer horizons.

deficit problems. Consequently, taking sufficient measures to improve the degree of pass-through to the exchange rate will enchance stability.

Stock prices reflect the future economic situation of the economy and the tremulous behavior of players. Real interest rate movements, in particular, are one of the critical signals for stock price returns and they respond to them precipitously.[15] However, there is also a substantial behavior aspect in the very high frequency movements in economic terms. The players in the financial market attach different meanings to holding, increasing or decreasing policy rate decisions of a central bank. For instance, on 28 May 2018 the CBRT announced that it would use the one-week repo rate as the policy rate and that it would be set equal to the current funding rate of 16.50% starting from 1 June 2018. Therefore, the CBRT turned from three different interest rate policy rates to a one-interest-rate policy to simplify its tools. One can observe the behavior aspect of this change since the effect of the real interest rate on the stock market or other interest rates also has a behavior outlook. Stock prices reacted positively to the simplified interest rate policy of the CBRT with a bountiful return of 3.22% as of 28 May 2018; however, one would expect the reverse in terms of economic theory. Normally, loan interest rates or deposit interest rates should react to interest rate hikes but the adjustment speed has not been sufficient for the last couple of years. In particular, there is substantial heterogeneity at the micro-level and some banks may adopt very low deposit interest rates. Additionally, price differentiation is applied, which works as very low interest rates for small amounts of deposits and very high rates for greater amounts. Deposit and lending rates may vary even between different branches of the same bank. In particular, if the liquidity needs of a bank increases to meet the legal obligations of the authority and regulations, it may increase the deposit rate substantially for a period.[16] Since the real interest rate hikes reduce the liquidity in the market, banks usually are inclined to increase their interest rates. The second example of a behavioral aspect is that the Borsa Istanbul (BIST) responded to the decision of the CBRT to increase the one-week repo auction policy rate from 16.50% to 17.75% on 7 June 2018 with a more than 2% increase, and the Turkish lira fell by nearly 2%. This positive attitude of financial markets to the increase in the interest rate was interesting. The tight policy reaction to a two-digit stubborn inflation rate due to cost-based factors was perceived in the affirmative by markets. One can conclude from this observation that the root of rates hikes is essential to influence expectations and behavior of the financial market players (or actors). By increasing policy rates substantially, the CBRT gave a message to financial markets that they will apply tight monetary policy if they perceive the factors as long-term pressure over inflation. Based on Article 40, 52 of the CBRT law, the CBRT benefited from standing facilities, and one of which was the late liquidity window facility, which increased as a short-term tight monetary policy strategy (see CBRT 2018). One day later, on 8 June 2018 Moody's downgraded 17 banks and the BIST experienced a rough fall of 1.8% and the USD/TRY exchange rate increased by nearly 0.50%. In addition, Fitch reduced the grades of 24 banks on 21 July 2018. A third example may be given for the 24 July 2018 decision of the CBRT where it defiantly held the one-week repo auction rate constant at 17.75%. Since the market expected an increase of 1% to combat inflation rate aggressively, the stock market and Turkish lira plummeted very quickly. However, on 26 July 2018 stock prices jumped by nearly 3.5% and the USD/TRY exchange rate drifted downwards. Thus, it is not easy to explain or interpret movements of financial variables in response to real interest rate decisions. The initial movements of stock prices and the exchange rate are highly dependent on the news effect, short-term political decisions and market expectations. However, for longer terms, it is not easy to estimate the behavior of these investment tools. The behavior aspects of the financial market

[15] High real interest rate atmosphere in developing countries created a copious carry trade opportunity for financial and real sectors where they took money from low interest rate countries and sold them as a credit or used them to buy government bonds. When central banks reduce interest rates, according to the Gordon growth model of current stock prices, stock prices tend to increase (Mishkin 2016, p. 192).

[16] According to the interest rate risk management theory banks should consider the policy rate, the borrowing cost from foreign and domestic lenders, outlying risks and macroeconomic indicators while determining their lending and deposit interest rates.

and psychological factors seem to make economic identities harder to interpret and responses harder to explain more than ever. One can benefit from an event study such as Arslan (2017) to see the daily effects of policy rate changes on other financial variables and the reactions of market players.

6. Conclusions

This paper examines the effects of the policy real interest rate on the lending rate and the deposit rate, as well as stock prices and the real exchange rate, which were probed by the EG model, the VECM model and the NVECM model. The NVECM allowed the amplification of long-run and short-run dynamics, and the asymmetric adjustment mechanism. Several hypotheses were tested, such as completeness, symmetry and exogeneity within the same specification.

Several conclusions and policy suggestions can be attained from the study. Firstly, the loom of symmetry and the distinctive pass-through effect are important advantages for the CBRT to influence rates in the banking sector. In a well-functioning macro-financial market, the policy interest rate pass-through to banking sector lending and deposit rates and other financial variables should be perfect and symmetric. The results of the NVECM model support symmetry for Turkish financial markets and the pass-through effect is significant. The findings of the paper have highlighted some results, which researchers should fortify and re-examine with different methods. Symmetry and pass-through results have advantages for the CBRT to control and influence other financial variables.

7. Suggestions for Further Research

The paper can be extended in several ways and these will be mentioned briefly below.

