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A Rolling Window Causality Approach Toward Inflation and Inflation Expectations: An Application from Turkey

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Abstract: Expectations for the economic policymakers has been an important economic phenomena especially after 1980's. To control inflation via anchors like inflation targeting, creating Central Bank credibility are all methods to control the expectations. After 15 years of inflation targeting in Turkey this paper is centered upon the causality between inflation and expectations but not just in a static but also in a dynamic manner where a rolling window approach is used to find out the changing causality within periods.

Key Words: Inflation expectations, rolling window, causality.

1.INTRODUCTION

Since 1970's the relation between inflation and the inflation expectations has come a long way. After the first theoretical arguments about the importance of inflation expectations have been put forth by the ones like Friedman (1968), Phelps (1968) and Lucas and Rapping (1969), first generation of models have been developed that relate especially the sticky inflation to inflation expectations. Most of the models at that period saw the relation of inflation expectations and the actual inflation as a spirally self-inducting process i.e. higher inflation leads to higher inflation expectations and this higher inflation expectations leads to even higher actual inflation. Generally during 1970's this correlation had been found to be positive and high though it was empirically hard to isolate the relation of these facts from other social and political factors that may affect these two variables.

However after 1980's as most of the countries and their Central Banks gave up the inflation boosting monetary policies thanks to Lucas' critique, the linkage between inflation and their expectations also became looser and even in some cases the causality changed its direction. After 1990's Central Banks go further and created some inventions to damp down the vibration between inflation and inflation expectations. For example, announcing an inflation target is a way to loose (if not to hinder) the causality from inflation expectation toward the inflation. As economic agents took into account the valuable announcements of a credible Central Bank about the target inflation, importance of the past inflation experiences and lagged inflation expectations about both the actual inflation and the expectations lost their importance. Thus for most of the countries a structural break occurred during that period and controlling inflation via target announcing ended good. In 2018 according to CentralBankNews.info internet site there are 66 inflation targeting countries. However the success of this policy should be tested and be determined for every single of them when enough data is accumulated.

In general; inflation targeting generally is considered to blur the correlation between inflation and the expectance. Still, Çiçek, S, Akar, C. ve Yücel E. (2011) found positive Granger causalities between inflation and expectations during Turkey's inflation targeting period during the years 2003-2010. However during different time periods depending on the credibility of the Central Bank and government the correlation and causality between these two variables may change.

The current literature that is dedicated to the relation between inflation and inflation expectations has two subdomains. The first group of papers try to find a causal link between inflation and inflation expectations and the second subdomain generally focuses on the inflation expectation formation i.e. are agents expectations really rational, adaptive or are they using rule of thumbs like trend extrapolating. This second type of field that focuses on expectation formation is more related to experimental economics though its models can be used to find causal linkages[1].

This paper follows the first subdomain of literature instead of looking to micro foundations of

[1] There is a huge literature in this field see (Schmalensee, 1976) for a first experimental study, Adam (2007) for a model where inflation depends on expected inflation even in a steady state, Fehr and Tyran (2008) for heterogenous expectations and Pfajfar and Zakelj (2009) for a model that focuses on the perceptions of agents.

expectations it focuses on the factual relation between these two variables in Turkey after 2006. Though there is generally a high correlation between inflation expectations and actual inflation; for different time periods, countries and with different data patterns the causality results are fluctuant and crooked. Therefore the results in the literature lack a consistent answer.

This literature was sometimes also referred as "self fulfilment of inflation expectations" which implies that causality runs from expectations toward actual inflation. Ueda (2010) and Leduc, Sill and Stark (2005) found some results supporting this argument for Japan and US (for a specific time period). However, Fang and Zhu (2012) for China and Kantor and Kavli (2011) for South Africa found the reverse causality from actual inflation toward expected inflation. Debabrata, Patra and Ray (2010) for India and Kim and Lee (2013) for some Asian countries including Korea, Hong-Kong and Taiwan found that inflation expectations play an important role in driving actual inflation and expectation shocks have significant dynamic effects on actual inflation so the causality is duplex. So there are different results for different countries with different Monetary Policy applications, and different conditions. Leduc, Sill and Stark (2007) repeated the analysis for US for different time periods and found different results. They found that, while temporary shocks to expected inflation, led to a very persistent increase in actual inflation before 1979, it did not occur after 1979 where FED reacted more 'aggressively'. Xu, Liu, Chang, Peculea and Su (2016) on the other hand analyzed the causality in a dynamic time variation for the causality analysis in US. Such an analysis is better than 'full sample' causality analysis since structural changes and shocks may not only affect the expectations of people and also the link between the expectations and actual results.

