P-Star Approach to Modelling and Forecasting Inflation: Some Empirical Evidence from Turkey

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Abstract

P inflation model based on conventional equation of exchange is examined in this study. The developed model was forecasted through using monthly data obtained from Turkey implementation over the period from January 2002 to December 2014 and results supporting P* inflation model were obtained in general. The forecasted model was largely conformed with data used for various lag structures, ranging from 1 month to 24 months, while simulation results showed that P* inflation model can be used with early warning purpose. It can be pointed out that the developed P* model produces more reliable results for the explanation of short-run inflationary dynamics. It also shows us that structural factors should be taken into account for long-run analysis in order to make more realistic forecasts of inflation in Turkey*

Key words: P-star model, inflation determination, monetary policy

JEL Classification: E31, E51, E52

Introduction

Having come of the "*lost money*" problem (Goldfeld, 1973; Goldfeld, 1976) suggested by Stephan M. Goldfeld to the fore in literature on demand for money caused another significant problem to come up in early 1970s: *Which monetary aggregate should be monitored to pursue an efficient monetary policy?* Although the aforesaid problem was discussed in terms of several grounds, the most important part of this discussion was reserved to develop different monetary aggregates based or not based on a theory and evaluate performances of these aggregates through statistical criteria. However, results obtained from different studies, showing that different monetary aggregates give the best performance cause studies to be continued in order to provide a convenient and stable monetary aggregate definition (Şıklar, 1994). So called P* model related to inflation and its monetary dynamics was put forward partly as a result of these studies in recent years.

As a result of analyses, showing better performance on forecasting inflation when compared with alternative models related to forecasting prices leads P* model to be the focus of interest. Consistency of the model in question was researched within the context of a developing country and performance of the model was examined by using Turkish data in this study. In the period that inflation has proceeded to zeroin the world, Turkey, one of the world leaders regarding inflation, is a country in a position to provide an opportunity for presenting interesting findings based on P* model.

In the first section of the study, P* model and its theoretical bases are presented and results of studies conducted about this model are discussed briefly. The second section emphasizes basically necessary revisions which should be carried out for the implementation of P* model in Turkey and their reasons. In the third section, estimation method and data problems are discussed. Estimation of P* model and its performance are addressed in the fourth section. Key findings are emphasized in the conclusion section.

I. P Model and Inflation*

P* model was developed in order to establish the relationship between short-term price movements and long-term prices by Jeffrey Hallman, Richard Porter and David Small (shall be hereinafter referred to as HPS) (Hallman-Porter-Small, 1989; Hallman-Porter-Small, 1991). The equation underlying on the model is the conventional equation of exchange suggested by Irving Fisher for the first time in 1911:

(1)

$$M \times V = P \times y$$

Where M is the quantity of money, V is the velocity of circulation, P is the current price level, and y is the current real income level. General level of prices is determined as:

(2)

$$P = \frac{M \times V}{y}$$

by making use of the equation of exchange which is actually an identity. In the model developed by HPS, it is accepted that V and y tend to move towards their long term values, V* and y* (Hallman-Porter-Small, 1991, p.842). In other words, HPS accept that V and y fluctuate around a constant average. HPS, who use the average of M2 velocity of circulation occurred in the period of sample analyzed in order to obtain long-term equilibrium velocity of circulation (V*), obtain also long-term equilibrium income (y*) related to real income depending upon the term "potential GNP". When the aforesaid long-term equilibrium values are used, it is possible to write the P* equation as the follows:

(3)

$$P^* = \frac{M \times V^*}{y^*}$$

According to the abovementioned equation setting the P* value which can be called as long-term equilibrium price level, it is possible to remark that inflation is a monetary phenomenon. In case the equation (3) is written in logarithmic form and considered together with the equation of exchange pointed out in the equation (1)

(4)

$$p^* - p = (v^* - v) + (y^* - y)$$

Is attained, in the equation above, variables given with lower case letters correspond to logarithmic values of the same variables.

