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Economic Research Center

Research Report
On "Alternative inflation rate and model development" Project

Economic Research Center
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Content

1. **Forecasting inflation in Azerbaijan**

In second part of this research report, we invoke to different techniques to forecast inflation in Azerbaijan. We estimate ARIMA, VAR and Phillips curve for this end.

I. The Phillips Curve

Theoretical Framework for Phillips Curve

As known, one of frequently appealed methods of inflation forecasting is to use Phillips curve. The starting point for the theoretical derivation of the New Phillips Curve[1] (NPC) is an environment of monopolistically competitive firms that face some type of constraints on price adjustment. Nominal rigidities are generally introduced in the form of constraints on the frequency with which firms and/or workers can adjust their nominal prices and wages, respectively. An implication of such constraints is that price and wage-setting decisions become forward-looking, since agents recognize that the prices/wages they set will remain effective beyond the current period. A common specification is due to Calvo (1983), where a model is based on staggered price setting with stochastic time dependent rules. In this framework in any given time period each firm may adjust its price during that period with a fixed probability $1-\theta$, and, hence, with a probability θ it must keep its price unchanged. Thus, the expected time a price remains fixed is $1/(1-\theta)$. The parameter θ provides a measure of degree of price rigidity. As the adjustment probabilities are independent of the firm's price history, the aggregation problem is greatly simplified.

We assume that firms are identical ex ante, except for the differentiated product they produce and for their pricing history. Assume also that each faces a conventional constant price elasticity of demand curve for its product. Then the aggregate price level p_t evolves as a convex combination of the lagged price level p_{t-1} and the optimal reset price p_t^* (i.e. the price selected by firms that are able to change price at t), as follows:

$$p_t = \theta \cdot p_{t-1} + (1-\theta) p_t^* \qquad (1)$$

As there are no firm-specific firm-specific state variables, all firms that change price choose the same value of p_t^* which is based on maximization of expected discounted profits:

$$p_t^* = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{mc_{t+k}^n\} \qquad (2)$$

where β is the discount. In setting its price, the firm takes account of the expected future path of nominal marginal cost, given the likelihood that its price may remain fixed for multiple periods. Note that in the limiting case of perfect price flexibility ($\theta = 0$), the firm simply adjusts its price proportionately to movements in the current marginal cost. As the degree of price rigidity

[1] For an explicit derivation, see, e.g., Goodfriend and King (1997), King and Wolman (1996), or Woodford (1996).

increases ($\theta > 0$) the firm places more weight on expected future marginal costs in setting the current price.

Cost minimizing firms have their real marginal cost equal to the real wage divided by the marginal product of labor. Assuming the Cobb-Douglas technology the real marginal cost is given by:

$$MC_t = \frac{(W_t / P_t)}{(1-\alpha)(Y_t / N_t)}$$

where Y_t and N_t are the firm's output and employment, respectively.

Let $\pi_t = p_t - p_{t-1}$ denote the inflation rate at t, and mc_t the percent deviation of the firm's real marginal cost from its steady state value. By combining equations (1) and (2) it is possible to derive an inflation equation of the form:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda mc_t \qquad (3)$$

where $\lambda = \dfrac{(1-\theta)(1-\beta\theta)}{\theta}$.

The traditional Phillips curve relates inflation with some output gap measure as the relevant indicator of real economic activity. Under certain assumptions there is an approximate log-linear relationship between the output gap and marginal cost. Let denote by g_t the output gap defined as the difference between the actual and the potential level of output. Then, under certain conditions[2]:

$$mc_t = kg_t$$

where k is the output elasticity of marginal cost.

Taking into account this relationship in equation (3) we get the following relationship:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda k g_t \qquad (4)$$

As with the traditional Phillips curve, inflation depends positively on the output gap.

Under rational expectation the forecast error of π_{t+1} is uncorrelated with information set available at t and earlier. From equation (3) and (4) it follows that

$$E_t\{(\pi_t - \lambda mc_t - \beta\pi_{t+1})z_t\} = 0 \qquad (5)$$

$$E_t\{(\pi_t - \lambda k g_t - \beta\pi_{t+1})z_t\} = 0 \qquad (6)$$

where z_t is a vector of variables dated t and earlier. The estimation of the model by Generalized Method of Moments (GMM) are based on orthogonality conditions given by (5) and (6).

Following Gali and Gertler (1999) the hybrid Phillips curve can be justified on theoretical grounds that there are ω backward-looking firms which set their prices according to simple rule-of-thumb. That is, they set prices according to the following rule:

[2] In the standard sticky price framework without variable capital (e.g, Rotemberg and Woodford (1997)), there is an approximate proportionate relation between marginal cost and output. With variable capital the relation is no longer proportionate. Simulations suggest, however, that the relation remains very close to proportionate.

$$P_t^b = P_{t-1}^* \frac{P_{t-1}}{P_{t-2}}$$

Then it can be shown that inflation is determined as follows:

$$\pi_t = \lambda s_t + \gamma_f E\pi_{t+1} + \gamma_b \pi_{t-1}$$

The Phillips Curve Estimation

We estimate traditional, forward-looking new Keynesian and hybrid Phillips curve for the country. In our estimation we closely follow Gali and Gertler (1999), Gali and Lopez-Salido (2001) and Gali, *et al* (2001). The traditional Philips curve relates inflation to some cyclical indicator plus lagged values of inflation. We use both monthly and quarterly data in our estimation and report the results for both unemployment rate and output gap measure for the traditional Phillips curve. Lagged inflation term appears to be statistically significant. On contrary, both unemployment rate and output gap measure appear to be insignificant independent of the number of lags incorporated to the model[3]. The preliminary estimation results hint that backward-looking behavior might be an important factor in the determination of the inflation rate. Besides, in the same spirit with Gali and Gertler (1999) we estimate forward-looking new Keynesian and hybrid Phillips curve. The New Keynesian approach provides a framework that combines the theoretical rigor of Real Business Cycle (RBC) theory with Keynesian ingredients like monopolistic competition and nominal rigidities. As model assumes rational expectations we employ one period ahead inflation rate as the proper measure of future inflation expectations. We estimate forward-looking Phillips curve using unemployment gap, output gap and the share of labor cost as the respective measure of marginal cost which is in line with Gali and Gertler (1999). Both least squares and GMM estimation techniques are appealed to in our estimation[4]. When least squares are used in the estimation, output gap turns out to be insignificant similar to the outcomes of the traditional case. However, when labor share is used as the marginal cost measure, it appears to be important factor though its coefficient is small in size. In addition, GMM technique is also utilized for the same end. Rational expectations assumption allows us to impose the condition that the forecast error is orthogonal to information set. As a subset of information set we use four lags of inflation rate, labor share, gap, wage and commodity (oil) price inflation. Though forward-looking behavior seems to be significant as an underlying factor of current inflation, the share of labor cost is estimated to be insignificant. At last, we run regression of hybrid Phillips curve whose theoretical tenets are provided by Gali and Gertler (1999) and Gali and Lopez-Salido (2001). Least squares estimation shows that both forward and backward-looking behaviors enjoy similar powers in the formation of current inflation though once more, the marginal cost fails to be statistically significant. Therefore, it seems that output gap and marginal cost measures are not driving forces behind inflation, i.e. they are not as important as backward and forward-looking inflation expectations. Therefore, though Phillips curve are frequently used forecasting technique, it is not practicable in our case as the estimation output provides evidence against the existence of significant Phillips Curve relation.

[3] For the detailed information see the Appendix.
[4] For the estimation output see the Appendix

II. ARIMA Framework for Inflation Forecasting

Other forecasting methodologies we employ are ARIMA and VAR models. In the ARIMA case, we invoke to Box-Jenkins methodology. In this literature, the appropriate data generating process (DGP) of the variable of interest is determined. That is, we find out whether the variable of interest is either AR or MA or ARMA. When DGP of the variable of interest is examined during 2005-2009, the most appropriate form is AR (1) process for inflation. The estimation results are provided in the appendix for ARIMA model.

III. VAR Framework for Inflation Forecasting

Theoretical Framework

Theoretical underpinnings of the empirical model estimated in this paper heavily draw on model proposed by Maliszewski (2003). Model assumes three markets in the economy: goods and services, foreign exchange and money markets. Economy is in equilibrium if all three markets clear.

Aggregate demand for goods and services (also real income (Y)) is a function of the real money balances (M/P), the nominal exchange rate (E). Long-term price level (P) is defined by equilibrium conditions between aggregate demand and supply (lower case letters points to logarithmic transformation of corresponding variables):

$$y_t^D = \gamma(e_t - p_t) + \psi(m_t - p_t) \qquad (1)$$

The aggregate supply and petrol prices are exogenously given and in market equilibrium, aggregate supply is equal to aggregate demand and real income (Y):

$$y_t = y_t^S = y_t^D \qquad (2)$$

It is assumed that the goods market is always in equilibrium and equation (2) always holds.
In the foreign exchange market, flow demand for foreign exchange is a function of real exchange rate and real income. Foreign financing is exogenously given and as real income is fixed at the level of aggregate supply, the real exchange rate movements determine equilibrium in the market. The long-run equilibrium in the foreign exchange market can be represented as:

$$e_t - p_t = k_t + \lambda y_t \qquad (3)$$

where k_t is available foreign financing at time *t*.

Money demand is assumed to be a function of real income and money supply is given exogenously. Since real income and money supply is exogenous, real money balances ensures equilibrium in the market. Money market equilibrium can be expressed as follows:

$$m_t - p_t = \mu y_t \qquad (4)$$

If the foreign exchange and money market are in equilibrium, goods and services market will also clear by the application of Walras law.

If all markets clear, then we can determine two real variables ($m_t - p_t$) and ($e_t - p_t$), and if one of the nominal variables is fixed, say $e_t = \overline{e}$, other two can be pinned down where e_t provides nominal anchor for the system.

If money and foreign exchange markets are out of equilibrium and only goods market is in equilibrium (by assumption), fixing one variable does not allow finding the remaining two, but fixing two still determines the third one in equation (1).

Assuming that only goods market is in equilibrium, the equilibrium price level can be pinned down:

$$p_t = \frac{\psi}{\psi+\gamma} m_t + \frac{\gamma}{\psi+\gamma} e_t - \frac{1}{\psi+\gamma} y_t \qquad (5)$$

Above price equation describes relationship between overall price level, exchange rate, money, and real income which allows estimation of relations among variables even if money and exchange markets are out of equilibrium.

Note that the equilibrium money demand given above defined as a function of real income only. In economic literature, standard Cagan-type money demand formulation depends on expected future price-level inflation $\mathrm{E_t(p_{t+1}\text{-}p_t)}$ or expected exchange rate depreciation $\mathrm{E_t(e_{t+1}\text{-}e_t)}$ as well (see, for example, Choudhry (1998), Budina, *et al* (2002)). However, as inflation or exchange rate depreciation does not contain unit roots in Azerbaijani case, they are left off in the money demand equation

Methodology and Specification

We invoke to *vector autoregressive* (*VAR*) literature to formulate inflation model in Azerbaijan where each variable – prices (CPI), narrow money (M2) and nominal effective exchange rate (ER) is treated symmetrically i.e. as a priori endogenous variables. In addition to that, one exogenous variable – non-oil real GDP- was included into the model. This structure of the system allows for feedback among variables, that is, past values of each variable are incorporated in each equation describing the data generating process (DGP) of a time series.

A stationarity test is carried out before including variables in the model. If they are stationary, we introduce them in levels. If not, then we use appropriate transformations by differencing the series to make them stationary.