For Turkey a structural change occurred just after the 2001 economic crises. The Central Bank became less dependent to the government policies thanks to the changes in Central Bank Law. Also the Central Bank changed its anchor policy. While the Central Bank of the Republic of Turkey during 1980's and 1990's used crawling peg as an anchor and unleashed the interest rates. This policy did not help to suppress the high inflation rates (Acaravcı A. and Bozkurt C. 2006). Due to the Fisher effect the interest rates increased even faster and Turkey could not solve its chronically high inflation problem. After 2001 Central Bank began to control interest rates letting the exchange rates to float. One year later the Bank begun to so-called hidden inflation targeting without announcing any target to public and from 2006 on the bank targets the inflation officially. Though inflation targeting in Turkey seems to stabilize inflation and its expectations to a degree, the 2007-2012 Global Financial Crisis, the coupe trial of 2016 and the arguments about the interest rate policies between the government and the Central Bank especially after 2012 and sharp depreciation of TL against major exchange rates after the mid of 2013 may have changed the link between inflation and expectations. Therefore a dynamic analysis between inflation and inflation expectations similar to Xu, Liu, Chang, Peculea and Su (2016) may be important to understand weather inflation targeting in Turkey does the trick or not.The contribution of this paper is to analyze the inflation and inflation expectation causality for Turkey dynamically. Though there are some causality investigations about the different causes of inflation in Turkey in literature (Kara, ve Tuğer, 2010), (Çiçek, Akar ve Yüce; 2011) a dynamic causality analysis between expectations and inflation does not exist.

The paper is organized as follows, after the literature revive in the first part the methodology and data set will be given in the second part, the empirical results will be presented in the third part and in the fourth part it will be concluded.

2. DATA AND METHODOLOGY

To measure the causality relation between inflation and inflation expectations the two data sets that are used in this paper are the one year inflation on a monthly basis and one year forward inflation expectation of public.

Twelve month inflation data is simply calculated from the percentage change of the CPI of the Turkish Statistical Institute on same month of the previous year. Though there are some papers like Kelly (2008) that use the retail price index RPI instead of CPI and justify this argument depending on studies of Bank of England (2008) that suggests "*that the general public are more likely to refer to RPI than CPI".* However; in Turkey announced targeted inflation referrers to the year-end inflation rates; the change for 12-month CPI (http://www.tcmb.gov.tr). Indeed it is more plausible for public to set their expectations not on retail but on consumer inflation.

For the inflation expectations data, a 12 month ahead expectation which is generally assumed as near or short term expectation by Central Banks[2] is used. The long term expectations are generally used as a synonymous to trend inflation (Clark and Davig, 2009)

[2]2 See www.clevelandfed.org for detailed information.

and when the trend inflation increases the more volatile and unstable the economy and inflation expectations become (Ascari and Sbordone (2013). Though it is a good topic to investigate deeply for this paper it is beyond of the scope. To get the short-term expectations the respondents of the surveys assign probabilities to particular ranges of expected 12 month ahead CPI inflation of the following year, CBRT's metadata ask the respondents the average of the aggregated probability estimates for each interval of 0.01 for the 12-month ahead inflation expectations, and for each predetermined and fixed interval (<3.50, 3.50-4.49, 4.50-5.49, 5.50-6.49, 6.50-7.49, ≥7,50). For Turkey the inflation expectations data is held from the sixth month of 2005 onwards. Therefore the data presented only spans the period of inflation targeting. The monthly data from the Central Bank of Turkish Republic "1E (Appropriate Mean) Expected CPI over the Next Twelve Months (%)" data is used for the analysis. The inflation data is calculated from the Turk Stat's Monthly General Consumer Price Index that began from January 2003. However, since the data of inflation expectations is not dated so far, the analysis spans the period from mid-2005 till the end of 2017.

