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Analysis of Inflation in Turkey via Ridge Regression

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Abstract
The aim of this study is to analyze inflation in Turkey between the years 2003-2014 and also compare the inflation for the period 2003-2014 with inflation in the years 1963-1983 in Turkey. When multiple linear regression modeling is used for inflation analysis, multicollinearity problem occurred between independent variables. In this study to eliminate the problem in concern ; ridge regression, which is one of the biased estimation methods, is used. Ridge regression method, gives smaller mean square error made by the least squares method based on β parameter estimator without removing variables of the model.
Keywords: Multicollinearity, Ridge Regression, Inflation

I. Introduction

Inflation, is an economical situation expressing the constant and noticable increase in the general level of prices in a country. The indicators related with prices should be evaluated in order to determine the impact of price increases on economic growth and development. Inflation, for whatever reason, is a symbol of the the distribution of income, structure of expenditure, formation or combination of the cost, changes encountered by sharing of resources and burdens of a society. The severity and continuity of events as it comes forth from changes in the structure of the economic conditions and the system, sometimes it can also be the cause of the structural change (İmir, 1986: 51). Inflation, can be due to versatile and various reasons and is a phenomenon that affects many aspects of economic and social life. When the model is predicted with variables affecting inflation, generally it is seen that statistically significant strong relationships between the independent variables occur.

In the multiple regression model, the factors that affects the events are independent variables, the event that basis of analysis is the dependent variable. When N represents the number of observations for each variable on population, the linear relationship is shown as;

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \varepsilon_i \qquad (i=1,2,3, \ldots ,N).$$

This functional relationship is intended to be shown with the matrix notation;

$$Y = X\beta + \varepsilon$$

and,

Y, dependent variable vector which has Nx1 dimensions,
X, independent variable vector which has Nx(k+1) dimensions,
β, parameter vector which has (k+1)x1 dimensions,
ε, error vector which has nx1 dimensions.

When the sample size is equal to "n", the relationship between variables can be written as;

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + \ldots + b_k X_{ki} + e_i \qquad (i=1,2,3, \ldots ,n).$$

This functional relationship in the form of matrix is shown in the following figure.

$$Y = Xb + e$$

e: error vector which has nx1 dimensions.

Least squares estimation technique, gives the estimated parameter values to ensure that the smallest sum of the error terms is obtained. However the implementation of the least squares

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estimation in research one needs to check the validity of the assumptions underlying technique. These assumptions are briefly; the expected value of the error terms is zero, the variance of the error terms is fixed (σ^2) and the error terms is normally distributed. Also the error term should be independent from each other and there should not be any relationship between independent variables.

Multicollinearity problem occurs where one of the assumptions for the multiple linear regression model, namely there should not be any strong statistically significant relationship between independent variables, is not satisfied. When there is a linear relationship between the independent variables, since this affects the value and sign of the regression coefficient, predictions can be made different than it should be actually (Gujarati, 1998: 326). Standard errors of the parametric estimations determines the relationship between the variables in the presence of multicollinearity is greater, so that this leads to significant differences in the direction and value of the actual correlation coefficients.

There are several techniques used for the reduction of multicollinearity problem. Some of these techniques can be listed as; obtaining more data, the removal of one or more independent variables from the model, clustering the independent variables, and biased estimation techniques. In this study, ridge regression technique is discussed, which resolves multicollinearity without removing independent variables from the model but provides biased estimates.

Several studies are found in the literature related with the inflation in Turkey, about the status of independent variables being associated with each other. İmir (1986), estimated an inflation model by ridge regression when method multicollinearity problem is occurred between independent variables. Baldemir (1997), described the determination methods of multicollinearity in his study about inflation in Turkey. Girginer and Yenilmez (2005), obtained the estimation of model parameters by ridge regression when multicollinearity problem is occurred to determine the economic factor which brings inflation. Aktaş ve Yılmaz (2003), compared two techniques by modeling the ISE index with Liu and ridge regression estimators. Various factors in different periods of inflation causes several effects. Therefore, in the study 1963-1983 period and the 2003-2014 period is discussed and ridge regression analysis performed for these periods were reviewed for changes in the model over time.

II. Ridge Regression Technique

In the multiple regression models to use determination of cause - effect relationships, where correlation between independent variables, multicollinearity arises. The ridge regression one of the proposed techniques in order to resolve or minimize this important problem, allows to take all factors effective on an event to the model and the effects to be seen together.