It is also important to check whether there are trends, seasonality and structural shifts in DGP of time series. Note that I use *logarithmic transformation* of corresponding variables.

Therefore, structural VAR model of order *p* (VAR(p)) can be represented as follows:

$$\underbrace{\begin{bmatrix} 1 & \phi_{12} & \phi_{13} & \phi_{14} \\ \phi_{21} & 1 & \phi_{23} & \phi_{24} \\ \phi_{31} & \phi_{32} & 1 & \phi_{34} \\ \phi_{41} & \phi_{42} & \phi_{43} & 1 \end{bmatrix}}_{\mathbf{\Phi}} \underbrace{\begin{bmatrix} cpi_t \\ m_t \\ er_t \\ rgdp_t \end{bmatrix}}_{\mathbf{Y_t}} = \underbrace{\begin{bmatrix} \alpha_{10} \\ \alpha_{20} \\ \alpha_{30} \\ \alpha_{40} \end{bmatrix}}_{\mathbf{\Gamma_0}} + \underbrace{\begin{bmatrix} \gamma_{11}^1 & \gamma_{12}^1 & \gamma_{13}^1 & \gamma_{14}^1 \\ \gamma_{21}^1 & \gamma_{22}^1 & \gamma_{23}^1 & \gamma_{24}^1 \\ \gamma_{31}^1 & \gamma_{32}^1 & \gamma_{33}^1 & \gamma_{34}^1 \\ \gamma_{41}^1 & \gamma_{42}^1 & \gamma_{43}^1 & \gamma_{44}^1 \end{bmatrix}}_{\mathbf{\Gamma}_1} \underbrace{\begin{bmatrix} cpi_{t-1} \\ m_{t-1} \\ er_{t-1} \\ rgdp_{t-1} \end{bmatrix}}_{\mathbf{Y_{t-1}}} +$$

$$
+\ldots+\begin{bmatrix} \gamma_{11}^{p} & \gamma_{12}^{p} & \gamma_{13}^{p} & \gamma_{14}^{p} \\ \gamma_{21}^{p} & \gamma_{22}^{p} & \gamma_{23}^{p} & \gamma_{24}^{p} \\ \gamma_{31}^{p} & \gamma_{32}^{p} & \gamma_{33}^{p} & \gamma_{34}^{p} \\ \gamma_{41}^{p} & \gamma_{42}^{p} & \gamma_{43}^{p} & \gamma_{44}^{p} \end{bmatrix} \begin{bmatrix} cpi_{t-p} \\ m_{t-p} \\ er_{t-p} \\ rgdp_{t-p} \end{bmatrix} + \begin{bmatrix} u_{cpit} \\ u_{mt} \\ u_{ert} \\ u_{rgdpt} \end{bmatrix}
$$

$$
\qquad\qquad \mathbf{\Gamma_p} \qquad\qquad\qquad \mathbf{Y_{t-p}} \qquad \mathbf{U_t}
$$

or in matrix representation:

$$\mathbf{\Phi Y_t = \Gamma_0 + \Gamma_1 Y_{t-1} + \ldots + \Gamma_p Y_{t-p} + U_t}$$

where t indicates time, p is the length of lag; $\mathbf{\Phi}$ is the matrix of contemporaneous response of each included variable to the changes in other included variables. $\mathbf{Y_t}$ is the joint vector of five model variables, $\mathbf{Y_{t-p}}$ is the vector of p lag of them, $\mathbf{\Gamma_p}$ is the matrix of coefficients of model variables with lag p, $\mathbf{U_t}$ is the vector of error terms which is assumed to be zero-mean independent white noise process with time invariant positive definite covariance matrix $\mathbf{E(u_t u_t^{'}) = \Sigma_u}$.

In my model, I use the some extension of the above VAR model by including deterministic terms and seasonal dummies as well. Kumah (2006) and Barbakadze (2008) emphasized the importance of seasonality in inflation dynamics for Kyrgyz Republic and Georgia respectively, which we believe, equally applicable to the country under consideration as well.

The VAR in the reduced (or standard) form can be derived as follows:

$$\mathbf{Y_t = \Phi^{-1}\Gamma_0 + \Phi^{-1}\Gamma_1 Y_{t-1} + \ldots + \Phi^{-1}\Gamma_p Y_{t-p} + \Phi^{-1}U_t}$$

To simplify the notation I denote $\mathbf{\Phi^{-1}\Gamma_0}$ by $\mathbf{A_0}$, $\mathbf{\Phi^{-1}\Gamma_i}$ by $\mathbf{A_i}$ (where **i**=1,…,p) and $\mathbf{\Phi^{-1}U_t}$ by $\mathbf{V_t}$ and hence, we end up with the following reduced form model:

$$\mathbf{Y_t = A_0 + \sum_{i=1}^{p} A_i Y_{t-i} + V_t}$$

To retrieve all the coefficients of the primitive system from the reduced form estimators appropriate restrictions should be imposed upon the standard form VAR, otherwise, they are not identifiable. In other words, error terms in $\mathbf{V_t}$ are needed to be orthogonalized by imposing restrictions as they are contemporaneously correlated, that is, they can not be interpreted as *structural shocks.* Because $\mathbf{\Phi}$ contains twenty five elements and the variance-covariance matrix $\mathbf{E(v_t v_t^{'}) = \Sigma_v}$ imposes fifteen restrictions, we need ten more to recover all the coefficients of the primitive system. we further assume that real GDP do not *contemporaneously* affect narrow money and inflation does not have *contemporaneous* impact on money.

Estimation Results

As pointed out in the previous section we use consumer price index (cpi), money supply (M2), nominal effective exchange rate (neer) and non-oil real gdp (rngdp) in our VAR model. The estimation results are provided in the appendix for the model.