Before the data sets are used for the full sample causality analysis the stationarities of the data sets are checked with Augmented Dickey Fuller and Phillips and Perron Stationarity Tests. Both of these tests rejected the null hypothesis of non-stationarity of the unit root. In other words both the inflation and inflation expectations data are *I(0)* stationary for the 2005-2017 period. Therefore, the standard Granger Causality in the bivariate vector auto regression model (VAR) framework can be used. In case the series were non-stationary; Toda and Yamamoto (1995) proposed estimating an augmented VAR model with non-stationary variables to obtain a standard asymptotic distribution for the Wald test. Kelly (2008) used this type of causality between inflation and expectations as the series it use were *I(1)* stationary.

The VAR model for the casual relation between inflation and expectations can be set as

$$\begin{bmatrix} \pi_t \\ \pi^e_t \end{bmatrix} = \begin{bmatrix} \varphi_{11} \\ \varphi_{21} \end{bmatrix} + \begin{bmatrix} \varphi_{12}(L) & \varphi_{13}(L) \\ \varphi_{22}(L) & \varphi_{23}(L) \end{bmatrix} \begin{bmatrix} \pi_t \\ \pi^e_t \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (1)$$

where πt and $\pi_e t$ are respectively inflation at time t and expected inflation at time t, $\phi 11$ and $\phi 21$ are time independent constant terms and $\varepsilon 1t$ and $\varepsilon 2t$ are the error terms that cannot be explained by the lagged inflation and inflation expectations. Φ_{ij} (L)'s in the 2x2 matrix represent the coefficients before the lagged inflation and inflation expectations and $\phi_{ij}(L)$= for i=1,2; j=2,3 and k for the lag period when lag defined as $L^k \pi_t = \pi_{t-k.}$ The highest lag period p depends on the Lag Order Selection Criteria[3] and changes for different models and data sets.

If p=2 the VAR matrix equation (1) can be re-written with two equations below;

$$\pi_t = \phi_{11} + \delta_{12}\, \pi_{t-1} + \delta_{13}\, \pi_{t-2} + \theta_{12}\, \pi^e_{t-1} + \theta_{13}\, \pi^e_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\pi^e_t = \phi_{21} + \delta_{22}\, \pi_{t-1} + \delta_{23}\, \pi_{t-2} + \theta_{22}\, \pi^e_{t-1} + \theta_{23}\, \pi^e_{t-1} + \varepsilon_{2t} \quad (3)$$

If the inflation expectation does not Granger cause the inflation hypothesis will be tested than H_0= $\theta_{12} = \theta_{13}$=0 and vice versa if the actual inflation does not Granger cause the inflation expectation hypothesis will be tested than H_0= $\delta_{22} = \delta_{23} = 0$. For equations (2) and (3) using restricted and unrestricted squared errors an F-test for the joint significance of lagged endogenous variables in that equation and their p values are calculated using likelihood ratio (LR) and Lagrange multiplier (LM) statistics. The F-statistics are obtained instead of the Wald statistic (X^2) just because of having small samples and not knowing the real variance term σ^2 of the model. If the p values exceed 0.05, at five percent significance level the null hypotheses are not rejected. In other words for the equation (2) $\theta_{12} = \theta_{13}$=0 hypothesis will not be rejected and it can be said that Inflation expectation does not Granger cause inflation. In a similar way for the equation (3) $\delta_{22} = \delta_{23}$ = 0 hypothesis will not be rejected and it can be said that actual inflation does not Granger cause inflation expectations.

In this paper after applying the full-sample Granger causality test, the sub samples in a rolling-window manner are taken and it is checked whether the causality stays same through time or not. When time series data is prone to structural brakes or changes through time the hidden assumption that the parameters of the VAR model are constant over time is violated and causality becomes instable (Balcılar ve Özdemir, 2013). However; since the estimation window in a rolling-window setup moves over the sample period, the impact of structural breaks is reduced. (Gerlach and Tillmann, 2011). If it is demanding short-run parameter stability can be tested if the series are not co-integrated (Andrews and Ploberger, 1994).

