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RESEARCH ARTICLE

A VAR Framework of Exchange Rates, Interest Rates, and Inflation Through COVID-19 in Turkey: Empirical Evidence From Linear Cointegration and Causality Analysis

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Abstract

In this study, we investigate the impact of exchange rates and interest rates on inflation in Turkey using monthly data from January 2004 to July 2020 obtained from the Turkish Statistical Institute. Our vector autoregressive (VAR) model showed an evidence of stochastic behaviour among the series. The autoregressive distributed lag (ARDL) results showed a short-run and long-run covariate between exchange rates, interest rates and inflation. Specifically, the findings showed a short-run and long-run relationship between inflation, producer price index (PPI), and Turkish interbank offer rates (TIBOR). However, there was no connection between inflation and dollar exchange rates (DSR) and commercial banks' interest rates (CBIR). The VAR Granger causality results revealed the variables to be exogenous except DSR, which displayed endogenous to other variables. Nevertheless, the results revealed unidirectional causality from the producer price index (PPI) to DSR and unidirectional causation from TIBOR to CBIR. It means an increase in production costs through raw materials importation led to devaluation of the Turkish lira. Similarly, TIBOR rates drive CBIR high, making domestic lending more expensive, which will inhibit loan provisions to the private sectors, which will result in an economic contraction and eventually high inflation. Our unit roots breakpoint results pointed to breaks in the dataset were between 2016-2019, reflecting the effects of the Fetullah Terrorist Organization (FETO) failed coup, the 2018 U.S. embargo, and an assumed fiscal dominance as the major and direct causes of economic instability and inflation. However, Covid-19 may have acted as a contributing factor since then. Thus, we recommend that the monetary authorities articulate policy to avoid the assumed fiscal dominance.

1. Introduction

Price stability is one the major missions of all monetary authorities, specifically the central banks across the globe. This includes ensuring the interest rate is as low as possible in order to stimulate economic activities. In addition, central banks are saddled with controlling interest rate volatility, maintaining their respective countries' employment, equitable income distribution, stabilization of their currencies' exchange rate, and maintaining adequate balance of payments (BOP) in foreign trade. Price stabilization is normally one of the indicators used to make enduring monetary policies. This allows

economic sectors to make informed and educated choices that will allow circulation of resources more adequately through reliable information.

Constant reduction in interest rates will result in reduction in the risk premium of inflation, which will eventually reduce the cost interest rates. Lower interest will stimulate investment activities and induce economic development in the short and long runs, whereas a higher interest rate will inhibit economic development in the short and long runs. For example, an increase in inflation puts pressure on employees whose salaries are fixed and other fixed-income earners. They would be negatively affected as the purchasing power parity (PPP) of the currency would devalue as the prices of goods and services increase, which will exacerbate income inequality. This condition will spill into the production sector, resulting in an increase of the producer price index (PPI). The spillover from the increase in the PPI will result in an increase of the consumer price index (CPI) as the prices of goods and services spiral higher[1][2][3].

The spiralling cost of goods and services will result in cost-push inflation. A continuous rise in interest rates encourages investors to prefer investment in interest-yielding assets such as financial assets rather than investment in the risky production sector. These are the reasons that this area of study has garnered the interest of researchers across the spectrum. Thus, the relationship between exchange rates, inflation, PPI, CPI are well documented in previous literature. For example, Özen et al.[3], Asari et al.[4], Rittenberg[5], Rana and Dowling[6] studied the relationship between interest rates, exchange rates, and inflation in various countries. Turkey's economy is well accustomed to inflation rate volatility; however, the implementation of expansionist monetary policy by the U.S. immediately after the 2007/2008 financial crisis resulted in exchange rate stability in Turkey which directly induced a fall in the inflation rate. Interest dropped in Turkey in terms of USD/TRY appreciation and a significant drop in PPI, which led to a positive rise in PPP and CPI up until before the FETO coup in 2016.

Following the famous failed FETO coup, there was a significant increase in exchange rate conversion of the US dollar to the Turkish lira. Likewise, there was a significant rise in the interest rate, which directly affected PPI, PPP, and CPI simultaneously (see[7][3]). By 2018 all the macroeconomic indicators under study had spiralled in a negative direction. Efforts of the Turkish monetary authorities to buttress the weak economy proved abortive. For instance, the monetary authorities raised the interest rate in an attempt to stop continuous depreciation of the Turkish lira against the U.S. dollar. However, a move that led to further deterioration of the Turkish lira. This led to the rise in PPI, and subsequently the negative impact was felt on both the PPP and CPI. This weakening of the Turkish lira has had a negative significant effect on the Turkish economy. A notable momentum in the case of Turkey is a drop in exports, partly due the sanction and an upsurge in imports, which is presupposed for depreciation of currency that would result in high inflation (see[3]). Theoretically, the relationship between exchange rates and interest rates is negative. However, in terms of movement, there is a positive upward movement; i.e., an increase in interest rates would lead to a rise in exchange or depreciation of the currency and vice-versa, consequently a rise in inflation (see[1][2][4][3]).

Based on the above fundamental consequences of monetary policies, the current study attempts to empirically investigate the causality relationship between the exchange rate, interest rate and inflation in the case of Turkey. There are similar previous studies on Turkey; for example,[3] examined the impacts of these three macroeconomic variables in the case of

Turkey; albeit the study focussed on the period after the FETO failed coup in 2016. In other words, the study was between 2016-2019 prior to the Covid-19 pandemic. Similarly,[7] examined the relationship among these three macro variables, but the study was limited to periods before the FETO coup; i.e., between 2002 and 2016. This study is unique in that it spans from January 2004 to July 2020, capturing the impact of the business cycle that resulted from the Covid-19 pandemic. Specifically, the objective of this study includes determining the causality relationship between the exchange rate, interest rate and inflation, to investigate the impact of the exchange rate on inflation, and the severity of the observed volatility among the series. We believe that a study of longer periods will provide more accurate grounds for a policy-oriented conclusion rather than a spurious conclusion.

This study contributes to the ongoing debates on inflation, interest rates and exchange rates. Specifically, we found that inflation in Turkey is a long-existing condition. However, the current inflation was a spillover from the FETO 2016 failed coup and 2018 U.S. sanctions against Turkish exports. The current Covid-19 might just be a contributory factor. Our findings show that DSR has no direct causation of inflation. Nevertheless, PPI is a direct cause of high exchange rates, which result in devaluation of the local currency. It also showed that an increase in TIBOR drives high the commercial banks' interest rates, making lending to consumers and the private sector unattainable, which will inhibit investment development in the private sector. This would eventually lead to a fall in production due to high cost of production. As the cost of material increases more Turkish lira would be required to obtain the U.S dollar which would result in an increase in inflation ultimately PPP falls. It is assumed that Turkish monetary authorities are going through fiscal dominance issues in finding ways to handle the aftermath of both the 2016 failed coup and 2018 U.S. embargoes on Turkish exports. This conclusion is as a result of government changes in the central bank and Ministry of Finance during those periods. In general, inflation has a short-run and long-run relationship with PPI and TIBOR. Nonetheless, we find no short-run and long-run connection between inflation and DRS and CBIR. Overall model Johansen cointegration results showed that there is at least one cointegration model in our study, which implies that our model is grounded for policy implementations.

The rest of the study is arranged as follows: next is a review of previous studies, which is followed by methodology; then the results and discussion of them; finally, the conclusion and policy suggestions.

