



CENTRAL BANK OF THE
REPUBLIC OF ARMENIA

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***EQUILIBRIUM REAL EXCHANGE RATE
MODEL OF ARMENIA***

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ABSTRACT

The equilibrium real exchange rate (ERER) is one of the key indicators for assessment of the state of economic development of a country. So it is of great importance to uncover the variables that influence on the RER and to forecast RER's future path. Like a very common technique used in the literature for developing and transition countries we also used cointegrating equations in form of a restricted single-equation model, as far as Armenia has short-run time series problem, which does not allow estimating the VEC model. After some econometric tests 4 variables out of 30 were found to have significant explaining impact on RER. They are current transfers as a ratio of GDP, capital inflow, government investments in GDP, and nominal effective exchange rate as short-run (only) variable. Thus, the only policy instrument which the authorities may use to effect the level of the ERER is government investments (perhaps also total government spending). This model has enabled to estimate short-run and long-run real exchange rates, the adjustment paths to their equilibrium levels after external shocks, and it also observes the misalignments and explains the reasons of it. Besides it was used to assess the steady-state level of appreciation, which according to this model is estimated about 5.8 % per annum based on the developments of the last five years.

Equilibrium Real Exchange Rate Model of Armenia

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Introduction

The equilibrium real exchange rate (ERER) model is the key objective for the assessment of the economy general equilibrium. Since the real exchange rate (RER) together with the real interest rate are the country's most important relative prices, a vital importance comes out to uncover the influence of other variables on the RER and to forecast RER's future path. It will enable to estimate the change of country's price competitiveness relative to partner countries, and, as a result, to estimate the future trends of the trade balance sheet.

On the other hand, the forecast of the RER provides some information about the future value of the nominal exchange rate conditional on information about future prices.

These issues are rather urgent for Armenia, considering the dynamics of nominal and real exchange rates over last years.

This analysis has been done on the basis of large-scale work done by the Monetary Policy Department in the field of the RER estimation methodology, partial and general equilibrium models based on the RER ("*Wage, Productivity and Prices*", "*Trade Elasticity*", "*1-2-3 Models*"), as well as in the field of purchasing power parity and the influence of Balassa-Samuelson effect.

Chapter 1 of this work deals with the conception, definition and the methods of estimation of the ERER.

Chapter 2 deals with the testing of purchasing power parity as the most simple and applicable model of the ERER.

Chapter 3 presents the RER model as an error correction model, which enables to separate long-run and short-run influence of factors. We estimated the scope and the term of the impulses of the influencing factors.

In the last chapter we have estimated the ERER, separated the short-run and long-run ERERs, explained the ERER misalignment as the misalignments of fundamentals and the policy variables.

Equilibrium Real Exchange Rate

In general, economists mean by "a forecast of an indicator" the value which that indicator will have most probably in future. The same relates to the forecast level of the RER. Though, the notion of "future" in this case can be separated according to short-term and long-term horizons. Since the RER is a fundamental indicator for a country and it is interrelated most likely with similar fundamentals, the forecast of it will be more precise for a long-term period when all fundamentals are in their steady-state level. ***The ERER is formed when all the fundamentals are in their steady-state levels and when the economy is in internal and external equilibrium, and this becomes the most probable value of the RER in long-run period.***¹

We need here to state definition of the internal and external ***equilibrium*** so as they are used in order to determine the level of the ERER.

External equilibrium means a situation when the current account deficit value is financed/ can be financed by a steady inflow of capital (sustainability of external liabilities).

Internal balance means a situation when market for nontraded goods is in its steady-state equilibrium (full employment and inflation level).

On the other hand, the long-run equilibrium of the RER is such a short-run equilibrium state when its determining variables, i.e. fundamentals, policy and exogenous variables are in their long-run steady state. At the same time the long-run fundamentals are also conditioned by policy and exogenous variables which enable to estimate the level of the ERER only through them.

In fact, the long-run equilibrium is a state, when all variables, including policy and fundamental get their steady-state levels given the long-run (permanent) values of exogenous variables. It means that any short-run fluctuation of exogenous variables is uncovered and separated, that all policy variables

¹ See Nurkse (1945), Edwards (1989).

correspond to their steady long-run values, and that all fundamental economic indicators accomplish their endogenous adjustment and get their steady-state levels.

The fundamentals may include wages (for internal balance), net foreign liabilities (for external balance) and capital stock in the sectors of economy (for both external and internal balances).

In view of these variables the internal balance is characterized as the equilibrium of the market of goods and services under full employment and the given capital stock.

As regards the external equilibrium, it supposes that the current account should be equal to net capital inflow thus providing the steady-state level of the country's net foreign liabilities.²

Many analysts use a slightly different approach for external balance. In the conception of the ERER they use only exogenous net capital inflow instead of stock of net foreign liabilities (flow instead of stock). It becomes possible when these conditions hold:

- i) net foreign liabilities do not have reverse effect on future capital flows,
- ii) moreover, the steady capital inflow is exogenous as compared also with other fundamental variables,
- iii) since the capital has a very slight effect on debt stock in the nearest future, the debt stock can be treated as a constant, or the net debt stock will have a weak effect on short-run ERER via macroeconomic mechanisms.

The abovementioned conditions are very much similar to the conditions of a low-income country, which gets its external financing mostly in the form of grant-like international loans.

Different economists include different economic variables in the models of the ERER and they uncloze and comment those interrelations quite variously.

Briefly reviewing these models we can divide them into two groups: one for developed countries and another one for transitional countries.

Generally, the theory of purchasing power parity is considered to be the main and the easiest model for application. If the behavior of the real exchange rate meets the requirements of the absolute or relative purchasing power parity (i.e. it holds the law one price absolutely or relatively), this theory can fully explain the behavior of the real exchange rate and to forecast it.

Otherwise we need to apply to other models.

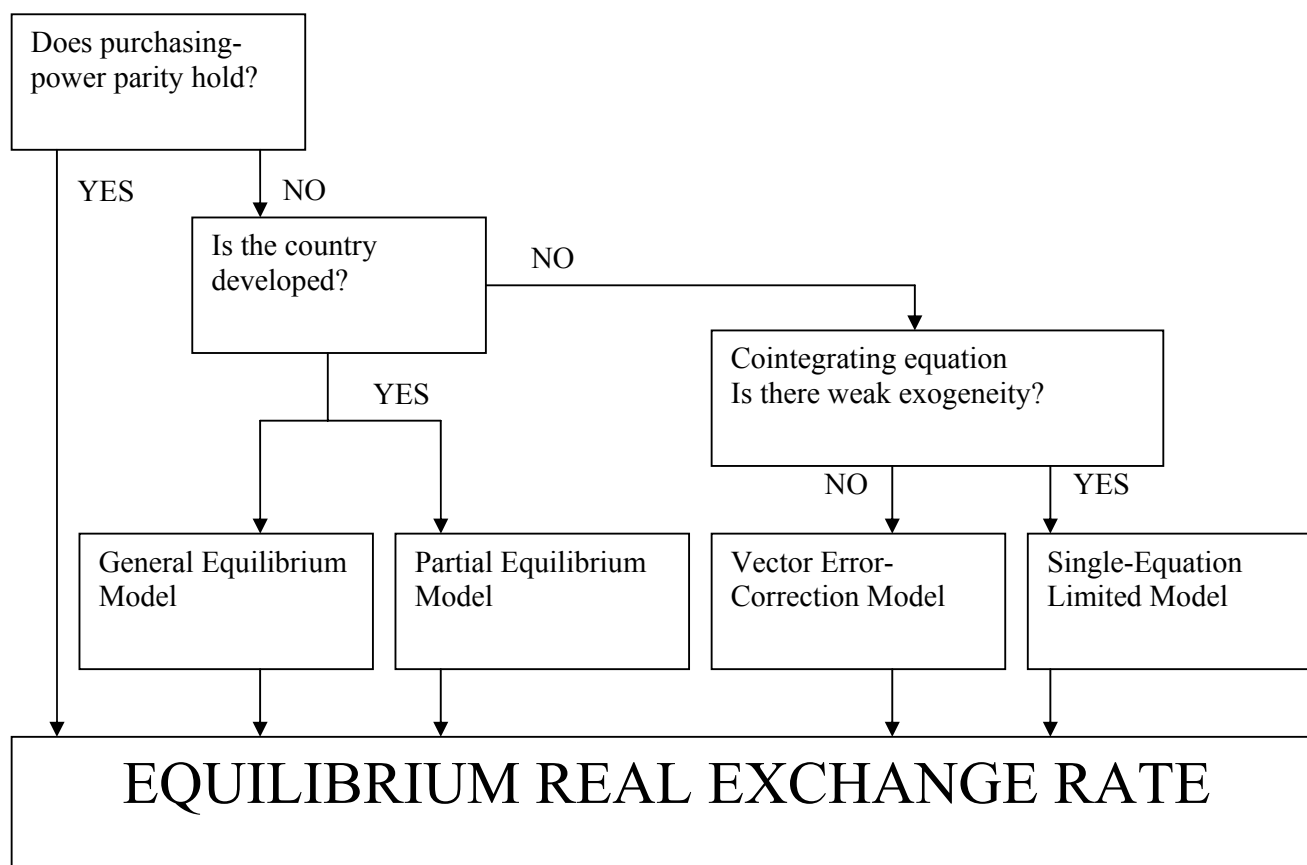
In case of developed countries there are no essential institutional objectives for the economy and we can use the equilibrium models. Models of partial equilibrium (only external equilibrium), e.g. the model of trade elasticity, or models of general equilibrium (both external and internal equilibrium), e.g. 1-2-3 model of Devarajan-Lewis-Robinson, NATREX, Fundamental Equilibrium Exchange Rate Model, etc can be mentioned among them.

