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The Causal Analysis of the Relationship between Inflation and Output Gap in Turkey

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Abstract: *The purpose of the paper is to study dynamic relationships between the inflation and output gap by using Granger causality, Impulse response and variance decompositions analysis within VECM framework for the quarterly data over the first period of 2003 and second period of 2016. The results of the study indicate that the output gap Granger cause the inflation in Turkey both in short-and long-runs. Also, sign of the causality is negative and same causal relationships between two variables hold beyond the sample period. The results should be taken as an evidence of the conclusion that the output gap has important implications for the CBRT's monetary policy.*

Keywords: *output gap, inflation, Granger causality, Impulse response, variance decomposition*
Jel Codes: *E3; E31; E32.*

I. INTRODUCTION

The nature of the relationship between inflation and the output gap has been a subject of economic research more than half of century. Knowing the true nature of this relationship, especially the direction and sign of the causality between these variables can be used as a major finding to design the monetary policy mainly aiming to control the inflation. As mentioned in (Tiwari et al., 2014), despite the fact large body of literature on this topic are available, it is hard to claim that there is consensus on describing the exact structure of this complex and important relationship.

As is well known, the output gap is defined as the difference between actual and potential output and often used as an indicator of the economic cycle, because it allows the demand fluctuations to be disentangled from the fluctuations coming from the supply side. During the business cycles, most of the economists and policy makers want to know if the current output is above or below its potential. As is explained in (Jahan and Mahmud, 2013*)*, the output gap can move in two directions: positive and negative. It can be positive, when actual output is more than potential output. This happens when demand is very high and, to meet that demand, factories and workers operate far above their most efficient capacity. It can be negative when actual output is less than what an economy could produce at full capacity. A negative gap means that there is spare capacity, or slack, in the economy due to weak demand. An output gap should be also understood that an economy is working at an inefficient rate—either overusing or under using its resources.

The output gap is usually considered and taken as an important variable for monetary policy since it is a crucial source of inflation pressures in the economy and provides a summary indicator of the relative demand and supply components of economic activity. In other words, the output gap measures the degree of inflation pressure in the economy and is an important link between the real side of the economy and inflation. When demand for goods and services presses against the economy’s capacity to produce, this tends to put upward pressure on prices. All else equal, if the output gap is positive over time, prices will begin to rise in response to demand pressure in key markets.

On other hand, when demand is weak, it tends to push prices down. In other words, when the rate of inflation consistently comes in lower than expected, it is generally a sign of weak demand and of spare or unused capacity. Thus, if actual output falls below potential output over time, prices will begin to fall to reflect weak demand.

The output gap can be used as a major ingredient in policymaking. We know that all over the world, in many countries including Turkey, one of the major policy goal for the central Banks is achieving and maintaining full employment which corresponds to an output gap of zero. It is a well-known fact that the major policy challenge to almost all central banks is to keep inflation under control, and the output gap is a key determinant of inflation pressure. Since the output gap gauges when the economy may be overheating or underperforming, it will have immediate implications for monetary policy(Mathai, 2009).

The goal of this paper is to try to explore how output gap influences inflation developments in Turkish economy by using Granger concept of causality. The rest of the paper is organized as follows: Section 2 reviews the literature; section 3 explains methodology of paper and data used in the study; sections 4 discusses the empirical results and section 5 concludes the paper.

II. LITERATURE REVIEW

The relation between inflation and economic activity is a popular research topic which has particular importance for the monetary policy. Actually, central banks formulate their policies by checking some indicators which may provide information on the future course of inflation. The deviations of output from its potential level which is referred to as output gap is an important indicator of inflation and is an important subject both in academic circles and among policy makers. The output gap is an important variable form one tary policy as it is a key source of in flation pressures in the economy. Recent studies focused on estimatingpotentialoutput and the output gap with different methods of estimation.

Tiwari, Oros and Albulescu (2014) use discrete and continuous wavelet methodologies for the study of the inflation–output gap nexus in the case of France and determine that the output gap is able to predict the inflation dynamics in the short- and medium-runs, and these results have important implicationsto the Phillips curve theory. The role of outputgap in inflation dynamics is that, as a result of therigidity of theprices in theshortterm, demandshocks provoke a supplyreactionthatcausestheactualandpotentialoutputtodiffer. But, these difference scann ot last in the long term and will start a price adjustment process to restore equilibrium a gain (BoltandvanEls,2000).