2. Review of literature

There is abundant theoretical and technical literature on the connection between interest rates, exchange rates, and inflation. On the theoretical ground, literature is unanimous as to the relationship between exchange rates and inflation (see Hasan et al. 2021). As indicated in the previous studies, among the most important financial capital asset market players are the arbitrageurs, whose activities capitalize on the differences between two different financial markets. They make profits by targeting the weaknesses of one vis-à-vis the other. The arbitrage activities can be argued to be economically useful by eliminating differences between asset prices across markets through the law of one price. Thus, one of the unique features of foreign exchange (forex) products, which are over-the-counter (OTC), is that they enable the measure of PPP around the globe. In other words, they measure one country's currency against another country's currency in their purchasing power of goods and services (see Camilleri et. al., 2019). It means a currency's purchasing

power is relative. Technically, it is defined as the real differences between the quantity of goods and services the currencies can buy at home. Thus, an increase in exchange will lead to an equivalent or higher PPI, which would negatively affect PPP and CPI[8][3][7].

Similarly, previous studies established a connection between interest rates and inflation. For example, Fisher effect theory defined the nominal interest rate as the addition of the real interest rate and the expected rate of inflation in each country. This is technically known as the Fisher domestic effect. According to this theory, a rise in the inflation rate will result in an equal amount rise in the nominal interest rate, holding the real interest rate fixed. In general Fisher's theory indicates that a difference in the nominal rate of interest between hypothetical nations would result in an equal rise in the rate of inflation in both countries. In the event of an increase in the inflation rate, if the nominal interest rate remained unchanged, it would make investment unattractive to investors. In other words, there would be no incentive for money supply; thus, the supply of capital will fall (fall in investment) whereas demand for money (hoarding of cash) will increase. As for the interest rate, which is the price for capital borrowed, an increase in interest rates will result in a rise in production cost, which will lead to a rise in inflation. An increase in interest would eventually lead to a reduction in consumption, which will invariably inhibit interest-rate growth, thereby stabilizing the economy[1][8][3][7].

On the relationship between exchange rates and interest rates, Fisher further postulated that the discrepancies between two related nations' interest rates are equivalent to the expected variations in the exchange rates of the associated nations. These relationships are similar to that of domestic interest rates and foreign interest rates as elaborated in the previous sections. The depreciation of domestic currency results from a fall in the nominal interest rates. Thus, demand for foreign currency increases due to local currency's loss of value. A lack of adequate return on investment as a result of a fall in interest rates – i.e., return on capital in the depreciating economy – would sensitize foreign investors to withdraw their invested funds. Both scenarios would lead to a rise in interest rates. However, a rise in exchange rates might be the result of a mismatch between demand and supply from an inflow of capital[1][9]. Production costs would rise due to devaluation of the local currency as importation of foreign raw materials becomes more expensive for the local producers.

Previous studies have adopted several empirical approaches to study the nexus of interest rates, exchange rates and inflation rates. For instance, Dogan et al.[8], using a nonparametric approach in the context of Fisher's effect, explored the relationship between these macro variables in Turkey. Their findings affirmed Fisher's theory. However, they find a unidirectional Granger causality from inflation to interest rates. Similarly, Özen et al.[3] used the ARDL model and pairwise Granger causality to study the connectedness between interest rates, exchange rates and inflation rates. Their results established a long-run relatedness between the three rates. Further, they established that the impact of exchange rates on PPI is higher compared to interest rates. They found unidirectional Granger causality from PPI to US dollar's exchange etc. in the case of Turkey. It indicates that producers' cost of production causes weakning of the Turkish lira against the U.S dollar. Özcan and Yılgör[7], based on Fisher's hypothesis using Granger causality, investigated the causal relationship between inflation and interest rates. Their finding affirmed a unidirectional relationship from inflation to interest rates in the case of Turkey.

Asari et al.[4] explored the same connectedness using a vector error correction model (VECM) in the case of Malaysia.

Their findings showed that inflation impacted interest rates, which invariably impacted the exchange rates. They found a long-run connectedness between interest rates and inflation rates; the inflation rate negatively affects the exchange rate. Pham et al.[9] explored the relationship between the macro variables under study across five ASEAN countries. They found exchange rates to have an effect on inflation in the case of Singapore, Philippines and Indonesia. In a nutshell, they found some sort of connectedness among the variables albeit to various degrees. Likewise, Nasir et al.[10] explored the nexus of exchange rate pass-through (ERPT) inflation. They found the expected exchange rate to have a direct influence on inflation in the case of the Czech Republic. Ha et al.[11] examined exchange rate pass-through inflation across 55 countries using structural augmented auto regressive models. They found a positive pass-through for those countries with flexible exchange and moderately stable inflation rate. Conclusively, there is an intimate connection between the exchange rate and the inflation rate. Extended research on inflation-targeting nations and non-targeting nations[9][10] found different behaviour among the variables in nations with inflation targeting policy and countries without such policies.

Despite there being studies on the relationships between interest rate, exchange rate, and inflation rate in Turkey as reviewed in the previous sections, those studies left a gap for further study on the subject. For instance, Dogan et al.[8] studied the subject-matter of this research in Turkey between 2002 and 2018. Özen et al.[3] examined the instability of macro variables after the failed FETO coup; i.e., between 2016 and 2019. Özcan and Yılgör[7] studied the same subject between 2002 and 2016. The current study spans from January 2004 to July 2020 and thus covers the periods before and after the failed FETO coup as well as the impacts of Covid-19.

3. Methodology

3.1. Data source and variables definition

To investigate the interconnectedness between interest rate, exchange rates and inflation, the monthly dataset for Producer Price Index (PPI), Consumer Price Index (CPI), U.S. Dollar Selling Rate (shortly termed DSR), Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate (TIBOR), and Commercial Banks' Interest Rate on Credit (CBIR) were acquired from the Turkish Statistical Institute (https://www.tuik.gov.tr/Home/Index) spanning from January 2004 to July 2020.

3.2. Procedure

Before conducting cointegration tests among the variables, it is imperative to establish the order of integration among the variables under study by testing for stationarity of the series. It is noteworthy that Turkey went through Several incidences of economic and political instability that resulted in breaks due to shocks. We began with a descriptive statistic and adopted Augmented Dickey Fuller 'ADF'[12] and Elliott-Rothenberg-Stock[13] unit roots to establish the stationarity of the series. However, traditional unit roots are not equipped to account for structural breaks[14], while interest rate and exchange rate are subjected to constant fluctuations. Therefore, we use a vector autoregressive (VAR) decomposition framework to account for the volatility in the Turkish economy "dataset" as a result of several shocks throughout the

periods under study. This is followed by the ARDL Bounds test to determine the long-run relationship in the series and VAR Granger causality.

3.3. Cointegration ARDL bounds test

To estimate the long-run connectedness between PPI, CPI, DSR, TIBOR, and CBIR, we adopt the ARDL bounds test (see Pesaran 2001) to scrutinise the level of cointegration in the series under study. Although other cointegration tests such as Johansen and Juselius (1990) have been employed to establish long-term relationships, the ARDL bounds test is flexible compared to other approaches. This is because the ARDL bounds test accommodates any series order; i.e., regardless whether it is at the level I(0) or first difference I(1) or mixture of both level and first difference. The ARDL model is specified as follows:

$$\begin{aligned}\Delta lnCPI_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta lnCPI_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta lnPPI_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta lnDRS_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta lnTIBOR_{t-i} \\ + \sum_{i=1}^{p} \beta_5 \Delta lnCBIR_{t-i} + \lambda_1 lnCPI_{t-1} + \lambda_2 lnPPI_{t-1} + \lambda_3 lnDRS_{t-1} \\ + \lambda_4 lnTIBOR_{t-1} + \lambda_5 lnCBIR_{t-1} \\ + \varepsilon_t \qquad (1)\end{aligned}$$

ε_t is the error term accounting for the noise or disturbance in the model, the sigmaΔ indicating that the operator is at the first difference. We adopt an ARDL bound test to estimate the level of cointegration among the series. The null hypothesis is that there of no cointegration among the series; i.e., $H_0 = 0$ and the alternative hypothesis is $H_1 \neq 0$; i.e., there is cointegration among the series tested. Specifically, our analysis focuses on the bounds test F-statistic value, which a priori must be greater than the upper bounds statistics in order to establish a long-run relationship among the series. However, if the F-statistic falls below the lower bounds the model is not a true estimate of a long-run connection; i.e., we accept the null hypothesis of no cointegration. Similarly, if the F-statistic falls between the lower and upper bounds, the model is inconclusive. Our VAR model was stated according to Brooks's[15] specification in equations 2 and 3 in the framework of Johansen cointegration to determine a long run in the series.

