Inflation modeling in the Kyrgyz Republic

1. Selection of variables for the model of inflation in Kyrgyzstan

Consumer price index (**CPI**) – is an inflation indicator in the Kyrgyz Republic which is calculated based on price changes of 348 items of goods and services.

Taking into account conditions in which inflation process are formed in Kyrgyz economy when the inflation model was developing the following factors were chosen to be the main ones that affect inflation dynamics:

1. Nominal exchange rate (**KGS**) – which shows the dynamics of change of price of one US dollar vis-à-vis Kyrgyz soms;
2. Monetary aggregate M2 (**M2**) – the broadest monetary aggregate in national currency;
3. World commodity price dynamics of the Food and Agriculture Organization of UN (**FAO**) – is the most relevant estimation of world commodity price index which affect domestic price level. The first includes dynamics of five the most wide spread agricultural goods (grains, sugar, vegetable oil milk and meat);
4. Fuel price dynamics (**OIL**) – is based on prices of Brent oil as the price delivered to the Kyrgyz Republic is formed based of the price changes on this particular sort;
5. Gross disposable national income (**VRND**) – is an estimate of aggregate volume of resources or income of Kyrgyz economy which is formed from all sources, particularly:

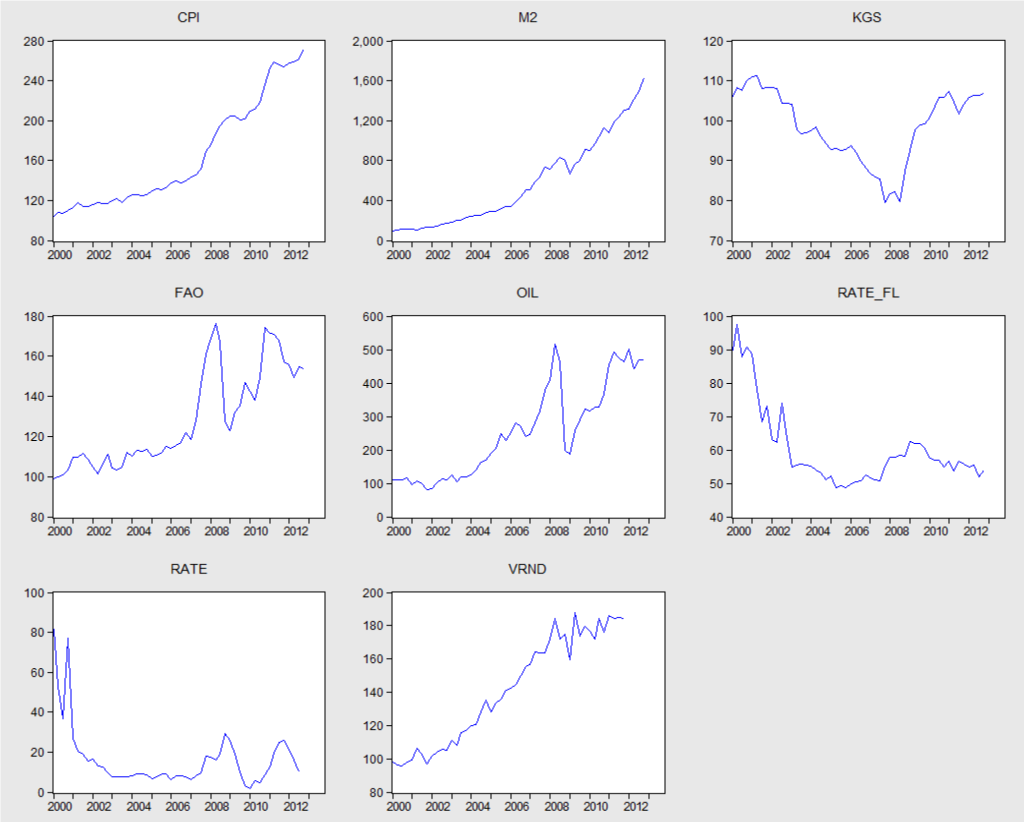
   VRND *= GDP + Factor incomes from abroad + Transfers (including remittances)*
6. Interest on loans (**RATE_FL**) – is a weighted average interest rate on loans of commercial banks for a period;
7. Discount rate of the National bank (**RATE**) – is an weighted average of return on 28 day the NBKR Notes for the last 4 auctions, this variables is accounted as a policy rate of the National bank.

The data in the model is quarterly which is not that noisy as monthly data but still allows to have more observations then the annual one. The sample size is from first quarter of 2000 till the fourth quarter of 2012.

Variables are chain based in real terms with a base year of 2000 (Q4 of 1999 = 100). The data is non stationery and in order to use the OLS method the series were transferred into first logarithm difference (dlog).