Unlike the developed countries, in the transitional countries cointegrating equations either in form of system of equations or a restricted single-equation models, are providing better results rather than using structural models.

The Monetary Policy Department has been using different models of estimating the ERER till now. However, the use of all these models arises some problems in view of estimating the equilibrium levels of prior conditions and exogenous variables. Therefore, we need to use another models of estimating the ERER, which are illustrated in this work.

The models of the ERER can be presented in the chart below:

² See Montiel (1997).



Purchasing Power Parity Theory

This theory has the most simple and wide usage. The corner-stone of this theory is the “law of one price” according to which the prices of identical goods in different countries should be the same, excluded difference of transportation costs.³

According to the theory of absolute purchasing power parity the domestic prices in Armenia must be equal to foreign prices expressed in US dollars adjusted at AMD/USD exchange rate, as follows:

$$P \times e = P^* \quad \text{or} \quad \varepsilon = \frac{P}{P^*} \times e = 1$$

To verify whether the theory of absolute purchasing power parity is applicable or not, we have to check the stationarity of the RER first. After that, if it is stationary, then using the regression equation we must find out whether the theory of absolute or relative purchasing power parity is to be applied.

³ The theory is discussed in details in the working paper of the Monetary Policy Department “Methodology of Calculation of the Real Exchange Rate in Armenia” in view of application of this law for similar or different goods.

The stationarity of RER has been checked by Dickey-Fuller test and the hypothesis that RER is stationary variable was rejected (*Table 1*).

Table 1.

Null Hypothesis: the REER has a unit root

Exogenous: Constant

Lag Length: 4 (Automatic based on SIC, MAXLAG=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.744238	0.4010
Test critical values:	1% level	-3.632900	
	5% level	-2.948404	
	10% level	-2.612874	

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

This means that a long-run ERER is not explained by purchasing power parity theory, and it is necessary to study the long-run relations between economic fundamentals and the RER which can be done by cointegration analysis.

Model of the Real Exchange Rate

Choice of variables

To choose the variables we studied voluminous literature about RER models . The variables used in those models can be divided into several groups⁴:

1. external trade effect – terms of trade, openness of economy, imports and exports,
2. productivity effect – productivity, prices of non-tradables relative to tradables, wages and income differentials,
3. capital inflow effect – direct and portfolio investments, public loans, current and capital transfers, grants,
4. fiscal policy effect – budget deficit, expenditures, wages of public institutions, public consumption,
5. investment effect – private and public investments, savings,
6. monetary policy effect – domestic credit, real interest rate differential, interventions, international reserves or net foreign assets,
7. nominal effective exchange rate.

It must be noted that some analysts may use the interventions and net foreign assets as proxies for capital inflow and the growth of these variables will lead to the appreciation of the RER, whereas being as monetary policy variables their growth will result in the increase of money supply and the depreciation of the RER, mostly depending on currency regime and the practical results of the model.

The application of the nominal effective exchange rate is very popular in the literature and is observed as a variable with short-run effect and it has no effect on long-run level of the RER.

We studied all these variables and for the purpose of analysis we found it necessary to test all of them in order to find some steady and long-run relationship. The set of variables have undergone some changes. We have not observed the variables which are not urgent for Armenia (i.e. variables of foreign trade policy). Instead, we used variables, which despite of being omitted by the analysts, are of great

⁴ The full list is available in Annex 1.

importance for Armenia (i.e. interventions). Thus, separating time series of these variables – 30 in number (Annex 1), in the first phase of modeling we tried to uncover relationship between each time series and the RER. As a first step we tested the stationarity for these variables. Almost all variables appear to be stationary for the first difference. Then using Granger causality test and bivariate regressions we have chosen the variables which are significant and have the expected signs. The results are presented in Annexes 3 and 4. Since in this phase we are only interested in existent relationship, we therefore confine attention only to the significance of coefficients, signs and lags of variables. Starting from the results of the abovementioned process the indicators for capital inflow were used as long-run variables (general capital inflow, long-run capital inflow, direct foreign investments, private transfers, exports, NFA and interventions as proxy capital inflow). Public consumption and government investments are used as policy variables, and the nominal effective exchange rate as a variable of short-run effect.

We proceeded to step two, in which we tested if there is cointegration between the chosen variables and the RER by Johansen cointegration test. Again a choice have been made, we used the set of variables, which pass the test of cointegration with RER. The variables are as follows: capital inflow, government investments (weighted by GDP). Since these variables are integrated of the same order (all variables are difference stationary) and there is cointegration between the latter and the RER (Annex 5), we can estimate the regression by the least square method, getting super-consistent estimates.

Before specifying a model, we analyzed the developments of the selected variables and the RER. Especially, reasoning from the developments of the RER, we have advanced a hypothesis that at the beginning of the year 2003 a structural change happened, that is, the downward trend of the RER has leapt since 2003 and become upward. The general economic developments during that period also evidence the structural movements in the economy, that is, the betterment of current account recorded in 2001-2002, economic growth, wages and the prices for real estate leap, interest rates slump, etc. Thus, we had to include these structural changes in the model. By analyzing bivariate regressions we saw that the effect of transfers has not been significant till 2003, but then it became significant and possessed a right sign. Despite Johansen test denies cointegration between transfers and the RER in 1997-2007, it was left in the selected, as a determinative factor of the structural movement of the RER, the impact of which will be included starting from 2003 (the availability of cointegration is not possible to check for short period of 2003-2007).

Specification of the Model

In general, the theoretical literature mainly suggests the vector error-correction model (VEC) for the RER modeling. In order to use the latter the time series must, besides having some special statistical features (e.g. the time series must meet the requirement for the same order of integration), be long enough in order not to leave us with few degree of freedom after lag length choice. In emerging countries with time series not long enough, it is common to use single-equation model, which in its turn demands satisfaction of weak exogeneity requirement for explanatory variables.

What are the advantages and disadvantages of both versions?

The advantage of the VEC model is that we use additional information on relationship between variables, but due to short time series the estimation of such system becomes not real. Despite of aforesaid, the short time series can be used in the single-equation estimation, though actually we shall miss information on relationship between the variables. If the variables (for our case – the economic fundamentals) meet the condition of weak exogeneity, the disadvantage of model information loss disappears, i.e. we estimate a single equation and get quite effective estimations.