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} \ldots\ldots \beta_x y_{t-x} + \varepsilon_t \qquad (2)$$

$$\Delta y_t = \Pi y_{t-x} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} \ldots\ldots \Gamma_{x-1} \Delta y_{t(x-1)} + \varepsilon_t \qquad (3)$$

Herein Γ and Π are coefficient matrices, wherein Π encompasses evidence of long-run relatedness. The cointegration model in Johansen-Juselius's framework is based on trace and maximum eigenvalue test statistics in an attempt to reveal the extent of cointegration among the series as well as number of cointegrating vectors. The Johansen-Juselius's trace and maximum eigenvalue is stated in equations. 4 and 5

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln\left(\lambda_i\right) \qquad (4)$$

$$\lambda_{\max} = -T\ln\left(\lambda_{r+1}\right) \quad (5)$$

wherein r is the number of cointegrating vectors. Operationally, r is used to explore the cointegration association in trace test statistics, whereas, r+1 is use to explore the cointegration association in the maximum eigenvalue[15].

3.4. Granger causality test

We used a VAR Granger causality test to investigate the level of causality among the variables under study in order to complement the results of long-run connectedness in the model. This is in order to ascertain whether the relationship among the series is unidirectional or bidirectional. Therefore, the VAR model is assumed to be more appropriate as variables are appraised symmetric and endogenous. According to Rossi and Wang[16], VAR Granger/Block Exogeneity Wald Tests are more reliable and robust than the traditional Granger causality models. Eq. 6 is the VAR model specification

$$\begin{bmatrix} CPI_t \\ PPI_t \\ DRS_t \\ TIBOR_t \\ CBIR_t \end{bmatrix} = \alpha_0 + \alpha_1 \begin{bmatrix} CPI_{t-1} \\ PPI_{t-1} \\ DRS_{t-1} \\ TIBOR_{t-1} \\ CBIR_{t-1} \end{bmatrix} + \alpha_2 \begin{bmatrix} CPI_{t-2} \\ PPI_{t-2} \\ DRS_{t-2} \\ TIBOR_{t-2} \\ CBIR_{t-2} \end{bmatrix} + \ldots \alpha_p \begin{bmatrix} CPI_{t-p} \\ PPI_{t-p} \\ DRS_{t-p} \\ TIBOR_{t-p} \\ CBIR_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (6)$$

wherein t represents time, VAR's lag is denoted by p, the vector's constant is α_0, and the parameters of the matrices are $\alpha_1, \alpha_2, \alpha_3 \ldots \alpha_p$. Interpretation of variables remains unchanged as defined in previous sections. Rossi and Wang[16] propose that VAR-Granger causality allows endogenous variables to be treated as exogenous variables on an individual basis. This study implements Wald tests Chi-Square (X^2) to decide the significance of the combination of lags of other endogenous variables in every single equation of the model. In order to save space and for the sake of conciseness, we presented the treated joint impact of further endogenous variables that lagged in the individual equations of the model.

4. Empirical results

This study's preliminary results include descriptive statistics, correlation matrix among the group, and unit root tests for stationarity of the series under study. This is followed by ARDL short- and long-run analysis to establish the level of covariance among the series and reported.

Table 1 is the descriptive statistics, which indicate that the coefficient of LNPPI is the highest mean; the next is LNCBIR; however, LNDRS has the lowest mean coefficient. Nevertheless, the mean across the group seems symmetrical in nature. Likewise, less than one standard deviation is observed across the group, which implies that the group is moderately stable because standard deviation is one of the static approaches of assessing volatility.

Table 1. Descriptive statistics

	LNCPI	LNCBIR	LNDSR	LNPPI	LNTIBOR
Mean	2.2006	2.7471	1.2159	5.3288	2.2017
Median	2.1782	2.7530	1.0367	5.3128	2.0149
Maximum	3.2284	3.5404	2.1541	6.1951	3.2581
Minimum	1.3838	2.5404	0.7929	4.6488	0.4055
Std. Dev.	0.3039	0.3240	0.3866	0.4150	0.6448
Skewness	0.6737	0.0588	0.9966	0.4335	-0.6137
Kurtosis	4.6685	2.4507	2.7961	2.3545	3.3257
Jarque-Bera	38.1367	2.6169	33.2883	9.6878	13.3696
Probability	0.0000	0.2702	0.0000	0.0079	0.0013
Observations	199	199	199	199	199

The skewness indicates that the group is positively skewed except for TIBOR having a negative extreme tail. This implies that Turkey's central bank overnight interest rates would be lower than the mean in the nearest future while other variables' values would be greater than the current mean in the nearest future. Moreover, the coefficient of Kurtosis shows LNCPI and LNTIBOR are not normally distributed as K>3 while other variables' normality cannot be disputed. Kotkatvuori-Örnberg[17] posited that