According to the last equation obtained, current price level P shows deviation from the level of long-term equilibrium value P* on the condition that V and/or y show deviation from the level of V* and y* which are the long-term equilibrium values. In other words, the difference between long-term equilibrium price level and current price level is the fundamental cause of inflation according to P* model because V and y in short-term can show deviation from long-term values. In this respect, for example, the large quantity of money which is not reflected in current prices yet can lead current velocity of circulation to fall below long-term equilibrium value and/or cause output to rise above potential income level. Under these circumstances, inflationary pressure increases since current price level is lower than the long-term equilibrium price level. As demand for money and interest rate show adjustment belatedly to eliminate the large quantity of money, the current velocity of circulation moves towards the long-term equilibrium value (V*). Existing lags in adjustment of nominal prices and creation of inflationary expectations lead current output level to move towards potential output level in similar way. At the end of this adjustment process, the current price level also shows tendency to rise up to the long-term equilibrium price level.

When the abovementioned explanations are taken into account, it becomes possible to determine inflation directly by using P* model. Provided that the current inflation rate exceeds the long-term equilibrium inflation rate, the current inflation rate in later periods falls up to the long-term equilibrium inflation rate (Fisher-Flessig, 1995, p.4).

While P* value determines P value in the long run, HPS point out short-term dynamic structure of inflation as (Hallman-Porter-Small, 1991, p.848):

(5)

$$\Delta \pi_t = \alpha (p_{t-1} - p^*_{t-1}) + \sum_{i=1}^{4} \beta \Delta \pi_{t-i}$$

In this equation, πrepresents inflation rate. When $p_{t-1} - p^*_{t-1}$ term (named as price gap)is replaced with the equivalent given in equation (4), we obtain

$$\Delta\pi_t = \gamma_1(y^*_{t-1} - y_{t-1}) + \gamma_2(v^*_{t-1} - v_{t-1}) + \sum_{i=1}^{4} \beta\Delta\pi_{t-i} \quad (6)$$

This equation represents two opinions providing alternatives to each other about how inflation rate shows adjustment in the event of disequilibrium. According to the approach which can be named as Phillips curve, inflation shows adjustment with regard to output gap (real sector disequilibrium) so it becomes $\gamma_2=0$. According to the alternative approach, also known as monetarist approach, inflation shows adjustment with regard to velocity of circulation gap (monetary sector disequilibrium) and it becomes$\gamma_1=0$. HPS impose a constraint which points out that the terms such as output and velocity of circulation gaps enter into the equation of dynamic inflation, having the equal weights ($\gamma_1=\gamma_2=\alpha$) in original P* model. According to HPS, this constraint represents that current real output level has not a direct effect upon inflationary dynamics. To be able to see this, if the logarithm of equation (3) is taken and replaced with P* value,

$$\Delta\pi_t = \alpha(p_{t-1} - m_{t-1} - v^*_{t-1} + y^*_{t-1}) + \sum_{i=1}^{4} \beta\Delta\pi_{t-i} \quad (7)$$

is obtained. As can be seen, this is out of question that current output level has a direct effect upon inflationary dynamics (Atta-Mennah, 1996, p.5-6). The model developed in the equation (6) is forecasted by using USA data and both velocity of circulation and output gap terms are found meaningful in statistical terms. Tests require $\gamma_1=\gamma_2$constraint to be accepted (Hallman-Porter-Small, 1991, p.849). As stated in the study conducted by HPS, opinions suggested about P* model are not new (Hallman-Porter-Small, 1991, p.841). Thus, Humprey (1989) proved with its evidences in his study that economists from David Hume to Milton Friedman, who support quantity theory of money, accepted P* inflation model.

P* model was tested empirically in various studies and mixed results were obtained. Furthermore, the model in question came under several criticisms. In this respect, it is possible to divide criticisms expressed for the model into two fundamental groups as theoretical criticisms and criticisms about forecast performance. Lawrence Christiano expressed one of the theoretical criticisms pointed out. According to Christiano, adjustment process to long-term values lasts for 10-20 years because P* model is based on quantity theory of money (Christiano, 1989, p.3-18). However, this criticism is in the position of an empirical claim, which must be tested on the condition that the model gives a good performance in terms of forecasting. The second criticism for P* model in theoretical base expresses that velocity of circulation is not stable and a persistent fall was observed in velocity of M2 circulation, depending upon various financial innovations in the period examined by HPS (Christiano, 1989, p.6). However, this presumption was tested by HPS, Jeffry Halmann and Richard Anderson and the used data set required the rejection of hypothesis in question (Hallman-Porter-Small, 1991, p.842; Hallman-Anderson, 1993, p.12). Another criticism expressed by Robert Pechenino and Robert Rasche about the model is related to the approach concerning the fluctuation of velocity of circulation and output around long-term equilibrium values (Pecchenino-Rasche, 1990, p.425). These criticisms are attached to discussions about how long-term equilibrium values should be calculated as matter of course. For instance, each method proposed to calculate the GDP gap such as trend, supply-side econometric models or Okun's Law carries some disadvantages.