Restricted Model

Asymptotic properties of the standard t-ratios reported are retained when they are applied to parameters in a VAR with differenced series , whereas problems may occur for the standard t-ratios of integrated variables in the levels VAR representation. Restrictions in our model for individual parameters and groups of parameters in VAR are based on model selection criteria.

We use sequential elimination of regressors (SER) strategy which sequentially deletes those regressors which lead to the largest reduction of the given criterion until no further reduction is

possible. Bruggemann et al.(2001) have shown that this strategy is equivalent to sequentially eliminating those regressors with the smallest absolute values of t-ratios until all t-ratios (in absolute value) are greater than some threshold value γ. Note that a single regressor is eliminated in each step only. Then new t-ratios are computed for the reduced model. They argue that choosing $\gamma = \{[\exp(c_T / T) - 1\ ](T - N + j - 1)\ \}^{1/2}$ in the j th step of the elimination procedure results in the same final model that is obtained by sequentially minimizing the selection criterion defined by the penalty term c_T. The threshold values for the t-ratios correspond to the critical values of the tests. We use $c_T(AIC) = 2$ which is relatively less restrictive and for an equation with 20 regressors and sample size of 100 corresponds to eliminating all regressors with t-values that are not significant at the 15–20% (Bruggemann et al., 2001). The outcomes of weak exogeneity tests are taken into account in subset modeling via sequentially eliminating regressors.

Estimation results of the subset (restricted) VAR

The detailed estimation results are provided in the appendix for the model. The structural equation for inflation can be shown separately as follows:

$$CPI_t = 0.005 + 0.560 CPI_{t-1} + 0.042 M_{t-1} + 0.005 s_1 - 0.009 s_6 - 0.015 s_7 - 0.009 s_8 + u_{cpi,t}$$

where s_i denotes the seasonal dummy for the ith month. Subset model only reveals the significant seasonal effect during summer months and in the beginning of the year.

Appendix

Phillips Curve estimation results

a. Traditional Phillips curve with unemployment rate (*least squares*)

$$\pi_t = 0.7\pi_{t-1} - 0.18^* \Delta un_t$$

a. Traditional Phillips curve with output gap (*least squares*)

$$\pi_t = 0.7\pi_{t-1} + 0.012^* gap_{t-1} - 0.011^* gap_{t-2} - 0.01^* gap_{t-3}$$

b. Forward-looking Phillips curve with output gap (*least squares*)

$$\pi_t = 0.7E\pi_{t+1} - 0.02^* gap_t$$

c. Forward-looking Phillips curve with labor share (*least squares*)

$$\pi_t = 0.58E\pi_{t+1} + 0.006s_t$$

d. Forward-looking Phillips curve with labor share (*GMM*)

$$\pi_t = 0.86E\pi_{t+1} + 0.001^{*}s_t$$

e. Forward-looking Phillips curve with unemployment gap (GMM)

$$\pi_t = 0.12^{*}\pi_{t+1} + 0.54gap_t$$

f. Forward-looking Phillips curve with output gap

$$\pi_t = 0.84\pi_{t+1} + 0.02^{*}gap_t$$

g. Hybrid Phillips curve with labor share (*least squares*)

$$\pi_t = 0.42E\pi_{t+1} + 0.43\pi_{t-1} + 0.002^{*}s_t$$

**statistically insignificant at 5 percent level*

ARIMA estimation result

$$\pi_t = 0.015 + 0.62\pi_{t-1} - 0.021sd - 0.017sd - 0.014sd$$

Using above specification, the quarterly forecast of inflation (cumulative) will be as follows for the year 2010.

Iq	IIq	IIIq	IVq
2.2	2.57	3.14	7.01

VAR estimation results

$$\begin{bmatrix} cpi_t \\ m_t \\ neer_t \\ rngdp_t \end{bmatrix} = \begin{bmatrix} 0.006 \\ 0.0085 \\ -0.015 \\ 0.152 \end{bmatrix} + \begin{bmatrix} 0.585 & 0.030 & -0.076 & 0.012 \\ 0.676 & 0.574 & -0.201 & 0.014 \\ 0.069 & 0.056 & -0.230 & -0.013 \\ 0.258 & -0.055 & 0.606 & -0.469 \end{bmatrix} \begin{bmatrix} cpi_{t-1} \\ m_{t-1} \\ neer_{t-1} \\ rngdp_{t-1} \end{bmatrix} + \begin{bmatrix} u_{cpi,t} \\ u_{m,t} \\ u_{neer,t} \\ u_{rngdp,t} \end{bmatrix}$$

Estimation results of the subset (restricted) VAR

$$\begin{pmatrix} CPI_t \\ M_t \\ NEER_t \\ RNGDP_t \end{pmatrix} = \begin{pmatrix} 0.005 \\ 0.086 \\ - \\ 0.130 \end{pmatrix} + \begin{pmatrix} 0.560 & 0.042 & --- & --- \\ --- & 0.659 & --- & --- \\ --- & --- & -0.228 & --- \\ --- & --- & --- & -0.421 \end{pmatrix} \begin{pmatrix} CPI_{t-1} \\ M_{t-1} \\ NEER_{t-1} \\ RNGDP_{t-1} \end{pmatrix} + \begin{bmatrix} u_{cpi,t} \\ u_{m,t} \\ u_{neer,t} \\ u_{rngdp,t} \end{bmatrix}$$

The structural equation for inflation can be shown separately as follows:

$$CPI_t = 0.005 + 0.560CPI_{t-1} + 0.042M_{t-1} + 0.005s_1 - 0.009s_6 - 0.015s_7 - 0.009s_8 + u_{cpi,t}$$

where s_i denotes the seasonal dummy for the *i*th month. Subset model only reveals the significant seasonal effect during summer months and in the beginning of the year.