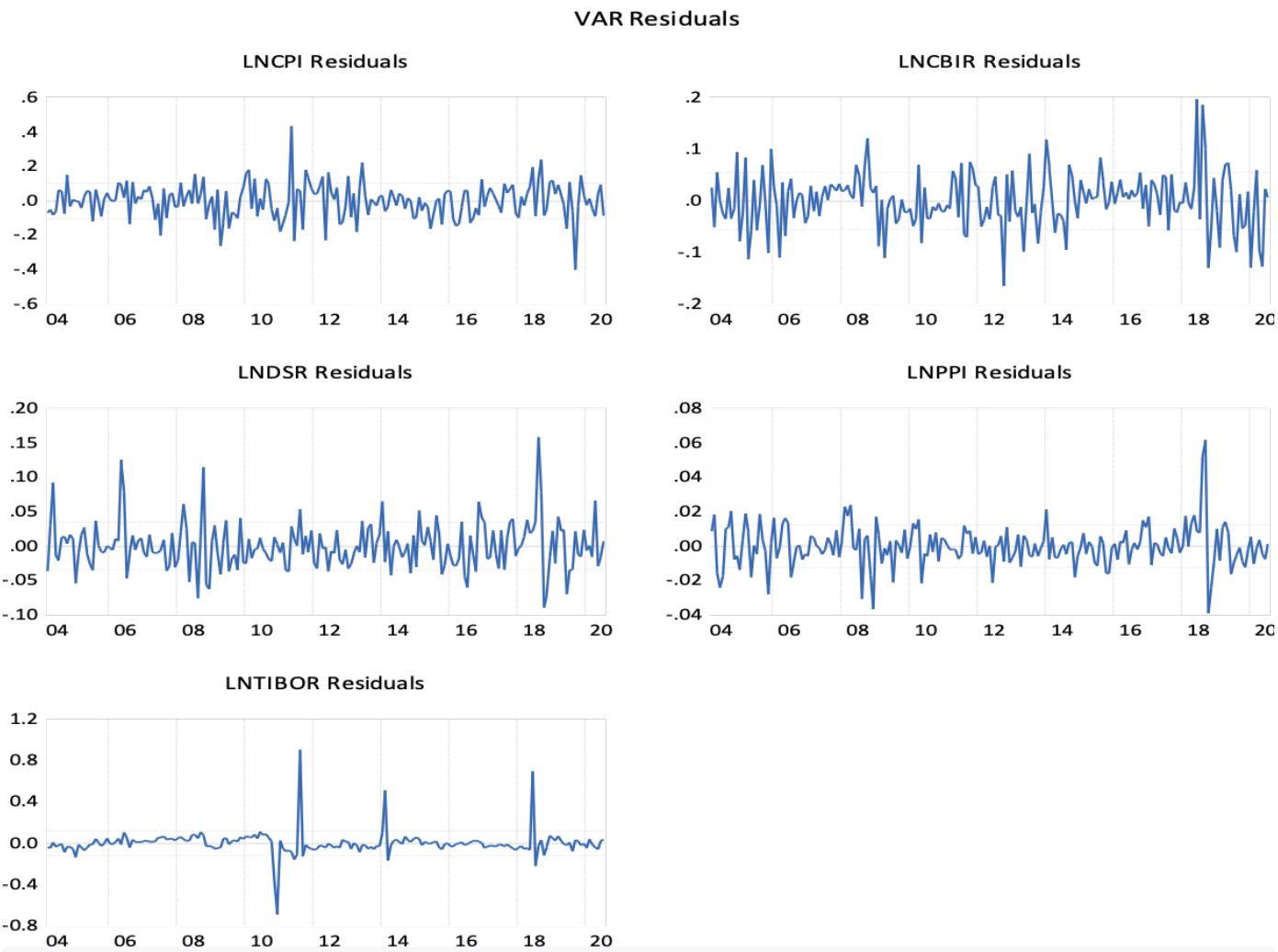

Fig. 1. Producer Price Index (PPI), Consumer Price Index (CPI), U.S. Dollar Selling Rate (shortly termed DSR), Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate (TIBOR), and Commercial Banks' Interest Rate on Credit (CBIR)

skewness and kurtosis are evidence that the distribution of a series is not normal. The coefficients and probabilities of the Jarque-Bera (JB) statistics affirm the non-normality of the series. The JB results showed LNCPI, LNDSR, LNPPI, and LNTIBOR significant, which justified our Kurtosis' conclusion of non-normality of the series. Thus, our results concur with the affirmations of Dutta, et al.[18] and El Hedi[19] that the significance of the JB statistics is evidence of the non-normal distribution of a series. Our skewness is not zero; thus, it is safe to conclude that our series exert marginal contribution to the final conclusions. Previous studies such as Chang et al.[20] stated that a non-zero skewness of a distribution shows that the series contribution to the outcome of the study is marginal. Fig. 1 is the graphical representation of the variables under study.

Coefficients of correlation among the variables under exploration are shown in Table 2 below. A high correlation is observed between LNPPI and LNDSR and relatively acceptable correlation between LNCPI, LNCBIR, LNDSR, LNPPI and LNTIBOR. The results show the majority of the correlation was significant at 5%. This finding is in line with Özen et al.'s[3] assertion of a strong relationship between interest rates and exchange rates, which in this study is further obvious due to the ongoing Covid-19 pandemic.

Table 2. Correlation Coefficient Matric Analysis

Variables	LNCPI	LNCBIR	LNDSR	LNPPI	LNTIBOR
LNCPI	1.000000				
LNCBIR	0.5359***	1.000000			
LNDSR	0.6158***	0.1658**	1.000000		
LNPPI	0.5102***	-0.1129	0.9255***	1.000000	
LNTIBOR	0.5205***	0.8353***	0.1054	-0.1672*	1.000000

*Note: asterisks ***, **, and * denote 1%, 5%, and 10% significance levels respectively.*

Startlingly, a positive, albeit insignificant, correlation was observed between LNDSR and LNTIBOR. LNPPI and LNDSR have the highest connection. The next higher correlation is between LNTIBOR and LNCBIR. In general, the significant positive connectedness established among the variables under study indicates that most of the variables in the group are moving in the same trend in exacerbating interest rates. However, the negative correlation between LNPPI and CBIR and between TIBOR and LNPPI indicate the presence and nature of disturbance in the dataset. Thus, in Table 3 we further investigate the stability among the series using ADF and ERS. This further illuminate's robust results on the series' stationarity.

Table 3. Unit root tests

Variables	Level				First difference		
	ADF	ERS	Breakpoint		ADF	ERS	Breakpoint
LNCPI	-1.0185	9.7502	2008M11	ΔLNCPI	-8.8184***	36.4866	2018M09
LNCBIR	-2.3258	15.7716	2018M03	ΔLNCBIR	-9.3354***	0.5891***	2018M09
LNDSR	1.4449	92.4917	2017M09	ΔLNDSR	-11.4862***	0.1523***	2018M08
LNPPI	1.2815	644.9325	2016M10	ΔLNPPI	-9.3833***	0.2398***	2018M09
LNTIBOR	-2.5311	10.9942	2008M10	ΔLNTIBOR	-10.3179***	0.3433***	2019M06

*Note: asterisks ***, **, and * denote 1%, 5%, and 10% significance levels respectively. Δ denotes first difference. ADF-Augmented Dickey-Fuller (ADF)[12] and Elliott, Rothenberg and Stock (ERS)[13]. PPI denotes Producer Price Index, CPI is Consumer Price Index, DSR is U.S. Dollar Selling Rate, TIBOR is the Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate, and CBIR is Commercial Banks' Interest Rate on Credit*

As evident in Table 3, we obviously reject the initial hypothesis that the series is stable at level. According to Elyas and Masih[21] a lack of stationarity among the series necessitated further investigation to establish the level of cointegration among the series. Our stationarity test results indicate the series is stationary. Our findings show that the series is stationary at first difference I~(1). To further establish the stability at first difference we ran the turning point analysis. Amazingly, inflation in Turkey's economy is vulnerable to global and national financial or economic crises. The impacts of 2007-2009 financial crisis are observed for LNCPI and LNTIBOR at level. Similarly, consistent inflation due to internal

political instability is observed, precisely immediately after the unpopular failed FETO coup in 2016. Most importantly, the unrestricted inflationary impact of the 2018 U.S. trade embargo on Turkish exports such steel, etc. is observed. Consequences of the embargo include drop in demand for the Turkish lira, which led to the depreciation of the exchange rates, increased domestic lending interest rates, etc. up until 2019 immediately before the Covid-19 pandemic.

Imperatively, there is a need to conclude that the Covid-19 pandemic is not majorly responsible for the long-term inflation rates in Turkey as observed from the turning points analysis. Perhaps Covid-19 is acting as a remote cause. Inflation in Turkey might be attributed to the conflict between fiscal policy and monetary policies following external shocks from the global financial crisis and the U.S. trade embargo on Turkish goods. This conflict between fiscal and monetary policies is technically known as fiscal dominance[22]. Conclusively, the Covid-19 pandemic's negative economic impacts are yet to materialize. In general, having the series stable at first difference fulfils one of the required conditions for adopting the ARDL model[23][24][25]. From Table 4, CPI represents inflation, which is in line with previous CPI inflation models[26]. Thus, we conducted one method of analysis to measure impacts of fluctuations in interest rates and exchange rates on inflation in Turkey. However, it is imperative to determine the VAR lag selection model and establish long-term equilibrium in the model. The VAR lag selection results shown in Table 4 indicate the appropriate lag is 3 based on Akaike information criterion (AIC) and final prediction error (FPE). To determine the series' long-term equilibrium, a Johansen cointegration model Table 5 was adopted.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	12.79160	NA	6.35e-07	-0.079506	0.004119	-0.045651
1	1592.641	3062.973	8.18e-14	-15.94532	-15.44356	-15.74218
2	1664.295	135.2652	5.08e-14	-16.42138	-15.50150*	-16.04897*
3	1693.425	53.50464*	4.88e-14*	-16.46352*	-15.12552	-15.92184

Table 4. VAR lag selection model

** indicates lag order selected by the criterion: LR: sequential modified LR test statistic (each test at 5% level); FPE: final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.*

The Johansen cointegration test results in Table 5 indicate there is at least one cointegrating equation significant at 5% critical level between inflation and exchange rates and interest rates. These findings further affirm our CPI inflation model and the existence of a long-run equilibrium among the series. In essence, the fluctuation in exchange rates and interest rates have a long-term direct impact on inflation in Turkey over the period under investigation as exhibited in Table 6. It further affirms current increasing inflation rates in Turkey as a result of Covid-19 pandemic.