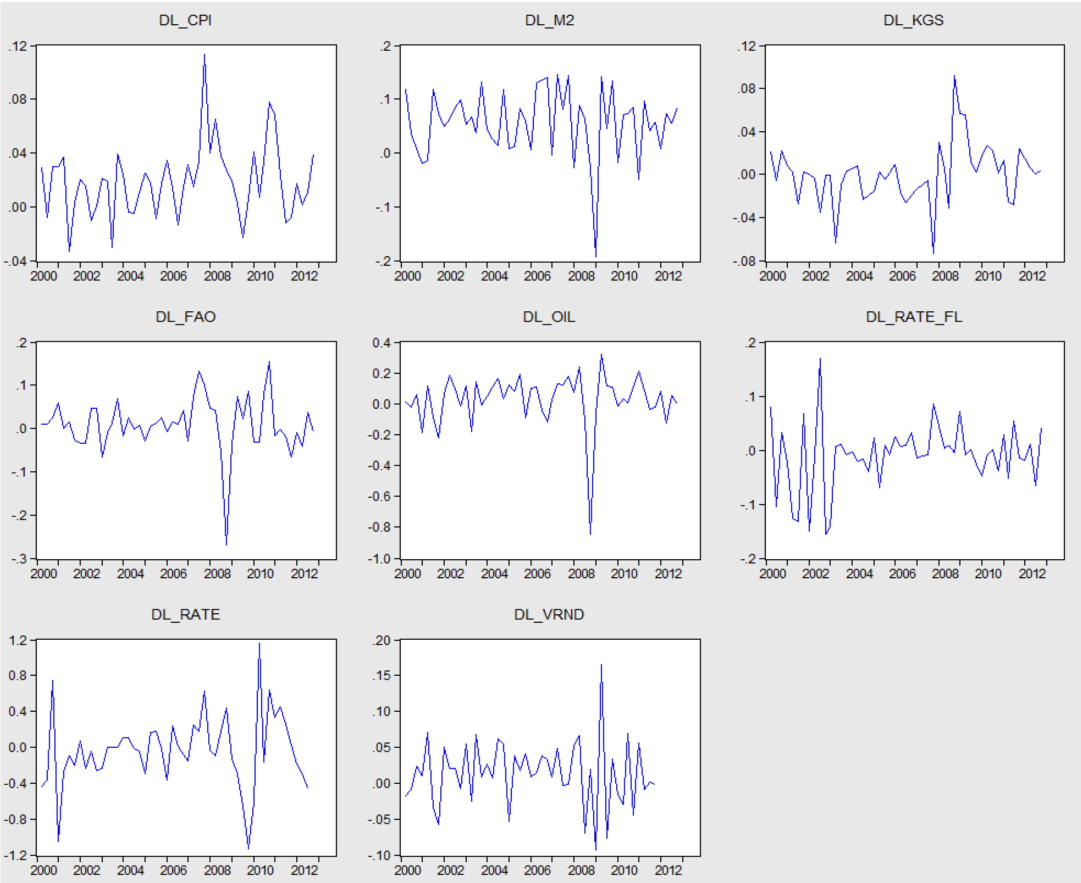
Graph 1. Dynamics of variables used in the model (in levels)

(percent, 1999Q4 = 100)



Graph 2. Dynamics of variables used in the model (first difference)

(percent, 1999Q4 = 100)



The first step was to check for stationerity, trend and the constant.

Table 1. Probability of statistically **not** significance of trend and constant

	dlog(CPI)	dlog(M2)	dlog(KGS)	dlog(FAO)	dlog(OIL)	dlog(RATE_fl)	dlog(RATE)	dlog(VRND)
@trend	0,1714	0,7918	0,1407	0,8466	0,8875	0,1916	0,3093	0,7922
C	0,2051	0,0017	0,2065	0,5129	0,6413	0,0903	0,2146	0,2403

Using the Augmented Dickey-Fuller Test we check for presence of a unite root and receive the following results:

Table 2. Probability of unit-root process

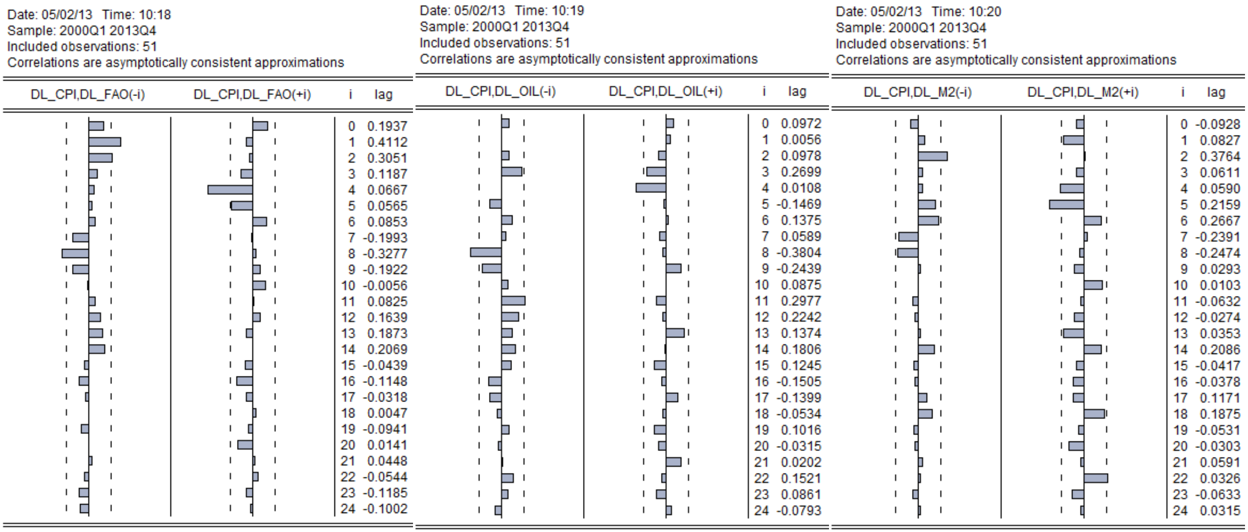
	dlog(CPI)	dlog(M2)	dlog(KGS)	dlog(FAO)	dlog(OIL)	dlog(RATE_fl)	dlog(RATE)	dlog(VRND)
Augmented Dickey-Fuller test statistic prob.	0,0003	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Low probability of the null hypothesis of the AD-F test indicates no unit-root in all data series and their stationerity.

