Forecasting Inflation in Azerbaijan

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Abstract

The study examines different forecasting models of Azerbaijani inflation. For this purpose it develops four models: Vector Equilibrium Correction Model of markup approach, a simple dynamic Monetary Model, a New Keynesian Phillips Curve and Autoregressive model. The explanatory variables of inflation are forecasted using auxiliary equations in a simple system approach. Moreover, for robustifying forecasts during and after the crisis periods intercept correction method is used.

Based on the conducting forecast analyses such as forecast bias and encompassing tests, and also comparison of RMSEs it is concluded that Vector Equilibrium Correction Model is better than other three models for forecasting dynamics of the Azerbaijani inflation.

The results of the study particularly constructed models maybe useful for related agencies in forecasting future dynamics of inflation and or at least in comparison of forecasts from different models.

Key words: Markup approach, Monetary model, New Keynesian Phillips Curve, cointegration, error correction modeling, general to specific modeling approach, forecasting, intercept correction, forecast bias test, forecast encompassing test, inflation, Azerbaijan

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1. Introduction

Investigation of inflation process is important at least by two points of view: inflation is a sign of macroeconomic stability and inflation is an indicator of social welfare. Therefore, ultimate goal of monetary policy in each country is to keep inflation in desired level. Additionally, in the case of Azerbaijan economy importance of modeling and forecasting the inflation is amplified by some undesirable consequences of oil boom. Azerbaijani economy has demonstrated substantial economic growth during the recent years, especially since 2004, mainly sourced from oil sector. However, high oil price in the world markets and an increase in the oil extraction and export have leaded to an expansion in the fiscal expenditures and therefore high money growth causing some challenges such as high inflation rates, appreciation of real exchange rate, and therefore an increase in import and deterioration of non-oil sector and its exports. It is worth to note that inflation has risen 1.8 times during the 2004-2010[2].

Thus, it is important to model and forecast future dynamics of the inflation, as a sign of macroeconomic stability and cost of welfare and one of the causes of decreasing in the non-oil export, in the presence of continuous oil boom in the economy.

The objective of this study is to forecast dynamics of the inflation in the Republic of Azerbaijan by examining different models.

The study develops four different models of the inflation: A Vector Equilibrium Correction Model (VeqCM) of markup approach, a simple dynamic Monetary Model (MM), a New Keynesian Phillips Curve (NKPC) and an Autoregressive Model (AR). According to results from Markup Approach, there is a cointegration between domestic price and markup variables in Azerbaijan. VeqCM indicates that the inflation is mainly effected by its inertia, dynamics of the markup variables, excess demand in the real sector and also deviation from the long-run equilibrium. MM shows that the money supply has a statistically significant effect on the inflation. This impact starts with contemporaneous values of the money supply and continuous up to its fourth lag. According to estimated NKPC, the inflation in present period positively depends on its past value while negatively affected by the change in unemployment rate. Moreover, Azerbaijani inflation also depends on its first and third lags in the AR framework.

In addition, the explanatory variables for inflation are forecasted using auxiliary equations. Thus the study uses system of equations for forecasting the inflation and Enders (2004) emphasizes that a system has a better forecast performance rather than a single equation. Hendry and Doornik (1994) also indicate ten reasons of why system analysis is relevant. Moreover, the study also employs the intercept correction method for robustifying the forecasts during and in the post-crisis periods. As Clements and Hendry (2008) state, the models for understanding and forecasting economic processes are far from perfect explanations of their behavior especially when unexpected shift happens at unanticipated time, like a crisis.

Conducting forecast analyses such as visual inspection of the forecasts graphs, forecast bias and encompassing tests, comparison of RMSEs indicate that VeqCM with two Intercept Corrections is better than other three models in forecasting dynamics of the Azerbaijani inflation.

Obtained results particularly constructed models can be considered as practical contribution of the study into forecasting issues of Azerbaijani inflation. Related agencies can use these models in forecasting future dynamics of the inflation and or in comparison of forecasts from different tools.

The rest of the paper is organized as below. Review of appropriate theoretical and empirical literatures is given in Section 2. This followed by a *Theoretical Framework* section discussing theoretical model and statistical properties of the employed approach. *Data* and *Econometric Methodology* sections consist of required data, its description and also addressed econometric methodology for estimation respectively. The long-and short-run estimation

[2] Statistical bulletins of the Central Bank of Azerbaijan, http://cbar.az/pages/publications-researches/statistic-bulletin/

outputs and their brief interpretation are given in Section 6. Forecasts from different models and their comparative analyses are discussed in the section namely *Forecasting inflation in Azerbaijan* while *Conclusion* section summarized main findings of the study and their possible practical contributions. *Reference* section comprises list of reviewed literatures and some large estimation outputs as forms of tables and graphs are placed in *Appendix*.

2. Brief literature review

Lissovolik (2003) discusses that inflation process can be theoretically modeled as: (i) an interaction of supply and demand for money-Money Market Approach (Jonsson, 1999); (ii) a markup pricing mechanism-markup approach (de Brouwer and Ericsson, 1998); or (iii) particular factors affecting external disequilibria pressures (Purchasing Power Parity approach by Cassel (1918, 1921, 1922)) -Foreign Market Approach. Combination of the above mentioned three approaches has been also extensively used in the empirical studies.

There are a number of papers that employ either one or combination of the above mentioned approaches to model and forecast inflation in small open new emerging (transition) economies. For example, Kim (2001) for Poland; Golinelli and Ezoneplus (2002) for the Czech Republic, Hungary and Poland; Kuijs (2002) for the Slovak Republic; Shamloo (2011) for Macedonia; Vizek (2007) for Croatian; Lissovolik (2003) and Leheyda (2005) for Ukraine; Zavkiev (2005), Fahad and Vtyurina (2010) for Tajikistan; Algozina (2006) for Kazakhstan; Bogetic and Mladenovich (2006) and Chernookiy (2004) for Belorussia.

Since the present study employs markup approach it would be preferable to focus on papers that use this approach especially in case of countries like Azerbaijan. As mentioned above, the present study closely follows the paper by De Brower and Ericsson (1998) which is devoted to modeling and forecasting Australian inflation over the quarterly period 1977:3-1993:3 by using the general to specific modeling approach. The study concludes that the level of consumer prices is a markup over domestic and import costs, with adjustments for dynamics and relative aggregate demand. Kim (2001) analyzes Poland inflation employing markup approach along with money market and foreign market approaches. By applying cointegration and error-correction modeling (ECM) over the quarterly period 1990-1999 he finds that wages as a proxy for markup is one of the main determinants of Poland inflation. Lissovolik (2003) uses wages, administrative prices and exchange rates as the markup variables over the monthly period 1996:2-2002:9. In the framework of cointegration and ECM he finds that these variables play significant role in analyzing and (ex-post) forecasting Ukrainian inflation. Another application of markup approach to Ukrainian inflation are conducted by Leheyda (2005). By employing cointegration and ECM framework she concludes that nominal wages as proxies for unit labor cost, exchange rate and import costs have significant effect on prices only in the long run but not in the short run over the monthly period of 1997:1-2003:12. Basko (2005) models and forecasts markup factors (manufacturing cost) of Belorussian inflation by using variables of unit labor cost and oil price together with monetary variables within the framework of cointegration and ECM. His main findings are that markup variables are important in analyzing and forecasting Belorussian inflation over the monthly period 1995:12-2004:6.

Regarding modeling and forecasting inflation in Azerbaijan there are limited (or publicly unavailable) studies. Some of them are Hasanli and Hasanov (2002), Hasanov (2004), Hasanov (2005), Hasanov and Hasanli (2011) and also inflation analyses of The Central Bank of the Azerbaijan Republic (CBAR), international organizations and local think tanks. To our best knowledge none of them employ markup approach in their analyses. In this regard this is the first study that uses markup approach and therefore determines what the markup variables of Azerbaijani inflation are. Moreover since the study uses resent methodologies of modeling and forecasting, developed models and their forecasts can be useful in forecasting Azerbaijani inflation and in comparative analyses of forecast properties of the different models. Finally the study at least can be considered as a contribution to the limited literature pool of Azerbaijani inflation.

3. Theoretical Framework

de Brower and Ericsson (1998) expresses that the domestic general price level is a markup over total unit costs, including unit labor costs, import prices, and energy prices. Assuming linear homogeneity, the long-run relation of the domestic consumer price level to its determinants is

$$CPI = \mu \bullet \left(ULC^{\gamma}\right)\left(MPI^{\delta}\right)\left(API^{\kappa}\right) \tag{1}$$

Where, CPI, ULC, MPI and API are indexes of Consumer Price, Unit Labor Cost, and Import Price and Administrative Price[3] respectively; γ, δ, κ are the elasticities of the CPI with respect to ULC, MPI, and API respectively, each of which is hypothesized to be greater than or equal to zero; μ is a markup coefficient.