As far as Armenia also has short-run time series problem, which does not allow estimating the VEC model, we tried to use the single-equation model. Since it is very important to check the condition of weak exogeneity of explanatory variables to define a single-equation model, we used two approaches to check the weak exogeneity. In one case, we checked the weak exogeneity of variables by Cointegration Test from “Eviews 6” package, setting respective restrictions on cointegrating vectors, and here the hypothesis of weak exogeneity has not been rejected (Annex 6). Since the government

investments/GDP variable is the policy variable and it depends on the realized fiscal policy, the exogeneity of the latter in the model is proved also theoretically. As regards the capital inflow, the main part of it consists of private direct investments and investments of government sector, which do not depend on exchange rate behavior. The weak exogeneity of transfers has been checked by using instrumental variables and then by Houseman test.

As a pre-version we estimated regression with variables having long-run effect, which are the general capital inflow (CAPINFMSM), share of private transfers in GDP (TRANSFSM), share of government investments in GDP (GINV_GDP). Before using them for estimation, the time series have been adjusted, in particular, the time series of the RER and the nominal effective exchange rate have been seasonally adjusted using Method X12 of Eviews package, transfers/GDP time series have been also adjusted using Method X12. After that, considering the time series fluctuations we smoothed it again using Holt-Winters method of smoothing with non-seasonal components. The time series of capital inflow has also been adjusted twice by Holt-Winters method of smoothing with non-seasonal components. The application of Holt-Winter's method in this case was strictly expedient, because we use smoothed time series of both transfers and capital inflows as the analog of the use of instrumental variables, i.e. it helps to avoid the problem of weak exogeneity. The time series of RER, nominal effective exchange rate and capital inflow in all equations were used in logarithmical expression, and all the equations went through Breush-Godfrey auto-correlation checking test, besides we checked the stability of coefficients using recursive estimates.

Equation 1:

Dependent Variable: LOG(REER_SA)

Method: Least Squares

Date: 10/30/07 Time: 16:12

Sample (adjusted): 1998Q1 2006Q4

Included observations: 36 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CAPINFMSM)	0.049914	0.004746	10.51751	0.0000
D2*(TRANSFSM(-1))	1.494971	0.241367	6.193773	0.0000
D2	-0.316352	0.032319	-9.788365	0.0000
GINV_GDP(-4)	1.133265	0.399216	2.838729	0.0079
C	4.450602	0.021420	207.7736	0.0000
R-squared	0.942494	Mean dependent var		4.626882
Adjusted R-squared	0.935074	S.D. dependent var		0.087511
S.E. of regression	0.022298	Akaike info criterion		-4.640357
Sum squared resid	0.015414	Schwarz criterion		-4.420423
Log likelihood	88.52642	Hannan-Quinn criter.		-4.563594
F-statistic	127.0190	Durbin-Watson stat		1.504088
Prob(F-statistic)	0.000000			

$$\text{REER_SA} = 0.05 \cdot \text{CAPINFMSM} + 1.49 \cdot \text{D2} \cdot \text{TRANSFSM}(-1) - 0.31 \cdot \text{D2} + 1.13 \cdot \text{GINV_GDP}(-4) + 4.45$$

(10.51)⁵ (6.19) (-9.78) (2.83) (207.77)

This equation shows that the chosen variables are significant, have the expected signs and according to the stability readiness tests they are relatively steady, though the Durbin-Watson criterion (criterion that features the autocorrelation of the first order) is quite smaller than two and shows that the

⁵ In brackets are indicators of t-statistics.

model has first order autocorrelation which also may be due to the missed explanatory variable. Since this equation embodies only variables which characterize long-run relationship, we tried to explain the equation's residual by short-run variables such as the nominal effective exchange rate in order to analyze the short-run effect of nominal exchange rate on the ERER. We studied the NFA, interventions and the nominal effective exchange rate as variables which determine short-run misalignment of the RER and for which Granger's causality test shows unilateral causality. We have chosen only the nominal exchange rate, because if we took all of them we would face multicollinearity, whereas the nominal exchange rate bears the influence of both interventions and NFA. The equation below shows that the nominal exchange rate really explains about 30 percent of short-run misalignments of the ERER (it has been observed as residual of equation 1), thus we can include it in the model as a variable with short-run effect.

Equation 1.1:

Dependent Variable: RESID03

Method: Least Squares

Date: 10/30/07 Time: 16:13

Sample (adjusted): 1998Q1 2006Q4

Included observations: 36 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
LOG(NEER_SA)	0.072948	0.021023	3.469855	0.0014
C	-0.366074	0.105545	-3.468407	0.0014
R-squared	0.261510	Mean dependent var		8.14E-16
Adjusted R-squared	0.239790	S.D. dependent var		0.020986
S.E. of regression	0.018297	Akaike info criterion		-5.110171
Sum squared resid	0.011383	Schwarz criterion		-5.022198
Log likelihood	93.98308	Hannan-Quinn criter.		-5.079466
F-statistic	12.03990	Durbin-Watson stat		1.843572
Prob(F-statistic)	0.001435			

$$\text{RESID031} = 0.07 \cdot \text{NEER_SA} - 0.36$$

(3.46) (-3.46)

On our next phase of modeling we tried to join the short-run and long-run effects and estimated the following ADL model. The estimation resulted in equation as follows:

Equation 2:

Dependent Variable: LOG(REER_SA)

Method: Least Squares

Date: 10/29/07 Time: 10:57

Sample (adjusted): 1998Q1 2007Q2

Included observations: 38 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
LOG(REER_SA(-1))	0.546849	0.081233	6.731878	0.0000
LOG(NEER_SA)	0.363281	0.085903	4.228945	0.0002
LOG(NEER_SA(-1))	-0.331287	0.082034	-4.038424	0.0004
LOG(CAPINFMS)	0.020114	0.005154	3.902993	0.0005
D2*(TRANSFSM(-1))	0.763427	0.154862	4.929711	0.0000

GINV_GDP(-2)	0.554438	0.219466	2.526303	0.0172
GINV_GDP(-4)	0.689790	0.219990	3.135549	0.0039
D2	-0.144705	0.028011	-5.166022	0.0000
C	1.827424	0.308774	5.918321	0.0000

R-squared	0.987054	Mean dependent var	4.634162
Adjusted R-squared	0.983483	S.D. dependent var	0.090689
S.E. of regression	0.011655	Akaike info criterion	-5.862746
Sum squared resid	0.003939	Schwarz criterion	-5.474897
Log likelihood	120.3922	Hannan-Quinn criter.	-5.724752
F-statistic	276.3949	Durbin-Watson stat	1.769811
Prob(F-statistic)	0.000000		

$$\begin{aligned} \text{REER_SA} = & 0.54 * \text{REER_SA}(-1) + 0.36 * \text{NEER_SA} - 0.33 * \text{NEER_SA}(-1) + 0.02 * \text{CAPINFISM} + \\ & (6.73) \quad (4.22) \quad (-4.03) \quad (3.90) \\ & 0.76 * \text{D2} * \text{TRANSFSM}(-1) + 0.55 * \text{GINV_GDP}(-2) + 0.68 * \text{GINV_GDP}(-4) - 0.14 * \text{D2} + 1.82 \\ & (4.92) \quad (2.35) \quad (3.20) \quad (-5.16) \quad (5.91) \end{aligned}$$

As shown above all the explanatory variables of Equation 2 are statistically significant and have right signs. The coefficients of the nominal exchange rate and the lagged nominal exchange rate are approximately equal with opposite sign. The hypothesis of the equality of the coefficients has been checked using Wald test which does not reject the hypothesis that the coefficients are equal with opposite sign.