2. Inflation model parameterization:

In order to specify the equation we had a look at Cross Correlation Test where we pair wise compare CPI with all factors that affect it.

Graph 3. Cross Correlation Test of CPI, FAO, OIL, M2

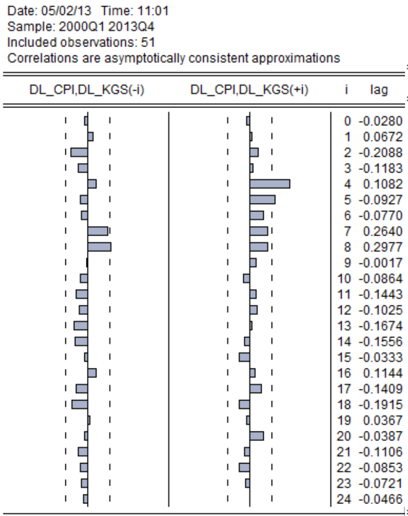


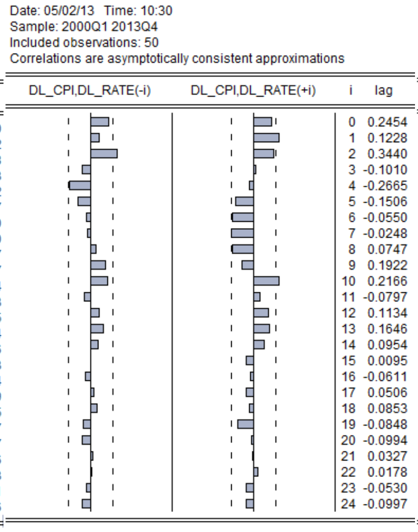
Here we can see statistically significant affect of world food price index, monetary aggregates and oil prices on inflation. All of them affect domestic prices with a certain lag.

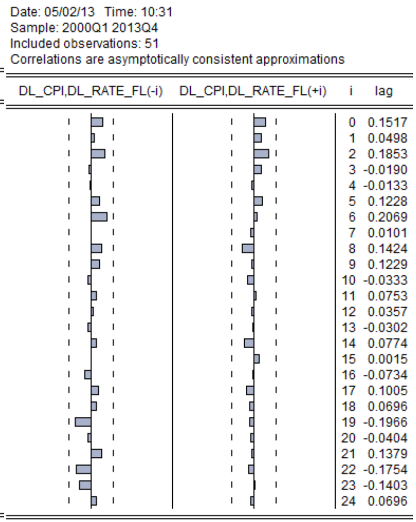
In general Cross Correlation Test certifies the following:

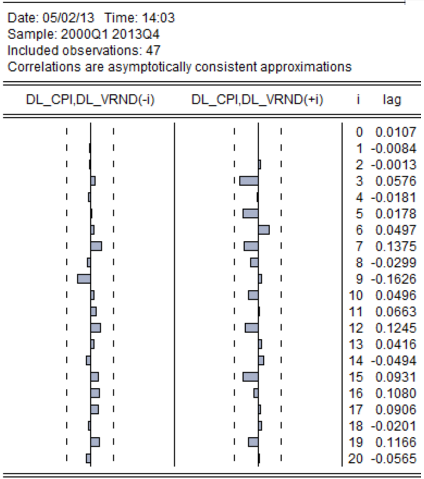
1. World food prices positively affect inflation with a lag of 1 quarter.
2. World oil pries positively affect inflation with a lag of 3 quarters. Such a long pass-through is due to longer period of oil extraction and its transportation to retailers in Kyrgyzstan.
3. Monetary aggregate M2 also positively affect domestic price level with a log of 2 quarters that is in line with theoretical concepts.

Graph 4. Cross Correlation Test of CPI, KGS, RATE, RATE_fl, VRND









The results need to discussions:

1. There is no statistically significant interlink found between inflation rate and the exchange rate what is impossible in theory. Despite that result it was decided to leave the variable in the model with one quarter lag.
2. There is significant positive relationship between discount rate and inflation with a 2 quarter lag and negative relationship with a 4 quarter lag. The positive effect of the interest rate on inflation is contrary to economic logic and can not be included in the model of inflation. In the dynamics of the model will include the discount rate with a 4 quarters lag, that is the most likely in terms of the Kyrgyzstan economy.
3. Average credit interest rate does not seem to be statistically significant as it was expected due to mentioned above low level of financial intermediation level. It was decided to exclude this variable from the model.

Before constructing the model let introduce a dummy variable that accounts for shocks. The following periods of instability were included in this variable:

1. January-September 2000 – aftermaths of Russian crises;
2. October 2007-September 2008 – world commodity and oil prices shocks;
3. October 2010-June 2011 – grains prices splash due to bad harvest in Russia and Kazakhstan and imposed export limitation.

Inflation model (based on OLS)

Taking into account cross correlation tests we specify a regression equation of inflation as a function of all listed above variables.