Valadkhani (2014) examines the way in which output gap influencesq uarterly inflation duringt he period1970q1–2013q1 in Canada, the UK andthe US byadopting a Markovregime-switching model.An interesting finding of this paperrelates to the positive but varying impact of the output gap on inflation. Twosignificantlydifferentregimesareidentifiedwherebytheprobability ofswitchingtoregime 2 (representedby a relatively high outputgap coefficient) peaksmarkedly and consistently across all three countries only when quarterly changes in inflation become noticeably large and volatile.

Some studies focuses on the asymmetric effects of output gaps on inflation. There is a consensus among economists that the excessdem and which isproxiedby the outputgap can affectinflationin the shortrun in an asymmetric manner. Some studies providereli ableevidence that risingo utputgaps can be more inflationary than falling outputgap saredisinflationary. (Clark, Laxton, &Rose, 2001; Clements&Sensier, 2003).

One of the main indicators of inflationary pressures is the outputgap.The outputgap is not directly observable and estimates have to be inferred from the data.Claus (2000) evaluates whether the outputgap, given the uncertainty surrounding its measurement, is still a usefulindicator of inflationary pressures in New Zeal and. There lationship between inflation and four different measures of the outputgap was teste dover the period 1971q1 to 1999q3.Overall, there sults suggest that the output gap provides a useful signal to the monetary authority. When the out put gap is positive two times out of three in flati on will increase in the next quarter and three times out of five inflation will increase the following year.

Michaelides and Milios(2009)estimates Total Factor Productivity (TFP) change for the Russian economy in the time period 1994–2006.Theyalsocalculatepotentialoutputandoutputgapusing a Cobb-Douglas(CD) production function and a Hodrick–Prescott filter. The relationship between output gap and inflation is examined and the results suggest that there is a strong (causal) relationship between outputgap and inflation in the Russian economy.

Assenmacher-Wesche and Gerlach (2008) decompose inflation in Switzerlandinto two frequency bands and show that inflation is Grangercausedbymonetary factors at low frequencies, defined as those corresponding to periodicities of more than 4 years, but is Grangercausedby the output gap at high frequencies.

Lungu, Wytone and Chiumia (2012) determine the level of outputgap for the Malawi economy and link ittoinflation dynamics. Given the uncertainty surrounding measurement of the outputgap, this paperutilizes three of themostpopular methodologiestoestimate Malawi'spotential output level and outputgap namely; linear timetrend, the Hodrick-Prescottfilter, and the structuralvectorautoregressive (SVAR) model.They have concluded that outputgap in Malawi has a negative relationship with inflation developments. Positive outputgaps have coincided with lowdecreasing inflation suggesting that other factors have been behind the price dynamics.

Gerlach and Wensheng, (2006) studies the relationship between inflation and the outputgap in Mainl and China by fitting Phillips-curvemodels for the period 1982–2003. A number of time-seriestechniquesareemployedtoestimatepotentialoutputandtoconstructmeasures of theoutputgap. These are strikingly similar, and movements in them appearassociated with swings of inflation.

Output gap estimates appears as an important subject especially in times of crises. According to Bou is et al. (2012) output gaps influence policy controlled interest rates and they are very important indicators that guide monetary policy decisions. But if there is high uncertainty about the output gap estimates, monetary policy should put more weight on alternative indicators of inflation pressures like unit costs and wage settlements.

BoltandvanEls(1998)describes the construction of output gaps for 11 EU countries which is based on the production function method to derivepotential output. Subsequently, it is examined whether the seconstructed outputgap scontain information on future inflation. With the exception of Belgium, changes in the calculated outputgaps significantly precedefluctuations in inflation in the countries considered. However, the inflation effects of the changes in the outputgaps differ considerably across countries. Further more, the evidence suggests that particularl ysustained changes in the outputgap smaygeneratesubstantial inflation effects.