[3] Some of the mostly used Lag Order Selection Criteria are sequential Likelihood Ratio test (LR), Final Prediction Error (FPE), the Akaike Information Criteri$\left(\sum_{k=1}^{p} \varphi_{ij} L^k\right)$IC), the Schwarz Information Criterion (SIC), the Ha…-Quinn Criterion (HQC), and the specific-to-general sequential Portmanteau test. For a review of the procedures see Lütkepohl (1993) and for a performance comparison among AIC, SIC and HQC see Ivanov and Kilian (2005).

Xu, Liu, Chang, Peculea and Su (2016) applied the rolling window approach with a bootstrapping, a process that produces larger number of sample statistic, by reproducing new samples with computer simulation. Though it is common to use such a method because of cheaper data acquiring, its assumptions, bias and generalizations are criticized by some methodologists[4]. In this paper a rolling window approach without bootstrapping will be used.

The rolling window span for subsamples in this paper is chosen to be five years. Alternative trials for three, four, five and six year namely subgroups of 36, 48, 60 and 72 samples were given a try. Most of the sub sample groups found to be normally distributed when VAR Residual Normality Test of Cholesky was applied. Generally the highest AIC criteria results were achieved when 60 and 72 sub sample groups were used. Five year sub group was chosen over six year sub group in this paper just to obtain more causality data since every one extra year meant to lose extra twelve data point.

Before the VAR was applied ADF test for data stationarity has been applied and both the Inflation and expectation data has been found *I(0)* stationary for the July 2003 to January 2018 period. When VAR model was applied similarly VAR stability was checked and no AR root has been found outside the modulus and the war stability condition was checked. Also Portmanteau Autocorrelation test was applied and it cannot be rejected that there is no autocorrelation of the residuals for twelve lags. Similarly for the sub-sample periods the Null Hypothesis that there is no heterokedasticity cannot be rejected[5]. For the lag length of the VAR the alternative criteria like LR: sequential modified LR test statistic, Final prediction error, Akaike information criterion, Schwarz information criterion, Hannan-Quinn information criterion can be used. Lütkepohl (2006) claims that Final prediction error and Akaike information criterion outperforms Schwarz information criterion and Hannan-Quinn in selecting the true model order under small sample conditions. For this dataset generally the results show that the best lag length is "two" generally for all of the criteria mentioned above both for the full dataset from 2003 to 2018, and for most of the sub samples if not for all subsample periods; thus *VAR(2)* has been chosen as the final model.

3. RESULTS AND DISCUSSION

3.1 VAR results of the Whole Data Set:

As mentioned above when *VAR(2)* was applied with Inflation and Inflation Expectations data and results are obtained. VAR Granger Causality/Block Exogeneity Wald Test was applied to full sample period 2003 to 2018 for 173 observations the "static" Granger Causality test in Table 1 shows that for Turkey inflation is still the cause of inflation expectations, however expectations do not cause inflation.

Table 1: VAR Granger Causality/Block Exogeneity Wald Test Results for İnflation and İnflation Expectation 2003-2018

Sample: 2003M07 2018M01			
Dependent variable: _12MONEXP			
Excluded	Chi-sq	df	Prob.
INF	15.05437	2	0.0005
Dependent variable: INF			
Excluded	Chi-sq	df	Prob.
_12MONEXP	2.272441	2	0.321

As can be seen from Table 1 the causality in general does not run from Inflation Expectations toward inflation. According to this result it seems that "self fulfilment of inflation expectations" is not a problem for Turkey for the last 15 years where Turkey targets inflation.

Inf = 0.816 + 1.102*Inf(-1) - 0.235*Inf(-2) + 0.330* Inf Exp (-1) - 0.282*_Inf Exp (-2)

In addition the sum of coefficients of Inflation Expectations are far too low (in this data set 0,048). This means even if the result of causality test were significant the total impact of any change in lagged inflation expectations will not affect the actual Inflation much in quantity: A one percentage increase in lagged inflation expectations will increase inflation just 0,048 percent.