Table 3. Inflation model

Dependent Variable: DLOG(CPI)
Method: Least Squares
Date: 05/22/13 Time: 16:47
Sample (adjusted): 2001Q2 2012Q4
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(FAO(-1))	0.162554	0.056238	2.890441	0.0062
DLOG(OIL(-3))	0.033359	0.019125	1.744234	0.0888
DLOG(M2(-2))	0.119059	0.048707	2.444401	0.0190
DLOG(KGS(-1))	0.314314	0.112625	2.790798	0.0080
DLOG(RATE(-4))	-0.008586	0.006683	-1.284725	0.2063
DUMMY	0.031316	0.008657	3.617273	0.0008
C	0.005025	0.003507	1.432702	0.1597

R-squared	0.652870	Mean dependent var	0.018611
Adjusted R-squared	0.600801	S.D. dependent var	0.027394
S.E. of regression	0.017308	Akaike info criterion	-5.138643
Sum squared resid	0.011983	Schwarz criterion	-4.863089
Log likelihood	127.7581	Hannan-Quinn criter.	-5.034950
F-statistic	12.53846	Durbin-Watson stat	2.067956
Prob(F-statistic)	0.000000		

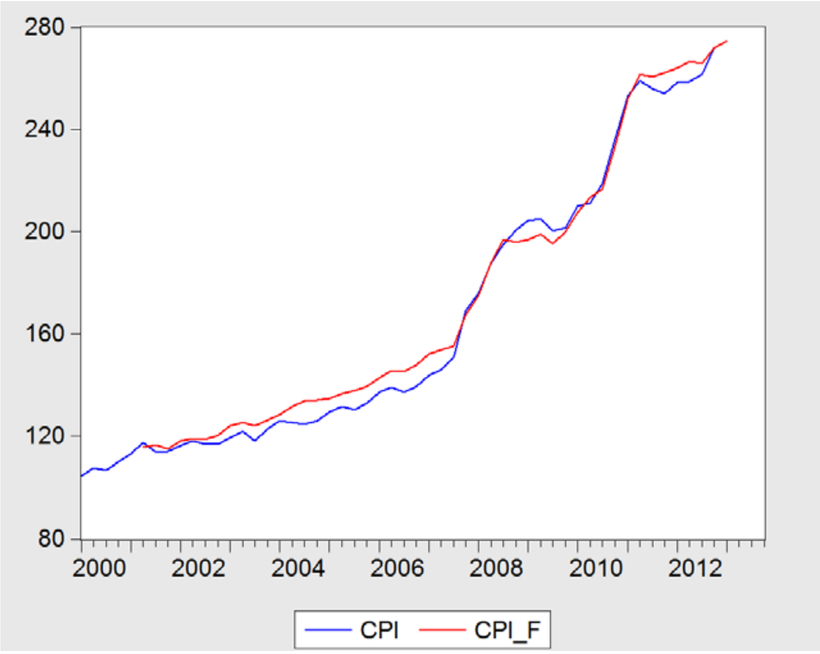
The adjusted model seem to be appropriate. All coefficients are statistically and economically significant. Likely of affect the discount rate on inflation is very low, which is a consequence of the low level of financial intermediation in the economy, while the discount rate factor is not contrary to economic logic; we can save it in our model.

The model has relatively high descriptive power – more than 60 percent and adjusted R-squared is about 60 percent. Durbin-Watson statistics are also appropriate – 2.06 that indicate of no autocorrelation in errors. Summarizing we can conclude that the model is adequate.

The most significant factors are exchange rate and external prices of imported goods.

Graph 5. Actual and estimated CPI

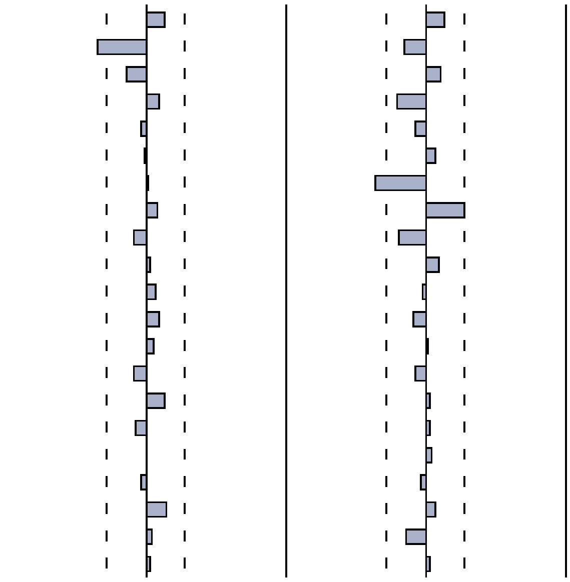
(*percents, 1999Q4 = 100*)



There is seem to be no strong relationship between inflation and the gross disposable national income (VRND). This factor would include the demand side of inflation process in economy and need further examination in order to test for its indirect affect on inflation. Knowing that national income is a sum of GDP, factor revenues and transfers, which is around 120 percent of GDP, it can affect inflation though nominal exchange rate or/and monetary aggregate M2.

