# The empirical analysis of monetary policy long run effects. Consequences of inflation volatility

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## Դրամավարկային քաղաքականության երկարաժամկետ ազդեցության էմպիրիկ գնահատումը: Գնաճի տատանողականության հետևանքները

***Լևոնյան Սուրեն Ռ.***
Հայաստանի Պետական Տնտեսագիտական Համալսարան,
տնտեսամաթեմատիկական մեթոդներ ամբիոնի ասպիրանտ (Երևան, ՀՀ)
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**Ամփոփագիր.** Գնաճի կայունությունը երկրի տնտեսության զարգացման հիմնարար դրույթներից մեկն է: Գնաճի կարճաժամկետ տատանողական վարքագիծը իր բացասական հետևանքներն է թողնում թե՛ դրամավարկային քաղաքականության արդյունավետության, և թե՛ կայուն տնտեսական աճի վրա: Հոդվածի նպատակն է բացահայտել, թե արդյո՞ք դրամավարկային քաղաքականությունը ունի երկարաժամկետ ազդեցություն տնտեսության իրական հատվածի վրա, ինչպես նաև գնահատել գնաճի տատանողականության ազդեցությունը տնտեսական աճի վրա:
Կոինտեգրացիայի հայտնաբերման նպատակով օգտագործվել է F Bounds թեստը, իսկ երկարաժամկետ ազդեցությունները գնահատելու նպատակով կառուցվել են ARDL մոդելներ: Գնահատումներից պարզ դարձավ, որ դրամավարկային քաղաքականությունը ունի երկարաժամկետ ազդեցություն գնաճի, բայց ոչ ՀՆԱ ճեղքի վրա: Մասնավորապես, մոդելում ներառված փոխանցումային մեխանիզմի բոլոր լծակները ունեն նշանակալի ազդեցություն գնաճի վրա, իսկ ՀՆԱ աճը հանգեցնում է գնաճի տեմպերի արագացման: Դրամավարկային քաղաքականության ցուցանիշների և ՀՆԱ ճեղքի միջև երկարաժամկետ կապի բացակայությունը կարելի է բացատրել փողի չեզոքության հանգամանքով, ըստ որի, փողի շուկայում կատարվող փոփոխությունները չունեն երկարաժամկետ ազդեցություն իրական ցուցանիշների վրա:
Գնաճի տատանողականության ազդեցությունը տնտեսական աճի վրա գնահատելու նպատակով կառուցվել և գնահատվել է պանելային գծային ռեգրեսիոն մոդել, որի արդյունքները ցույց են տալիս, որ գնաճի տատանողականության ցածր մակարդակ ունեցող երկրներում տնտեսական աճը կայուն է: Այսինքն, կա հստակ կախվածություն երկարաժամկետ գնաճի և ՀՆԱ ճեղքի տատանողականության միջև:
**Հանգուցաբառեր՝** Գնաճ, կոինտեգրացիա, տոկոսադրույք, դրամավարկային քաղաքականություն, ՀՆԱ:

## Эмпирическая оценка долгосрочного воздействия денежно-кредитной политики. Последствия волатильности инфляции

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**Аннотация.** Стабильность инфляции является одним из основополагающих положений экономического развития страны. Краткосрочное волатильнное поведение инфляции оказывает негативные последствия на эффективность денежно-кредитной политики и на устойчивость экономического роста. Цель статьи - выявить, оказывает ли денежно-кредитная политика долгосрочное влияние на реальный сектор экономики, а также оценить влияние инфляционных колебаний на экономический рост.
Для обнаружения коинтеграции использовался F-Bounds тест, а для оценки долгосрочного влияния использовались модели ARDL. Из оценки стало ясно, что денежно-кредитная политика оказывает долгосрочное влияние на инфляцию, но не на разрыв ВВП. В частности, все каналы трансмиссионного механизма, включенные в модель, оказывают существенное влияние на инфляцию, а рост ВВП приводит к ускорению темпов инфляции. Отсутствие долгосрочной связи между показателями денежно-кредитной политики и разрывом ВВП можно объяснить нейтральной теории денег, согласно которого изменения на денежном рынке не оказывают долгосрочного влияния на реальные показатели экономики.
Для оценки влияния инфляционной волатильности на экономический рост была построена и оценена панельная линейная регрессионная модель, результаты которого показывают, что экономический рост стабилен в странах

с низким уровнем инфляционной волатильности. Иными словами, существует четкая зависимость между волатильностью долгосрочной инфляции и разрыва ВВП.
**Ключевые слова.** Инфляция, процентная ставка, коинтеграция, монетарная политика, ВВП.