Similarly though causality that runs from inflation toward expectations is still significant at 5 per cent significance level the sum of the coefficients of the lagged inflation are even smaller (0,006).

[4] A more detailed review of the method can be found in the book "Exploring the Limits of Bootstrap" by R. Lepage and L Billard 1992.

[5] As the VAR Model has been applied in a Rolling window manner, to show all of the results of the sub-sample test would be impossible in this short paper. Still for three different time periods the results of the tests are shown in Appendix 1.

The VAR estimation of Inflation Expectations for the whole period is given below:

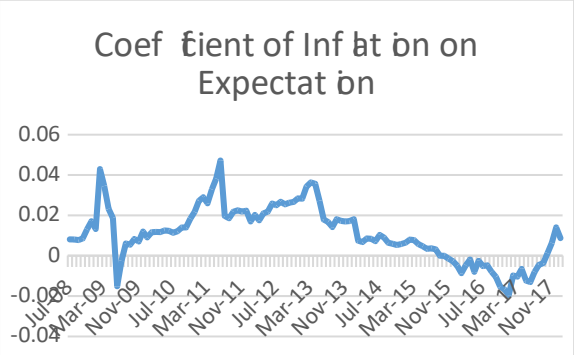
Inf Exp=0.475+1.320* Inf Exp (-1) - 0.392*_ Inf Exp(-2) + 0.088*Inf(-1) - 0.082*Inf(-2)

The coefficients of the lagged inflations Inf(-1) and Inf (-2) nearly neutralize each other so that the total effect of inflation on inflation expectations becomes nearly zero. In other words a one percentage point increase of inflation two periods before effects the inflation expectations first positively but then negatively one period later so that the total effect cancels out. The model for *VAR(3), VAR(4)* also give canceling out coefficients and when *VAR(1)* is applied the VAR Granger Causality/Block Exogeneity Wald Test finds no causality at all. Thus it can be claimed that inflation targeting in Turkey has been successful and has broken the link from inflation expectations toward inflation.

3.2 VAR results with the Rolling Window Approach:

The causality and the coefficients may change over time. These changes may be due to government or central bank policies applied or due to different political and social circumstances in Turkey and the world. During the last 10 years Turkey encountered a financial recession period mostly due to the financial crisis in USA that speeded worldwide after 2008, some political struggles like the 15 July coup and some international political tensions with Russia, Europe and USA and wars in neighbor countries Syria and Iraq.

Graph 1: Rolling Window Causality of Inflation on İnflation Expectations



All these factors can easily change both the expectations and the reflection of expectations toward inflation. Therefore instead of checking for structural breaks during this period the rolling window causality may give detailed information about both the causality between inflation and expectations in short term and how agents change their behaviors during hard times compared to less hard times.

Of course the causality results may also indicate the credibility of the Central Bank of Turkey as it is pursuing an Inflation Targeting Policy where the variation of inflation should be low and actual inflation should proximate the target if not hits it.

The outcome for the rolling window approach showed that the causality between inflation and inflation expectations is temporary and generaly it disappears during growth periods where economy and politics is stable, but during turbulances like 2009 worldwide crisis or after the 2016 for a 1 year period the causality became a problem.

4. CONCLUSION

As a conclusion, the theory remais inconclusive and the literature shows indecisively conflicting resuts between the relation between inflation and inflation expectations This paper tried to approach this inconclusive phenomena in a more dynamic manner and differenciate the periods when the causality acts one directional, two directional or no causality occurs at all.

For Turkey, a static causality from expectations to inflation has not been found. However the inflation caused the expectations to change for 2003-2017 period. When dynamically analyzed, the causality is not persistant and appears especially during political and economic turmoils. After turmoilsit disappears again.

This paper shows that a deeper analysis and maybe a longer period of analysis will help to understand how inflation expectations form and when the expectations became irrelevant. Maybe other variables like inflation target, growth and even a political stability index and some experimental and behavioral economic interpretation which are beyond the scope of this paper may be helpful to understand the mechanism how inflation expectations form.

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