There have been a number of studies from 1970 until today about ridge regression estimator developed by Hoerl and Kennard. When independent variables are related to each other in multiple linear regression, mean square error obtained with ridge regression estimator is less than the mean square error obtained with least squares estimator (Erar, 2013:305).

The difference of the ridge regression technique from the least squares technique is the presence of ridge parameters k*. Ridge regression estimator takes value to overcome the negative impact of multicollinearity on the total of the error squares as,

$\hat{b}(k^*) = (W'W + k^*I)^{-1}WY$
W is the standardized matrix of X and
$0 < k^* < 1$.
When $(W'W + k^*I)^{-1}W'W = Zk^*$,
$\hat{b}(k^*) = Zk^*\,\hat{b}_{EK}$ (Hoerl and Kennard,1970:60).
$\hat{b}(k^*)$ estimator is biased.
When k* = 0 or $k^* = I$,
$E[\hat{b}(k^*)] = \hat{b}$
then, it gives the $\hat{b}$ which is least squares estimator.
The variance of the ridge regression estimator, is
$Var[\hat{b}(k^*)] = Zk^*(W'W)^{-1}W'Var\,(Y)W(W'W)^{-1}Z'$
$= \sigma^2 Zk^*(W'W)^{-1}Z'k^*$ and,

k * (the ridge parameter) 's is a decreasing function; but when k* increases, mean square error of the regression coefficients decreases to a minimum and then increases (Hoerl and Kennard,1970:60). Some suggestions are given for determining the value of k*, which gives the coefficients with smaller mean square error than least square solution. The first of these suggestions is Ridge Trace. When the $\hat{b}_j$'s calculated from k* are drawn one by one against the value of each k * in the range of [0,1]; k * value on which all $\hat{b}_j$'s plotted curves start to become parallel to the horizontal axis is determined as the ridge parameter (Marquardt and Snee, 1975: 6-7).

Another factor used to determine the ridge parameter k * is variance inflation factor (VIF) which takes value from 1 to 10, and usually k* value is adopted as corresponding to values around 7 in practice (Marquardt and Snee, 1975: 6-7).

In the ridge technique used to estimate with the smallest error in the presence of multicollinearity, k*'s is proposed to be determined by the following formulas (equations) (Farebrother, 1975:128).

$$k^* = \frac{\hat{\sigma}^2}{\hat{b}'_{EK}\hat{b}_{EK}}$$
$$k^* = \frac{k\hat{\sigma}^2}{\hat{b}'_{EK}\hat{b}_{EK}}$$
$$k^* = \frac{k\hat{\sigma}^2}{\sum_{j=1}^{k}\hat{\propto}_j^2}$$

When the multicollinearity is very strong, since the least squares estimations can not be obtained, use of the first two formulas is not appropriate. To calculation of ridge parameter with the help of the last formula, $\propto_j$ (principal component estimator) which must be obtained (Hoerl, Kennard and Baldwin, 1975:109).

III. Research Model and Results

Turkey's economy is experiencing inflation issue since the early 1970s. Inflation arises for reasons such as negative developments in the world conjuncture, production bottlenecks created by the lack of foreign exchange and energy, the rise in oil prices, the increasing external dependence of the industry. In the light of these views on the factors affecting inflation rates in the 2003-2014 period in Turkey is determined as; consumption expenditure, public expenditure, industrial input prices, dollar exchange rate, money supply and oil prices. SPSS 20 and NCSS 10 softwares are used to analyze the data.

The data on the variables are taken quarterly when the research models are estimated.
$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2 + \hat{\beta}_3 X_3 + \hat{\beta}_4 X_4 + \hat{\beta}_5 X_5 + \hat{\beta}_6 X_6$

The dependent variable of the model is determined as;
Y_i = WPI (Wholesale Price Index)
and the independent variables of the model are determined as;
X_1 = Consumption Expenditure
X_2 = Public Expenditure
X_3 = Industrial Input Prices
X_4= Exchange Rate (Dollar)
X_5 = Money Supply
X_6 = Oil Prices

The regression model according to OLS (Of Least Squares) is obtained as,
$\hat{Y}_i = 80{,}4167 - 0{,}2817X_1 + 0{,}0169X_2 + 0{,}6171X_3 - 0{,}2178X_4 + 0{,}0689X_5 - 0{,}0304X_6$.
$\hat{\beta}_1$ and $\hat{\beta}_4$ estimation values are negative.