Wald Test:
Equation: EQ13ADL

Test Statistic	Value	df	Probability
F-statistic	1.975321	(1, 29)	0.1705
Chi-square	1.975321	1	0.1599

Considering the abovementioned, we can presume that the nominal exchange rate has only short-run effect on the ERER. Moreover, it explains about 26 percent of short-run misalignments (see coefficient R^2 of equation 1.1). Regarding this restriction, in order to separate and estimate the long-run and short-run effects of the explanatory variables, we have developed the Error Correction model via the linear modification of ADL model. Estimating the latter we got the results as follows⁶:

Equation 3:
Dependent Variable: D(LOG(REER_SA))
Method: Least Squares
Date: 10/29/07 Time: 12:36
Sample (adjusted): 1998Q1 2007Q2
Included observations: 38 after adjustments

	Coefficient	Std. Error	t-Statistic	Prob.
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⁶ It follows from the restriction (C(2)+C(3)=0) that only the first difference time series of the nominal exchange rate are used in error correction model.

LOG(REER_SA(-1))	-0.384062	0.065714	-5.844477	0.0000
D2*(TRANSFSM(-1))	0.798189	0.155340	5.138345	0.0000
LOG(CAPINFMSM)	0.016364	0.004480	3.652652	0.0010
D(LOG(NEER_SA))	0.327222	0.083305	3.928016	0.0005
D2	-0.135574	0.027686	-4.896766	0.0000
(GINV_GDP(-2))-(GINV_GDP(-4))	0.640859	0.214073	2.993648	0.0055
GINV_GDP(-4)	1.303306	0.316879	4.112945	0.0003
C	1.673986	0.293487	5.703774	0.0000
R-squared	0.860338	Mean dependent var	0.002995	
Adjusted R-squared	0.827750	S.D. dependent var	0.028535	
S.E. of regression	0.011843	Akaike info criterion	-5.849482	
Sum squared resid	0.004208	Schwarz criterion	-5.504728	
Log likelihood	119.1402	Hannan-Quinn criter.	-5.726821	
F-statistic	26.40063	Durbin-Watson stat	1.780180	
Prob(F-statistic)	0.000000			

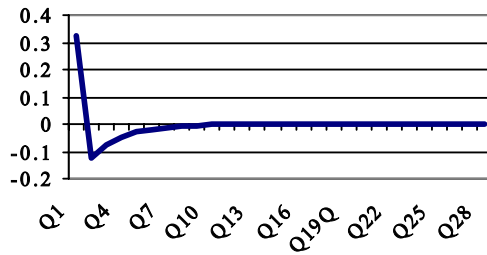
$$\begin{aligned}
D(\text{REER}) = & -0.38*\text{REER_SA}(-1)+0.79*D2*\text{TRANSFSM}(-1)+0.02*\log(\text{CAPINFMSM}(-1))+ \\
& \quad (-5.84) \quad (5.13) \quad (3.65) \\
& +0.32*D(\text{NEER_SA})-0.13*D2+0.64*(\text{GINV_GDP}(-4)-\text{GINV_GDP}(-2))+1.30*\text{GINV_GDP}(-4)+1.67 \\
& \quad (3.92) \quad (-4.89) \quad (2.99) \quad (4.11) \quad (5.70)
\end{aligned}$$

Here LOG(REER_SA(-1)) coefficient is a error correction term. We get the coefficient of long-run effect of transfers as a ratio of D2*(TRANSFSM(-1)) coefficient to error correction term with opposite sign and it is 2.07, which is a little bigger than the coefficient get in Equation 1. The coefficient of long-run effect of capital inflow is calculated similarly and is 0.04, which is quite close to the respective coefficient we have got in Equation 1. We have not included the short-run effect of these coefficients, because they are not statistically significant. We consider that the short-run effect of abovementioned variables on the RER is expressed via nominal exchange rate, which has been included in the equation already. As regards the government investments, the latter has both short-run and long-run effects on the ERER. The coefficient of long-run effect is 3.39, i.e. in long-run period the increase in the share of government investments in GDP results in appreciation of the RER, and the adjustment coefficient or the coefficient of short-run effect (LOG(GINV_GDP(-2))-LOG(GINV_GDP(-4)) coefficient) is 0.64. Long-run coefficient of government investments is not equal to the coefficient in Equation 1, possibly because the government investments have both long-run and short-run effects, which can not be separated in Equation 1. However, for forecasting we have used the developed error correction model.

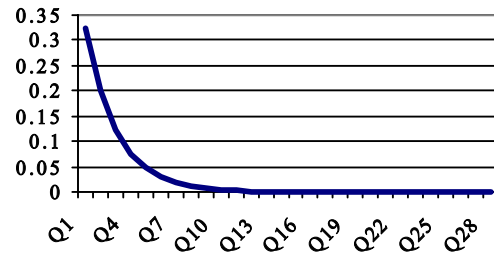
Using unit-shocks we shall illustrate the effect of variables in the course of time. For the shock of transfers and government investments we have observed the increase of their share in GDP by 1 percentage point, while the other variables have been simply given 1 percent shock. The charts illustrate that the cumulative effect of the long-run variables lasts 2-3 years, the increase in the share of transfers in GDP by 1 percentage point produce 2.07% appreciation of the RER, capital inflow increase by 1 percentage point results in 0.04% appreciation. Talking about long-run effect of government investments, we think it has two-phased effects. First, the effect is displayed by the enforcement of appreciation due to increase in expenditure in nontradable sector, and in long-run period – by increase in productivity due to investments. As a result, the accumulative effect on the RER equals 3.39% (shock is 1 percentage point increase in the share of government investments in GDP).

The charts below illustrate the effect of shocks on the RER. For example, the effect of 1 percent appreciation of nominal effective exchange rate results in 0.32% appreciation of the RER, which decline in future and in long-run period the nominal exchange rate has no effect on the RER.