Stability of inflation indirectly increases economic well-being by increasing the effectiveness of monetary policy and reducing uncertainty about the future. Studies conducted in different countries show that the countries with lower rate of inflation have higher rates of economic growth [**11**, p. 181]. The final goal of central banks is to ensure low and stable level of inflation in the long run. However, the role of monetary policy in the long run has been extensively studied by various economic schools. One of the hypotheses of long run monetary policy relationship with real sector of economy is described by key classical macroeconomic hypothesis – the principle of money neutrality, according to which changes in money market, and therefore in inflation, do not affect in real sector in the long run [**7**, p. 1]. However, this theory has been criticized in many theoretical and empirical analyses. In works devoted to industrial and developed countries, a negative relationship was found between inflation and economic growth [**2**, p. 107], on the contrary, a positive relationship was found in works devoted to developing countries [**5**, p. 62].

For analyzing the long run effects of monetary policy in Armenia, an autoregressive distributed lag model (ARDL) was constructed and estimated using F-bounds cointegration technique. The model consists of 5 variables: output gap, core inflation as a targeted variables and variables representing 3 channels of monetary policy transmission mechanism: interest rate, credits to private sector, real effective exchange rate. The purpose of the article is to examine the long run relationship between the main monetary policy indicators and inflation, as well as to estimate the consequences of inflation volatility on GDP growth, which is analyzed with the help of a panel linear regression model.

The table presents the descriptive statistics of the time series included in the ARDL model.

**Table 1**. *Descriptive statistics of time series*

| | **Armenia** | | |
|---|---|---|---|
| | Output gap | Interest rate | Inflation |
| Mean | 0.94 | 6.95 | 4.07 |
| Median | 0.00 | 6.50 | 4.04 |
| Maximum | 16.83 | 16.00 | 13.80 |
| Minimum | -6.69 | 3.60 | -2.29 |
| St. deviation | 4.04 | 2.27 | 3.49 |

*Source*. Author's calculations

It is noticeable that the average level of inflation in the long run in Armenia matches with the targeted level of 4%. This suggests that, in general, the Central Bank ensures the targetted level of inflation, but the standard deviation of inflation is quite high (3.49), which means that inflation is volatile in the short run. In Armenia, even though the output gap is positive in the long run, but it is also highly volatile, which means that economic growth in Armenia is not stable. The average interest rate in Armenia for the observed period is 6.95%, which is quite high. From this we can conclude that for keeping inflation at a targeted level, the central bank implements a "policy of expensive money", which has a negative impact on the output gap and restrains the economic growth.

From the estimation of the monetary policy transmission mechanism's efficiency, it became clear that the tightening of monetary policy in Armenia has a significant negative effect on the real sector of the economy and the Central Bank is able to affect inflation with at least 3 channels in the short run. The GDP gap, in response to the interest rate shock, reacts with sharp decline, which leads to the reduction of inflation rate with a 3-quarter delay. In other words, the Central Bank keeps inflation in the targeted level in long run, but the problem here is the highly fluctuating behavior of inflation and output gap, which has a negative impact on the development of the economy [**8**].

For cointegration analysis, autoregressive distributed lag models (ARDL) consisting of 5 variables (The sources for obtaining the time series were the monetary policy statistics of the Central Bank of Armenia -

https://www.cba.am/am/SitePages/statmonetaryfinancial.aspx and the statistics of the National Accounts System of the Republic of Armenia Statistical Committee - https://armstat.am/am/?nid=202) were constructed to estimate the relationship between variables in the long run.

$$\Delta INF_t = C_0 + \delta_{INF} INF_{t-1} + \delta_{GDP} GDP_{t-1} + \delta_R R_{t-1} + \delta_{CRD} CRD_{t-1} + \delta_{REER} REER_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta INF_{t-i} + \sum_{i=0}^{q_1} \alpha_{2i} \Delta GDP_{t-i} + \sum_{i=0}^{q_2} \alpha_{3i} \Delta R_{t-i} + \sum_{i=0}^{q_3} \alpha_{4i} \Delta CRD_{t-i} + \sum_{i=0}^{q_4} \alpha_{5i} \Delta REER_{t-i} + \varepsilon_t, \quad t = \overline{2006Q1, 2021Q4} \quad (1)$$

$$\Delta GDP_t = C_0 + \delta_{GDP} GDP_{t-1} + \delta_{INF} INF_{t-1} + \delta_R R_{t-1} + \delta_{CRD} CRD_{t-1} + \delta_{REER} REER_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{q_1} \alpha_{2i} \Delta INF_{t-i} + \sum_{i=0}^{q_2} \alpha_{3i} \Delta R_{t-i} + \sum_{i=0}^{q_3} \alpha_{4i} \Delta CRD_{t-i} + \sum_{i=0}^{q_4} \alpha_{5i} \Delta REER_{t-i} + \varepsilon_t, \quad t = \overline{2006Q1, 2021Q4} \quad (2)$$

Where $\delta_{INF}, \delta_{GDP}, \delta_R, \delta_{CRD}, \delta_{REER}$ are the long-term coefficients, $INF_t$- core inflation, $GDP_t$- output gap, $R_t$- repo rate, $CRD_t$- credits to private sector in AMD, $REER_t$- real effective exchange rate, $p, q_1, q_2, q_3, q_4$- number of lags of corresponding variables, $\alpha_{1p}, \alpha_{2q_1}, \alpha_{3q_2}, \alpha_{4q_3}, \alpha_{5q_4}$- short-term coefficients, $\varepsilon_t$- error term.