This situation results the inverse relationships between consumption expenditure and inflation, and between exchange rate and inflation. These results are not in accordance with theoretical expectations. Therefore data is standardized, $W'W = R$ correlation matrix was created and is given in Table 1.The findings show that there can be multicollinearity among the variables. There are significant relationships, above the 80% correlation, between consumption expenditure and money supply, between industrial input prices and money supply, between consumption expenditure and oil prices, and between money supply and oil prices from the independent variables on the correlation coefficients matrix. This case shows that there can be multiple correlation problem between variables (İmir, 1986: 59).

Table 1. Correlation Matrix of the Variables

	inflation	consumption exp.	public exp.	industrial input p.	dollar exc. rate	money supply	oil prices
İnflation	1.0000						
consumption exp.	0.9098	1.0000					
public exp.	0.7621	0.7723	1.0000				
industrial input p.	0.9921	0.9267	0.7527	1.0000			
dollar exc. rate	0.7992	0.6153	0.5740	0.7913	1.0000		
money supply	0.9960	0.9201	0.7672	0.9896	0.8052	1.0000	
oil prices	0.8433	0.8877	0.6392	0.8780	0.4809	0.8397	1.0000

Another way to determine the presence of multicollinearity is variance inflation factor (VIF). These values are given in Table 2.

Table 2. Variance Inflation Factors for Independent Variables

Independent Var.	consumption exp.	public exp.	industrial input p.	dollar exc. rate	money supply	oil prices
VIF	11.3768	2.7287	98.9499	6.5101	65.1497	11.2425

Since the variance inflation factors for consumption expenditure, industrial input prices, money supply and oil prices are larger than 10, it shows presence of multicollinearity between variables (İmir, 1986: 59).

Another method used to determining the multicollinearity between variables is the use of eigenvalues of the correlation matrix. These values are given in Table 3.

Table 3. Eigenvalues of the Correlation Matrix

No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number (CN)
1	4.9157	81.928	81.928	1.000
2	0.5736	9.561	91.488	8.569
3	0.3797	6.329	97.817	12.946
4	0.0833	1.389	99.206	58.985
5	0.0412	0.687	99.893	119.289
6	0.0064	0.107	100.000	762.471

Since the value obtained by dividing the largest eigenvalue to the smallest eigenvalue is larger than 10,

$$\frac{\lambda_{max}}{\lambda_{min}} = \frac{4,9157}{0,0064} = 768,07 > 10$$

this indicates the presence of strong multicollinearity between variables.

k*	consumption exp.	public exp.	industrial input p.	dollar exc. rate	money supply	oil prices	Sigma	Max VIF
0.0010	-0.1127	0.0147	0.5278	-0.0699	0.6727	-0.0606	3.2053	74.9409
0.0020	-0.1058	0.0154	0.5186	-0.0628	0.6638	-0.0550	3.4468	58.8964
0.0030	-0.0992	0.0162	0.5103	-0.0560	0.6549	-0.0498	3.6655	47.6342
0.0040	-0.0929	0.0169	0.5026	-0.0495	0.6462	-0.0449	3.8656	39.4173
0.0050	-0.0869	0.0176	0.4955	-0.0434	0.6377	-0.0402	4.0503	33.2322
0.0060	-0.0811	0.0183	0.4888	-0.0375	0.6295	-0.0358	4.2219	28.4550
0.0070	-0.0756	0.0189	0.4825	-0.0319	0.6215	-0.0316	4.3824	24.6845
0.0080	-0.0704	0.0196	0.4765	-0.0265	0.6137	-0.0275	4.5330	21.6534
0.0090	-0.0653	0.0203	0.4709	-0.0214	0.6062	-0.0236	4.6751	19.1778
0.0100	-0.0604	0.0209	0.4655	-0.0165	0.5989	-0.0199	4.8096	17.1277
0.0200	-0.0208	0.0266	0.4229	0.0236	0.5380	0.0102	5.8675	7.9637
0.0300	0.0073	0.0314	0.3929	0.0519	0.4931	0.0318	6.6214	5.2724
0.0400	0.0283	0.0355	0.3704	0.0728	0.4589	0.0480	7.2152	4.3565
0.0500	0.0445	0.0392	0.3528	0.0889	0.4318	0.0606	7.7110	3.6715
0.0600	0.0574	0.0425	0.3386	0.1015	0.4099	0.0707	8.1410	3.1437
0.0700	0.0678	0.0456	0.3268	0.1115	0.3917	0.0789	8.5239	2.7272
0.0800	0.0765	0.0483	0.3169	0.1197	0.3764	0.0857	8.8715	2.3920