Equation (1) assumes that there are three kinds of sources of domestic inflation: wage inflation, imported inflation and administrative (energy) inflation (Surrey, 1989; Juselius, 1992). As stated Kim (1992), if increase in real wages exceeds productivity then inflation occurs. Other side according to the external theory of the inflation, import prices through exchange rate leads to increase in domestic price. Last sources of inflation, administrative price has a special role in the formation of inflation in new emerged market (or transition) economies (Lissovolik, 2003). In these economies including Azerbaijan some prices particularly prices of some main utilities, energy resources (diesel, gas, petrol) and services are administrated by government and when these prices are increased it instantly leads to an increase in firms costs and therefore general domestic price level.

In practice for linear estimation purpose it is useful to express Equation (1) in logarithm as below:

$$cpi = \mu + \gamma \bullet ulc + \delta \bullet mpi + \kappa \bullet api \tag{2}$$

Here and hereafter in the paper lowercase letters are denoted logarithm of the variables. Again as given in De Brower and Ericsson (1998), testable linear homogeneity hypothesis is as below:

$$\gamma + \delta + \kappa = 1 \tag{3}$$

4. Data

The study uses quarterly data on Indexes of Consumer Price, Unit Labor Cost, and Import Price and Administrative Price over the period 1999:1-2010:4. Additionally GDP gap and M1 monetary aggregates is also used in the short-run modeling. Detailed descriptions of the data are given Table A1-A2 and Figure A1 in the Appendix.

5. Econometric Methodology

Long-run modeling: The study employs Johansen's cointegration approach to analyze long-run relationship between variables. Johansen (1988) and Johansen and Juselius (1990) full information maximum likelihood of a Vector Error Correction Model is as following:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \mu + \varepsilon_t \tag{4}$$

Where, y_t is a (*n x 1*) vector of the *n* variables in interest, μ is a (*n x* 1) vector of constants, Γ represents a (*n x* (*k*-1)) matrix of short-run coefficients, ε_t denotes a (*n x 1*) vector of white noise residuals, and Π is a (*n x n*) coefficient

[3] By taking specific features of Azerbaijan economy into account we replace energy price with administrative prices. The point is that administrative prices which cover prices of some utility and services together with energy resources are adjusted by government and therefore have an instant impact on total unit cost.

matrix. If the matrix Π has reduced rank ($0 < r < n$), it can be split into a (n x r) matrix of adjustment coefficients α, and a (n x r) matrix of co-integrating vectors β. The former indicates the importance of the co-integration relationships in the individual equations of the system and of the speed of adjustment to disequilibrium, while the latter represents the long-term equilibrium relationship, so that $\Pi = \alpha\beta'$. k is number of lags; t denotes time and Δ is a difference operator.

Testing for co-integration, using the Johansen's reduced rank regression approach, centers on estimating the matrix Π in an unrestricted form, and then testing whether the restriction implied by the reduced rank of Π can be rejected. In particular, the number of the independent co-integrating vectors depends on the rank of Π which in turn is determined by the number of its characteristic roots that different from zero. The test for nonzero characteristic roots is conducted using Max and Trace[4] tests statistics.

Before conducting cointegration test, the stochastic properties of the data are assessed by means of Unit-Root Tests. For this purpose Augmented Dickey-Fuller (1981) unit root tests is used. The test maintain the null hypothesis of non-stationarity of the given time series.

Short-run modeling: In order to analyze the short-run relationships between variables the General to Specific Approach is employed to estimate error correction model. The idea behind this approach is that firstly general/unrestricted Autoregressive Distributed Lag Model (or Error Correction Model) with maximum lags of right hand side variables is estimated and then by excluding statistically insignificant and economically uninterpretable variables it is tried to get more parsimonious specification. Due to fact that this is a well-known and widely using methodology in the empirical analyses we are not going to discuss this approach here. But note that Campos, Ericsson and Hendry (2005), Davidson et al. (1987), Hendry et al. (1984), Ericsson et al. (1990), de Brouwer and Ericsson (1995, sec. 5.1) provide detailed discussion of the method.

6. Empirical results on modeling

Note again that name of variables with small letters indicate logarithmic expression of them. Augmented Dickey-Fuller unit root test results given in Table A3, indicate that *cpi, api, mpi* and *ulc* are non-stationary in the level and stationary in the first difference[5]. But GDPGAP is stationary in the level.

As a next step VAR of endogenous variables of *cpi, api, mpi* and *ulc* are estimated from fourth lag to one lag over the period 2000:1-2009:4 in order to define appropriate lag order. Centered seasonal dummies and intercept are included into VAR estimation as exogenous variables. As shown from Table A4, Progress to Date and Model Reduction Tests indicate that VAR with two lags is appropriate.

Thus, Johansen cointegration test is conducted on VAR with two lags. Max and Trace cointegration test statistics (especially in the case of degree of freedom adjustment) indicate that there is one cointegrating vector between *cpi, api, mpi* and *ulc* (see: Table A5 Panel A in the Appendix). Normalization of this vector with respect to *cpi* is as below:

$$cpi = \ln(\hat{\mu}) + 0.482\,api + 0.271\,mpi + 0.232\,ulc \tag{5}$$

The sum of these three coefficients is very close to unity and long-run homogeneity hypothesis given in (3) cannot be rejected statistically: $\chi^2(1) = 0.015[0.903]$. Under this hypothesis (5) becomes:

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[4] As Johansen (2002) shows, Since Trace tests tend to reject the null hypothesis of no cointegration in small samples, it is useful also look at degree of freedom adjusted test statistics in the cointegration test.

[5] Note that *m1*, i.e. logarithm expression of M1 monetary aggregate and *UR*, i.e. unemployment rate are also non-stationary in the level and stationary in the first difference, as indicated in Table A3.

$$cpi = \ln(\hat{\mu}) + 0.499\,api + 0.290\,mpi + 0.211\,ulc \tag{6}$$

Weak exogeneity test (Johansen, 1992b, c) indicates that all variables are weakly exogenous except *cpi* at least 5% significance level (see: Panel D of Table A5 in the Appendix). Test of jointly weak exogeneity of *api, mpi* and *ulc* also yields the same result: $\chi^2(3) = 5.023[0.170]$. Note that restriction of jointly weak exogeneity of these three variables together with long-run homogeneity holds as well: $\chi^2(3) = 5.038[0.284]$. Under this restriction the cointegrating vector becomes:

$$cpi = \ln(\hat{\mu}) + 0.469\,api + 0.295\,mpi + 0.236\,ulc \tag{7}$$

and feedback, α , coefficient (Johansen, 1992 b, c) of *cpi* is *-0.236* with the standard error of *0.034* which is expected and highly significant. It is easily observable that corresponding coefficients in (5), (6) and (7) are quite close to each other which can be considered as an indication of robustness of the obtained results. Regarding the long-run results finally note that multivariate statistics testing for stationarity (Johansen, 1995, p. 74) indicate non-stationarity of all the variables (see: Panel E of Table A5 in the Appendix) while tests for significance of the variables (Johansen and Juselius, 1990) show significance of each variables except *ulc* (see: Panel F of Table A5 in the Appendix). Maybe this case is related to multivariate framework of the test and or small number of observations. However *ulc* becomes highly significant in the short-run analysis. Note that this case is similar that of in de Brower and Ericsson (1995, 1998).

According to (7), in ceteris paribus 1% increase in each of *api, mpi* and *ulc* leads to 0.469%, 0.295% and 0.236% increase in *cpi* in the long-run. Approximately half of the overall impact comes from *api* which indicates importance of this factor in the price increasing in Azerbaijan. Note that finding that administrative prices have a statistically significant and large impact on inflation is consistent with other studies' findings conducting in other countries which is similar to Azerbaijan (Lissovolik, 2003, Lejeyda, 2005 inter alia).

Since *api, mpi* and *ulc* are weakly exogenous into system it is quite straightforward to move to single equation modeling of inflation instead of system.

As stated above, the modeling part of the study follows de Brower and Ericsson (1995, 1998) and by doing so we also include GDP gap into short-run estimation. This allows us to take into account an impact of excess demand of the real sector on inflation. Additionally in order to capture a big spike in the dynamics of inflation in the fourth quarter of 2004, impulse dummy namely Di04q4 taking unity in this point of period and zero otherwise, is also included into short-run estimation (Doornik and Hendry, 2009, Volume II).