Forecasting Results

In the table below the forecasting results of the CPI for 2010 are presented:

time	**forecast (%)**	**forecast (subset model%)**	**time**	**forecast (%)**	**forecast (subset model%)**
2010, *January*	1.91	1.72 (0.5)	2010, *July*	-0.62	-0.41
2010, *February*	0.74	1.06 (1.1)	2010, *August*	-0.17	0.55
2010, *March*	1.11	1.19 (1.3)	2010, *September*	0.75	0.99
2010, *April*	0.64	1.26 (0)	2010, *October*	1.46	1.18
2010, *May*	0.07	0.5	2010, *November*	1.46	1.25
2010, *June*	-0.87	-0.56	2010, *December*	1.42	1.29

2. Determinants of inflation in Azerbaijan

The empirical literature on inflation is really very vast: a large number of studies can be found for advanced economies as well as for transition and developing economies. Therefore our research on determining main determinants of inflation divides into two parts. In the first part we used cointegration approach to identify relationship between inflation and money supply. On the other hand we implemented Vector Avtoregression (VAR) to find out significant inflation determinants.

1. Determinants of inflation: Cointegration approach

1.1. Methodological framework

In order to run factor analysis of inflation in Azerbaijan first of all we decided to use cointegration method. The cointegration approach following Juselius (1992) and Metin (1995) is applied. The authors used the cointegration techniques to trace the sectoral sources of inflation: monetary, labour and foreign and then use the short-run equation with the error-correction terms from the different sectors to evaluate the sources of the Danish and Turkish inflation, respectively. Under this approach, inflation is viewed as a result of the excess demand in the different markets.

There exists a number of inflation studies on Russia. In one of the earlier works (Korhonen, 1998), the author has studied the relationship between inflation and money supply growth. The effect of the monetary expansion was felt within three months. In the later studies on Russia, it was also found that inflation is caused by the money growth (e.g., Ohnsorge and Oomes, 2004).

The impact of the monetary, labour and foreign sectors on Polish inflation was analyzed in Kim (2001). The labour and external sectors had a large impact on the inflation, while the monetary sector appeared not to have any significant impact.

In the study on the monetary transmission mechanisms and inflation in the Slovak Republic (Kuijs, 2002), the author estimated the long-run cointegrating relationships for the goods, labour, money and foreign exchange markets. It was found that the inflation was influenced through the foreign prices, exchange rate and wages, and insignificantly through the aggregate demand. The money supply had a slight but rapid effect on the prices.

1.2. Estimation procedure

The empirical model has been used to evaluate the impact of M2 to the CPI (I) is described below:

$CPI = \alpha + \beta * M2$ (1)

We have used monthly data on CPI and M2 for Azerbaijan over the period of 2000-2009, which is taken from Central Bank of Azerbaijan.

We analyze the time-series properties of the data. We have conducted the Augmented Dickey-Fuller (ADF) unit root test.

These unit-root tests are performed on both levels and first differences of all variables. Tables in the next slide report the results of non-stationary tests for CPI and M2 using Augmented Dickey-Fuller (ADF) test. We reported a constant but no time trend result of ADF tests.

Test results indicate that the hypothesis of a unit root in CPI and M2 cannot be rejected as a level while the hypothesis of a unit root in CPI and M2 is rejected as a first difference at least at the 5 and 1 percent levels of confidence, indicating that all the variables in question are integrated of order one I(1).

Table. 1 ADF test result for M2

Null Hypothesis: M12 has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.079671	0.0016
Test critical values:	1% level	-3.499910	
	5% level	-2.891871	
	10% level	-2.583017	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(M12)
Method: Least Squares
Date: 02/23/10 Time: 16:22
Sample (adjusted): 2002M01 2009M12
Included observations: 96 after adjustments

Table 2. ADF test result for M2 (first difference)

- Null Hypothesis: D(M2) has a unit root
- Exogenous: Constant, Linear Trend
- Lag Length: 11 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.312423	0.9985
Test critical values	1% level	-4.056461	
	5% level	-3.457301	
	10% level	-3.154562	

- *MacKinnon (1996) one-sided p-values.

- Augmented Dickey-Fuller Test Equation
- Dependent Variable: D(M2,2)
- Method: Least Squares
- Date: 02/23/10 Time: 16:43
- Sample (adjusted): 2002M01 2009M12
- Included observations: 96 after adjustments

Table 3. ADF test result for CPI

- Null Hypothesis: CPI has a unit root
- Exogenous: Constant, Linear Trend
- Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.235977	0.4376
Test critical values	1% level	-4.046072	
	5% level	-3.452353	
	10% level	-3.151673	

- *MacKinnon (1996) one-sided p-values.

- Augmented Dickey-Fuller Test Equation
- Dependent Variable: D(CPI)
- Method: Least Squares
- Date: 02/23/10 Time: 16:52
- Sample (adjusted): 2001M02 2009M12
- Included observations: 107 after adjustments

Table 4. ADF test result for CPI (first difference)

- Null Hypothesis: D(CPI) has a unit root
- Exogenous: Constant
- Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		4.442998	0.0004
Test critical values:	1% level	3.492523	
	5% level	2.888669	
	10% level	2.581313	

According to our estimations there is dependence of CPI on M2:

<u>CPI = 0.0179888377888*M2 + 105.302066962</u>

Table 5. Granger Causality Test

- Pairwise Granger Causality Tests
- Date: 02/23/10 Time: 17:23
- Sample: 2000M12 2009M12
- Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
M2 does not Granger Cause CPI	107	3.80814	0.0254
CPI does not Granger Cause M2		4.68998	0.0113

Granger Causality Test reports the causality test results between CPI and M2. Lag length is taken 2. The probability values for F statistics are given on the right side of the previous Table. If these probability values are less than any α level, then the hypothesis would be rejected at that level. We found bi-directional causality between CPI and M2. The content of policy implications has been determined according to the direction of causality between these two variables.