0.0900	0.0838	0.0509	0.3084	0.1265	0.3633	0.0915	9.1917	2.1179
0.1000	0.0900	0.0533	0.3010	0.1321	0.3520	0.0964	9.4897	1.8906
0.1075	0.0940	0.0550	0.2960	0.1358	0.3444	0.0996	9.7018	1.7442
0.2000	0.1222	0.0706	0.2579	0.1579	0.2874	0.1217	11.7961	0.9934
0.3000	0.1339	0.0812	0.2370	0.1636	0.2575	0.1304	13.5031	0.7206
0.4000	0.1392	0.0881	0.2235	0.1637	0.2392	0.1341	14.9134	0.5496
0.5000	0.1416	0.0927	0.2135	0.1618	0.2262	0.1354	16.1324	0.4346
0.6000	0.1425	0.0959	0.2056	0.1591	0.2162	0.1356	17.2130	0.3533
0.7000	0.1425	0.0981	0.1989	0.1561	0.2080	0.1351	18.1865	0.2936
0.8000	0.1420	0.0996	0.1931	0.1530	0.2011	0.1342	19.0736	0.2485
0.9000	0.1411	0.1005	0.1880	0.1500	0.1950	0.1331	19.8892	0.2134
1.0000	0.1400	0.1010	0.1833	0.1470	0.1897	0.1318	20.6440	0.1856

Another method used to determining the multicollinearity is the sum of the inverse of the eigenvalues (Webster,1995). This value is,

$$\sum_{j=1}^{6} \lambda_j^{-1} = 142{,}09$$

and larger than 6 which is the number of variables. So there is a strong multicollinearity.

As seen from the measure of $W'W$, VBÇ and $\sum \lambda_j^{-1}$, there is a strong correlation between independent variables and the inflation rate. To estimate $\hat{\beta}$ coefficients with the minimum variance it is need to resolve this multicollinearity.

The parameter estimations [β*(k*)] calculated with k* in the range of [0-1] in order to see the effects of multicollinearity, trying to resolve with ridge regression technique, on the coefficient $\hat{\beta}$ are given in Table 4.

Table 4. [β*(k*)] parameter estimations calculated with k*

The ridge trace drawn on the basis of this estimations is shown in Figure 1. When the ridge trace is examined, since the none of the coefficients $\hat{\beta}_j^*$(k*) approach zero with increasing value of k*, all of the variables will be remain in the model and it should be taken next values from 0,02 of the k*. Because the regression coefficients for the dollar exchange rate and oil prices changed the sign and have become more stable after the k * = 0.01. The signs of all the coefficients are appropriate to the theoretical expectations after the value of k*=0.03. Therefore the value of k* is taken as 0.03 in the ridge regression model.