Graph 6. Cross Correlation Test between KGS и VRND

Date: 05/22/13 Time: 19:38
Sample: 2000Q1 2013Q4
Included observations: 47
Correlations are asymptotically consistent approximations



DL_KGS,DL_VRND(-i)	DL_KGS,DL_VRND(+i)	i	lag
		0	0.1314
		1	-0.3592
		2	-0.1342
		3	0.1007
		4	-0.0339
		5	-0.0160
		6	0.0246
		7	0.0845
		8	-0.0965
		9	0.0331
		10	0.0668
		11	0.1031
		12	0.0605
		13	-0.0885
		14	0.1354
		15	-0.0740
		16	0.0113
		17	-0.0331
		18	0.1626
		19	0.0486
		20	0.0319

Test indicates that is indeed statistically significant effect of VRND on the nominal exchange rate (KGS) in first lag. Specifying the model with this fact we can see the following:

Table 5. Modeling of effect of VRND on KGS

Dependent Variable: DLOG(KGS)
Method: Least Squares
Date: 05/22/13 Time: 15:32
Sample (adjusted): 2000Q3 2012Q1
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(VRND(-1))	-0.218311	0.083188	-2.624311	0.0118
C	0.002414	0.003988	0.605298	0.5480

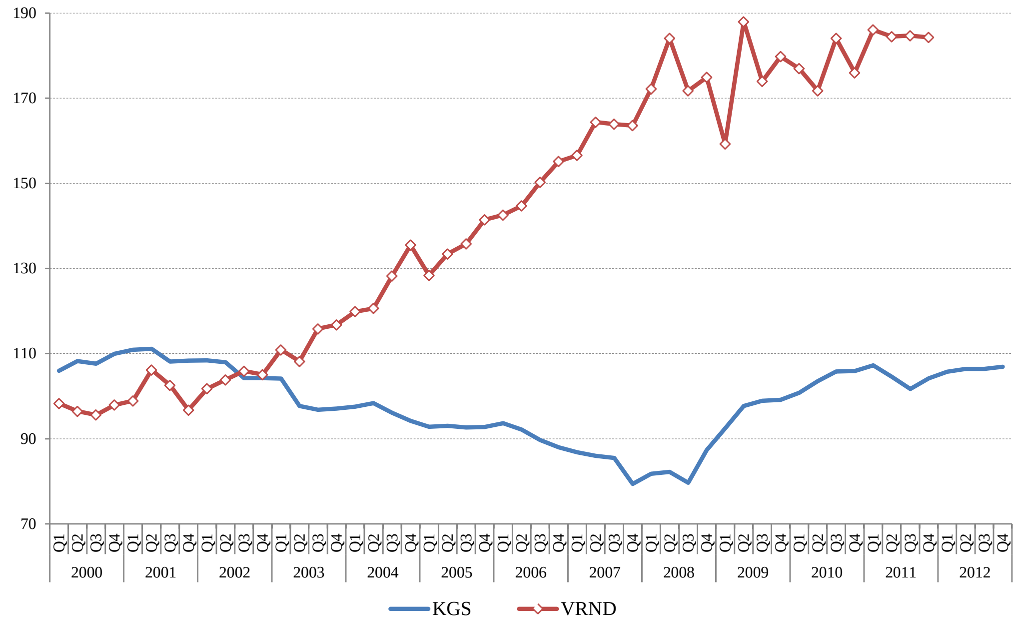
R-squared	0.132731	Mean dependent var	-0.000505
Adjusted R-squared	0.113458	S.D. dependent var	0.027888
S.E. of regression	0.026258	Akaike info criterion	-4.400051
Sum squared resid	0.031027	Schwarz criterion	-4.321322
Log likelihood	105.4012	Hannan-Quinn criter.	-4.370425
F-statistic	6.887007	Durbin-Watson stat	1.624169
Prob(F-statistic)	0.011816		

We may conclude that the dispodable income affect in first exchange rate dynamics and later on it influence inflation, i.e. VRND↑ → (after one quarter) KGS↓ → (in one quarter) CPI↓.

Thus the effect of disposable income on inflation is indirect and pass-through takes about 6 months long.

Negative relationship between **VRND** and **KGS** is due to the fact that in the structure of VRND significant proportion takes remittances, which form a significant inflow of foreign currency into the economy of Kyrgyzstan. Hereby, dynamics of VRND and KGS from 2000 to 2012 can be divided into two periods:

1. 2000-2008 – period of economic activity growth, increase in the inflow of remittances and strengthening of the som;
2. 2009-2012 – period of economic instability in the global financial crisis, volatility in world commodity markets, and reduction in the inflow of remittances.



The identical analysis done with incomes influence on monetary aggregate assuming at the same time that M2 depends on price of loans of commercial banks (RATE_fl):

Graph 7. Cross Correlation Test of M2, VRND, RATE_fl

Date: 05/22/13 Time: 19:45
Sample: 2000Q1 2013Q4
Included observations: 47
Correlations are asymptotically consistent approximations

DL_M2,DL_VRND(-i)	DL_M2,DL_VRND(+i)	i	lag
		0	0.2241
		1	0.0807
		2	0.1803
		3	-0.2306
		4	0.0976
		5	-0.0533
		6	0.1201
		7	-0.1953
		8	0.1958
		9	-0.2113
		10	0.1290
		11	-0.0035
		12	0.0254
		13	-0.0259
		14	-0.0126
		15	0.0424
		16	0.0789
		17	-0.0439
		18	-0.1205
		19	-0.0008
		20	-0.0451

Date: 05/02/13 Time: 16:34
Sample: 2000Q1 2013Q4
Included observations: 51
Correlations are asymptotically consistent approximations