Table 5. Johansen cointegration vector

H_0 H_1	Trace Stat	(5%C.V)		H_0 H_1	Max-Eigen Stat	(5%C.V)
r = 0 r ≥1	74.2019	68.8189		r = 0 r ≥1	36.2748	33.8767
r ≤ 1 r ≥2	37.9471	47.8561		r ≤ 1 r ≥2	17.5300	27.5843
r ≤ 2 r ≥3	20.4171	29.7971		r ≤ 2 r ≥3	13.2996	21.1316
r ≤ 3 r ≥4	7.1175	15.4947		r ≤ 3 r ≥4	5.7189	14.2646
r ≤ 4 r ≥5	1.3986	3.8415		r ≤ 4 r ≥5	1.3986	3.8415

*Trace test indicates 1 cointegrating eqn(s) at the 0.05 level*** *Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level*

Table 6 shows the results of the short- and long-run cointegration among the series under study. The results reveal significant long-run and short-run connectedness between CPI and PPI. A 1% increase in PPI will result in approximately 15.15% increase in CPI and vice-versa. The implication is hyper increase in cost of production, which in turn erodes purchasing power parity (PPP), rendering Turkish lira value depreciated and less competitive against foreign currencies such as the U.S. dollar. At the micro level, depletion of Turkey currency's PPP will drive prices of consumers' goods and services higher.

Table 6. Linear ARDL model results

Short-run Analysis				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
CointEq(-1)	-0.2380	0.0374	-6.3729	0.0000***
ΔLNCPI	0.2123	0.0657	3.2185	0.0015***
ΔCBIR	0.1847	0.1209	1.5274	0.1284
ΔPPI	1.5154	0.4439	3.4132	0.0008***
ΔTIBOR	0.1439	0.0549	2.6172	0.0096***
ΔDSR	0.0000	0.0000	0.0000	****
Long-run Analysis				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNCPI	0.2123	0.0692	3.0677	0.0025***
LNCBIR	0.1847	0.1341	1.3767	0.1703
LNDSR	0.0191	0.0764	0.2499	0.8029
LNPPI	1.5154	0.5609	2.7015	0.0076***
LNTIBOR	0.1439	0.0564	2.5522	0.0115***
C	0.0061	0.3756	-0.0162	0.9871
Diagnostics results	^{2}			
B-G: Ser. Correlation	1.3864			0.5000
ARCH	0.3967			0.5288
B-P-G: Hetero.	10.7631			0.5493
CUSUM	Stable			
CUSUM of Sq.	Stable			

Note: asterisks ***, **, and * denote 1%, 5%, and 10% significance levels respectively. PPI denotes Producer Price Index, CPI is Consumer Price Index, DSR is U.S. Dollar Selling Rate, TIBOR is the Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate, and CBIR is Commercial Banks' Interest Rate on Credit.

Statistically significant short-run and long-run connectedness was observed between LNCPI and LNTIBOR in both the short term and long term. A 1% increase in LNTIBOR will result in a 14.39% increase in LNCPI and vice-versa. The implication is that an increase in overnight lending rates would drive the cost of loans higher, which would in turn increase the cost of lending to the commercial sectors. Invariably, with other LNCPI inflation analysis, high cost of production would drive the LNCPI higher due to eroding PPP. In general, there is long-run cointegration in our model as shown in the ARDL Bound test results in Table 7. Surprisingly, we found no connection between LNCPI and LNDSR in the short run; however, a statistically insignificant relationship was observed between LNCPI and LNDSR in the long run. It means that dollar exchange rates have no impact in determining Turkish LNCPI at the micro level. In other words, consumers' goods and services are not being influenced by exchange rates in the short run and long run in Turkey. Our finding is in contrast to Özen et al.'s[3] result, which established a statistically significant relationship between LNCPI and dollar exchange rates. Our findings indicate that Turkey's economy is less reliant on importation of the majority of consumers' goods and

services. Intuitively, the apparent inflation in Turkey is driven by both LNPPI and LNTIBOR.

Table 7. Cointegration-Bound test results

Cointegration-Bound Test Model				
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	6.855119	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Furthermore, a statistically insignificant relationship was observed between LNCPI and LNCBIR, which implies that commercial banks' interest rates do not induce inflation in Turkey. It means lending rates seem to be held stable over the periods under study. Perhaps, the LNCBIR was highly controlled through the Turkish Central Bank's various monetary policies over time, which is probably as a result of pressure from fiscal dominance. Specifically, during the Covid-19 pandemic the Turkish Central Bank and government rolled out various intervention policies to aid the economy. Specific assistance programs have been designed aiming at certain sectors of the economy. For instance, the Minister of Finance and Central Bank Governor were replaced by the President, which is a clear act of fiscal dominance. It further elucidated that the Turkish Central Bank is not autonomous or independent in its policy formulation and implementation. Furthermore, commercial banks' interest rates were levelled down almost to 0% and debt restructuring programs were put in place. In addition, the period of delay in loan repayment before a loan becomes nonperforming was extended. Finally, many of these policies are directed at individuals, production facilities and small and medium enterprises (SMEs) across Turkey. **Table 7** presents the VAR direction of causality among the series. To justify our statistical inferences and the reliability of our model, several diagnostic tests were conducted. The model passed serial correlation, heteroscedasticity, and ARCH tests. Above all, CUSUM and CUSUM of square Fig. 2, are significant at the 5% level, attesting to the stability of the dataset and reliance of the model as a whole.