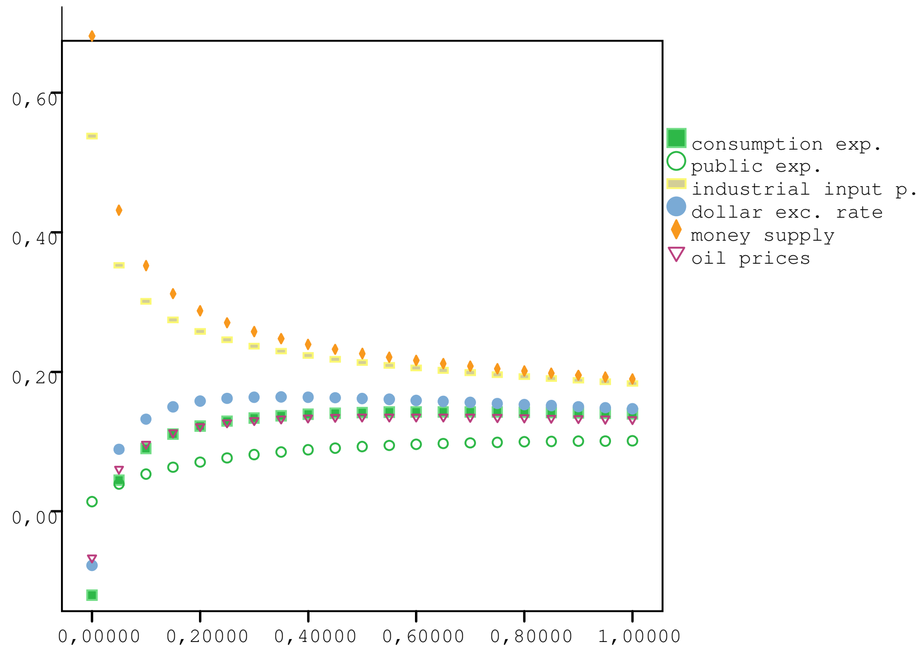

Figure 1. Ridge trace

In addition, when the k * is 0.03, R^2 is 97.9% and VIF values are smaller than 10, so more stable and reliable results are obtained.

The ridge regression model, which indicates the effects of independent variables to the inflation rate in Turkey between 2003-2014, is estimated as

$$\hat{Y}_i = 0{,}0073X_1 + 0{,}0314X_2 + 0{,}3929X_3 + 0{,}0519X_4 + 0{,}4931X_5 + 0{,}0318X_6.$$

R^2=0,9798 $\hat{\sigma}^2 = 1887{,}7$

As seen from the results of analysis carried out, money supply is the most effective increase in prices. Secondly changes in industrial input prices, then the dollar exchange rate, increases in oil prices, public expenditure and consumption expenditure are effective.

IV. Results

The first aim of this study is to analyze inflation in Turkey between the years 2003-2014 and the second aim is to compare the inflation for the period 2003-2014 with the years 1963-1983 in Turkey.

Since the variables included in the linear model to analyse the inflation in Turkey between 1963 -1983 vary depending on each other, the least square technique is inadequate. The results obtained by applied ridge regression technique are in accordance with the theoretical expectations.

In the study for 1963 - 1983 period, ridge parameter k * was 0.02 and the ridge regression model was determined as follows

$$\hat{Y}_i = 0{,}0314X_1 + 0{,}0225X_2 + 0{,}0687X_3 + 0{,}0337X_4 + 0{,}0224X_5 + 0{,}0420X_6 + 0{,}2853X_7.$$

R^2=0,9995 $\hat{\sigma}^2 = 1673{,}54$

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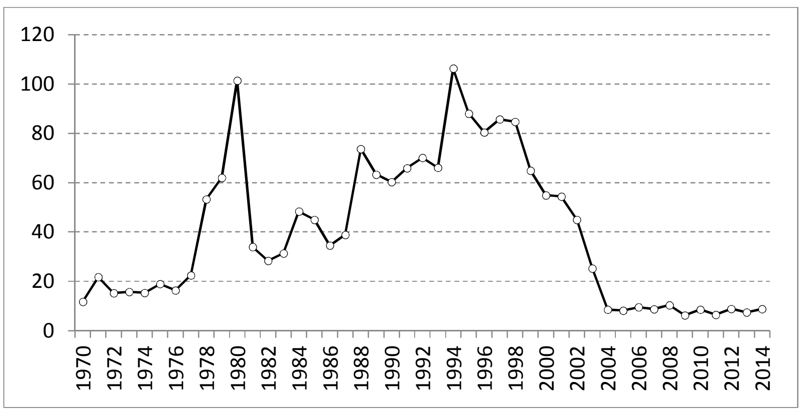
At that time, the gross national product price deflator which gives an idea about the overall cost of the economy is taken as dependent variable and money supply, money supply of the previous period, consumption expenditure, capital expenditure, support purchase credits, oil prices and industrial input prices are taken as independent variables to the model. As can be seen from the model, the result of analysis performed on the basis of the observation in 1963 - 1983 period, industrial input prices is the most effective on the price increase and as a result of the analysis performed on the basis of observation in 2003 -2014 period money supply is the most effective. While the second order of the factors affecting inflation was consumption expenditure in 1963 -1983 period, in 2003 – 2014 period the changes in industrial input prices is in the second order. For the 1963 -1983 period, rises in oil prices takes the third place while the fourth order for the 2003 – 2014 period.