The general to specific approach is applied to unrestricted ECM with three lags of the right hand side variables (Δcpi , Δapi , Δmpi , Δulc and $GDPGAP$) and obtained much more parsimonious specification over the period 2000:1-2009:4 is as below:

$$\begin{aligned}\Delta cpi = &\underset{(0.002)}{0.001} + \underset{(0.065)}{0.338}\,\Delta cpi_{t-1} + \underset{(0.018)}{0.139}\,\Delta api - \underset{(0.021)}{0.181}\,\Delta api_{t-1} + \underset{(0.029)}{0.116}\,\Delta mpi \\ &+ \underset{(0.010)}{0.038}\,\Delta ulc + \underset{(0.011)}{0.031}\,GDPGAP - \underset{(0.034)}{0.186}\,ECM_{t-1} - \underset{(0.004)}{0.015}\,CS_{1t} - \underset{(0.004)}{0.035}\,CS_{2t} \\ &- \underset{(0.003)}{0.031}\,CS_{3t} + \underset{(0.008)}{0.044}\,Di04q4\end{aligned} \tag{8}$$

Here, ECM is residuals from the long-run equation of *cpi* in (7), T=40, $R^2 = 0.96$, $\hat{\sigma} = 0.665\%$ AR: F(3.25)=0.98 [0.42], ARCH: F(3,34)=0.41 [0.75], Normality: $\chi^2(2) = 2.81[0.25]$, Hetero: F(17,21)=1.29 [0.29], RESET: F(2,26)=1.36 [0.27]. Standard errors are in parentheses.

(8) passes successfully residuals autocorrelation, normality, heteroscedasticity and misspecification tests. The specification also has not any problem with parameter stability as shown from Figure A2 in the appendix.
According to (8), dynamics of inflation are mainly affected by its own inertia, dynamics of markup variables, excess demand in the real sector and also deviation from the long-run equilibrium relation. Approximately 19% of overall disequilibrium is adjusted towards the long-run equilibrium level within one quarter.

7. Forecasting inflation in Azerbaijan

Together with the VeqCM given in (8) the study also builds three other alternative models for forecasting Azerbaijani inflation. One is simple dynamic monetary model[6] (MM), another is New Keynesian Phillips Curve (NKPC) and the last one is autoregressive (AR) model. According to monetary theory, inflation is always and everywhere a monetary phenomenon (Friedman and Schwartz, 1963). Therefore it is quite reasonable to examine forecast ability of MM reflecting a short-run impact of money growth on inflation. NKPC type models are widely used in modeling and forecasting inflation processes. These types of models mainly reflect impact of past (or expected) values of inflation and output gap (or unemployment rate) on present inflation (Mankiw, 2000; Shamloo, 2011). Since impact of the output gap on the inflation is taken into account in equation (8), we are going to use so-called accelerationist type of NKPC models which analyzes inflation as a function of its past value and unemployment rate. AR models have some advantages in terms of application such that they are widely employed in forecasting, they have a simple structure and do not require other explanatory variables (Fahad and Vtyurina, 2010).

Note that MM and AR are estimated by using *Automatic Model Selection* with Large Residuals in the 5% significance level in Oxmetrics 6.20 program package (see: Doornik and Hendry, 2009). Also note that in order to endogenize the explanatory variables of the inflation in VeqCM, MM and NKPC auxiliary equations are built for them. Otherwise, these equations will use given values of the explanatory variables which is not so relevant (Sekine, 2001). On the other side together with auxiliary equations we have system of equations for forecasting the inflation and Enders emphasizes that a system has a better forecast performance rather than a single equation (Enders, 2004). Moreover, Hendry and Doornik (1994) indicate ten reasons of why system analysis is relevant.

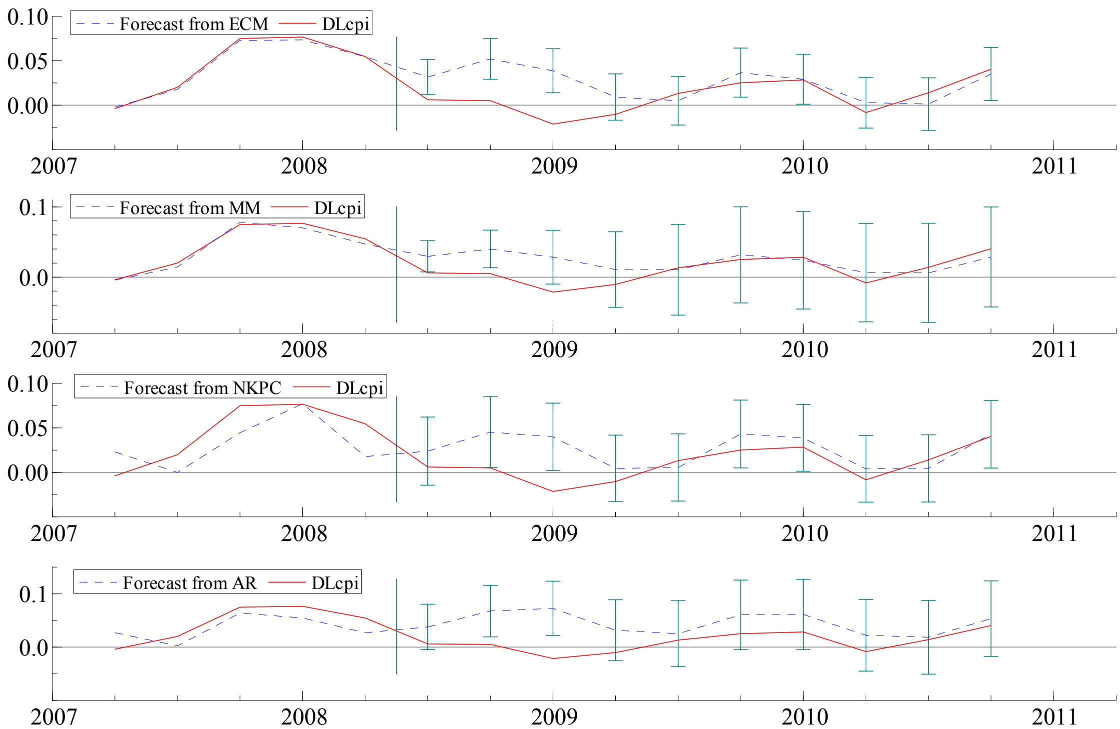
The models and their some statistical properties are given in Table A6. The results of markup approach are widely discussed above through equation (7) and (8). As shown from Panel B in the Table, money supply has a statistically significant effect on inflation as predicted by theory. This impact starts with contemporaneous values of money supply and continuous up to fourth lag and reached its the highest level after six months. Panel C indicates that NKPC type relationship holds in Azerbaijan economy. Exactly saying inflation in present period positively depends on its past value while negatively affected by the change in unemployment rate (DUR)[7]. Additionally Panel C shows inflation in Azerbaijani mainly depends on its first and third lags in the AR framework.

Inflation is forecasted over the period 2008:3-2010:4 by using these four models. Graphs of inflation forecasts from these models are plotted below in Figure 1.

[6] Since this monetary model does not reflect impact of other variables such as interest rate, income, deviation from long-run equilibrium we called it "simple".

[7] Unemployment rate is a non-stationary as shown from the Table A3 and Figure A1, therefore its change, DUR, is used in NKPC.

Figure 1: Forecasts of inflation from the ECM, MM and AR over the period 2008:3-2010:4[8]



As shown from the Figure 1, all four models have very similar forecast performance. Especially in a sense that, none of them can predict dynamics of inflation accurately during the financial crisis. Maybe because as Clements and Hendry (2008) state, the models designed for understanding and forecasting economic processes are far from perfect representations of their behavior especially when unexpected shift happens at unanticipated time, like a crisis. Forecasted values are systematically above actual inflation numbers. In overall, there are quite large gap between forecasted and actual values and most of the actual values are outside forecast confidence interval until 2009:2 which seems more problematic and should be corrected. Moreover, conducted forecast analysis such as forecast encompassing test (Ericsson, 1992; Ericsson, 1993; Clements and Hendry, 2008) and forecast bias test (Clements, Joutz and Stekler, 2007) and also comparison of Root Mean Squared Forecast Error (RMSE) yield mixed results in terms of choosing proper forecast model(s). For example, based on comparison of RMSEs and Forecast Encompassing Test results, given in Panel A of Table 8 and Table 9 respectively, one may prefer MM model. However, Forecast Bias Test Result in Panel A of Table 9 indicates that this model has a serious problem with forecast bias.

Literature of forecasting indicates that sometimes it does matter that from which point of time you start to forecast. In our case we estimate model over the good time and our forecast period starts from crisis time. Perhaps because of this reason the models produce bad forecasts during the financial crisis period. But we think that such kind of forecasting exercise is useful in terms of understanding how systematic forecast errors produced by models in extraordinary period like crisis can be corrected. This issue is explored below.

So, in this circumstance one of the relevant methods that can be used to improve forecast performance is an intercept correction (hereafter IC). Hendry (2006) discuses that shift in the intercept can cause systematic forecast failure. This idea also encourages us to use IC in our forecasts. A theory of IC is widely discussed in the Chapter 8 of Clements and Hendry (2000) inter alia.