1 % nominal exchange rate shock effect

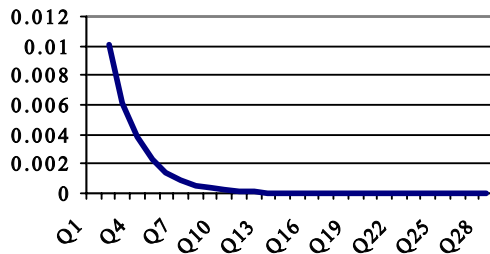


Impulse response

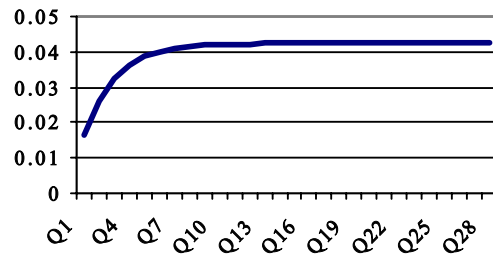


Cumulative response

1% capital inflow shock effect

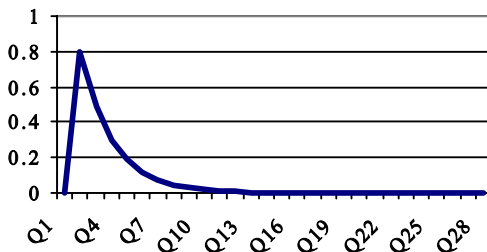


Impulse response

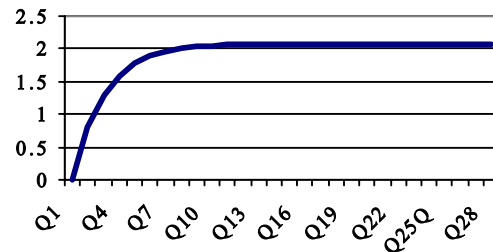


Cumulative response

1 percentage point transfers shock in GDP effect

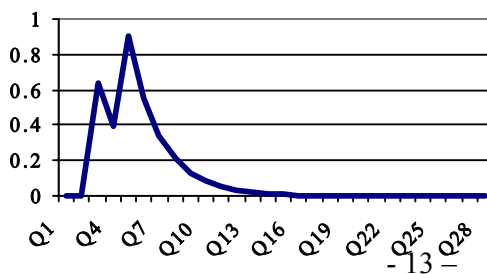


Impulse response

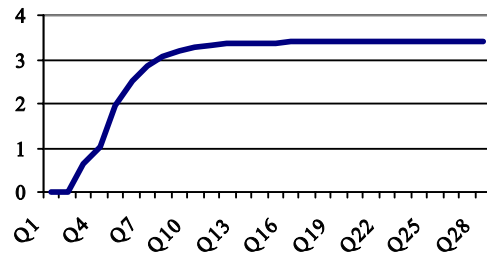


Cumulative response

1 percentage point government investments in GDP effect



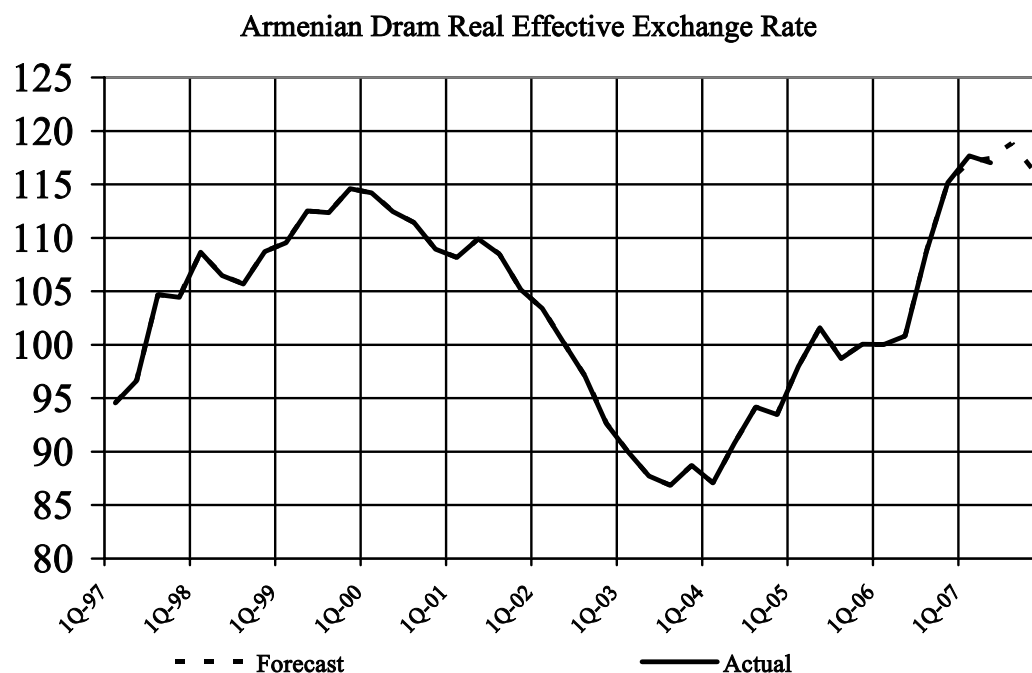
Impulse response



Cumulative response

Real exchange rate forecast using the model

We have forecasted RER using error correction model. First of all we made a conditional forecast for the period from the first quarter of 2007 to the forth quarter of 2007 and received the results, as follows:



According to this forecast in 2007 the Armenian dram real effective exchange rate shall appreciate by 10.9%, which is quite close to the preliminary data of 11.7%.

Estimation of the Equilibrium Real Exchange Rate

After the estimation of the equation we tried to estimate the ERE and calculate the actual RER misalignment. In literature, the ERE is observed by its long-run and short-run parameters. The short-run equilibrium exchange rate (SRER) is the actual exchange rate which is equal to the current values of its fundamentals. That is, for estimation of the SRER the error correction model is used excluding variables of short-run effect (nominal exchange rate). Supposedly, it is fluctuations of nominal exchange rate that produce the real RER misalignment from its short-run steady-state equilibrium.

The long-run equilibrium exchange rate (LRE) is the real exchange rate which is formed when the economic variables are adjusted and when they get their steady-state levels. For estimation of steady-state equilibrium of long-run fundamentals we applied to a widely used Hodrick-Prescott filter. By using equilibrium values of fundamentals (excluding short-run variables) in the error correction model, we obtained the long-run ERE.

We can meet in literature also a desirable real exchange rate (DRER). It is an exchange rate which equals to the desirable levels of fundamentals. Moreover, the desirable does not mean equilibrium level and it originates from the desirable goals of policy and on other conditions.

All these exchange rates are interrelated by the equation, as follows:

$$RER - DRER = (RER - SRER) + (SRER - LRER) + (LRER - DRER)$$

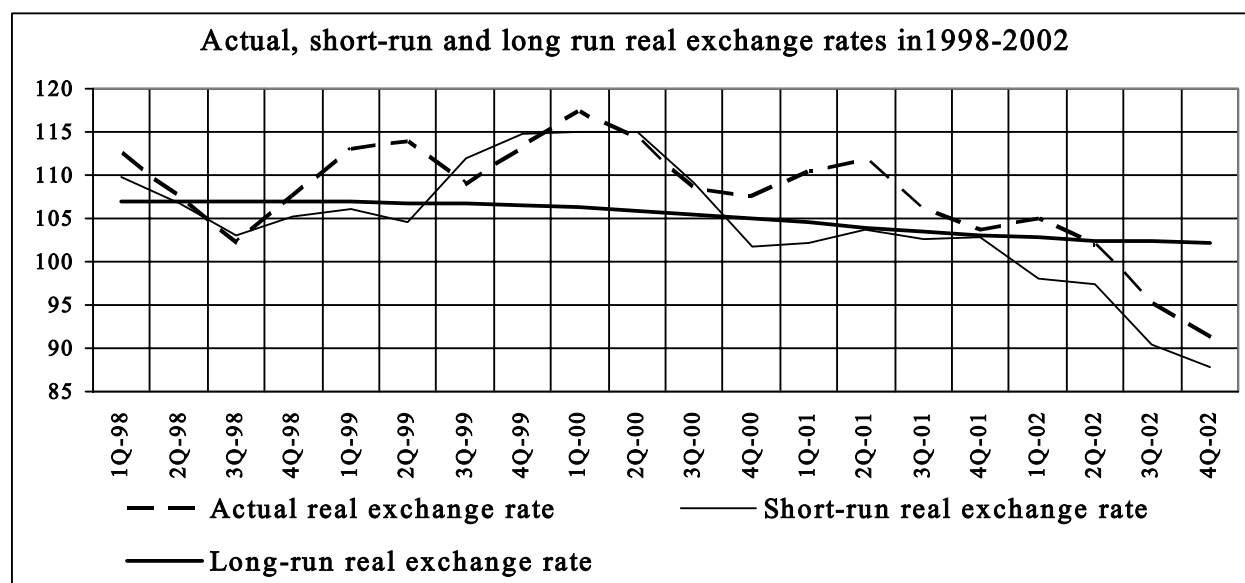
Here we can mark out the gaps between the actual and desirable RER, as follows:

1. the gap between the actual RER and the SRER which is zero if the RER is not effected by speculative nominal shocks,
2. the gap between the SRER and LRER due to slow adjustment speed of fundamentals,
3. the gap between the LRER and DRER due to wrong economic policy according to analysts.

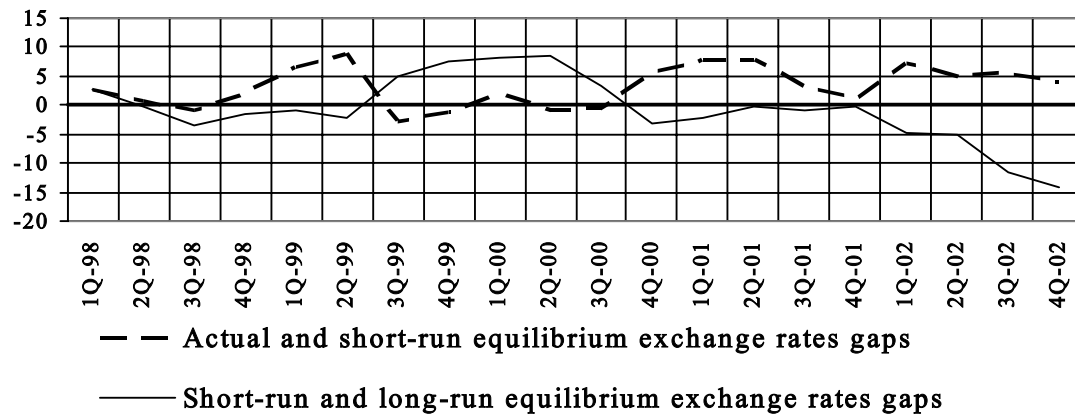
The gaps in the first and second cases are neutralized with time because of autonomous adjustment of nominal shocks and fundamentals, whereas in the third case it is necessary to adjust the economic policy to avoid the problems.