For thirty-year period before 2001, Turkish economy experienced relatively high inflation rates and faced chronical inflation problem as a consequence of unsuccessful disinflationary stabilization programs. Although inflation rates in some specific years, such as 1980 and 1944, exceeded a hundred percent in annual basis, it never reached to hyperinflation levels but increased stepwise up to 2002. While average annual inflation rate in consumer prices was 25 percent in 70s, it reached to 50 percent and 80 percent in 80s and 90s, respectively. Annual inflation rate that was 55 percent in 2001 dropped around to 6 percent in 2009 after implementing IMF supported disinflationary program in 2001. In the period of 2003-2014 considered in this study, average annual inflation rate in consumer prices is 8.5 percent. Throughout the full period aforementioned the course of inflation in Turkey can be seen from the following graph.



In the process of chronical inflation in Turkey, although substantial reductions have been provided after the implementation of IMF supported stabilization programs in 1980 and 1994, these reductions were temporary and inflation rates again started to increase a couple of years later. After the severe economic crises of 2001, with the implementation of the new Fund supported disinflationary stabilization program, Turkey intended to find a permanent solution to her chronicle inflation problem. Turkey has achieved some important structural reforms within the context of this stabilization program. Particularly, changes in laws and regulations related to the monetary policy conducting and the operations of banking sector have created some important transformation about the causes of structural inflation in Turkey. The most important changes related to our topic were the inflation targeting monetary policy regime (started in 2002 with covered mode and in 2006 with uncovered mode) and floating exchange rate regime (in 2001). In the process of restructuring the Turkish economy, abandonment of Central Bank short term credits to Treasury and advancements in the operational independency of the Central Bank were the main factors that contribute to slow down the inflationary process and pass to disinflationary phase. As a consequence of these developments Turkey regained the single digit inflation after thirty years of high inflationary environment.

In our first research covered the 1963-1983 period, we have identified the cost push factors as the prominent explanatory variables of inflation. When one thinks of that this period was characterized by the fixed exchange rate regime, it is possible to say that the cost push inflation could be considered as a natural consequence of the import substituted structure of production. After the above mentioned structural reforms it is observable that the prominent factors that explain the inflationary pressures during 2003-2014 period are the demand pull factors. If we accept that the inflation has gained inertia at 8 percent level recently, we can easily say that this level is the result of demand pull factors, predominantly money supply, and the some characteristics of the period under consideration. From the beginning of uncovered inflation targeting monetary policy regime in 2006 Turkish economy face a couple of external shocks stemming from international conjuncture. These shocks which raised in a great extent from the factors out of the control of the monetary policy and were permanent for a long time caused to miss the inflation targets in first 3 years of the inflation targeting regime. At the same time, the other important factor which prevents a sharp decline in inflation to the targeted levels during this period is the increasing energy prices. Starting in developed countries' financial markets and deepened to cover the whole world in the last quarter of 2008, the implications of global financial crises continued to affect the economy throughout 2009. From the beginning of the last quarter of 2008, the sharp contraction of aggregate demand and the decline in commodity prices caused the downward movements in inflation rate all over the world. In this period Turkey experienced a similar trend and the inflation rate was 5 percent, 100 basis points below the targeted level in 2009. In the face of these developments, in order to restrain the possible negative effects of international conditions Turkish Central Bank started to monetary expansion process at the end of 2008 and was one of the leading central banks that enter the interest rate reductions.

Fluctuations in capital flows and global liquidity cycles cause a rapid appreciation of domestic currency in emerging markets like Turkey. The overvalued currency also positively affects the firm balance sheets and this leads the banking sector to create excessive credit expansion. Excessive credit growth and overvalued local currency disturb the resource allocation and cause domestic aggregate demand to grow faster than national income. These developments together put a negative effect over macroeconomic and financial stability. Economics literature shows that excessive credit expansion is one of the leading factors that contribute the financial turbulences. Similarly, overvaluation of domestic currency in an open economy increases the systemic risk via balance sheet channel and negatively contributes the macroeconomic and financial stability. Since sudden contraction of credit volume or a rapid depreciation of domestic currency also create some risky position for macroeconomic and financial stability, the Central Bank has started to use new policy tools such as reserve option mechanism and interest rate corridor. These macro prudential policy tools aim to soften the effects of volatility of capital flows, to ensure an acceptable level of credit growth and a consistent level of foreign exchange rate with economic fundamentals.

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