The second group criticism expressed for P* model is about forecasting performance of the model. It is inferred from comparisons made by HPS that the developed model showed better performance than other models within the frame of statistical criteria (Hallman-Porter-Small, 1989, p.28). Christiano (1998) compared P* model with the explanatory power of other factors determining prices (such as monetary base, Treasury bill rate) and obtained mixed results. The results obtained from the aforementioned study, in which similar tests were conducted by Hallman, Porter and Small, support P* model (Hallman-Porter-Small, 1991, p.856).

Besides the above mentioned studies, it is necessary to refer the existence of studies aiming to test prospective forecasting performance of P* model.

The result demonstrating that P* model displays an unreasonable dynamic behavior was obtained from tests performed within the context of a series of monetary policy rules by Pacchenino and Rasche (1990). In the study conducted for OECD countries, Hoeller-Poret (1991) determined that P* model gives better results than alternative models used for the same purpose. It was implied in the study conducted by Kool-Tatom (1994) that forecasting performance of P* model increases when an open economy is taken into account. Fisher- Fleissig (1995) tried to define a term called "natural rate of inflation" by using P* model in tests performed with alternative monetary aggregates and suggested that P* model gives the best results in this context. Atta Mensah (1996) pointed out in his study conducted for Bank of Canada that P* model can be used as an indicator providing a distant early warning about inflation after necessary revisions are carried out with regard to national economy.

II. P Model and Its Implementation in Turkey*

In the original version of P* model it is assumed that velocity of circulation shows a consistent structure and income elasticity of demand for money is equal to unity. In a developing economy, which undergoes fast inflationary process and payment-transition mechanisms began to develop recently, it is out of question for velocity of circulation to assure stability. Moreover, unit root tests reveal that velocity of circulation is not stable statistically. Therefore, P* model becomes applicable for Turkey only after necessary revisions are carried out. Taking into account the method suggested by Joseph Atta Mensah (1996, p.7) for this purpose, long-term demand for money function are presented as the following:

$$m_t - p_t = \varphi_0 + \varphi_1 y_t + \varphi_2 i_t + \xi_t \quad (11)$$

Where m_t, p_t, y_t and i_t stand for respectively the quantity of money, price, real income, nominal interest rates. The residual term (ξ) in this equation represents the difference between the quantity of money supply and long-term demand for money and it is called as "money gap". All variables, which are the parts of equation above, except for interest rate, are represented with their logarithmic values. The relation among long-term equilibrium price level (p*) corresponding to current quantity of money, long-term interest rate and potential output can be written as:

$$p^* = m_t - \varphi_0 - \varphi_1 y_t^* - \varphi_2 i_t^* \quad (12)$$

The difference between long-term equilibrium price level and current price level, namely money gap is obtained by using the equations (11) and (12) to obtain:

$$p^* - p = \varphi_1 (y_t - y_t^*) + \varphi_2 (i_t - i_t^*) + \xi_t \quad (13)$$

According to this equation, the price gap is equal to the sum of output gap weighted with income elasticity (φ_1), interest rate gap weighted with interest elasticity (φ_2) and money gap (ξ) . In this case, short-term dynamic inflation model developed by HPS takes its final form as:

$$\pi_t = \theta_0 + \theta_1 ygap_{t-1} + \theta_2 mgap_{t-1} + \theta_3 igap_{t-1} + \sum_{i=1}^{k} \theta_4 \pi_{t-i} + \xi_t \quad (14)$$

Where ygap, mgap and igap represent the output, money and interest rate gaps, respectively.

III. Data and Methodology

Data and manipulation methods required for the estimation of last obtained equation (14) are pointed out in this section of the study.