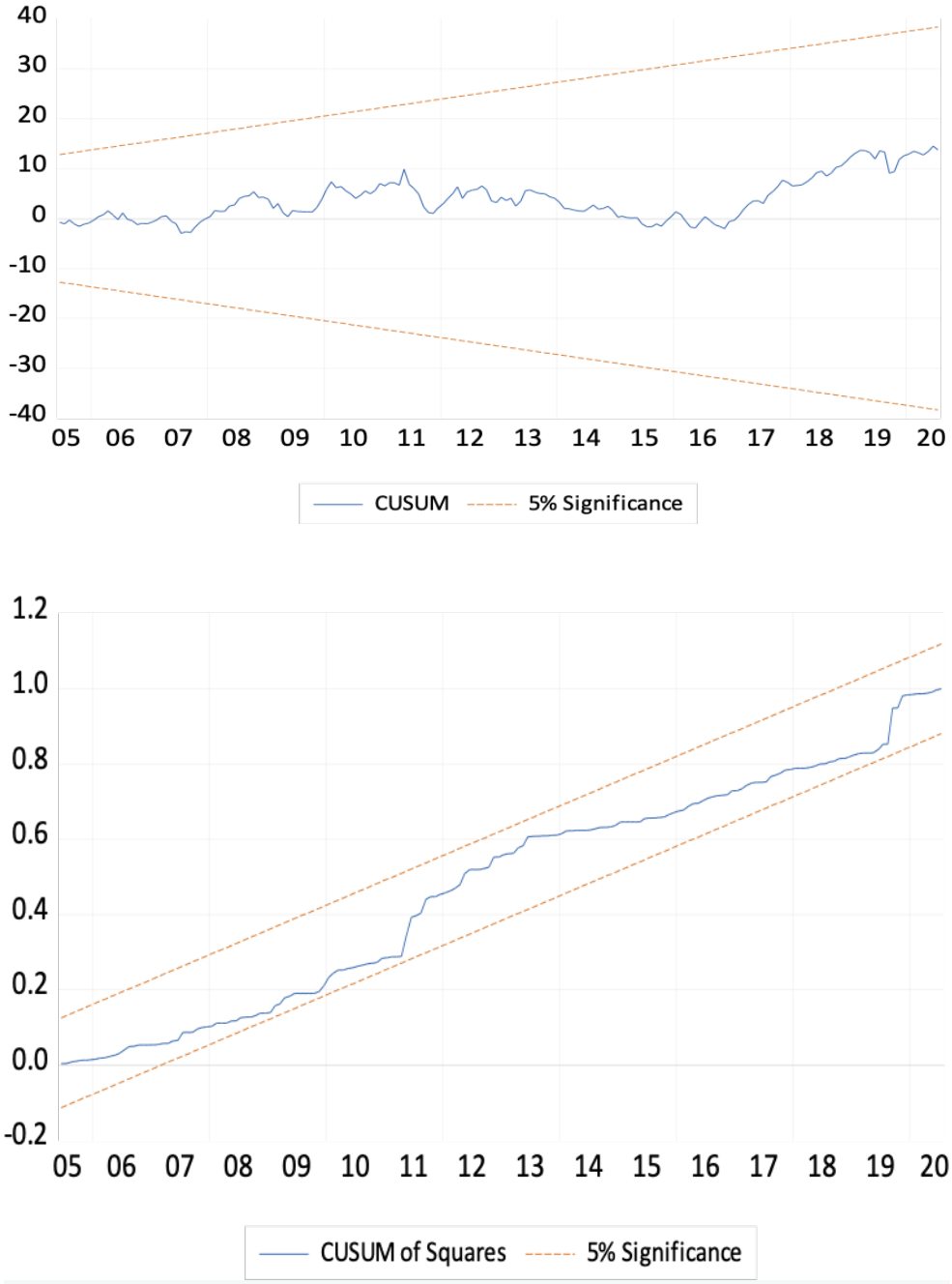

Fig. 2. CUSUM and CUSUM of Square of interest rates, Exchange rates in Turkey

As evident in Table 7, a unidirectional Granger causality is observed between LNCPI and LNTIBOR. This affirms our ARDL analysis that LNCPI has significant impact on the Turkish Central Bank overnight interest rates but not the reverse. However, LNCPI Granger causes all the variables, which signifies inherent causation among the series. Similarly, a unidirectional Granger causality was found from LNCBIR to other variables that include LNCPI, LNDSR, and LNPPI. It implies that commercial banks in Turkey are vital monetary policy channels. It establishes the Central Banks' reliance on the commercial banks in determining and implementation of the interest rates set by the central bank in Turkey. However, a bidirectional Granger causality was observed between LNCBIR and LNTIBOR, which is not surprising as it affirms the level of cointegration within the Turkish banking industry. To put it simply, an increase in commercial banks' interest rate would positively impact the overnight lending rates and vice-versa.

Table 8: VAR Granger Causality/Block Exogeneity Wald Tests

Depend. Var.	Excluded Var.		χ^2	Pob.
LNCPI	LNCBIR.		1.6797	0.4318
	LNDSR		0.2063	0.9020
	LNPPI		0.5535	0.2789
	LNTIBOR		4.8529	0.0883*
	All		22.4112	0.0042***
LNCBIR.	LNCPI		11.0435	0.0040***
	LNDSR		18.2619	0.0001***
	LNPPI		7.4011	0.0247**
	LNTIBOR		6.2738	0.0001***
	All		33.4913	0.0001***
LNDSR	LNCPI		3.3313	0.1891
	LNCBIR.		0.0865	0.9577
	LNPPI		1.0957	0.5782
	LNTIBOR		1.7319	0.4206
	All		13.0622	0.1097
LNPPI	LNCPI		0.0115	0.9942
	LNCBIR.		9.2238	0.8941
	LNDSR		10.5076	0.0052***
	LNTIBOR		1.4702	0.4795
	All		13.6541	0.0912*
LNTIBOR	LNCPI		1.6576	0.4366
	LNCBIR		9.7293	0.0077***
	LNDRS		3.0633	0.2162
	LPPI		2.6629	0.2641
	All		31.8047	0.0001***

*Note: asterisks ***, **, and * denote 1%, 5%, and 10% significance levels respectively, CPI is the consumer price index, CBIR is commercial banks interest rates, DSR is the dollar selling rate (US $), PPI is the producer price index, and TIBOR is the Turkey interbank offer rates; that is, the Turkish Central Bank's overnight interest rates.*

Furthermore, we found no Granger causation from LNDSR to all other variables. This is consistent with our ARDL analysis that dollar exchange rates do not induce inflation in Turkey. This is in contrast with Özen et al.'s[3] conclusion that the dollar exchange rate did induce inflation in Turkey. Interestingly, a unidirectional Granger causality was found between LNPPI and LNDSR, which indicates that PPP indexes dollar exchange rates. Perhaps, this causation is justifiable due to

importation of raw materials for production in Turkey. From a nuanced point of view, Turkey is one the major oil importing nations and a strong emerging economy with accelerating industrial policy orientation, specifically in military hardware and automobiles. Thus, increases in importation of raw materials for production dictates high demand for foreign currency, which would amplify exchange rates. There is, however, significant direct and/or indirect causation from LNPPI to all the series under investigation. Likewise, LNTIBOR has a direct and/or indirect causation with other variables, which is reasonable as the Turkish overnight lending rates act as the major source of interest rates in the economy. It furthers shed light on the imperative role of the Turkish financial industry in inducing economic growth and development over the periods under study.

The Granger causality analysis of the series exogeneity, enables plot of endogeneity visualization of the dataset in Fig. 3, which shows the nature of connections and covariance among the series throughout the periods under study. It indicates a long-run covariate and volatility among the series. We establish the robustness of our analysis through VAR responding to innovation and variance decomposition of the series in Fig. 5 and 6 to account for various volatility in the overall model. As evident in Fig. 5, each of the variables responded to financial innovations in Turkey throughout the period under study. For instance, until recently, around 2016, a large variance existed between LNCPI and other variables, which indicates a relatively stable inflation regime before the failed FETO coup. A large variance is also observed for LNCBIR and other variables and a rigid response to innovations as shown in Fig. 5 and 6. Perhaps little or no innovation to the LNCBIR (by the monetary policy) was available throughout parts of the period under investigation. A similar volatility and response to innovation were observed across other variables.

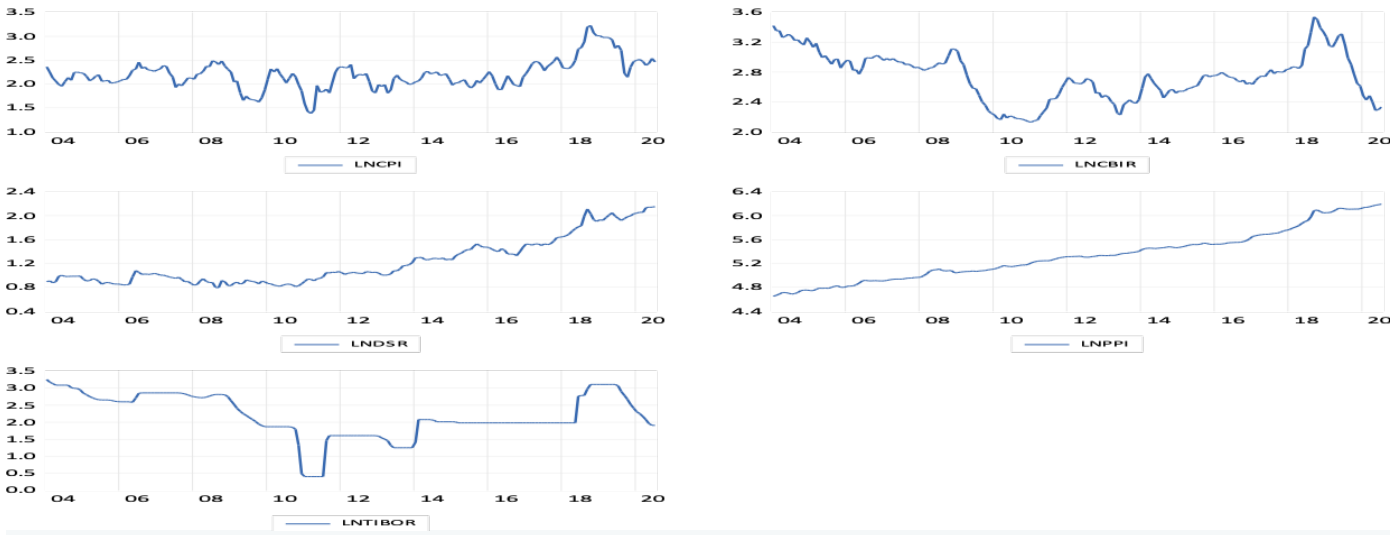

Fig. 4. Endogeneity of Consumer Price Index (CPI), Producer Price Index (PPI), U.S. Dollar Selling Rate (DSR), Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate (TIBOR), and Commercial Banks' Interest Rate on Credit (CBIR)