DL_M2,DL_RATE_FL(-i)	DL_M2,DL_RATE_FL(+i)	i	lag
		0	-0.0319
		1	0.0078
		2	-0.0347
		3	0.0228
		4	-0.2669
		5	0.0121
		6	0.0537
		7	-0.0385
		8	-0.1075
		9	0.0505
		10	-0.0909
		11	-0.0935
		12	0.1072
		13	-0.0651
		14	-0.1526
		15	0.1075
		16	0.0603
		17	-0.0448
		18	-0.1180
		19	0.0144
		20	-0.0731

Cross Correlation Test indicates correlation between VRND and M2 without lags and negative significant effect of RATE_fl on M2 with lag of 4 quarters. In other words increase in VRND in three months affect M2 growth and the later leads to increase of RATE_fl which in its turn results in lower deceleration after 12 month. The following model was specified:

Table 6. Regression model of M2, VRND, RATE_fl

Dependent Variable: DLOG(M2)
Method: Least Squares
Date: 05/22/13   Time: 15:34
Sample (adjusted): 2001Q2 2011Q4
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(VRND)	0.329654	0.200206	1.646569	0.1075
DLOG(RATE_FL(-4))	-0.273311	0.149279	-1.830878	0.0746
C	0.049876	0.010121	4.927794	0.0000

R-squared	0.133337	Mean dependent var	0.057780
Adjusted R-squared	0.090004	S.D. dependent var	0.065670
S.E. of regression	0.062645	Akaike info criterion	-2.635451
Sum squared resid	0.156976	Schwarz criterion	-2.512576
Log likelihood	59.66219	Hannan-Quinn criter.	-2.590138
F-statistic	3.077017	Durbin-Watson stat	2.288420
Prob(F-statistic)	0.057149		

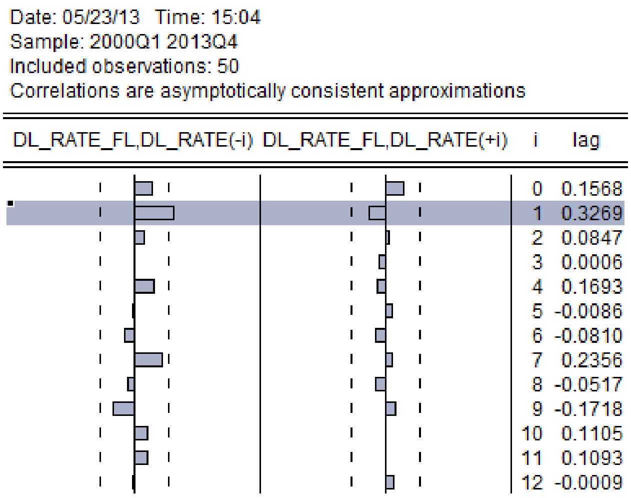
This regression indicates presence of relationship between VRND and inflation through money stock with 6 months lag, i.e. increase in disposable income leads to growth in inflation in 6 months. Besides the coefficient of effect of KGS on inflation is higher than the one of affect of M2 on inflation.

We can imply that increase of disposable income (VRND) stronger affect inflation through national currency's appreciation rather than inflation increase though money growth. This is holds for a short time span.

The interest rate of loans of commercial banks (RATE_FL) also has an impact on inflation through changing the quantity of money in the economy: RATE_FL↑ → (after 4 quarters) M2↓ → (after two quarters) CPI↓.

Also we found a significant effect of the National Bank discount rate (RATE) to RATE_FL, which demonstrated by Cross Correlation Test:

Graph 8. Cross Correlation Test of RATE and RATE_fl



Cross Correlation Test indicates significant influence of the National Bank discount rate (RATE) to interest rate of commercial banks loans (RATE_fl) with one quarter lag.

Table 7. Regression model of RATE and RATE_fl

Dependent Variable: DL_RATE_FL
Method: Least Squares
Date: 04/19/13 Time: 18:28
Sample (adjusted): 2000Q3 2012Q4
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_RATE(-1)	0.047249	0.020653	2.287759	0.0266
C	-0.009819	0.008305	-1.182334	0.2429

R-squared	0.098318	Mean dependent var	-0.011810
Adjusted R-squared	0.079533	S.D. dependent var	0.060870
S.E. of regression	0.058399	Akaike info criterion	-2.803842
Sum squared resid	0.163704	Schwarz criterion	-2.727361
Log likelihood	72.09606	Hannan-Quinn criter.	-2.774718
F-statistic	5.233841	Durbin-Watson stat	2.377619
Prob(F-statistic)	0.026599		

As a result, our inflation model describes weak, but still statistically significant effect of the interest rate channel to inflation. As noted earlier, the weakness of this effect is due to a low of integration of the banking system to the economy of our country.

However, with the development of the domestic economy and banking system the role of the interest rate channel will increase, the lag length of the impact of interest rate on inflation will decline.

Combined regression model of inflation (based on two-stage OLS)

This hypothesis can be supported when all 4 regression models are put in a one system as following.