We do not have for an object the disclosure of the DRER level (it is a subject of a deep analysis by itself, and it is necessary to analyze also the effect of the RER on other variables), we have just attended to calculation of short-run and long-run ERER and estimation of gaps.

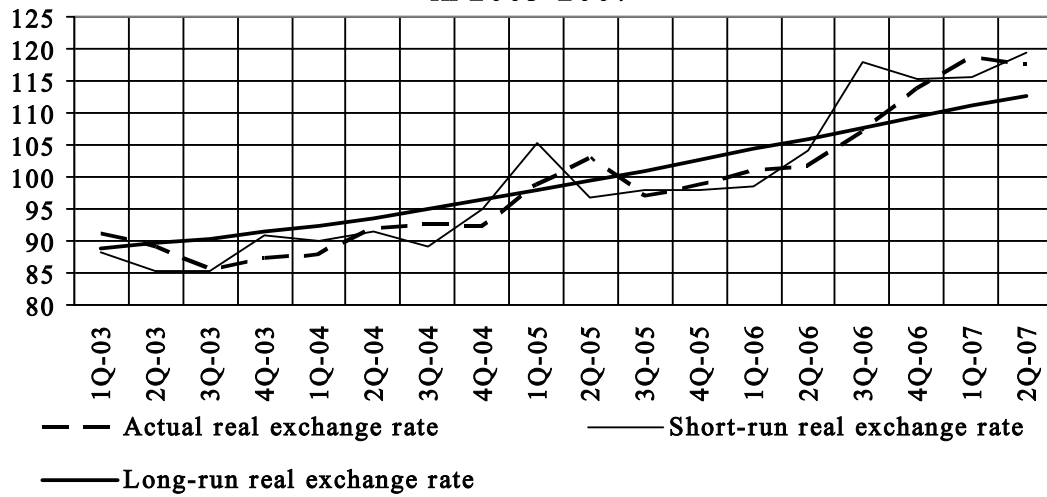
In view of aforesaid, we calculated the short-run ERER using error correction model long-run coefficients of fundamentals and we calculated the long-run ERER using equilibrium level of fundamental variables using the same coefficients (using Hodrick-Prescott filter).



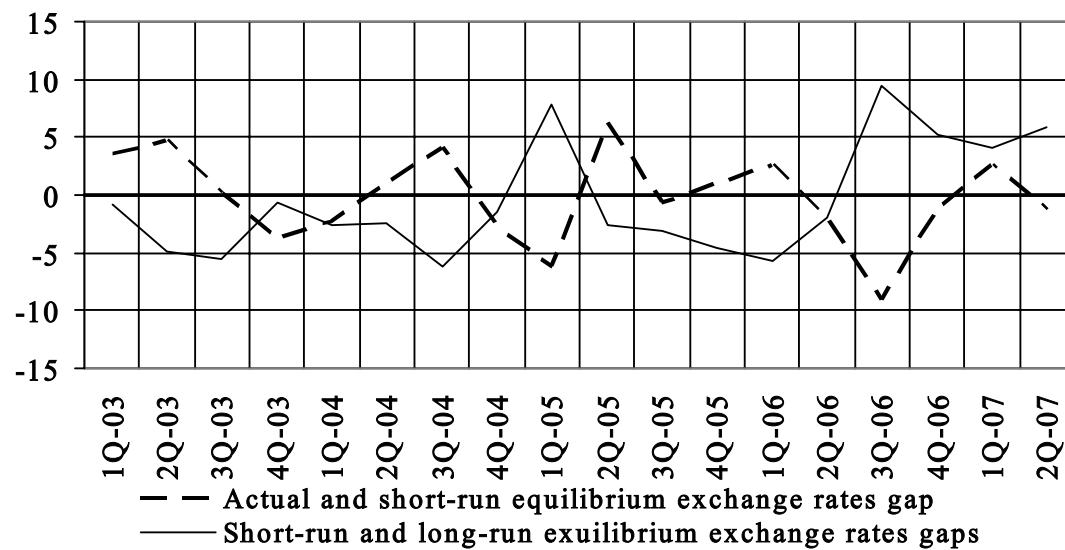
Actual, short-run and long run real exchange rates in 1998-2002



Actual, short-run and long-run real real exchange rates
in 2003-2007



Real Exchange rate gaps in 2003-2007



Real exchange rate analysis			
	Total gap	Long-run and short-run exchange rate gap	Short-run and actual exchange rate gap
1Q-98	5.29	2.66	2.63
2Q-98	0.55	-0.13	0.69
3Q-98	-4.56	-3.53	-1.03
4Q-98	0.64	-1.54	2.18
1Q-99	5.88	-0.72	6.60
2Q-99	6.76	-2.17	8.94
3Q-99	2.17	4.89	-2.73
4Q-99	6.43	7.66	-1.23
1Q-00	10.18	8.10	2.08
2Q-00	7.75	8.64	-0.90
3Q-00	2.78	3.44	-0.67
4Q-00	2.66	-3.05	5.70
1Q-01	5.87	-2.14	8.01
2Q-01	7.39	-0.35	7.75
3Q-01	2.53	-0.78	3.31
4Q-01	0.64	-0.36	1.00
1Q-02	2.60	-4.62	7.22
2Q-02	-0.22	-5.04	4.82
3Q-02	-6.21	-11.68	5.47
4Q-02	-10.09	-14.10	4.01
1Q-03	2.70	-0.88	3.58
2Q-03	-0.18	-4.90	4.72
3Q-03	-5.41	-5.53	0.12
4Q-03	-4.36	-0.62	-3.74
1Q-04	-4.88	-2.53	-2.35
2Q-04	-1.57	-2.49	0.92
3Q-04	-2.12	-6.16	4.04
4Q-04	-4.27	-1.46	-2.81
1Q-05	1.63	7.79	-6.16
2Q-05	3.66	-2.54	6.19
3Q-05	-3.75	-3.05	-0.70
4Q-05	-3.72	-4.64	0.92
1Q-06	-3.10	-5.65	2.55
2Q-06	-4.04	-1.89	-2.14
3Q-06	0.27	9.46	-9.19
4Q-06	3.92	5.26	-1.34
1Q-07	6.65	4.09	2.56
2Q-07	4.50	5.79	-1.29

Figures highlighted in red denote sectors of overvaluation, figures in blue denote sectors of undervaluation. The difference between short-run and actual exchange rates is explained by policy errors, and the difference between the long-run and short-run real exchange rates is explained by misalignment of equilibrium levels of fundamentals.

Thus, before 2003 the actual exchange rate had overvaluation of its short-run equilibrium level mainly due to market participants' expectations of depreciation. In order to neutralize that the Central Bank sold mainly foreign currency in currency market keeping the real exchange rate in overvaluation level.

Starting from the forth quarter of 2004 the Central Bank became a buyer in the foreign currency market which produced undervaluation of the Armenian dram and also the adjustment of market participants' expectations in the first-half of 2005. The same happened also in the third quarter of 2006, when the CBA bought over 100 million US dollars, thus undervaluating actual real exchange rate. Moreover, if we observe the situation from the point of view of policy, we can say that the policy of the CBA was justified because within the same period there was a huge misalignment of short-run real exchange rate from its long-run level – due to effect of fundamentals. As a matter of fact, the actions of the CBA were directed at the neutralization of that effect.