With different interest rates: One can obtain new results using the three-month Treasury bill rate as a short-term interest rate and a 10-year composite government bond yield as a long-term interest rate for Turkey.

Role of competition: Forging regulations relating to increasing competition has potential to further increase the efficiency of the banking sector, which is good news for the economy. There is limited competition in the banking sector so banks are not eager to adjust their rates. Moreover, there have been competition penalties given by the Competition Committee, such as in 2013, when the inquiry encompassed 12 banks for disturbing market competition. As of June 2018, the banks are expecting the final decision for their appeal to the State Council. Therefore, increasing competition is crucial for efficiency and consumer benefits. As mentioned by Grigoli and Mota (2017), Leroy and Lucotte (2016), and Apergis and Cooray (2015), to reduce the asymmetry in the market, increasing competition is usually a proposed strategy for a healthy interest rate transmission to banking sector rates. The potential effects of competition in the banking sector on pass-through and the symmetry mechanism may be evaluated using the micro-level banking sector data or an interaction term, such as market capitalization to GDP, following Leroy and Lucotte (2016). This is planned to be investigated by the current author in a separate study.

Level of the real interest rate: The meaning of the real interest rate may differ from time to time. For instance, a high interest rate may be a reflection of high risks, the inflation rate and uncertainties in the economy. On the other hand, high real interest rates may be a result of a high level of confidence in the economy. Therefore, the roots behind increasing the interest rate is essential for the markets. We may clearly claim that the real interest rate level is considered by market participants during the phase of decision making, since a fall in the real interest rate is a boon for financial markets and the blazing investment level. Hence, it has a substantial behavioral finance aspect. The question now should be about the level of the real interest rate. For instance, Gavin (2018) considers the nominal policy rate as extreme if it is above or below the rate of time preference plus per capita consumption growth. Hence, very high and very low real interest rates are potentially dangerous for the economy in terms of fighting inflation and current account deficit problems since more than half of government debt securities are held by the banks in Turkey, as of November 2017, within a value of TRY 324 billion (USD 83 billion, 9.75% of nominal GDP). Individuals only hold 1.51% of this amount, that is, nearly

TRY 4.91 billion (USD 1.26 billion or 0.15% of nominal GDP). (Tatliyer 2018, p. 21). Thus, the level of the interest rate is crucial for the banking sector and its profitability. One can try to answer the question about the level of the optimum real interest rate for Turkey for sustainable macroeconomic indicators.

Logistic Smooth Transition Regression (LSTR) with a different transition variable: There are various types of nonlinear methods considering a specific threshold in either single equation types or those in the form of vector notation. The logistic smooth transition regression (LSTR) model and nonlinear smooth transition error-correction model (see Chinn et al. 2014, for instance) are single equation models. One can consider capital flows and financial depth (M2/GDP) as two adaptable transition variables and analyze the effect of the interest rate on stock price returns, house price returns and the exchange rate by using the LSTR model of Terasvirta (1994, 1998, 2004) for Turkey. Hence, when capital flows or financial depth level are high, a bubble in the market may result and the interest rate may affect financial variables differently compared to when they are low. This will vary among the countries in scope. This is important because when the level of the transition variable is higher than its threshold value, the effect of the interest rate on financial markets may be different compared to the period when it is lower. The LSTR model is widely used in many areas in economics. For instance, Steeley (2004) applies the LSTR model to Korea, Singapore, Taiwan and Thailand, and Steeley (2005) to Hungary, Poland, the Czech Republic and Russia equity markets. Arango et al. (2002) benefit from the LSTR model and the exponential smooth transition regression (ESTR) model to analyze the effect of the interest rate on stock market returns for Bogota and take lagged stock returns as a transition variable. Aslanidis et al. (2002) use output and interest rates to estimate the LSTR model for UK stock market returns. Baaziz (2015) estimates a Taylor rule for Brazil using the LSTR model and takes the TED spread as a transition variable. Beckmann et al. (2015) take lagged stock returns as a transition variable and apply the ESTR model to analyze the effect of stock prices on gold price returns for several countries. Sahin (2013) models money demand equation using the LSTR model for Turkey. Belke et al. (2014) use capacity utilization as a transition variable and benefit from the ESTR model to estimate the effect of domestic and foreign demand and the exchange rate on exports. Bonga and Makakabule (2010) take the dividend yield as a transition variable and estimate the effect of foreign stock returns on domestic stock returns. Bredin and Hyde (2008) use US stock price returns as a transition variable and analyze the effect of the exchange rate, oil prices and output on Ireland and Denmark stock returns. Sahin (2016) conducts an analysis on the short-run and long-run effect of exchange rates on stock market returns by using several methods including the LSTR model. Cheikh (2012) takes the exchange rate as a transition variable and uses the LSTR model to test the exchange rate pass-through to inflation for European countries. Cheikh and Rault (2016) also test it by considering economic growth as a transition variable for Finland. Cheikh et al. (2018) benefit from the STR model and explore an asymmetric relationship between oil prices and stock prices for Gulf Cooperation Council (GCC) countries. Kani et al. (2014) benefit from the LSTR model for the gas market in Iran by taking the price of gas as a transition variable. Stimel (2009) applies the LSTR model to estimate a Phillips curve by using inflation as the transition variable. Wei et al. (2010) consider government size as the transition variable and analyze the effects of government expenditures on economic growth.

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