In order to use this method firstly we create dummy variable namely Dsh08q3 (taking unity in 2008:3-2010:4 and zero otherwise) and then include it all of four models. Since most actual values are outside forecast confidence

[8] Note that all forecasts are introduced in the paper are produced in the version of *standard errors with parameter uncertainty*.

interval until 2009:2 we use IC based on averaging forecast errors in 2008:3, 2008:4 and 2009:1. Thus, models are re-estimated over the period 2000:1-2009:1[9] and their forecasts for the period 2009:2-2010:4 are illustrated in Figure 2:

Figure 2: Forecasts of inflation from the ECM, MM and AR with IC over the period 2009q2-2010q4

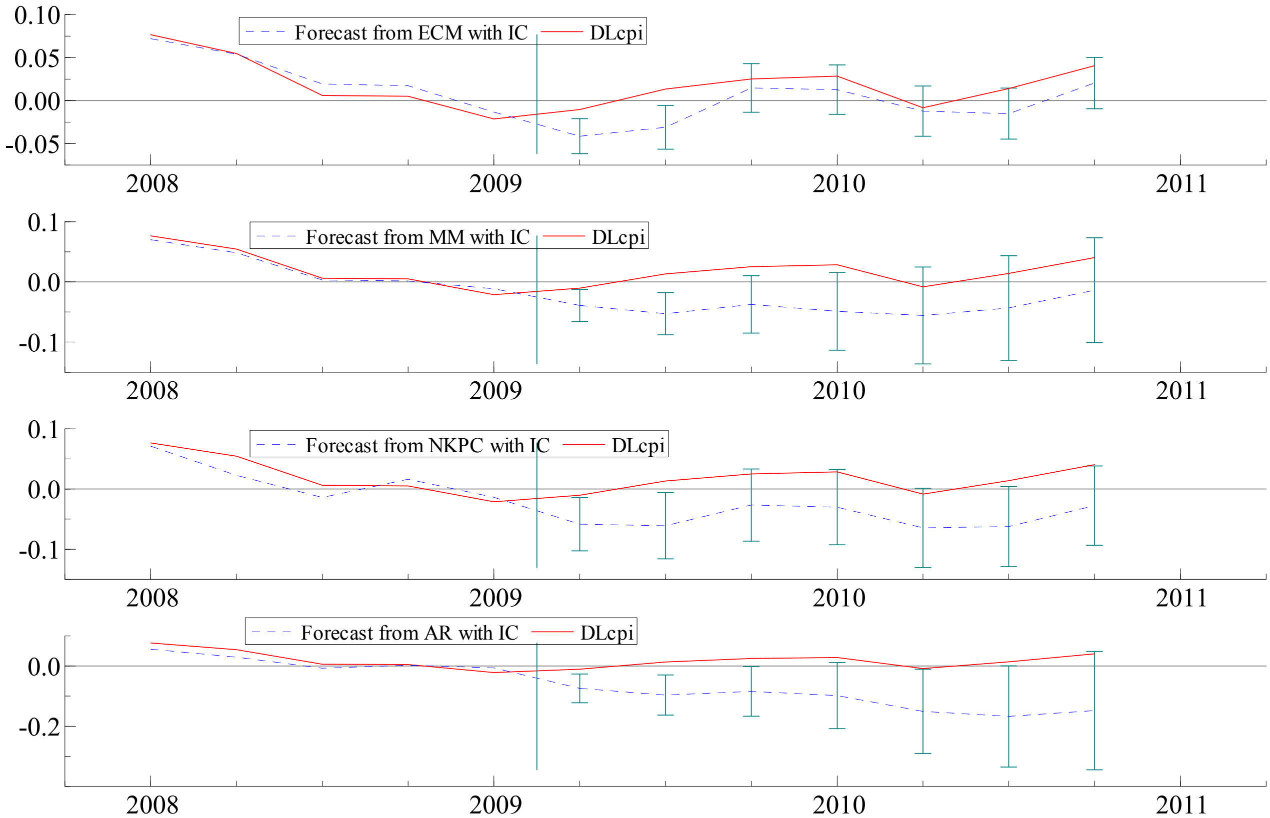
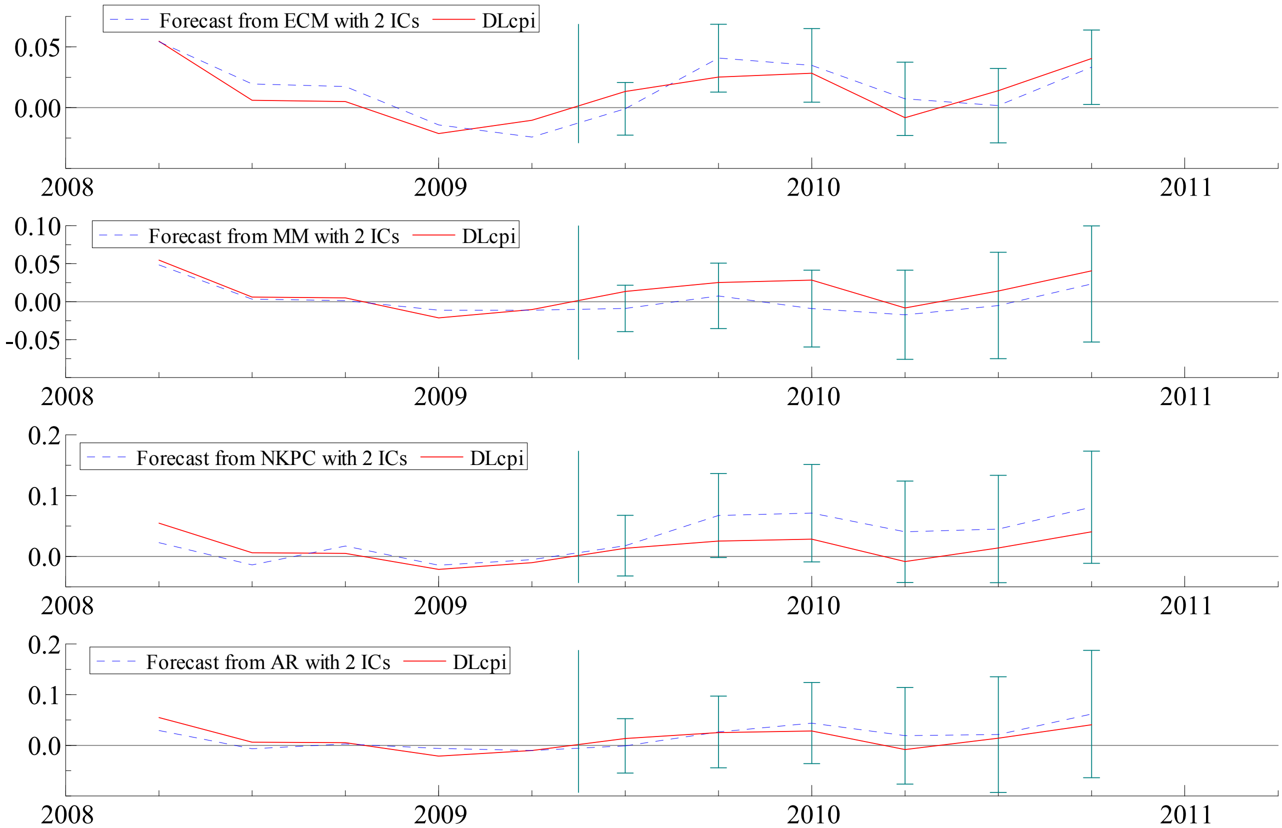


Figure 2 shows that actual inflation values are approximated by models quite well in the period 2008:3-2009:1. Now forecasted numbers are systematically below actual ones. This may relate to dynamics of macroeconomic variables as well as inflation that usually change after recession. Since actual numbers are systematically above forecasted values and most of them are outside forecast confidence interval we decided to use second shift dummy namely Dsh09q2 which takes unity in 2009:2-2010:4 and zero otherwise in order to capture this post-crisis effect. Note that firstly we include only one forecast error (2009:2) into estimation period in order to keep enough observations for further forecasting analysis such as forecast bias and encompassing tests. But if we reveal that the intercept correction based on only one forecast error does not improve forecast performance we can use more forecast errors.

Thus, we use two ICs the first one is for capturing systematic forecast error during the crisis period and the second one is for the post-crisis recovering period. Estimation of the models with these two shift dummies over the period 2000:1-2009:2 yields the results reflecting in Table A7. The table shows dummies are statistically significant in all models and it also can be considered indication of reasonability of using IC. Forecasts of inflation from the models with two ICs over the period 2009:3-2010:4 are graphed in Figure 3.