Titan and Georgescu (2013), showed the importance of the output gap in analysin gmacroeconomicstability in general and businesscycle dynamics inparticular. They show and underline the importance and usefulness of the outputgap for policy analysis.

Koske and Pain (2008) show that output gapsremain a significant influence on inflation, but their influence is now weaker than in thepast, and the use fulness of output gapestimatesforreal-time inflation projections is limited.

Sarıkaya et al. (2005) estimated outputgap for theTurkish economy. They employ the extended Kalman filter technique in a multivariate setting in which economic content is utilized by the inclusion of inflation and outputgap dynamics. An important finding about the Turkish economy is that business cycle display ssharpturning pointsrat her than exhibiting a smooth pattern. Also outputgap seems to have contributed dramaticallytothedis inflation process in 2002-2004. But relative impact of outputgap on inflation dynamics has been rising since 2001.

III. METHODOLOGY AND DATA

To investigate the causal relationships between inflation and output gap, we have to first look at the time series properties of each variable in question such as whether they are stationary in their levels or first differences. To determine the order of integration of the series, we carry out breakpoint unit root tests for the output gap series, because of the breaks in series, as is seen in Figure 1 and traditional Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for the inflation series.

According to (Engle and Granger, 1987), if non-stationary time series have the same order of integration, for example order one, and if these time series' linear combination exist and stationary, which is integrated of order zero, then these time series are called co integrated time series. After finding that both variables are stationary at their first differences, that is I(1), we test the presence of co integration between two variables by using Johansen co integration test, in which the details of the method can be found in (Johansen, 1988) and (Johansen and Juselius, 1990). In the Johansen approach, there are two likelihood ratio (LR) tests that can be used for detecting the presence of co-integration between variables. The first is the trace test, which tests the null of at most r co-integrating vectors against the alternative that it is less than r. The second is the maximum eigen value test, which tests the null of r co-integrating vectors against the alternative of r+1. Both test statistics are distributed asymptotically as χ^2 with p-r degrees of freedom.

The Granger causality testis designed to detect direction of the possible causal relationship between two-time series by examining a correlation between the current value of one variable and past values of another variable. According to Granger (1969), X Granger causes Y, if current value of Y can be predicted better by taking into account of past values of X than by not doing so, provided that all other past information in the information set is used. If there is a co integration between variables in question, Vector Error Correction (VECM) framework should be used to analyze the dynamic relations between variables. As is indicated in Engle and Granger (1987), if the Granger causality test is carried out at first difference through vector auto regression (VAR) in the case of presence of co integration, then; the results of Granger causality tests will be misleading. Moreover, inclusion of error-correction term to the augmented version of Granger causality test will allow us to capture the long-run causal relationship. Therefore, we include the error-correction term in the augmented version of Granger causality test and following a bivariate *p*th order vector error-correction model (VECM) is formed to perform the Granger causality tests, Impulse Response (IRF) and Variance Decomposition (VDC) analysis. As a result, we estimate the following equations:

$$\Delta Ygap_t = \alpha_1 + \sum_{i=1}^{p} \beta_i \Delta\pi_{t-i} + \sum_{j=1}^{q} \delta_j \Delta Ygap_{t-j} + \varphi_1 ect_{1t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta\pi_t = \alpha_2 + \sum_{j=1}^{q} \phi_j \Delta Ygap_{t-j} + \sum_{i=1}^{p} \gamma_i \Delta\pi_{t-i} + \varphi_2 ect_{2t-1} + \varepsilon_{2t} \quad (2)$$

where Δ is difference operator, p and q are the optimal lag lengths. ect_{t-1} denotes the lagged residual term obtained from the long-run relationship, ε_{1t} and ε_{2t} are normally distributed with zero mean and finite covariance matrix error terms. The coefficients, φ_1 and φ_2 of ect_{t-1}, measure the error correction mechanism that derives the variables back to their long-run equilibrium relationship.