First of all, the variables added the suffix "gap" which are placed in short-term dynamic inflation model and represent deviations from long-term values are unobservable variables. Therefore, this data must be derived in order to forecast the model in question. Several methods to obtain the long-term equilibrium values (i.e., potential values) and the deviations from these long-run values in the short-run (i.e., gaps) are discussed in the literature. Christiano followed linear trend method for the estimation of potential output level while Bank of Japan used the same method for potential velocity of circulation and Christiano (1998) adopted the analyzed sample mean method for velocity of circulation. More complicated methods have been used for the calculation of potential values in recent years and, for example, Hoeller-Poret (1991) followed Hodrick Prescott filtering method for this purpose while Bomhoff (1990) adopted Kalman filter method in his study. Furthermore, it is necessary to remark that structural models are also used for the calculation of potential values.

For example, the calculation of potential GNP values was based on total production function by Bank of Japan (1992) and Ebrill-Fries (1990) implemented co integration analysis for the same purpose. Potential GNP values were determined by using of the structural VAR model developed in order to constitute GNP gap in a study conducted by DeSerres-Guay-St. Amant (1995). In another study, Coe-McDermott (1996) obtained long-term values by using of nonparametric forecast methods. Having regard to evidences obtained by Hoeller-Poret for OECD countries (1991) and by Herrero Pradhan for Spain, Hodrick Prescott filter method is used for the calculation of long-term equilibrium values of variables used in the present study and deviations observed from these equilibrium values in short-term.

Another variable that may pose a problem in the estimation phase is the specification of the long term interest rate. Taking the high inflationary process, the administrated interest rate system implemented in only one part of the period discussed and the oligopolistic structure of banking system into account, it is hard to state that short-term interest rate reflects the opportunity cost of holding money. Moreover, obtaining long-term interest rate is also not realistic due to the above stated reasons. Therefore, percent change in TL/$ exchange rate to reflect the opportunity cost of money holding is used. However this preference should be considered when interpreting the estimation results.

Data used for the present study consists of monthly basis data regarding to 2002:01-2014:12. Turkish Statistical Institute industrial production index was used as a proxy for real GDP for estimations since the income series are not available in monthly basis in Turkey. Forecasts for M1 and M2 money stock definitions of The Central Bank of the Republic of Turkey were given in order to avoid discussions about the definition of money and give suggestions for the purpose of target acquisition in monetary policy that The Central Bank will pursue.

IV. Estimation Results Of P Model*

In the light of the abovementioned explanations, the equation (14) is forecasted for the evaluation of forecasting performance also as the following:

$$\pi_t = \varphi_0 + \varphi_1 ygap_{t-j} + \varphi_2 mgap_{t-j} + \varphi_3 egap_{t-j} + \sum_{i=1}^{k} \varphi_4 \pi_{t-i} + \xi_t \quad (15)$$

Being different from the variables defined before, “e”represents percentage change in TL/$ exchange rate in this equation to be estimated. Furthermore, j values in variables of the equation which take part in index were determined for 1, 6, 12, 18 and 24 months, considering that The Central Bank would also use similar method. Based on Akaike Information Criterion which presents that “ultimate determination error” is minimum, ”k” value was determined for 18 months for the total value of φ_4 parameter included in the equation with the distributed lag. Values between parentheses demonstrate t statistics while values between brackets represent marginal significance levels below the forecast results related to parameters in Table 1 demonstrating the forecast results. Moreover, AdjR^2 stands for the coefficient of determination adjusted for degrees of freedom, SER represents standard error of the regression equation and DW represents Durbin Watson autocorrelation test statistic. [1]

[3]Statistically significant results could not be obtained in the estimations performed by using M2 money stock definition. Therefore, results obtained by using only M1 money stock definition are emphasized in the relevant table and further sections of the study.

Table 1: Estimation Results Of P* Inflation Model

Parameter	*k = 1*	*k = 6*	*k = 12*	*k = 18*	*k = 24*
φ_0	-0,001 (1,213) [0,192]	0,023 (1,025) [0,211]	-0,018 (0,066) [0,966]	0,020 (0,253) [0,0756]	-0,003 (0,489) [0,547]
φ_1	0,051 (2,145) [0,019]	0,021 (1,831) [0,071]	0,077 (1,941) [0,0582)	0,099 (3,145) [0,001]	0,061 (1,745) [0,079]
φ_2	0,143 (1,458) [0,081]	0,332 (2,077) [0,040]	0,215 (3,474) [0,001]	0,096 (4,122) [0,001]	0,066 (2,877) [0,009]
φ_3	0,200 (3,774) [0,001]	0,101 (2,172) [0,033]	0,004 (1,665) [0,064]	0,012 (1,144) [0,099]	0,001 (0,084) [0,821]
φ_4	1,854 (1,988) [0,047]	0,551 (4,251) [0,001]	0,957 (1,887) [0,068]	0,622 (4,011) [0,001]	0,518 (3,876) [0,001]
AdjR^2	0,544	0,699	0,613	0,789	0,801
SER	0,015	0,009	0,044	0,009	0,022
D.W.	1,788	1,913	1,746	1,755	1,862