[9] In order to save space we do not report estimation results here and they can be obtained from authors under request.

Figure 3: Forecast of inflation from the ECM, MM and AR with 2 ICs over the period 2009q3-2010q4



By comparing Figure 2 with Figure 3 one can conclude that there is significant improvement in forecasts of inflation. As Figure 3 shows, forecasted values of inflation from the models quite closely follow actual values and all these values are inside 95% forecast confidence interval which is desirable.

Since forecasts look accurate from the visual inspection of Figure 3, we are going to analyze forecast performances of these models by employing forecast bias test, comparison of RMSEs and encompassing test as before.

Firstly we conduct forecast bias tests in order to define whether or not the models with IC have any bias in their forecasts. According to the test results given in Panel B of Table A8, VeqCM and AR with 2 ICs have not any bias in their forecasts while MM and NKPC with 2 ICs have.

As shown from the Panel B of Table A8, VeqCM with 2 ICs has smaller RMSE than other three models. Secondly, AR model with 2 ICs has a better forecast performance than MM with 2 ICs. NKPC with 2 ICs has the worst forecast performance in terms of RMSE.

Finally, we conduct forecast encompassing test on the models. It is important to note that due to we have only 6 number of forecast observations encompassing test results may not be so convincing. The test results of conducted pairwise forecast encompassing test are given in Panel B of Table A9. According to the results, VeqCM and AR models with 2 ICs encompass MM and NKPC with 2 ICs at 1% significance level and the former two can also encompass each other. Moreover, MM and NKPC with 2 ICs cannot encompass each other at 1% significance level. Note again that since we have a few forecast observation in encompassing test the results should be interpreted with caution.

Thus, based on the above given forecast analyses it can be concluded that VeqCM with two ICs has a better forecast properties rather than other three models. Better forecast performance of VeqCM with 2 ICs can be explained by the fact that it is a model that has more information set than the other three models, especially in a sense that it contains 2 kinds of information: (a) the short-run dynamics of explanatory variables and also (b) deviation from the long-run.

8. Conclusion

Four different models of Azerbaijani inflation are built: Vector Equilibrium Correction Model (VeqCM) using a markup approach, a simple dynamic Monetary Model (MM), a New Keynesian Phillips Curve (NKPC), and Autoregressive Model.

I find a congruent model between domestic price and markup variables in the long-run. There is a linear homogenous price relationship. The administrative price, import price and unit labor cost coefficients are 0.469%, 0.295% and 0.236% respectively.

The VeqCM, inflation is mainly affected by its inertia, dynamics of the above mentioned explanatory variables, and excess demand in the real sector. Approximately 19% of overall disequilibrium is adjusted to long-run equilibrium level within the one quarter.

The MM shows that money supply has a statistically significant effect on inflation. This impact starts with contemporaneous values of money supply and continuous through four lags.

The NKPC indicates that current inflation depends positively on past values and negatively with changes in the unemployment rate.

The simple Azerbaijani inflation model is a third order autoregressive model.

The explanatory variables for inflation are forecasted using auxiliary equations in a simple system approach.

Intercept correction method is employed to robustify forecasts during and after the crisis periods.

Three forecast analysis tests were performed: forecast bias, RMSE, and Encompassing tests.

It is concluded that the VeqCM with two Intercept Corrections is better than other three models for forecasting future dynamics of the Azerbaijani inflation.

The results of the study particularly constructed models maybe useful for related agencies in forecasting future dynamics of inflation or at least in comparison of forecasts from different models.

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10. Appendix

Table A1: Variables and their descriptions

Notation	Definition of variable	Construction	Source
CPI	Consumer Price Index, %, 2000Q4=100, SA		CBAR
ULC	Unit Labor Cost, %, 2000Q4=100, NSA	$ULC = \frac{L*W}{RGDPN}$	
L	Employment in Non-oil sector, millions of people, NSA		SSCAR
W	Average wage in the economy, manat, NSA		SSCAR
RGDPN	Real GDP in Non-oil sector, millions of manat, at 2000 prices, NSA	$RGDPN = \frac{GDPN}{CPI}$	
GDPN	GDP in Non-oil sector, millions of manat, NSA		CBAR
MPI	Import price index in manat, %, 2000Q4=100	$MPI = \$MPI * ERUSD$	
MPIUSD	Import price index in US Dollars		CBAR
ERUSD*	Index of manat US Dollar bilateral exchange rate, 2000Q4=100, NSA.		CBAR
API	Administratively adjusted prices, %, 2000Q4=100, NSA		SSCAR
GDPGAP	GDP gap	$GDPGAP = gdprtc - 6.133 - 0.004 * t$	
gdprtc	Logarithm of Trend-cycle component of RGDP, NSA	Real GDP is decomposed its three components: trend-cycle component, seasonal component and irregular component and then trend-cycle component is taken	
RGDP	Real GDP, millions of manat, at 2000 prices, NSA	$RGDP = \frac{GDP}{CPI}$	
GDP	GDP, millions of manat, NSA		SSCAR
M1	Monetary aggregate, cash in circulation plus demand deposits, millions of manat, NSA		CBAR
UR	Unemployment rate, %	$UR = \frac{UEMP}{EAP} * 100$	
UEMP	Unemployment, thousands, NSA		SSCAR
EAP	Economically active population, thousands, NSA		SSCAR

Note: SA, NSA mean seasonally adjusted and not seasonally adjusted respectively; t – stands for liner time trend; CBAR-Central Bank of Azerbaijan Republic; SSCAR-State Statistical Committee of Azerbaijan Republic; *-an increase means depreciation of manat.

Table A2: Descriptive statistics of the variables

	cpi	*api*	*mpi*	*ulc*
Mean	4.915	4.915	4.896	5.143
Median	4.854	4.795	4.890	5.104
Maximum	5.378	5.392	5.254	5.777
Minimum	4.582	4.603	4.548	4.557
Std. Dev.	0.278	0.335	0.229	0.386
Observations	44	44	44	44

Table A3: ADF Unit Root Test Results

Variable	In the level						In the first difference					
	b_0	*trend*	CS	κ	b_1+1	**Actual value**	b_0	*trend*	CS	κ	b_1+1	**Actual value**
cpi	Yes	Yes	Yes	1	0.90813	-1.915	Yes	No	Yes	0	0.45169	-3.668**
api	Yes	Yes	No	0	0.86305	-1.941	Yes	No	No	0	0.21511	-4.951**
mpi	Yes	No	Yes	1	0.95627	-1.175	Yes	No	Yes	0	0.41770	-3.719**
ulc	Yes	Yes	Yes	2	0.51653	-2.284	Yes	No	Yes	1	-1.0445	-8.05**
GDPGAP	No	No	No	5	0.85582	-2.299*						
m1	Yes	Yes	Yes	1	0.91897	-1.960	Yes	No	Yes	0	0.48184	-3.493*
UR	Yes	Yes	No	0	0.96848	-0.8316	Yes	No	No	0	0.13742	-6.217**

Notes: For a variable y, the augmented Dickey-Fuller (1981) statistics $ADF(\kappa)$ is the t-ratio on b_1 from the regression:

$$\Delta y_t = b_0 + b_1 y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{3} \gamma_i CS_{it} + \psi trend + \varepsilon_t ,$$

here, Δ stands for first difference operator, κ is the number of the lags of the dependent variables, b_0 is a constant term, $CS_{it}, trend$ are centered seasonal dummies and liner trend respectively, ε_t is a white noise.

The sample is: 2000(1) - 2009(4); * and ** denote rejection at the 5% and 1% critical values.

Table A4: Tests for Progress and Model Reduction

Progress to date						
Model	T	p	log-likelihood	SC	HQ	AIC
VAR(4)	40	80	367.114	-10.978	-13.134	-14.356<
VAR(3)	40	64	344.113	-11.303	-13.029	-14.006
VAR(2)	40	48	331.692	-12.158<	-13.452<	-14.185
VAR(1)	40	32	298.184	-11.958	-12.821	-13.309
Model reduction						
VAR(4)	→	VAR(3):	F(16,52)	=1.5019	[0.1349]	
VAR(4)	→	VAR(2):	F(32,64)	=1.2385	[0.2306]	
VAR(4)	→	VAR(1):	F(48,67)	=2.035	[0.0036]**	
VAR(3)	→	VAR(2):	F(16,64)	=0.91289	[0.5585]	
VAR(3)	→	VAR(1):	F(32,79)	=2.134	[0.0035]**	
VAR(2)	→	VAR(1):	F(16,77)	=3.516	[0.0001]**	

Notes: VAR(k) indicates Vector autoregression with k lags. T and p stand for the number of observations and parameters respectively, SC, HQ and AIC are the Schwarz, Hannann Quinn and Akaike information criteria.