Using Eqs. (1) and (2), we can have the following different cases of causal relations (short-run Granger causality) based on the Wald χ^2 -test; (i) inflation Granger-cause output gap only when lagged values of $\Delta\pi$ in Eq. (1) may be statistically different from zero while values of $\Delta Ygap$ are not in Eq. (2). The joint significance of the coefficients of lagged values of π variable indicates that the output gap responds to short-run shocks to the stochastic environment. (ii) Output gap Granger-cause inflation only when lagged values of $\Delta Ygap$ in Eq. (2) may be statistically different from zero while values of $\Delta\pi$ are not different from zero in Eq. (1); (iii) bidirectional causality occurs when both the lagged values of $\Delta\pi$ and $\Delta Ygap$ in Eqs. (1) and (2) are significantly different from zero and (iv) there is no causal relation between current account deficits and unemployment when both the lagged values of $\Delta\pi$ and $\Delta Ygap$ in Eqs. (1) and (2) are significantly not different from zero. In this case, we can conclude that the variables are independently moving on their paths without influencing each other.

We can detect presence of long-run causality by testing the statistical significance of coefficient of the error correction term (ect_{t-1}) with negative sign. The significance of the speed of adjustment term indicates that the long-run equilibrium relationship is directly driving the dependent variable.

After detecting the direction of the causality between inflation and output gap, we use impulse responses to detect the sign of the causality.To capture the sign of the Granger causality, one has to look at the sign of the impulse responses (IRFs) for all periods. If the response function is positive for all periods, fading away to zero, this should be taken as an indication of positive causality. But on the other hand, it is positive, then negative, and then dampens down; it may be interpreted as a sign of absence of a clear-cut sign of causality. In this case, it could be said that the sign of causality depends on the time horizon.

To determine whether or not same directional causality holds beyond the sample period, we can use the variance decompositions.By portioning the variance of the forecast error of a certain variable, say inflation, into proportions attributable to shocks in each variable, such as output gap, in the system including its own, VDCs might indicate Granger causality beyond the sample period.

In this study, we used quarterly data for Turkey from 2003Q1 to 2016Q2, as tabulated by the Central Bank of the Rep. of Turkey. As is constantly stated, measuring the output gap is no easy task, because of the difficulty of not being able to measure boththe level of potential output, and hence the output gap. Thus, it should be understood clearly that output gap cannot be observed directly, and so cannot be measured precisely: they can be simply estimated. Various methodologies are used to estimate potential output,but they all assume that output can be divided into a trend and a cyclical component. The trend is interpreted as ameasure of the economy's potential output and the cycle as ameasure of the output gap.

As is explained in (Gerlach and Peng, 2006), there are mainly two approaches that researchers can use to estimate potential output and the output gap. The first approach iscalled as the production function approach, which usesthe information regarding the sources ofgrowth of factor accumulation and the state of total factor productivity (Hu and Khan, 1996), Chow and Li (1999) and (Heytens and Zebregs, 2003).Obviously this approach has an advantage of providing an understanding of the sources of growth. On the other hand, the main disadvantage of this approach is that it requires high quality data on the capital stock and the labour force. We know that in many countries, these types of data suffer from considerable measurement errors and lack credibility.

Another approach involves identifying the trend in real GDP with potential output and to use time series techniques to estimate it. A frequently used tool is the Hodrick–Prescott (HP) filter, which decomposes actual output into a long-run trend and cyclical components (Hodrick& Prescott 1997). In this study, we use this approach to obtain the potential output.

Figure 1 displays the time series plots of the variables used in the study.