Table 7. Descriptive statistics of regression model

System: SYS1
Estimation Method: Two-Stage Least Squares
Date: 05/22/13 Time: 16:25
Sample: 2001Q2 2011Q4
Included observations: 43
Total system (balanced) observations 172

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.1607	0.0588	2.7311	0.0070
C(2)	0.0307	0.0197	1.5553	0.1219
C(3)	0.1233	0.0503	2.4506	0.0154
C(4)	0.3019	0.1176	2.5675	0.0112
C(5)	-0.0096	0.0071	-1.3512	0.1786
C(6)	0.0323	0.0090	3.5888	0.0004
C(7)	0.0039	0.0037	1.0450	0.2976
C(8)	-0.2174	0.0870	-2.4992	0.0135
C(9)	0.0017	0.0043	0.4030	0.6875
C(10)	0.3975	0.2054	1.9348	0.0548
C(11)	-0.2957	0.1478	-2.0007	0.0471
C(12)	0.0484	0.0101	4.7823	0.0000
C(13)	0.0551	0.0226	2.4337	0.0161
C(14)	-0.0093	0.0090	-1.0275	0.3058

Equation: DLOG(CPI) = C(1)*DLOG(FAO(-1)) + C(2)*DLOG(OIL(-3)) + C(3)*DLOG(M2(-2)) + C(4)*DLOG(KGS(-1)) + C(5)*DLOG(RATE(-4)) + C(6)*DUMMY + C(7)
Instruments: DLOG(FAO(-1)) DLOG(OIL(-3)) DLOG(M2(-2)) DLOG(KGS(-1)) DLOG(RATE(-4)) DUMMY DLOG(RDN) DLOG(VRND(-1)) DLOG(RATE_FL(-4)) DLOG(RATE(-1)) C
Observations: 43

R-squared	0.665122	Mean dependent \	0.018745
Adjusted R-squared	0.609309	S.D. dependent va	0.028338
S.E. of regression	0.017713	Sum squared resid	0.011295
Durbin-Watson stat	2.085364		

Equation: DLOG(KGS) = C(8)*DLOG(VRND(-1)) + C(9)
Instruments: DLOG(FAO(-1)) DLOG(OIL(-3)) DLOG(M2(-2)) DLOG(KGS(-1)) DLOG(RATE(-4)) DUMMY DLOG(RDN) DLOG(VRND(-1)) DLOG(RATE_FL(-4)) DLOG(RATE(-1)) C
Observations: 43

R-squared	0.132198	Mean dependent \	-0.001458
Adjusted R-squared	0.111032	S.D. dependent va	0.02883
S.E. of regression	0.027182	Sum squared resid	0.030294
Durbin-Watson stat	1.62559		

Equation: DLOG(M2) = C(10)*DLOG(RDN) + C(11)*DLOG(RATE_FL(-4)) + C(12)
Instruments: DLOG(FAO(-1)) DLOG(OIL(-3)) DLOG(M2(-2)) DLOG(KGS(-1)) DLOG(RATE(-4)) DUMMY DLOG(RDN) DLOG(VRND(-1)) DLOG(RATE_FL(-4)) DLOG(RATE(-1)) C
Observations: 43

R-squared	0.15379	Mean dependent \	0.05778
Adjusted R-squared	0.111479	S.D. dependent va	0.06567
S.E. of regression	0.061901	Sum squared resid	0.153271
Durbin-Watson stat	2.294421		

Equation: DLOG(RATE_FL) = C(13)*DLOG(RATE(-1)) + C(14)
Instruments: DLOG(FAO(-1)) DLOG(OIL(-3)) DLOG(M2(-2)) DLOG(KGS(-1)) DLOG(RATE(-4)) DUMMY DLOG(RDN) DLOG(VRND(-1)) DLOG(RATE_FL(-4)) DLOG(RATE(-1)) C
Observations: 43

R-squared	0.126228	Mean dependent \	-0.010739
Adjusted R-squared	0.104916	S.D. dependent va	0.062581
S.E. of regression	0.059207	Sum squared resid	0.143725
Durbin-Watson stat	2.379096		

Abbrevation:
C(1) – coefficient at FAO in **CPI** equation
C(2) – coefficient at OIL in **CPI** equation
C(3) – coefficient at M2 in **CPI** equation
C(4) – coefficient at KGS in **CPI** equation
C(5) – coefficient at RATE in **CPI** equation
C(6) – coefficient at DUMMY in **CPI** equation
C(7) – constant in **CPI** equation
C(8) – coefficient at VRND in **KGS** equation
C(9) – constant in **KGS** equation
C(10) – coefficient at VRND in **M2** equation
C(11) – coefficient at RATE_FL in **M2** equation
C(12) – constant in **M2** equation
C(13) – coefficient at RATE in **RATE_FL** equation
C(14) – constant in **RATE_FL** equation

All coefficients keep their statistical significance and the mentioned order of interrelations among each other. When the whole sample divided into periods:

- 2001 till 2007 – period of price stabilization then the most significant variables are world food prices (FAO) and a money stock (M2):

System: SYS1
Estimation Method: Two-Stage Least Squares
Date: 05/23/13 Time: 13:25
Sample: 2001Q2 2007Q4
Included observations: 27
Total system (balanced) observations 108

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.268002	0.109423	2.449243	0.0162
C(2)	0.012037	0.033604	0.358218	0.7210
C(3)	0.161990	0.084633	1.914030	0.0587
C(4)	0.324990	0.222132	1.463053	0.1468
C(5)	-0.001527	0.012198	-0.125184	0.9006
C(6)	0.053690	0.025174	2.132777	0.0355
C(7)	0.001927	0.006251	0.308356	0.7585
C(8)	-0.104104	0.115129	-0.904240	0.3682
C(9)	-0.010398	0.004456	-2.333345	0.0218
C(10)	-1.352790	0.776674	-1.741773	0.0848
C(11)	-0.091631	0.176166	-0.520142	0.6042
C(12)	0.093890	0.020228	4.641595	0.0000
C(13)	0.108151	0.053134	2.035465	0.0446
C(14)	-0.009231	0.014066	-0.656257	0.5133
Determinant residual covariance		1.10E-12		

- 2006 till 2012 – period of instabilicty in the world food and oil markets strongly increase the affect of FAO and M2 variables in the model.