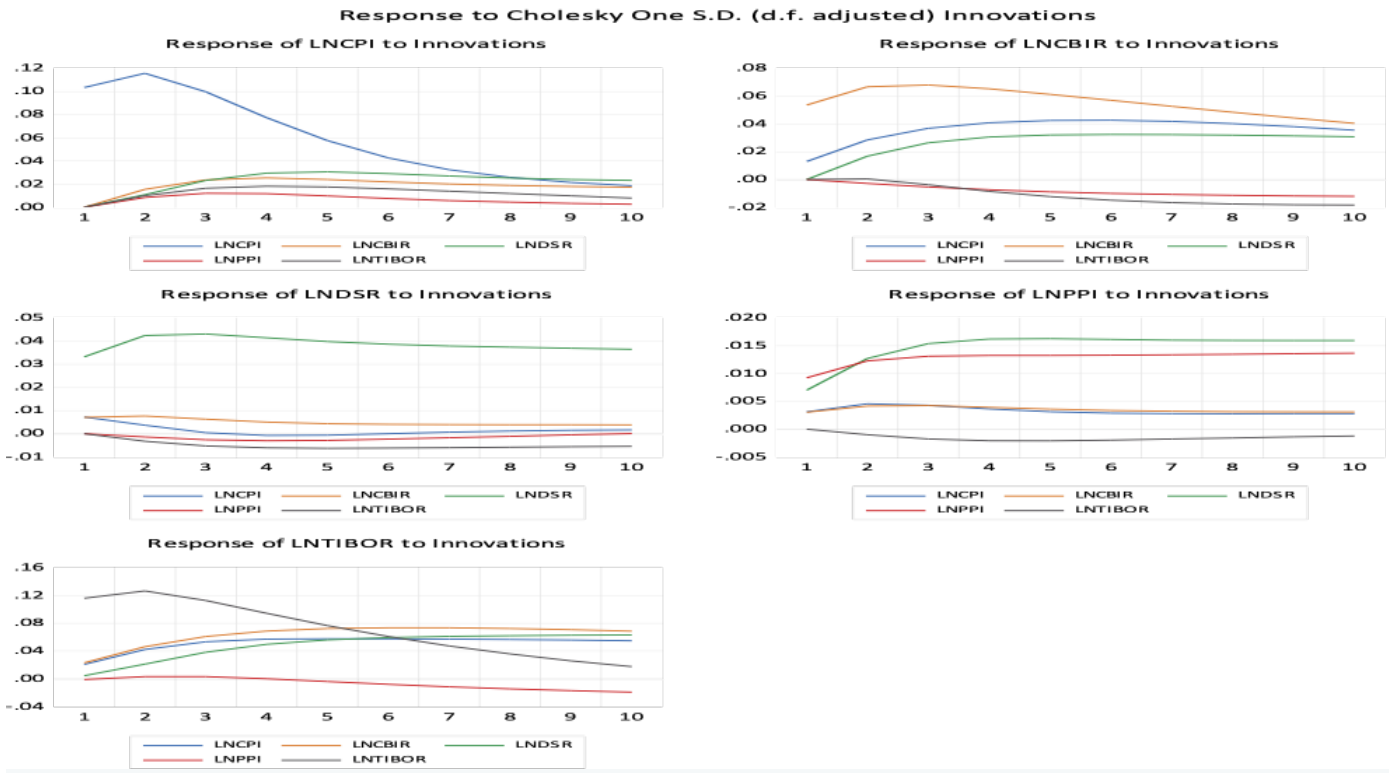

Fig. 5. Cholesky response to innovation of Consumer Price Index (CPI), Producer Price Index (PPI), U.S. Dollar Selling Rate (DSR), Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate (TIBOR), and Commercial Banks' Interest Rate on Credit (CBIR)

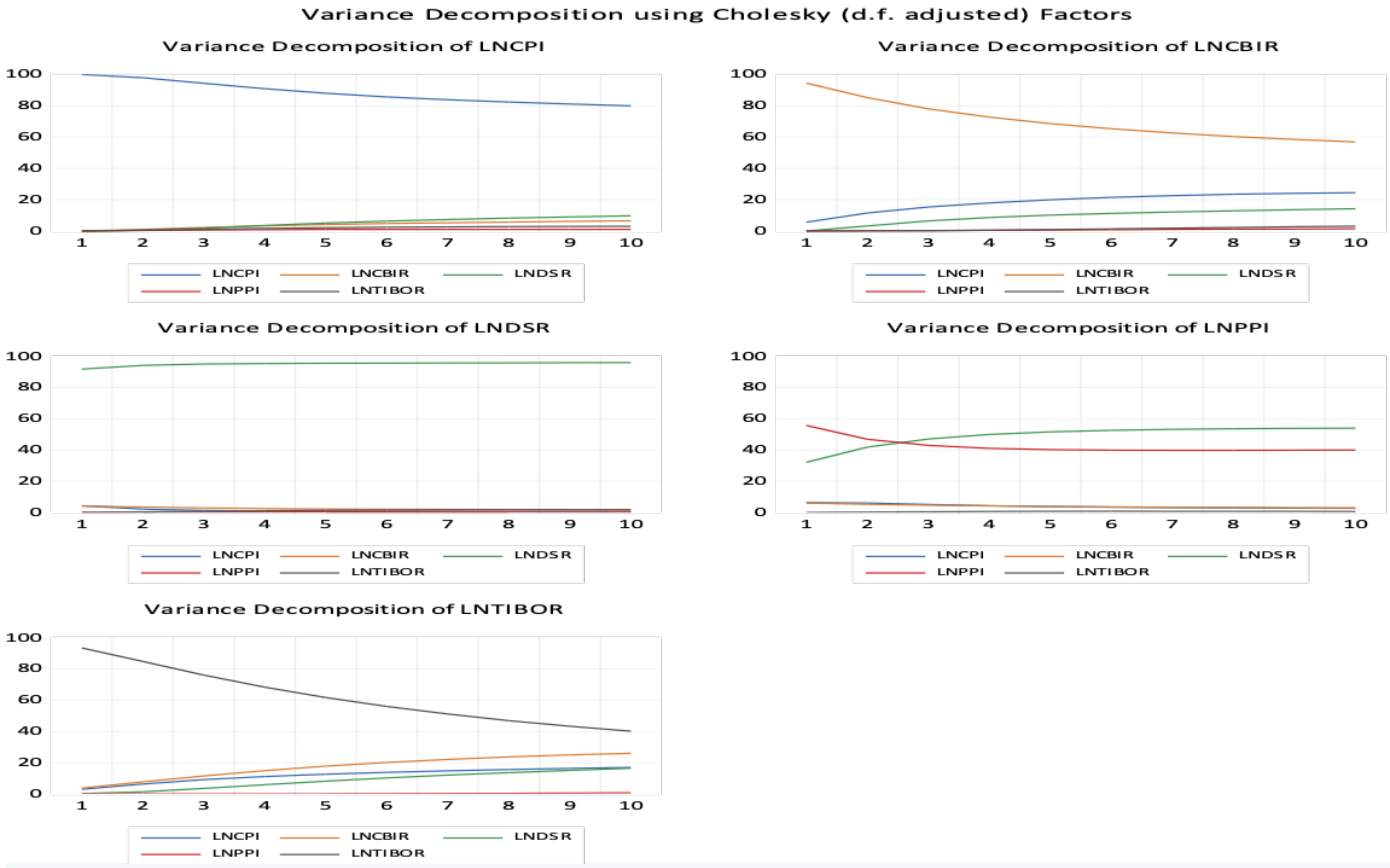

Fig. 6. Cholesky variance decomposition of Consumer Price Index (CPI), Producer Price Index (PPI), U.S. Dollar Selling Rate (DSR), Turkish Central Bank's Overnight Interest Rate/Turkish Interbank Offer Rate (TIBOR), and Commercial Banks' Interest Rate on Credit (CBIR)