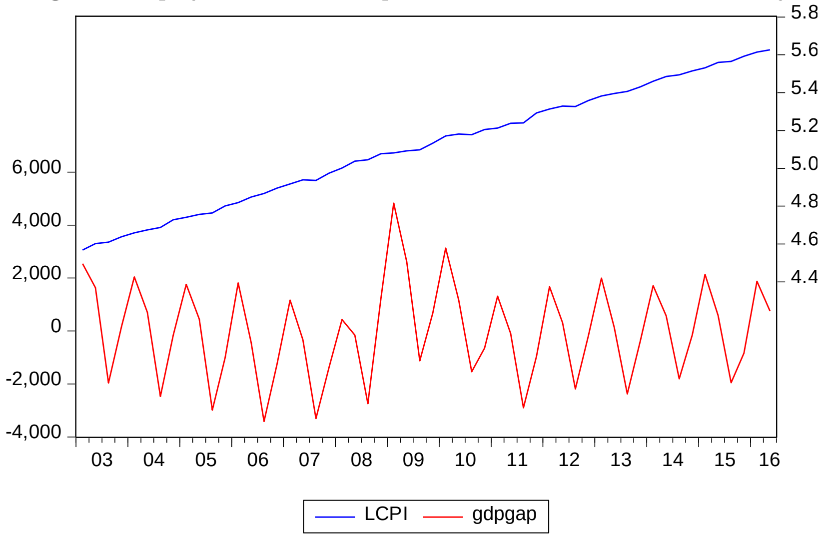

Figure 1: The time seriesplots of variables

Since output gap exhibit clear seasonality, before carrying out any unit root tests and other tests, we first remove the seasonal component in output gap by using the Tramo/Seats method.

IV. EMPIRICAL RESULTS

In the study, we use VECM framework to study the dynamic relations between inflation and output gap. To do this, we first look at the time series properties of each variable by examining whether or not they are stationary in levels or first differences by carrying out breakpoint unit root tests provided by Eviews 9.5 and well known traditional ADF and KPSS tests (Table 1). The results of the unit root tests indicate that both variables are stationary at their first differences; that is, they are integrated of order one.

Table 1. Results of the unit root tests

	Lag length	ADF	Bandwidth	KPSS
$Ygap\_SA$	1	-3,88[a]	-	-
$\Delta Ygap\_SA$	1	-6,85[*a]	-	-
π	6	-2,07	6	0,88
$\Delta\pi$	2	-8,16[*]	15	0,31[*]

Notes: For all tests, a constant is included. For the ADF test, optimal lag lengths are determined by using SIC with a maximum lag of 10. For KPSS test, the spectral estimation method is the Bartlett Kernel, while bandwidth is the Newey-West.
* Significant at 1% level of significance.
a breakpoint ADF test statistics.

After establishing that both series are stationary at their first differences, that is I(1), we tests the presence of cointegration between two variables by using Johansen cointegration tests (Table 2). The results of both Trace and the maximum eigenvalue testindicate that inflation and output gap are cointegrated. In other words, they constitute a long run relationship.

Table 2. The results of Johansen co-integration test.

Trace				**Max Eigenvalue**			
H_0	H_1	Statistics	%5 critical values	H_0	H_1	Statistics	%5 critical values
$r=0$	$r\geq 1$	24,64827	15,49471	$r=0$	$r=1$	22,39848	14,26460
$r\leq 1$	$r\geq 2$	2,249784	3,841466	$r\leq 1$	$r=2$	2,249784	3,841466

As we indicated above, because of the cointegration, we estimate a VECM model with a8 lags and then perform the Granger causality tests (Table 3).

Table 3. Results of VECM Granger causality tests

Long Run		Short Run	
Null hypothesis	**Test Statistics**	**Null Hypothesis**	**Test Statistics**
$\Delta Ygap\_SA$ does notGranger cause $\Delta\pi$	-4,14508**	$\Delta Ygap\_SA$ does notGranger cause $\Delta\pi$	18,99**
$\Delta\pi$ does notGranger cause $\Delta Ygap\_SA$	0.35152	$\Delta\pi$ does notGranger cause $\Delta Ygap\_SA$	11,64
**Significant at 5% level of significance			

The results of the Granger test results indicate that there is unidirectional Granger causality running from output gap to inflation both in short- and long-runs. Also estimated adjustment coefficient is negative and significant. It shows that approximately 0.04% of short-run disequilibrium is corrected in a one year. To determine the sign of the causality, we estimate impulse response functions (Figure 2).