The empirical studies on the advanced transition economies show that the impact of monetary policy upon inflation is rather restricted: from either monetary aggregates or interest rates (e.g., Kim, 2001; Kuijs, 2002). On the other hand, there is a significant effect of the foreign prices, exchange rate and wages, sometimes that of the aggregate demand.

2.2. Determinants of inflation: VAR approach

2.2.1. Methodological approach

The structural approach to time series modeling uses economic theory to model the relationship among the variables of interest. Unfortunately, economic theory is often not rich enough to provide a dynamic specification that identifies all of these relationships. Furthermore, estimation and inference are complicated by the fact that endogenous variables may appear on both the left and right sides of equations.

These problems lead to alternative, non-structural approaches to modeling the relationship among several variables.

The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. The mathematical representation of a VAR is:

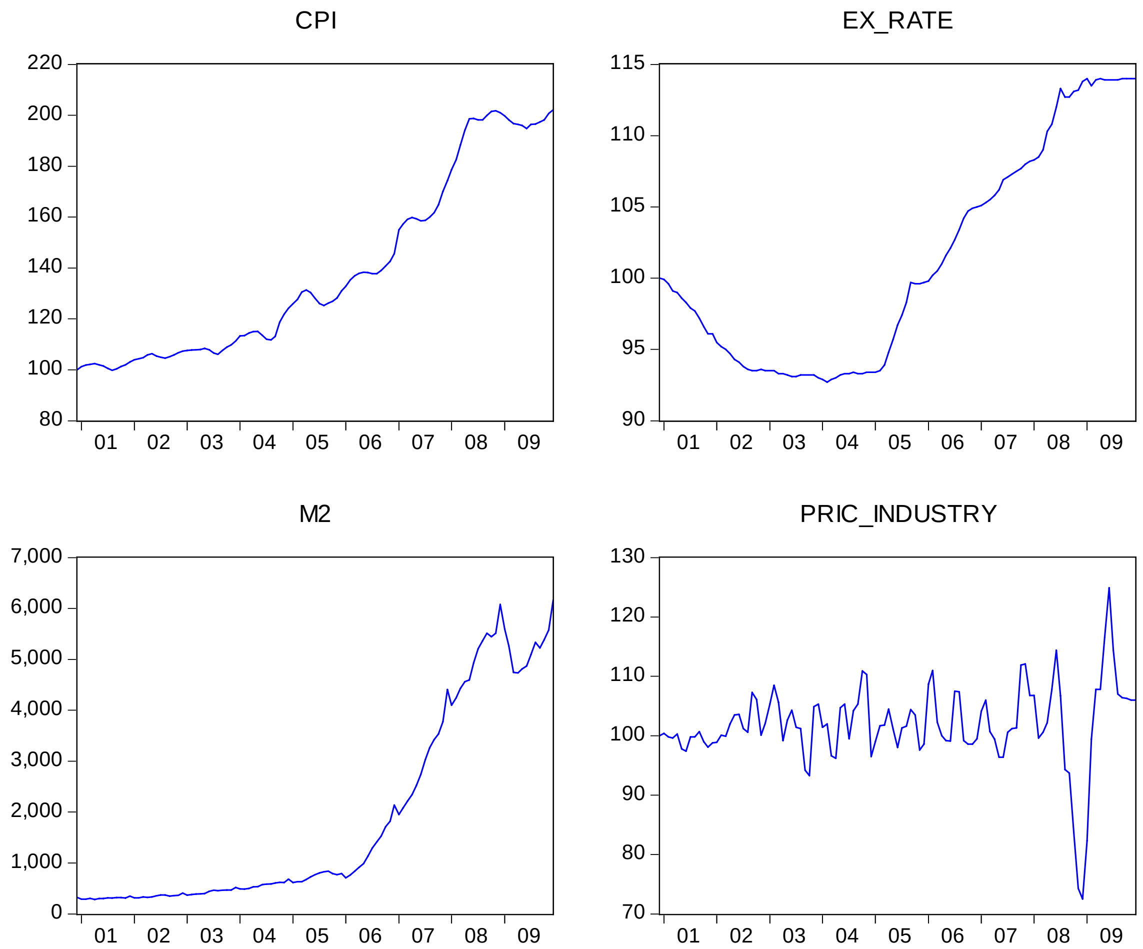
$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \epsilon_t$$

where is a vector of endogenous variables, is a vector of exogenous variables, and are matrices of coefficients to be estimated, and is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. Since only lagged values of the endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates. Moreover, even though the innovations may be contemporaneously correlated, OLS is efficient and equivalent to GLS since all equations have identical regressors.

2.3. Estimation procedure

We suppose that consumer price index (cpi), price index of industrial production (pric_industry), money supply (M2) and exchange rate of AZN (ex_rate) are jointly determined. Below we plot them in separate graphs.

Table 6. The dynamics of the main variables (2000-2009)



Using monthly data from January, 2000 – December 2009 we estimated a VAR(5)and VAR(1) for the I(0) variables cpi, ex_rate, pric_industry and M2. The output is large because involves estimating 4 equations with 5 lags for each variable, i.e. 20 parameters each plus the constant: 21x4=84 parameters.