According to the forecast results,φ_2 parameter which represents the effect of money gap on inflation shows statistically significant results in each lag structure selected from 1 month to 24 months. Output gap (φ_1) parameter reaches significance only with 18 and 24 month lags. Therefore, the effect of output gap on inflation is at negligible level for short-term. On the contrary, percentage change in exchange rate, which was included in the model in order to represent opportunity cost of holding money, gives statistically significant results in 1, 6 and 12 month lags contrary to output gap. It suggests that opportunity cost variable shows its effect on inflation only in 1 year and real factors stand out as the period is extended. Adjusted R^2 values and Figure 1 through 5 which present the n-sample static simulation results show that the developed model fits the data obtained from Turkey quite well. The forecasting performance of models especially for the determination of turning points is relatively high. In this context, it is pointed out that P* inflation model can be used as a distant early warning system because models related to 6 and 12 month lags detected successfully the rebound observed in inflation in April 2008.

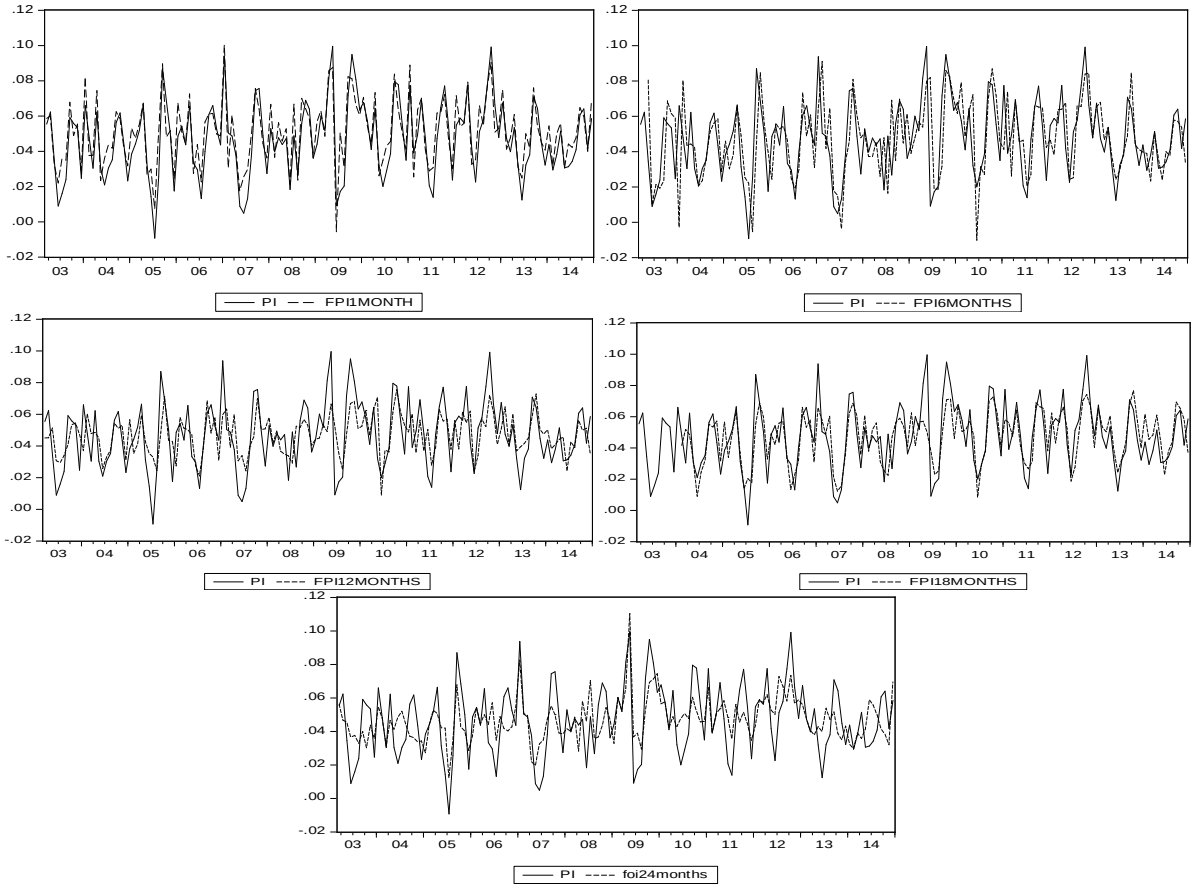

Figure 1-5: Actual and Forecasted Inflation Rates for Various Lags

Various diagnostic test results performed for the residuals obtained from models which were forecasted for several lag structures were demonstrated in Table 2 below. Two of the tests in question, Breusch-Godfrey and Ljung Box tests show the autocorrelation test statistics for residual terms. The null hypothesis that "there is no autocorrelation" in all tests performed for 1, 6 and 12 month time lags must be accepted at reasonable significance levels. The results of ARCH test, suggested by Engle for autoregressive conditional heteroscedasticity in residual terms, point out that the equations do not have any kind of problem in this direction. Finally, Jarque-Bera statistics, which represent tests related to normal distribution of residual terms, require the hypothesis that residual terms obtained have generally normal distribution to be accepted. The aim of these comprehensive diagnostic tests is to ensure that the relevant forecasts are unbiased in case estimated models are used with the aim of prospective simulation. All results show that the estimated models can be used for the purpose of simulation within the borders of statistical reliability.