Table A5: A Cointegration Analysis

Panel A: Null hypothesis for summary test statistics[10,11]				
Statistics	$r=0$	$r \le 1$	$r \le 2$	$r \le 3$
Eigenvalue	0.628	0.465	0.118	0.003
$\lambda_{\max}$	39.53**	25.00*	5.00	0.13
$\lambda_{\max}^{a}$	31.62*	20.00	4.00	0.11
λ_{trace}	69.67**	30.14*	5.14	0.13
λ_{trace}^{a}	55.74**	24.11	4.11	0.11
Panel B: Standardized Eigenvalues β'				
Variable	*cpi*	*api*	*mpi*	*ulc*
	1.000	-0.482	-0.271	-0.232
	2.545	1.000	1.735	-3.386
	0.161	-0.445	1.000	-0.014

[10] The VAR includes a two lags on each variable (*cpi, admpi, mpi, ulc*), an intercept, and quarterly dummies. The estimation period is 2000:1-2009:4.

[11] The statistics $\lambda_{\max}$ and λ_{trace} are Johansen's maximal eigenvalue and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of the cointegration rank r and, for example, rejection of $r=0$ is evidence in favor of at least one cointegrating vector. The statistics $\lambda_{\max}^{a}$ and λ_{trace}^{a} are the same as $\lambda_{\max}$ and λ_{trace}, but with a degrees-of-freedom adjustment.

	-2.703	-0.0311	0.652	1.000
Panel C: Standardized adjustment coefficients α				
cpi	-0.216	-0.011	0.036	-0.001
api	0.325	-0.132	0.148	-0.001
mpi	-0.234	-0.052	-0.029	-0.007
ulc	-0.170	0.189	0.163	-0.019
Panel D: Weak exogeneity test statistics[12]				
Variable	*cpi*	*api*	*mpi*	*ulc*
$\chi^2(1)$	10.21**	1.467	2.876	0.150
p value	[0.00]	[0.226]	[0.09]	[0.698]
Panel E: Multivariate statistics for testing stationarity				
Variable	*cpi*	*api*	*mpi*	*ulc*
$\chi^2(3)$	37.8**	35.5**	34.3**	35.8**
Panel F: Statistics for testing the significance of a given variable				
Variable	*cpi*	*api*	*mpi*	*ulc*
$\chi^2(1)$	10.5**	11.6**	3.9*	1.1

[12] The statistics for testing weak exogeneity, stationarity, and significance are evaluated under the assumption that $r = 1$. They are asymptotically distributed as $\chi^2(1)$, $\chi^2(2)$, and $\chi^2(3)$ respectively, if r actually is unity and if the associated null hypothesis is valid.

Table A6: Forecast models for the inflation

Panel A: Vector Equilibrium Correction Model of inflation

Identity for cpi		Identity for api		Identity for mpi		Identity for ulc		Identity for ECM		
Dcpi	1.0000	Dapi	1.0000	Dmpi	1.0000	Dulc	1.0000	cpi	1.0000	
cpi_1	1.0000	api_1	1.0000	mpi_1	1.0000	ulcs_1	1.0000	api	-0.46882	
								mpi	-0.29523	
R^2 = 1		R^2 = 1		R^2 = 1		R^2 = 1		ulc	-0.23595	R^2 = 1

MOD(1) Estimating the model by FIML The estimation sample is: 2000(1) - 2008(2)

Equation for: Dcpi

	Coefficient	Std.Error	t-value	t-prob	
Dcpi_1	0.380	0.068	5.610	0.000	
Dapi	0.131	0.018	7.370	0.000	
Dapi_1	-0.174	0.019	-8.970	0.000	
Dmpi	0.122	0.066	1.850	0.090	
Dulcsa_n	0.034	0.016	2.170	0.051	
GDPGAP	0.035	0.010	3.500	0.004	
ECM_1	-0.158	0.029	-5.410	0.000	
CS	-0.016	0.004	-3.830	0.002	
CS_1	-0.038	0.004	-9.030	0.000	
CS_2	-0.032	0.003	-10.500	0.000	
Di04q4	0.046	0.007	6.560	0.000	
Constant	0.001	0.002	0.605	0.556	sigma = 0.005906

Auxiliary Equation for: Dapi

	Coefficient	Std.Error	t-value	t-prob	
Constant	-0.002	0.004	-0.505	0.623	
Dapi_1	0.255	0.048	5.370	0.000	
Di07q1	0.365	0.019	19.000	0.000	
Di04q4	0.087	0.019	4.530	0.001	
Di05q1	0.091	0.019	4.690	0.001	sigma = 0.019742

Auxiliary Equation for: Dmpi

	Coefficient	Std.Error	t-value	t-prob	
Constant	0.020	0.005	3.640	0.003	
Di05q2	-0.098	0.030	-3.290	0.007	sigma = 0.031005

Auxiliary Equation for: Dulc

	Coefficient	Std.Error	t-value	t-prob	
Constant	0.033	0.018	1.890	0.083	
Dulc_1	-0.441	0.144	-3.060	0.010	
Di01q2	0.301	0.095	3.160	0.008	sigma = 0.097727

Auxiliary Equation for: GDPGAP

	Coefficient	Std.Error	t-value	t-prob	
Constant	0.008	0.006	1.220	0.245	
GDPGAP_1	1.628	0.145	11.200	0.000	
GDPGAP_2	-1.203	0.252	-4.770	0.001	
GDPGAP_3	0.622	0.162	3.840	0.002	sigma = 0.036812

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-1 test:	F(1,17) = 3.8224 [0.0672]	ARCH 1-1 test:	F(1,32) = 0.12191 [0.7293]
Normality test:	Chi^2(2) = 0.32172 [0.8514]	Hetero test:	F(17,16) = 0.56872 [0.8706]

Vector SEM-AR 1-1 test: F(25,79) =1.4056 [0.1294] Vector Normality test: Chi^2(10) = 18.148 [0.0525]
ZHetero test: not enough observations

Panel B: Monetary Model of inflation

MOD(2) Estimating the model by FIML   The estimation sample is: 2000(1) - 2008(2)
Equation for: DLcpi

	Coefficient	Std.Error	t-value	t-prob	
Dcpi_1	0.455	0.086	5.280	0.000	
Dcpi_2	-0.446	0.087	-5.110	0.000	
Dm1	0.062	0.028	2.240	0.037	
Dm1_2	0.145	0.019	7.630	0.000	
Dm1_3	0.054	0.021	2.590	0.018	
Dm1_4	0.084	0.020	4.100	0.001	
CSeasonal_1	-0.030	0.005	-6.020	0.000	
I:2004(4)	0.059	0.010	6.060	0.000	
I:2007(2)	-0.089	0.012	-7.630	0.000	
Constant U	-0.006	0.003	-1.790	0.090	sigma = 0.009725

Auxiliary Equation for: Dm1

	Coefficient	Std.Error	t-value	t-prob	
Dm1_1	0.688	0.166	4.150	0.001	
CSeasonal	-0.188	0.033	-5.700	0.000	
CSeasonal_1	0.103	0.039	2.650	0.016	
I:2006(1)	0.238	0.084	2.840	0.011	
Constant U	0.019	0.019	0.956	0.351	sigma = 0.074183

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-3 test:	F(3,19) = 3.2215 [0.0459]*	ARCH 1-3 test:	F(3,28) = 0.16286 [0.9205]
Normality test:	Chi^2(2) = 3.2749 [0.1945]	Hetero test:	F(14,19) = 0.45746 [0.9298]

Vector SEM-AR 1-3 test: F(12,40) = 2.8 [0.0072]**; Vector Normality test: Chi^2(4) = 3.1942 [0.5259];
Vector Hetero test: F(57,36) = 0.74624 [0.8410]

Panel C: NKPC model of inflation

MOD(3) Estimating the model by FIML   The estimation sample is: 2000(1) - 2008(2)
Equation for: Dcpi

	Coefficient	Std.Error	t-value	t-prob	
DLcpi_1	0.375	0.146	2.570	0.020	
DUR	-0.209	0.080	-2.620	0.018	
Di04q4	0.057	0.017	3.340	0.004	
CSeasonal	-0.019	0.010	-1.900	0.075	
CSeasonal_1	-0.052	0.010	-5.390	0.000	
CSeasonal_2	-0.038	0.008	-4.660	0.000	
Constant U	0.011	0.004	2.950	0.009	sigma = 0.015831

Auxiliary Equation for: DUR

	Coefficient	Std.Error	t-value	t-prob	
DUR_3	-0.185	0.068	-2.720	0.015	
Dsh04q4	-0.041	0.007	-5.970	0.000	
Di08q1	-0.129	0.018	-7.350	0.000	
Di00q2	-0.094	0.013	-7.310	0.000	
Constant U	0.024	0.004	5.540	0.000	sigma = 0.016999