Vector Autoregression Estimates
Date: 05/10/10 Time: 14:24
Sample (adjusted): 2001M05 2009M12
Included observations: 104 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CPI	EX_RATE	M2	PRIC_INDUSTRY
CPI(-1)	1.642084	0.020626	8.763603	0.759989
	(0.10742)	(0.02120)	(11.5242)	(0.34996)

	[15.2869]	[0.97289]	[0.76045]	[2.17164]
CPI(-2)	-0.702681	0.012423	-11.40958	-1.377687
	(0.21013)	(0.04147)	(22.5437)	(0.68459)
	[-3.34401]	[0.29955]	[-0.50611]	[-2.01241]
CPI(-3)	0.007445	-0.022463	1.301440	0.714860
	(0.22422)	(0.04425)	(24.0551)	(0.73049)
	[0.03320]	[-0.50760]	[0.05410]	[0.97860]
CPI(-4)	0.001489	0.023705	4.495078	-0.147243
	(0.20740)	(0.04093)	(22.2512)	(0.67571)
	[0.00718]	[0.57910]	[0.20201]	[-0.21791]
CPI(-5)	0.008005	-0.001045	-0.918231	0.042924
	(0.10577)	(0.02088)	(11.3474)	(0.34459)
	[0.07569]	[-0.05004]	[-0.08092]	[0.12456]
EX_RATE(-1)	-0.659407	1.227178	49.27835	-0.840646
	(0.51404)	(0.10145)	(55.1484)	(1.67471)
	[-1.28279]	[12.0958]	[0.89356]	[-0.50196]
EX_RATE(-2)	0.742919	-0.223078	39.25593	3.274450
	(0.78512)	(0.15496)	(84.2305)	(2.55786)
	[0.94625]	[-1.43961]	[0.46605]	[1.28015]
EX_RATE(-3)	0.178294	0.165457	-88.83281	-2.657860
	(0.79012)	(0.15594)	(84.7668)	(2.57415)
	[0.22566]	[1.06101]	[-1.04797]	[-1.03252]
EX_RATE(-4)	0.881715	-0.463096	-114.8044	-0.344741
	(0.78553)	(0.15504)	(84.2753)	(2.55922)
	[1.12244]	[-2.98697]	[-1.36225]	[-0.13471]
EX_RATE(-5)	-1.115089	0.260018	130.7168	0.633161
	(0.48136)	(0.09501)	(51.6424)	(1.56825)
	[-2.31653]	[2.73688]	[2.53119]	[0.40374]
M2(-1)	0.002532	-9.10E-05	0.856587	0.001060
	(0.00106)	(0.00021)	(0.11381)	(0.00346)
	[2.38724]	[-0.43473]	[7.52653]	[0.30657]
M2(-2)	-0.003132	-0.000560	0.089595	-0.005204

	(0.00144)	(0.00029)	(0.15499)	(0.00471)
	[-2.16829]	[-1.96321]	[0.57808]	[-1.10570]
M2(-3)	0.002025	0.000453	-0.042586	0.000225
	(0.00150)	(0.00030)	(0.16126)	(0.00490)
	[1.34713]	[1.52862]	[-0.26409]	[0.04593]
M2(-4)	-0.000131	0.000434	0.237830	-0.003164
	(0.00153)	(0.00030)	(0.16459)	(0.00500)
	[-0.08561]	[1.43265]	[1.44495]	[-0.63295]
M2(-5)	-0.000671	-0.000690	-0.222756	0.007169
	(0.00112)	(0.00022)	(0.11981)	(0.00364)
	[-0.60086]	[-3.13131]	[-1.85922]	[1.97042]
PRIC_INDUSTRY(-1)	0.033671	0.007699	0.615271	1.114631
	(0.03338)	(0.00659)	(3.58132)	(0.10876)
	[1.00866]	[1.16860]	[0.17180]	[10.2490]
PRIC_INDUSTRY(-2)	0.004795	-0.011737	8.504509	-0.761888
	(0.04859)	(0.00959)	(5.21255)	(0.15829)
	[0.09869]	[-1.22401]	[1.63154]	[-4.81319]
PRIC_INDUSTRY(-3)	-0.028550	0.003137	-3.070394	0.511644
	(0.05219)	(0.01030)	(5.59891)	(0.17002)
	[-0.54706]	[0.30454]	[-0.54839]	[3.00924]
PRIC_INDUSTRY(-4)	0.046509	-0.000429	4.150655	-0.426531
	(0.04872)	(0.00962)	(5.22716)	(0.15874)
	[0.95456]	[-0.04463]	[0.79406]	[-2.68706]
PRIC_INDUSTRY(-5)	-0.005962	0.003871	4.032038	0.192687
	(0.03571)	(0.00705)	(3.83160)	(0.11636)
	[-0.16693]	[0.54911]	[1.05231]	[1.65602]
C	-2.940693	-0.572803	-3130.389	32.40589
	(6.54976)	(1.29271)	(702.684)	(21.3387)
	[-0.44898]	[-0.44310]	[-4.45490]	[1.51864]
R-squared	0.998930	0.999127	0.995901	0.708415
Adj. R-squared	0.998672	0.998917	0.994913	0.638154
Sum sq. resids	140.0182	5.454256	1611591.	1486.176
S.E. equation	1.298833	0.256347	139.3440	4.231517

F-statistic	3874.248	4748.999	1008.305	10.08256
Log likelihood	-163.0335	5.726119	-649.2834	-285.8673
Akaike AIC	3.539105	0.293728	12.89006	5.901294
Schwarz SC	4.073069	0.827692	13.42403	6.435258
Mean dependent	140.5102	101.1865	1932.730	101.9048
S.D. dependent	35.64313	7.787818	1953.766	7.034511

Determinant resid covariance (dof adj.)	35311.56
Determinant resid covariance	14325.04
Log likelihood	-1087.906
Akaike information criterion	22.53666
Schwarz criterion	24.67251

It can be noted that CPI depends on previous CPI data and as deep as lag extend the dependence decreases. For example, 1 point growth in CPI in a lag before causes 1.6 point growth in CPI. But exchange rate of AZN negatively impact on CPI and 1 percent growth in exchange rate in a lag before diminishes CPI 0.66 percent. As lag moves deeper dependence rate between CPI and exchange rate fluctuates.

It is notable that relation between M2 and CPI embodies in our equation so lame. 1 unit increase in money supply accelerate the CPI 0.003 unit.

The price of industrial products has certain influence on CPI. For instance, 1 unit growth of industrial index cause CPI to move up 0.03 unit.

Then we repeated the analysis for VAR(1).