Table 2: Diagnostic Test Results

Test	***k = 1***	***k = 6***	***k = 12***	***k = 18***	***k = 24***
Breusch-Godfrey	2,145 (0,337)	1,555 (0,457)	2,854 (0,309)	3,019 (0,283)	3,057 (0,281)
Ljung-Box	2,171 (0,648)	1,897 (0,785)	4,233 (0,456)	1,412 (0,788)	0,879 (0,902)
ARCH	0,891 (0,477)	1,005 (0,399)	1,544 (0,225)	1,256 (0,327)	1,185 (0,349)
Jarque-Bera	5,854 (0,244)	5,618 (0,275)	2,768 (0,435)	3,154 (0,366)	7,613 (0,022)

V. Inflation Forecasting

The out-of-sample forecasting performance of inflation models which were forecasted above are examined in this section. First of all, each model is forecasted separately for 2002:01-2012:12 period and forecasts for k- month ahead are made in the forecasting method in question. As it can be remembered, k is used equal to 1, 6, 12, 18 and 24 in this study. After the sample was extended one month, each model was forecasted for 2002:01-2013:01 period again and forecasts for k-month ahead were made once more. This process was carried out until the whole data set available was completely used. Estimated values determined by the out-of-sample forecasting method and the actual values are shown in figures below and Theil-U parameters calculated depending on forecasted and actual values are given in Table 3. The results revealed that the forecasting performance of P* model is relatively high especially for short term. However, it is observed that error percentage due to covariance increases as prospective forecast period extends (i.e., as *k* increases especially to 18 and 24 months). It reveals that as the simulation period extends the systematic component of the existing errors also increase. Consequently, it can be pointed out that the developed P* model produces more reliable results for the explanation of short-run inflationary dynamics. It also shows us that structural factors should be taken into account for long-run analysis in order to make more realistic forecasts of inflation in Turkey.

Table 3: Theil's U Test Results

	k = 1	***k = 6***	***k = 12***	***k = 18***	***k = 24***
Theil's U Coefficient	0,075	0,116	0,223	0,328	0,310
Error due to					
Bias	0,001	0,092	0,035	0,110	0,108
Variance	0,072	0,175	0,235	0,360	0,238
Covariance	0,927	0,733	0,730	0,530	0,654