As regards the misalignment of short-run and long-run real exchange rates, it was caused by increase in government investments (in 1998 the share of government investments in GDP increased considerably owing to privatization account expenditure), also by fluctuations of capital inflow (during 2002 net government loans attraction reached its lowest level), and by growth rate of transfers (during 2002 the share of transfers in GDP in the third quarter ran up to 19.8% against 13.4% of the first quarter).

Conclusions

In fact, this model has made possible to determine the factors influencing the real exchange rate in Armenia. By defining these factors as short-run and long-run factors it became also possible to estimate their influence at different time periods.

For example, in a short-run period, 1 % appreciation of the nominal effective exchange rate produces 0.32% appreciation of the real exchange rate, which shall become zero with the course of time. 1% increase in the share of government investments in GDP produces 0.64% appreciation as the initial effect, and in a long-run period 1 percentage point increase in government investments produces 3.39% appreciation of the real exchange rate. 1 percentage point increase in the share of current transfers in GDP leads to 2.07% appreciation, whereas 1% increase in capital inflow produces 0.04% appreciation.

Thus, the only policy instrument which the authorities of the country may use to effect the level of the ERER is government investments (perhaps also total government spending). External shocks produce appreciation of the RER and in a short-run period the government may resist it only by reduction of government investments/government spending.

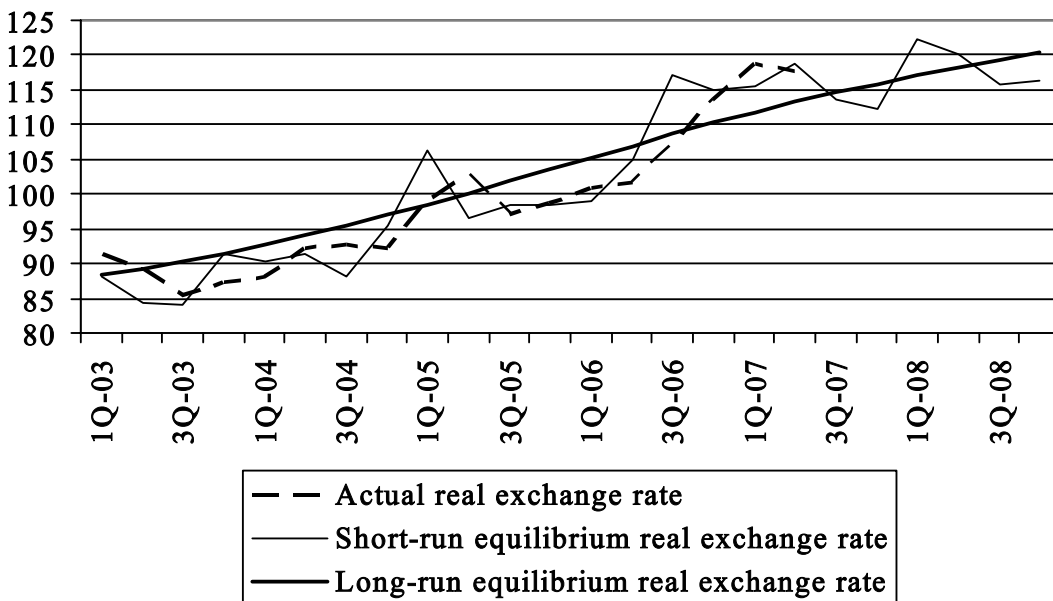
Besides the aforesaid, the use of the model has enabled to estimate short-run and long-run real exchange rates, to observe the misalignments and explain the reasons of it. The misalignments of long-run and short-run ERER are explained by fluctuations of fundamentals from their equilibrium levels, and the misalignments of long-run and short-run RER are due to the influence of economic policy.

It was very interesting to analyze the factor influence weight in the appreciation registered in 2003-2007. Starting from the first quarter of 2003 till the third quarter of 2007, the long-run equilibrium real exchange rate appreciated by 23.75, where 6.3 percentage point of appreciation (26.4% of total appreciation) was due to acceleration of capital inflow, 3.9 percentage point (16.4% of total appreciation) – due to increase in share of government investments in GDP, and 13.6 percentage point appreciation (57.2% of total appreciation) was due to increase in the share of transfers in GDP.

In general, the real exchange rate till 2002 was overvalued because of crisis in Russian Federation and the periodic selling of foreign currency by the CBA for neutralization of the expectations of depreciation. Then, till 2006 the real exchange rate was mainly undervalued because of the deflation period, weak capital inflow and the depreciation policy held by the CBA. Now we observe some trend of overvaluation – mostly due to increase in inflow of transfers.

It is obvious, that all this time the CBA has mainly been inclined to have an overvalued exchange rate, except for 2 quarters, when the external factors have appreciated the exchange rate essentially and the CBA has restrained that appreciation (Q1, 2005 and Q3, 2006).

For the third quarter of 2007 and for 2008 we estimated the ERER on the basis of estimated levels of fundamentals.



This chart illustrates that the misalignments between long-run and short-run ERERs are expected to be not very big (maximum 3%). In the second-half of 2008 the short-run real exchange rate shall be undervalued due to decrease in capital inflow and the decrease in the share of government investments in GDP in Q3, 2007. We think that the Central Bank must keep vigilant watch over developments of the real exchange rate in order not to record essential misalignments between the actual and equilibrium levels.

The other conclusion is also a steady-state level of appreciation, which according to this model is estimated about 5.8 % per annum based on the developments of the last five years.

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Variables explaining real exchange rate

1. Foreign trade
 - 1.1. Terms of trade (trade balance sheet) (TOT)
 - 1.2. Terms of trade (services balance sheet) (TOTGS)
 - 1.3. Price indices of export raw goods (INTEXPR)
 - 1.4. Openness of trade ($\frac{\text{Exports} + \text{Imports}}{\text{GDP}}$) (OPEN)
 - 1.5. Exports/GDP (EXP_GDP)
 - 1.6. Imports/GDP (IMP_GDP)
2. Productivity
 - 2.1. Price ratio of non-tradables and tradables (NT_T)
 - 2.2. Difference of ratio of consumer prices to producer prices in our country and abroad (CPIPPI)
 - 2.3. Difference between nominal GDP per capita in our country and abroad (NGDPPC)
3. Capital inflow
 - 3.1. Foreign assets by actual exchange rate /GDP (NFA_GDP)
 - 3.2. Long-run capital inflow (CAPINF_LONG_TERM)
 - 3.3. Direct investments (FDI)
 - 3.4. Portfolio investments (PORTFINV)
 - 3.5. Capital inflow (CAPINF)
 - 3.6. Grants/GDP (GRANTS_GDP)
 - 3.7. Transfers/GDP (TRANSF_GDP)
 - 3.8. External debt/GDP (EXDEBT_GDP)
4. Public sector
 - 4.1. Government consumption/GDP (GCONS_GDP)
 - 4.2. Government consumption of non-trade sector/GDP (GCONSNT_GDP)
 - 4.3. Wages/GDP (GOVWAGE_GDP)
 - 4.4. Budget deficit/GDP (DEF_GDP)
 - 4.5. Government expenditure/GDP (GEXP_GDP)
 - 4.6. Budget deficit less grants/GDP (DEF_GRANTS_GDP)
5. Investments
 - 5.1. Government investments/GDP (GINV_GDP)
 - 5.2. Investments/GDP (INV_GDP)
 - 5.3. Net domestic savings/GDP (NETDOMSAVINGS)
6. Monetary policy
 - 6.1. Domestic crediting/GDP (DOMCRED_GDP)
 - 6.2. Interventions (INTERV)
 - 6.3. Difference of real interest rate in our country and abroad (RIRD)
7. Nominal effective exchange rate (NEER)

Null hypothesis. Unit root (personal unit root processes)