Vector Autoregression Estimates
Date: 05/10/10 Time: 14:49
Sample (adjusted): 2001M01 2009M12
Included observations: 108 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CPI	EX_RATE	M2	PRIC_INDUSTRY
CPI(-1)	1.005569	0.036246	3.330524	0.008907
	(0.02369)	(0.00395)	(1.93445)	(0.06315)
	[42.4405]	[9.18036]	[1.72169]	[0.14104]
EX_RATE(-1)	-0.009782	0.972080	7.355460	0.038813
	(0.07233)	(0.01205)	(5.90500)	(0.19277)
	[-0.13524]	[80.6566]	[1.24563]	[0.20135]
M2(-1)	8.38E-05	-0.000504	0.930336	-0.000307
	(0.00045)	(7.5E-05)	(0.03675)	(0.00120)

	[0.18619]	[-6.72255]	[25.3187]	[-0.25582]
PRIC_INDUSTRY(-1)	0.050298	-0.004191	5.036536	0.728883
	(0.02582)	(0.00430)	(2.10833)	(0.06883)
	[1.94776]	[-0.97401]	[2.38888]	[10.5903]
C	-4.107717	-0.714441	-1534.766	23.05744
	(6.86067)	(1.14323)	(560.135)	(18.2854)
	[-0.59873]	[-0.62493]	[-2.73999]	[1.26098]
R-squared	0.997549	0.998515	0.994470	0.534722
Adj. R-squared	0.997454	0.998457	0.994256	0.516653
Sum sq. resids	334.7651	9.295583	2231480.	2378.010
S.E. equation	1.802816	0.300414	147.1899	4.804943
F-statistic	10481.55	17314.71	4630.914	29.59328
Log likelihood	-214.3355	-20.80540	-689.7918	-320.2073
Akaike AIC	4.061768	0.477878	12.86651	6.022358
Schwarz SC	4.185940	0.602051	12.99069	6.146530
Mean dependent	139.0797	101.1204	1871.955	101.8352
S.D. dependent	35.73018	7.648710	1942.019	6.911284

Determinant resid covariance (dof adj.)	133252.0
Determinant resid covariance	110237.1
Log likelihood	-1239.942
Akaike information criterion	23.33227
Schwarz criterion	23.82896

It is important to choose the optimal number of lags in the VAR. We cannot use the AIC and BIC reported in the VAR outputs to choose the optimal lag structure. We must take into consideration the number of observation.
To choose among the different structures, we must analyze the optimal number of lags:

VAR Lag Order Selection Criteria
Endogenous variables: CPI EX_RATE M2 PRIC_INDUSTRY
Exogenous variables: C
Date: 05/10/10 Time: 14:51
Sample: 2000M12 2009M12
Included observations: 104

Lag	LogL	LR	FPE	AIC	SC	HQ

0	-1870.782	NA	5.34e+10	36.05350	36.15521	36.09470
1	-1199.886	1277.282	181341.5	23.45935	23.96789	23.66537
2	-1139.143	110.9737	76812.68	22.59890	23.51426*	22.96974*
3	-1131.568	13.25487	90642.74	22.76093	24.08313	23.29659
4	-1111.701	33.23914	84701.96	22.68656	24.41559	23.38704
5	-1087.906	37.98079*	73692.55*	22.53666*	24.67251	23.40195

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

So we can estimate a VAR(5) based on AIC.

3. Conclusion

This research is an attempt to develop a simple theoretical framework of inflation determination appropriate for Azerbaijan and then test it empirically. Taking into account the data availability and reliability problems, we choose to concentrate on the simple theoretical and empirical set-up. The inflation is usually driven by demand-side and supply-side, internal and external factors, the theoretical and empirical problem is how to differentiate between these factors and at the same time take them into account simultaneously.

To sum up, four major blocks of factors determining inflation may be pointed out: demand-side (i.e., persistent increases due to the continued excess demand); real or supply shocks (or cost-push inflation; primarily, the negative productivity shocks, domestic currency depreciation, rising wages, interest rates, taxes, price shocks from inputs markets); inertial (expectations, sticky wages and prices) and institutional factors. In reality, it is a mixture of all factors that seems to cause the inflationary or disinflationary processes.

The slight impact of the monetary policy upon the inflation from the monetary aggregates as implied by the lagged money supply term directly and by the insignificance of the money market disequilibrium term, on the one hand, and the existence of the long-run relationship between money, prices, exchange rate and real output, on the other hand, raises the question about the possible implications for the use of the monetary aggregates as a good intermediate target to achieve price stability. To derive some more precise conclusions about the link between money and prices, one may want to try to incorporate the money velocity changes into the model. At present, there seems to be no independent monetary policy in Azerbaijan as the money supply depends on the foreign currency inflow, which creates the danger of the monetary overhang and leads to the very limited control over the inflation.

The major drawbacks of the applied cointegration technique are that, first of all, it has been applied in the presence of the rather short time span, data reliability problem and possible instability in the long-run relationships. The small sample does not allow considering a larger number of variables and lags
in the short-run model. The major challenge was to model inflation dynamics in the midst of the structural changes in the economy and high administrative interference into the prices. The cointegration technique may be quite difficult to apply in the economies that undergo structural changes (also dedollarization, demonetization, etc.) and in some years there could be some completely different long-run equilibrium. The break-down into the sub-samples is not quite appropriate for the meaningful analysis, since afterwards one ends up with the small sub-samples.

Second, each sector was estimated separately, thus, the biased estimators could be obtained. The potential alternatives could be estimating the long-run relationships based on a complete VAR model and the multi-equation short-run model afterwards, if the variables turn out to be endogenous, or focusing on one particular source of inflation. At the same time, the estimated macroeconomic model has been a step away from a-theoretical VAR models.

According to the model the monetary policy has low effect on CPI, inflation expectation is the most influential factor on CPI, fixed exchange rate is the subject to be discussed and weighted average inflation forecast for the end of 2010 is 8.3%.