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-3 test:	F(3,21) = 3.6692 [0.0286]*	ARCH 1-3 test:	F(3,28) = 1.5554 [0.2223]
Normality test:	Chi^2(2) = 2.0496 [0.3589]	Hetero test:	F(9,24) = 4.1445 [0.0025]**

Vector SEM-AR 1-3 test: F(12,42) = 0.93881 [0.5191] Vector Normality test: Chi^2(4) = 5.9884 [0.2000]
Vector Hetero test: F(57,36) = 0.74624 [0.8410] Hetero-X test: not enough observations

Panel D: AR model of inflation

EQ(1) Modelling **DLcpi** by OLS   The estimation sample is: 2000(1) - 2008(2)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Dcpi_1	0.440	0.126	3.490	0.002	0.303
Dcpi_3	0.362	0.142	2.560	0.016	0.189
CSeasonal_1	-0.037	0.008	-4.860	0.000	0.457
CSeasonal_2	-0.036	0.009	-4.160	0.000	0.382
I:2004(4)	0.063	0.018	3.380	0.002	0.290
Constant U	0.005	0.005	0.995	0.328	0.034

Sigma = 0.017606;   RSS = 0.008679;   R^2 = 0.712766;   Adj.R^2 = 0.661474;   F(5,28) = 13.9 [0.000]**;
log-likelihood = 92.4002;   no. of observations = 34;   no. of parameters = 6; mean(Dcpi) = 0.020898;   se(Dcpi) = 0.03026;

AR 1-3 test: F(3,25) = 0.1783 [0.9101];   ARCH 1-3 test: F(3,28) = 1.5312 [0.2282];   Normality test: Chi^2(2) = 1.0625 [0.5879];
Hetero test: F(6,26) = 1.5939 [0.1888];   Hetero-X test: F(11,21) = 2.6103 [0.0283]*;   RESET23 test: F(2,26) = 2.7116 [0.0852]

Note: *Where, DX indicates the first difference of X, Di04q4, Di07q1, Di05q1, Di05q2, Di01q2, I:2004(4), I:2007(2), I:2006(1) are impulse dummies respectively; _n indicates number of lags. Since intercept account for the growth rate of the dependent variable we keep them in the specifications even they are statistically insignificant.*

Table A7: Forecast models for inflation

Panel A: Vector Equilibrium Correction Model of inflation

MOD(4) Estimating the model by FIML The estimation sample is: 2000(1) - 2009(2)

Equation for: Dcpi

	Coefficient	Std.Error	t-value	t-prob	
Dcpi_1	0.392	0.058	6.810	0.000	
Dapi	0.131	0.017	7.680	0.000	
Dapi_1	-0.176	0.019	-9.390	0.000	
Dmpi	0.132	0.065	2.020	0.063	
Dulc	0.032	0.015	2.080	0.056	
GDPGAP	0.034	0.009	3.630	0.003	
ECM_1	-0.160	0.027	-5.890	0.000	
CS	-0.018	0.004	-4.930	0.000	
CS_1	-0.039	0.004	-10.200	0.000	
CS_2	-0.033	0.003	-12.200	0.000	
Di04q4	0.046	0.007	6.860	0.000	
Constant	0.001	0.002	0.699	0.496	
Dsh08q3	-0.010	0.004	-2.560	0.023	
Dsh09q2	0.018	0.008	2.340	0.034	sigma = 0.00611851

Auxiliary Equation for: Dapi

	Coefficient	Std.Error	t-value	t-prob	
Constant	-0.001	0.003	-0.405	0.691	
Dapi_1	0.252	0.045	5.580	0.000	
Di07q1	0.366	0.018	20.000	0.000	
Di04q4	0.086	0.018	4.700	0.000	
Di05q1	0.091	0.018	4.970	0.000	sigma = 0.0186408

Auxiliary Equation for: Dmpi

	Coefficient	Std.Error	t-value	t-prob	
Constant	0.013	0.007	1.850	0.085	
Di05q2	-0.100	0.039	-2.550	0.023	sigma = 0.0435219

Auxiliary Equatio for: Dulc

	Coefficient	Std.Error	t-value	t-prob	
Constant	0.034	0.018	1.930	0.074	
Dulc_1	-0.451	0.145	-3.100	0.008	
Di01q2	0.280	0.098	2.860	0.013	sigma = 0.106401

Auxiliary Equation for: GDPGAP

	Coefficient	Std.Error	t-value	t-prob	
Constant	-0.001	0.007	-0.122	0.905	
GDPGAP_1	1.805	0.140	12.900	0.000	
GDPGAP_2	-1.367	0.240	-5.700	0.000	
GDPGAP_3	0.494	0.146	3.380	0.005	sigma = 0.0437384

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-1 test: F(1,19) = 10.437 [0.0044]** ARCH 1-1 test: F(1,36) = 0.072882 [0.7887]

Normality test: Chi^2(2) = 0.40199 [0.8179] Hetero test: F(18,19) = 0.99292 [0.5043]

Vector SEM-AR 1-1 test: F(25,90) = 2.2968 [0.0023]** Vector Normality test: Chi^2(10) = 51.599 [0.0000]**

ZHetero test: not enough observations

Panel B: Monetary Model of inflation

MOD(5) Estimating the model by FIML **The estimation sample is: 2000(1) - 2009(2)**

Equation for: Dcpi

	Coefficient	Std.Error	t-value	t-prob	
Dcpi_1	0.485	0.077	6.300	0.000	
Dcpi_2	-0.431	0.083	-5.190	0.000	
Dm1	0.067	0.025	2.720	0.013	
Dm1_2	0.142	0.017	8.170	0.000	
Dm1_3	0.049	0.019	2.590	0.017	
Dm1_4	0.085	0.020	4.290	0.000	
CSeasonal_1	-0.031	0.005	-6.660	0.000	
Di04q4	0.059	0.009	6.280	0.000	
Di07q2	-0.090	0.011	-7.970	0.000	
Dsh08q3	-0.028	0.006	-4.580	0.000	
Dsh09q2	0.028	0.013	2.120	0.046	
Constant U	-0.006	0.003	-2.160	0.043	sigma = 0.009513

Auxiliary Equation for: Dm1

	Coefficient	Std.Error	t-value	t-prob	
Dm1_1	0.684	0.154	4.430	0.000	
CSeasonal	-0.204	0.031	-6.510	0.000	
CSeasonal_1	0.108	0.039	2.760	0.012	
I:2006(1)	0.256	0.083	3.080	0.006	
Constant U	0.015	0.018	0.840	0.410	sigma = 0.075566

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-3 test:	F(3,21) = 2.5783 [0.0808]	ARCH 1-3 test:	F(3,32) = 0.2748 [0.8431]
Normality test:	Chi^2(2) = 2.7121 [0.2577]	Hetero test:	F(15,22) = 0.40157 [0.9633]

Vector SEM-AR 1-3 test: F(12,46) = 2.418 [0.0159]* Vector Normality test: Chi^2(4) = 3.7331 [0.4433]
Vector Hetero test:F(60,45) = 0.67087 [0.9260] Hetero-X test: not enough observations

Panel C: NKPC model of inflation

MOD(6) Estimating the model by FIML **The estimation sample is: 2000(1) - 2009(2)**

Equation for: Dcpi

	Coefficient	Std.Error	t-value	t-prob	
DLcpi_1	0.508	0.123	4.150	0.001	
DUR	-0.134	0.069	-1.940	0.067	
Di04q4	0.060	0.017	3.540	0.002	
CSeasonal	-0.021	0.009	-2.390	0.027	
CSeasonal_1	-0.054	0.009	-5.870	0.000	
CSeasonal_2	-0.034	0.008	-4.240	0.000	
Dsh08q3	-0.034	0.010	-3.420	0.003	
Dsh09q2	0.054	0.021	2.530	0.020	
Constant U	0.009	0.004	2.490	0.022	sigma = 0.016086

Auxiliary Equation for: DUR

	Coefficient	Std.Error	t-value	t-prob	
DUR_3	-0.141	0.062	-2.280	0.034	
Dsh04q4	-0.037	0.006	-5.850	0.000	
Di08q1	-0.130	0.018	-7.420	0.000	
Di00q2	-0.095	0.013	-7.500	0.000	
Db08q3q4	-0.092	0.013	-7.190	0.000	
Constant U	0.023	0.004	5.300	0.000	sigma = 0.017077

Single-equation diagnostics using reduced-form residuals for Dcpi equation:

AR 1-3 test:	F(3,22) = 4.6134 [0.0119]*	ARCH 1-3 test:	F(3,32) = 1.19 [0.3291]
Normality test:	Chi^2(2) = 1.7542 [0.4160]	Hetero test:	F(12,25) = 3.3337 [0.0053]**