Date: 08/22/07 Time: 16:45

Choice: 1997Q1 2008Q4

Time series: REER, _DEF_GRANTS_GDP, CAPINF, CAPINF_LONG_TERM, CIPPI,
DEF_GDP, DOMCRED_GDP, EXP_GDP, EXTDEBT_GDP, FDI, GCONS_GDP,
GCONSNT_GDP, GINV_GDP, GOVWAGE_GDP, GRANTS_GDP, IMP_GDP, INTERV,
INTEXPR, INV_GDP, NEER, NETDOMSAVINGS, NFA_GDP, NGDPPC, NT_T, OPEN,
PORTFINV, RIRD, TOT, TOTGS, TRANSF_GDP

Exogenous variables: none

Lag automatic choice is made according to Schwarz's information standards from 0 to 7

Total number of observations: 1269

Cross-choice includes: 31

Interim ADF test results D()

Time series	Equat. ⁷	Lag	Max. lag	Observations
D(REER)	0.0082	2	9	44
D(DEF_GRANTS_GDP)	0.0000	1	9	43
D(CAPINF)	0.0000	0	9	46
D(CAPINF_LONG_TERM)	0.0000	2	9	44
D(CIPPI)	0.0000	1	9	38
D(DEF_GDP)	0.0000	1	9	43
D(DOMCRED_GDP)	0.0568	3	9	36
D(EXP_GDP)	0.0140	3	9	41
D(EXTDEBT_GDP)	0.0572	3	9	34
D(FDI)	0.0521	5	9	41
D(GCONS_GDP)	0.0000	2	9	42
D(GCONSNT_GDP)	0.0000	3	9	41
D(GEXP_GDP)	0.0000	2	9	42
D(GINV_GDP)	0.0000	1	9	43
D(GOVWAGE_GDP)	0.0006	7	9	37
D(GRANTS_GDP)	0.0000	1	9	43
D(IMP_GDP)	0.0126	3	9	41
D(INTERV)	0.0000	1	9	39
D(INTEXPR)	0.0000	0	9	46
D(INV_GDP)	0.0025	3	9	41
D(NEER)	0.0008	0	9	46
D(NETDOMSAVINGS)	0.1181	4	9	40
D(NFA_GDP)	0.0000	3	9	36
D(NGDPPC)	0.3873	3	9	35
D(NT_T)	0.0797	4	9	35
D(OPEN)	0.0000	2	9	35
D(PORTFINV)	0.0000	1	9	45
D(RIRD)	0.0000	0	9	39
D(TOT)	0.0000	0	9	46
D(TOTGS)	0.0000	0	9	46
D(TRANSF_GDP)	0.0002	3	9	41

⁷ Shows the probability of confirmation of hypothesis.

Annex 3

Long-run estimates of the equilibrium real exchange rate (unadjusted)										
	0 lag		1 lag		2 lags		3 lags		4 lags	
		%		%		%		%		%
Number of estimation of long-run coefficients	30		30		30		30		30	
o/w: statistically significant	10	33	9	30	8	27	8	27	11	37
o/w: statistically significant and possessing right sign	7	23	7	23	7	23	7	23	9	30
Long-run estimates of the equilibrium real exchange rate adjusted)										
	0 lag		1 lag		2 lags		3 lags		4 lags	
		%		%		%		%		%
Number of estimation of long-run coefficients	30		30		30		30		30	
o/w: statistically significant	11	37	12	40	14	47	11	37	11	37
o/w: statistically significant and possessing right sign	7	23	9	30	11	37	8	27	8	27

Annex 4

Granger cause two-step test				
Date: 08/22/07 Time: 17:08				
Choice: 1997Q1 – 2008Q4				
Lag:	1	2	3	4
Null hypothesis	Equat.	Equat.	Equat.	Equat.
DEF GRANTS GDP does not Granger Cause REER	0.46885	0.27942	0.03525	0.02237
CAPINF does not Granger Cause REER	0.61608	0.77061	0.75753	0.28002
CAPINF LONG TERM does not Granger Cause REER	0.77367	0.89867	0.40019	0.35214
CPIPPI does not Granger Cause REER	0.17708	0.14588	0.04054	0.22812
DEF GDP does not Granger Cause REER	0.70390	0.21464	0.06030	0.07734
DOMCRED GDP does not Granger Cause REER	0.14882	0.01428	0.02645	0.08999
EXP GDP does not Granger Cause REER	0.92924	0.51717	0.05842	0.12550
EXTDEBT GDP does not Granger Cause REER	0.06222	0.00036	0.00204	0.01719
FDI does not Granger Cause REER	0.91489	0.82289	0.89253	0.67236
GCONS GDP does not Granger Cause REER	0.30503	0.09640	0.26164	0.56133
GCONSNT GDP does not Granger Cause REER	0.22489	0.06537	0.19344	0.66413
GEXP GDP does not Granger Cause REER	0.34175	0.15589	0.29929	0.38626
GINV GDP does not Granger Cause REER	0.66449	0.29016	0.34500	0.40058
GOVWAGE GDP does not Granger Cause REER	0.03169	0.06394	0.04700	0.16257
GRANTS GDP does not Granger Cause REER	0.92802	0.37381	0.12016	0.25761
IMP GDP does not Granger Cause REER	0.05861	0.13535	0.01568	0.06970
INTERV does not Granger Cause REER	0.10383	0.33202	0.17641	0.61631
INTEXPR does not Granger Cause REER	0.70281	0.90356	0.80774	0.97702
INV GDP does not Granger Cause REER	0.30332	0.62254	0.31027	0.67910
NEER does not Granger Cause REER	0.65879	0.09181	0.04237	0.28933
NETDOMSAVINGS does not Granger Cause REER	0.20064	0.50820	0.67659	0.88468
NFA GDP does not Granger Cause REER	0.04108	5.3E-05	0.00146	0.01593
NGDPPC does not Granger Cause REER	0.05388	0.04605	0.04812	0.21545
NT T does not Granger Cause REER	0.70506	0.67789	0.69750	0.41779
OPEN does not Granger Cause REER	0.11170	0.00044	0.00264	0.01889
PORTFINV does not Granger Cause REER	0.62298	0.89564	0.90348	0.89950
RIRD does not Granger Cause REER	0.58460	0.95693	0.20423	0.08173
TOT does not Granger Cause REER	0.70962	0.16339	0.43508	0.31958
TOTGS does not Granger Cause REER	0.88682	0.06910	0.17640	0.13070
TRANSF GDP does not Granger Cause REER	0.57748	0.41468	0.05633	0.46596

The results of Johansen cointegration test show that the real exchange rate cointegrates with government investments and capital inflow

Sample (adjusted): 1997Q3 2007Q2				
Included observations: 40 after adjustments				
Trend assumption: Linear deterministic trend				
Series: REER SA GINV GDP SA				
Lags interval (in first differences): 1 to 4				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.413829	22.51902	15.49471	0.0037
At most 1	0.071772	2.755676	3.841466	0.0969
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.413829	19.76334	14.26460	0.0061
At most 1	0.413829	19.76334	14.26460	0.0061
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Sample (adjusted): 1997Q2 2007Q2				
Included observations: 41 after adjustments				
Trend assumption: Linear deterministic trend				
Series: REER SA CAPINFSM				
Lags interval (in first differences): No lags				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.375174	19.73629	15.49471	0.0108
At most 1	0.011029	0.454720	3.841466	0.5001
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.375174	19.28157	14.26460	0.0074
At most 1	0.011029	0.454720	3.841466	0.5001
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The results of the weak exogeneity test

Restrictions:

A(3,1)=0A(2,1)=0

Tests of cointegration restrictions:

Hypothesized No. of CE(s)	Restricted Log-likelihood	LR Statistic	Degrees of Freedom	Probability
1	76.12899	2.448137	2	0.294031
2	87.28973	0.448197	1	0.503193

According to limitation hypothesis, the 2-nd and the 3-rd variables, i.e. capital inflow and government investments, have weak exogeneity as compared with the real exchange rate. The result shows that the hypothesis is acceptable, in other words, it can be assumed that the capital inflow and government investments have weak exogeneity against the real exchange rate.