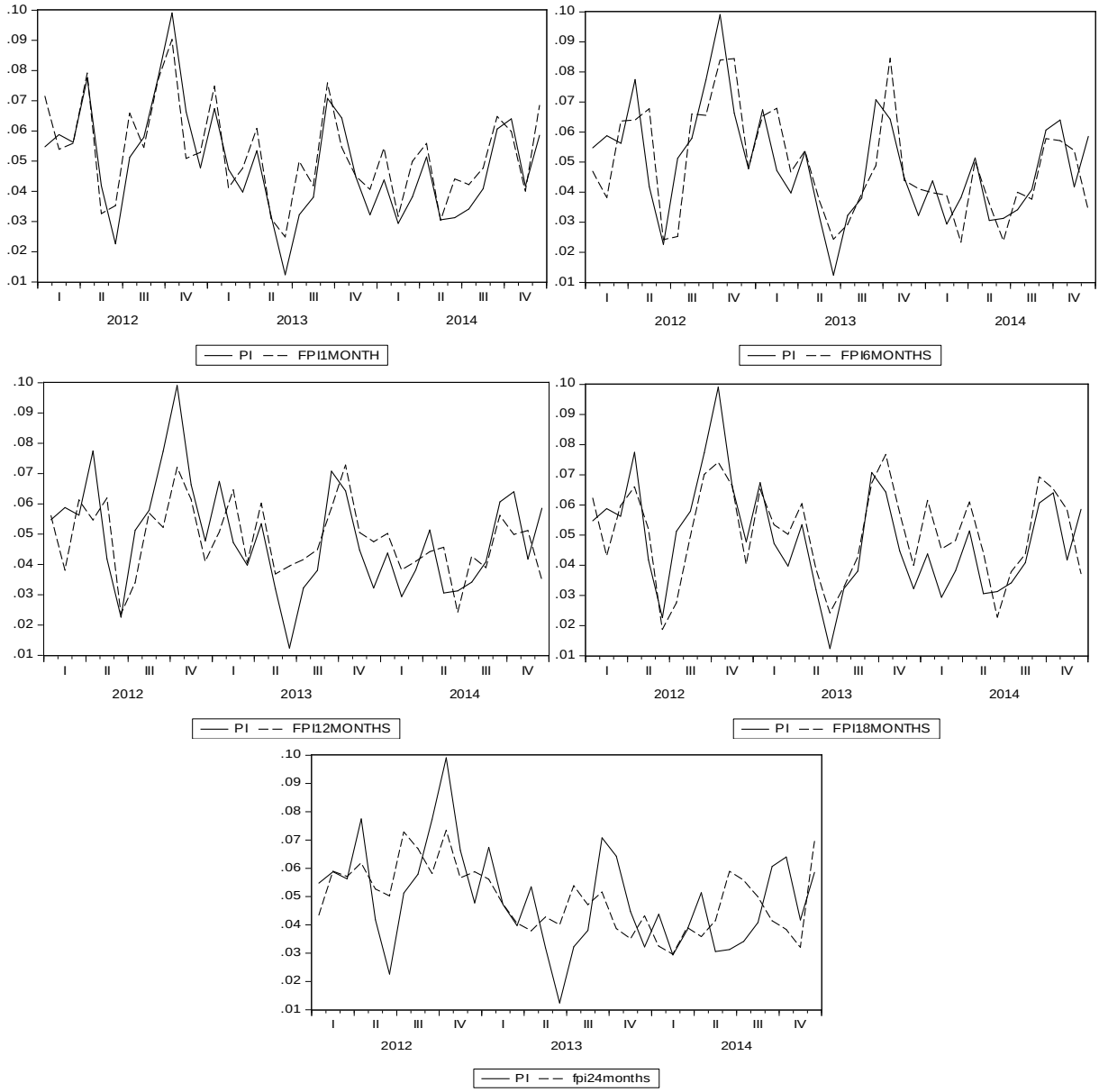

Figure 6-10: Dynamic Forecast Results for Various Lags

Conclusion

P* inflation model based on conventional equation of exchange was examined and tested through data obtained from Turkey. In P* model which regards the short-term price movements as deviation from long-term equilibrium price level, short-term price movements are analyzed by using the deviations of output, interest rate and the quantity of money from their long-run equilibrium levels. The results of this study support P* inflation model within the context of a developing country. The tests conducted show that the money gap is an important factor affecting the inflation rate both in the short and long terms. The results obtained also point out those financial factors in the short run and structural factors in the long run gain importance to explain inflationary dynamics. According to simulation results, the rise of systematic error component represents the existence of structural factors which determine inflation in the long run as the forecast period extends. The empirical results indicated high performance especially in 1,6 and 12 month lags, therefore, it reveals that P* inflation model can be used with the aim of early warning purpose and monetary aggregate which must be pursued for this purpose by the Central Bank, is the narrowly defined money stock.

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