Vector SEM-AR 1-3 test: F(12,48) = 0.96856 [0.4909]; Vector Normality test: Chi^2(4) = 8.6751 [0.0698];
Vector Hetero test: F(54,51) = 1.4185 [0.1052];

Panel D: AR model of inflation

EQ(1) Modelling **Dcpi** by OLS The estimation sample is: 2000(1) - 2009(2)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLcpi_1	0.491	0.116	4.220	0.000	0.372
DLcpi_3	0.375	0.139	2.690	0.012	0.195
CSeasonal_1	-0.037	0.008	-4.860	0.000	0.441
CSeasonal_2	-0.033	0.008	-4.150	0.000	0.365
I:2004(4)	0.065	0.018	3.540	0.001	0.294
Dsh08q3	-0.050	0.013	-3.920	0.001	0.338
Dsh09q2	0.064	0.024	2.670	0.012	0.192
Constant U	0.004	0.005	0.763	0.452	0.019

Sigma = 0.01748; RSS = 0.009166; R^2 = 0.723528; Adj.R^2 = 0.659018; F(7,30) = 11.22 [0.000]**; log-likelihood = 104.347; no. of observations = 38; no. of parameters = 8; mean(DLcpi) = 0.018159; se(DLcpi) = 0.029934;
AR 1-3 test: F(3,27) = 0.37307 [0.7731]; ARCH 1-3 test: F(3,32) = 2.5582 [0.0724]; Normality test: Chi^2(2) = 1.2669 [0.5308];
Hetero test: F(7,28) = 1.3994 [0.2447]; Hetero-X test: F(12,23) = 2.4523 [0.0312]*; RESET23 test: F(2,28) = 2.8096 [0.0773]

Table A8: Comparison of Forecast Bias Test and RMSEs

Models	VECM	MM	NKPC	AR
Panel A: Forecast period 1				
RMSE	0.0271	0.0227	0.0258	0.0437
Forecast Bias	-0.0149 (0.0076)	-0.0123 (0.0064)	-0.0160 (0.0067)	-0.0359 (0.0083)
Panel B: Forecast period 2				
RMSE	0.0125	0.0222	0.0379	0.0168
Forecast Bias	-0.0006 (0.0056)	0.0204 (0.0039)	-0.0349 (0.0065)	-0.0096 (0.0062)

Note:

Forecast period 1 is whole forecast period which covers 2008q3-2010q4. There is systematic bias in the forecasts of all of four models and in general forecast tests (RMSE, Bias and Encompassing Tests) results are mixed due to the recent financial crisis and post crisis effects.

Forecast period 2 covers 2009q3-2010q4. In order to account for crisis and post crisis effects intercept corrections are used in all of four models and therefore forecast period is diminished by 4 observations.

The Bias test specification is as follows

$$Forecast\ error_t = \alpha_0 + \eta_t$$
$$H_0 = There\ is\ no\ forecast\ bias$$
$$Joint\ Hypothesis\ \ \alpha_0 = 0$$

In the Forecast Bias Test, numbers in the cells are the intercept of a regression, α_0, and its standard error in parenthesis.

Table A9: Forecast Encompassing Tests Results

Hypothesis	F-stat [prob.]	
	Panel A	Panel B
VECM encompasses **MM**	F(3,7) = 4.2464 [0.0526]	F(3,3) = 1.6860 [0.3392]
MM encompasses V**ECM**	F(3,7) = 2.2973 [0.1645]	F(3,3) = 7.5054 [0.0660]
VECM encompasses **AR**	F(3,7) = 3.1500 [0.0956]	F(3,3) = 0.6411 [0.6381]
AR encompasses V**ECM**	F(3,7) = 11.9400 [0.0038]**	F(3,3) = 1.9894 [0.2932]
VECM encompasses NK**PC**	F(3,7) = 6.6728 [0.0184]*	F(3,3) = 0.4973 [0.7096]
NKPC encompasses V**ECM**	F(3,7) = 5.8299 [0.0256]*	F(3,3) = 12.804 [0.0324]*
AR encompasses **MM**	F(3,7) = 12.6050 [0.0033]**	F(3,3) = 3.4823 [0.1664]
MM encompasses **AR**	F(3,7) = 1.7056 [0.2522]	F(3,3) = 6.7918 [0.0750]
AR encompasses NK**PC**	F(3,7) = 39.0840 [0.0001]**	F(3,3) = 1.7068 [0.3357]
NKPC encompasses **AR**	F(3,7) = 12.0890 [0.0037]**	F(3,3) = 12.699 [0.0327]*
MM encompasses NK**PC**	F(3,7) = 2.3325 [0.1606]	F(3,3) = 7.0219 [0.0719]
NKPC encompasses **MM**	F(3,7) = 3.6760 [0.0709]	F(3,3) = 22.354 [0.0148]*

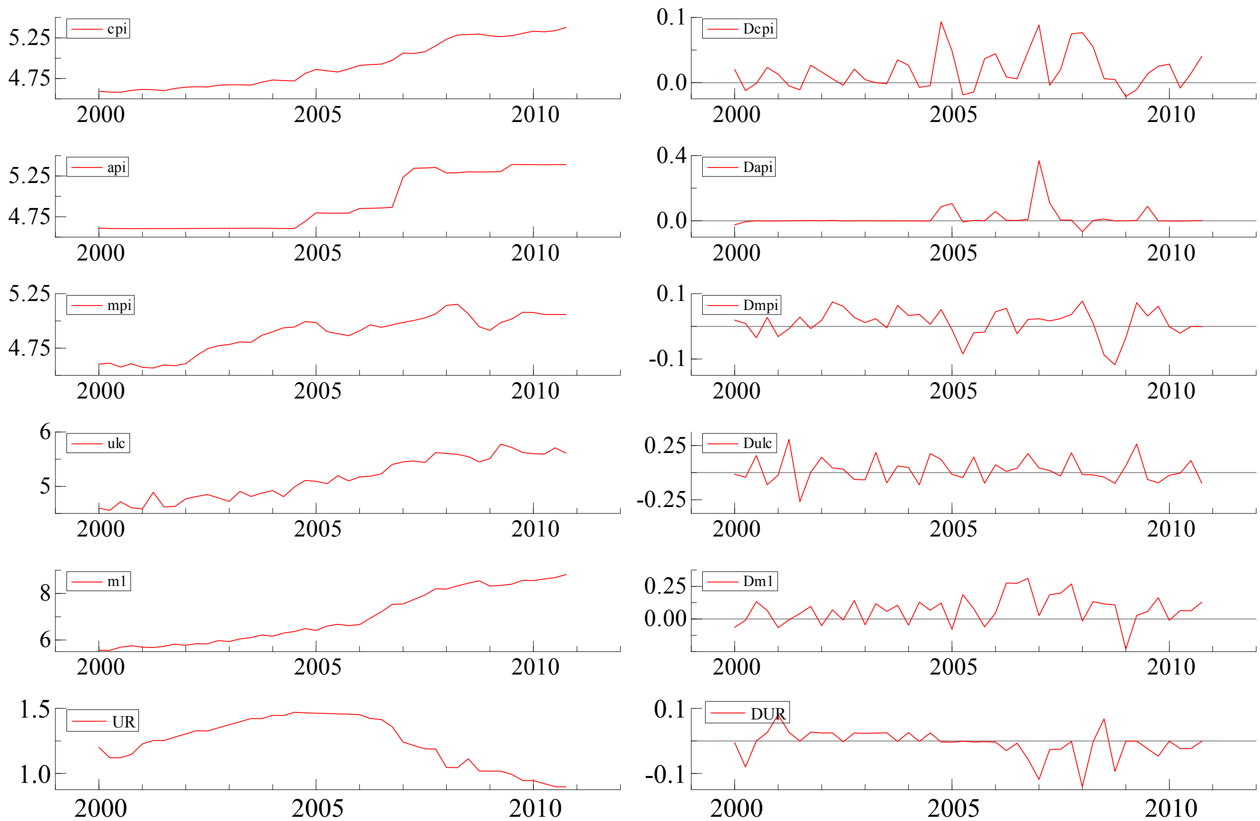
Note:

Panel A and Panel B cover Forecast Encompassing Test Results over the period 2008q3-2010q4 and 2009q3-2010q4 respectively.
The encompassing test specification is as follows

$$\pi_t^{Actual} = \beta_0 + \beta_1 \pi_t^1 + \beta_2 \pi_t^2 + \varepsilon_t$$

$$H_0 :\ Forecast\ 1\ encompasses\ Forecast\ 2$$
$$Joint\ Hypothesis\ \ \beta_0 = 0,\ \beta_1 = 1,\ \beta_2 = 0$$

Figure A1: Time profiles of the variables



Note: Dx indicates the first difference of x.

Figure A2: Stability Tests Results of equation (8)