System: SYS1
Estimation Method: Two-Stage Least Squares
Date: 05/23/13 Time: 13:27
Sample: 2006Q1 2012Q1
Included observations: 25
Total system (unbalanced) observations 99

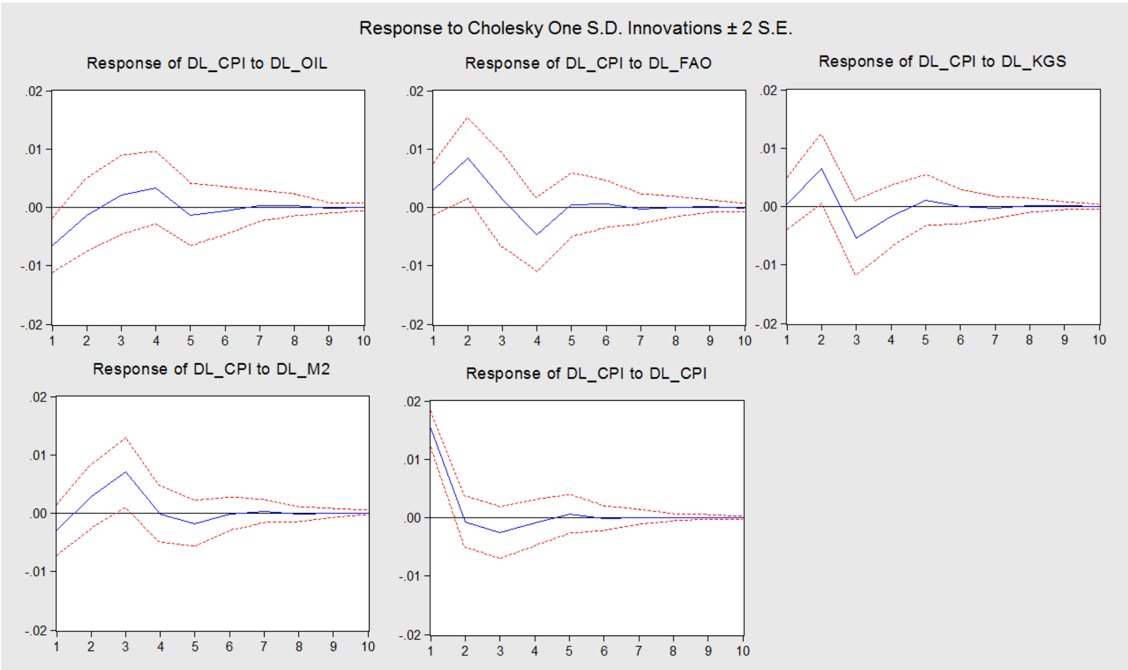
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.131470	0.073916	1.778638	0.0789
C(2)	0.028443	0.024215	1.174604	0.2434
C(3)	0.130912	0.057022	2.295810	0.0241
C(4)	0.265243	0.151449	1.751361	0.0835
C(5)	-0.015684	0.008800	-1.782320	0.0783
C(6)	0.031199	0.009809	3.180587	0.0021
C(7)	0.006417	0.004965	1.292464	0.1997
C(8)	-0.224745	0.121296	-1.852863	0.0674
C(9)	0.007978	0.006574	1.213467	0.2283
C(10)	0.389521	0.383553	1.015559	0.3127
C(11)	-0.767725	0.464535	-1.652673	0.1021
C(12)	0.054605	0.015796	3.456873	0.0009
C(13)	0.033342	0.013466	2.475986	0.0153
C(14)	0.003254	0.006195	0.525264	0.6008
Determinant residual covariance		5.06E-13		

The results of the regression analysis system at different periods confirms the strong and long-term dependence of inflation from the quantity of money in the Kyrgyzstan economy. This result, confirming the basis of economic theory, is an additional indicator of the correctness of our model.

VAR model of inflation in Kyrgyzstan

Based on the results of the regression model of inflation, we parameterize the VAR model, taking as endogenous variables as follows (the sequence of variables corresponds to the specification): dlog(OIL), dlog(FAO), dlog(KGS), dlog(M2), dlog(CPI). In the form of exogenous variables were taken constant and DUMMY.

VAR model has received the following impulse response function of inflation (CPI) for OIL, FAO, KGS, M2, and to itself (CPI):



The results indicate a significant dependence of inflation from the exchange rate (KGS), the quantity of money in the economy (M2), the global commodity prices (FAO), and from previous period inflation. In addition, the response of inflation correspond with the results of the regression model of inflation based on OLS and two-stage OLS. In total, it confirms the correctness of our inflation model.

3. Conclusion

Summarizing the evaluation and conclusions based on different modeling techniques, we can say that in this paper describes the basic mechanisms of the effect of inflation factors and their interaction with each other. Furthermore, these developments will be an acceptable instrument of short-term forecasting. Further work on the model of inflation will continue, including the use of new methods of modeling and forecasting.