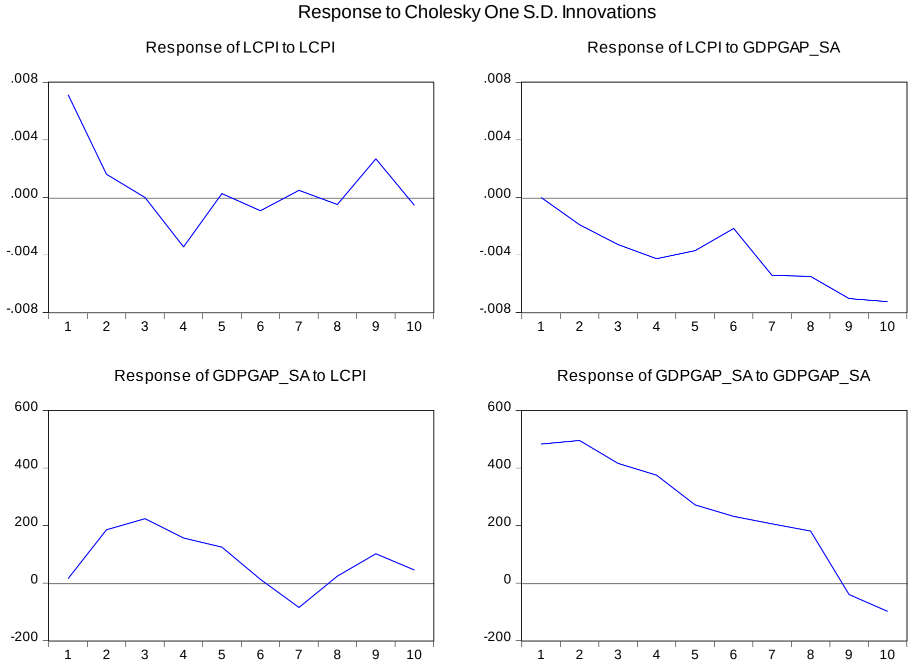

Figure 2: Impulseresponses

Since the responses of inflation to output shocks are all negatives for all time periods, we conclude that output gap is inversely Granger causing the inflation which confirms the expectation derived from economic theory which predicts an inverse relationship between negative output gap and inflation. Since almost all the sample period, Turkey's output gap is negative indicating that output gap will always put downward pressure on prices.

To determine whether this established causal relations between inflation and output gap hold beyond the sample period, we examine the variance decompositions (Figure 3).

Variance Decomposition of Inflation:				Variance Decomposition of Seasonally Adjusted Output Gap		
Period	S.E.	π	$Ygap\_SA$	S.E.	π	$Ygap\_SA$
1	0.007146	100.0000	0.000000	483.6942	0.100554	99.89945
2	0.007567	93.67257	6.327434	717.1086	6.721407	93.27859
3	0.008245	78.90796	21.09204	859.0460	11.49576	88.50424
4	0.009898	66.79027	33.20973	950.3831	12.11328	87.88672
5	0.010569	58.63964	41.36036	996.3652	12.60062	87.39938
6	0.010829	56.60061	43.39939	1023.175	11.96532	88.03468
7	0.012118	45.36140	54.63860	1047.104	12.07486	87.92514
8	0.013311	37.72877	62.27123	1062.930	11.77073	88.22927
9	0.015295	31.65225	68.34775	1068.574	12.56026	87.43974
10	0.016935	25.92524	74.07476	1074.037	12.61372	87.38628

Figure 3: Variance Decompositions

The results of variance decompositions show that most of the contribution to forecast error variance of inflation comes from the shock to output gap indicating that causal relationship between inflation and output gap holds beyond the sample period as well.

V. CONCLUSION

In this study, we aim to analyze the dynamic relations between inflation and output gap by using Granger causality tests, impulse responses and variance decompositions over the period of first quarter of 2003 and second quarter of 2016.

The main findings of the study indicate that there is unidirectional Granger causality running from output gap to inflation and the sign of the causality is negative and same causal relations hold even beyond the sample period. This results have provided some evidences confirming the predictions of economic theory which states an inverse relation between inflation and negative output gap.

The results of study also have some policy implications. First of all, the results contribute the ideas that CBRT should take into account of output gap designing monetary policies to fight against inflation. Secondly, to stimulate the economic growth and economic activity, there is a room for CBRT to adopt a new monetary policy in the form of lowering interest rates. But, knowing the fact that inflation is higher than its targeted value, this policy option should be used carefully.

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