5. Conclusion

This present study examines the long-run connectedness of interest rates, exchange rates and inflation. In addition, we scrutinise the type of variance and series' responses to financial innovations in Turkey over the period between January 2004 and July 2020. We conducted several statistical analyses such as Johansen cointegration test, ECM, and VAR Granger causality etc. to affirm the long-run impact of exchange rates and interest rates on inflation. The findings revealed a short-run and long-run covariance between CPI, PPI, and TIBR. Inflation is susceptible to the producer price index and interbank overnight lending rates. The results also revealed the majority of the variables to be exogenous. However, DSR displayed endogenous characteristics. Policy innovation as revealed by the response to innovation for each variable is positive albeit downward. It implies that even when there is innovation it is not dynamic to take care of the volatility thereof, which was visible between 2016-2019. Thus, in the presence of the Covid-19 pandemic Turkey is experiencing devaluation of the Turkish lira and depletion of PPP due to high inflation.

Moreover, our findings showed a bidirectional and one directional Granger causality among series, which assert long-term covariance assessments in our model. However, a lack of causation was observed from LNDSR; i.e., dollar exchange rates, to other individual variables, which implies that exchange regime management or some sort of effective monetary policies are mitigating the effects of external forces on Turkey's economy or financial system in general. Perhaps, it was as a result of the fiscal dominance at play[22]. Nonetheless, we found a significant Granger causality from LNDSR to all. Interestingly, there was a unidirectional Granger causality between LNCPI and LNPPI and a significant causation from LNCPI to all and from LNPPI to all, which is an indication of an inherent indirect causation among the series under study. Hence, for the Turkey economy to be resilient against inflation, authorities need to devise robust strategies and policies in synchronizing LNPPI and LNTIBOR in a way that would minimize their effect on inflation.

Notes

JEL Codes: E0, E3, E4, E5, E6, F0, F6, G0.

References

1. a, b, c, d *Fisher I (1930). The theory of interest. New York: Macmillan.*
2. a, b *Fahmy YAF, Kandil M (2003). "The Fisher effect: new evidence and implications." International Review of Economics and Finance. 12: 451–465.*
3. a, b, c, d, e, f, g, h, i, j, k, l, m *Özen E, Özdemir L, Grima S (2020). "The Relationship between the Exchange Rate, Interest Rate and Inflation: The Case of Turkey." Scientific Annals of Economics and Business. 67(2): 259-275.*
4. a, b, c *Asari FFAH, Baharuddin NS, Jusoh N, Mohamad Z, Shamsudin N, Jusoff K (2011). "A vector error correction model (VECM) approach in explaining the relationship between interest rate and inflation towards exchange rate volatility in Malaysia." World Applied Sciences Journal. 12(3): 49-56.*

5. ^Rittenberg L (1993). "Exchange Rate Policy and Price Level Changes: Causality Test for Turkey in the Post Liberalization Period." The Journal of Development Studies. 29: 245-259.
6. ^Rana PB, Dowling J Jr (1985). "Inflationary Effect of Small Continuous Changes in Effective Exchange Rate: Nine Asian LDCs." Review of Economics and Statistics. 67: 496-500.
7. a, b, c, d, e, fÖzcan K, Yılgör M (2017). "The Causal Relationship between Inflation and Interest Rate in Turkey." J. Asian Dev. Stud. 6(2): 15-21.
8. a, b, c, dDogan I, Orun E, Aydın B, Afsal MA (2020). "Non-parametric analysis of the relationship between inflation and interest rate in the context of Fisher effect for Turkish economy." International Review of Applied Economics. 34(6): 758-768.
9. a, b, cPham TAT, Nguyen TT, Nasir MA, Huynh TLD (2020). "Exchange rate pass-through: A comparative analysis of inflation targeting & non-targeting ASEAN-5 countries." The Quarterly Review of Economics and Finance. (in press).
10. a, bNasir MA, Huynh TLD, Vo XV (2020). "Exchange rate pass-through & management of inflation expectations in a small open inflation targeting economy." International Review of Economics and Finance. 69: 178–188.
11. ^Ha J, Stocker MM, Yilmazkuday H (2020). "Inflation and exchange rate pass-through." Journal of International Money and Finance. 105: 102187.
12. a, bDickey DA, Fuller WA (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." Journal of the American Statistical Association. 74(366a): 427-431.
13. a, bElliott G, Rothenberg TJ, Stock JH (1996). "Efficient Tests for an Autoregressive Unit Root." Econometrica. 64(4): 813-836.
14. ^Tursoy T, Faisal F (2018). "The impact of gold and crude oil prices on stock market in Turkey: Empirical evidences from ARDL bounds test and combined cointegration." Resources Policy. 55(C): 49-54.
15. a, bBrooks C (2008). Introductory Econometrics for Finance. (2nd ed.). Cambridge: Cambridge University Press.
16. a, bRossi B, Wang Y (2019). "Vector autoregressive-based Granger causality test in the presence of instabilities." Stata Journal. 19(4): 883-899.
17. ^Kotkatvuori-Örnberg J (2016). "Measuring actual daily volatility from high frequency intraday returns of the S&P futures and index observations." Expert Systems with Applications. 43: 213–222.
18. ^Dutta S, Essaddam N, Kumar V, Saadi S (2014). "How does electronic trading affect efficiency of stock market and conditional volatility Evidence from Toronto Stock Exchange?" Research in International Business and Finance. 39: 1–11.
19. ^El Hedi AM, Lahiani A, Nguyen DK (2015). "World gold prices and stock returns in China: Insights for hedging and diversification strategies." Economic Modelling. 44: 273–282.
20. ^Chang EC, Ren J, Shi Q (2009). "Effects of the volatility smile on exchange settlement practices: The Hong Kong case." Journal of Banking and Finance. 33(1): 98–112.
21. ^Elyas R, Masih M (2019). "Does environmental awareness determine GDP growth? Evidence from Singapore based on ARDL and NARDL approaches." Munich Personal RePEc Archive. 94683: 1–23.

22. [a, b]*Ahmed R, Aizenman J, Jinjarak Y (2021). "Inflation and Exchange Rate Targeting Challenges Under Fiscal Dominance." Journal of Macroeconomics. 67: 103281.*

23. [^]*Liu Y (2009). "Exploring the relationship between urbanization and energy consumption in China using ARDL (autoregressive distributed lag) and FDM (factor decomposition model)." Energy. 34(11): 1846–1854.*

24. [^]*Qamruzzaman M, Jianguo W (2018). "Nexus between financial innovation and economic growth in South Asia: Evidence from ARDL and nonlinear ARDL approaches." Financial Innovation. 4(20): 1–19.*

25. [^]*Malik MY, Latif K, Khan Z, Butt H, Hussain M, Nadeem MA (2020). "Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach." Science of the Total Environment. 726 (April): 1–17.*

26. [^]*Łyziak T (2019). "Do global output gaps help forecast domestic inflation? Evidence from Phillips curves for Poland." International Journal of Forecasting. 35: 1032–1041.*