Before estimating the model, the variables' order of integration was checked. Since this method can be applied when the variables are either stationary or can be integrated at the first order ($I(1)$ process) [**10**], the stationarity test was performed for checking if all included variables are stationary in first differences.

**Table 2.** *Results of the stationarity test*

Group unit root test: Summary
Series: INF, GDP, R, CR, REER
Sample: 2003Q1 2022Q4
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 3
Newey-West automatic bandwidth selection and Bartlett kernel

| Method | Statistic | Prob.** | Cross-sections | Obs |
|---|---|---|---|---|
| Null: Unit root (assumes common unit root process) | | | | |
| Levin, Lin & Chu t* | -12.8362 | 0.0000 | 5 | 365 |
| Null: Unit root (assumes individual unit root process) | | | | |
| Im, Pesaran and Shin W-stat | -14.2256 | 0.0000 | 5 | 365 |
| ADF - Fisher Chi-square | 130.846 | 0.0000 | 5 | 365 |
| PP - Fisher Chi-square | 116.747 | 0.0000 | 5 | 370 |

*Source*. Author's calculations

The test results show that all variables are either $I(0)$ or $I(1)$ process, therefore the ARDL model can be estimated. The number of lags of the variables in the model was selected according to Akaike's information criteria, and the cointegration relationship was checked by the F-Bounds test. In order to ensure that the estimated coefficients meet the classical conditions, residual tests were checked, results of which are presented below.

**Table 3.** *Results of tests of model residuals*

| | | | |
|---|---|---|---|
| **Breusch-Godfrey Serial Correlation LM Test:** | | | |
| F-statistic | 0.027737 | Prob. F (2,21) | 0.9727 |
| Obs*R-squared | 0.168618 | Prob. Chi-Square (2) | 0.9191 |
| **Heteroskedasticity Test: Breusch-Pagan-Godfrey** | | | |
| F-statistic | 0.753484 | Prob. F (40,23) | 0.7883 |
| Obs*R-squared | 36.29924 | Prob. Chi-Square (40) | 0.6376 |
| Scaled explained SS | 5.010312 | Prob. Chi-Square (12) | 1.0000 |
| **Histogram- Normality Test:** | | | |
| Kurtosis | 3.137477 | | |
| Jarque-Bera | 0.756153 | | |
| Probability | 0.685178 | | |

*Source*. Author's calculations

The results of the tests show that the conditions are satisfied: residuals of the model are normally distributed, homoscedastic and there is no serial correlation.

**Table 4.** *Cointegration test results*

| | | | | |
|---|---|---|---|---|
| CointEq(-1)* | -0.457377 | 0.073629 | -6.211884 | 0.0000 |
| F-Bounds Test | | | Null Hypothesis: No levels relationship | |
| Test Statistic | Value | Signif. | I(0) | I(1) |
| F-statistic | 5.282813 | 10% | 2.2 | 3.09 |
| K | 4 | 5% | 2.56 | 3.49 |
| | | 2.5% | 2.88 | 3.87 |
| | | 1% | 3.29 | 4.37 |

*Source*. Author's calculations

As can be seen from the results of the cointegration test, the value of the F statistic is greater than the critical value, which means that the null hypothesis of no cointegration is rejected at all levels of significance. In the presence of cointegration, the long run equation and the speed of adjustment can be calculated, which shows how quickly system comes to equilibrium. The speed of adjustment is -0.4573, which means that 45.7 percent of the deviation from the long run equilibrium is adjusted within one quarter, which means that the deviation shock vanishes in 7-8 quarters.

**Table 5.** *Estimated long run form of the model*

ARDL Long Run Form and Bounds Test

Selected Model: ARDL (6, 6, 8, 8, 8)

Sample: 2006Q1 2022Q4

Included observations: 64

Levels Equation

Case 2: Restricted Constant and No Trend

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| GDP | 1.729032 | 0.373142 | 4.633706 | 0.0001 |
| R | -0.958462 | 0.374042 | -2.562443 | 0.0174 |
| LOG(CRD) | 5.405886 | 1.537534 | 3.515945 | 0.0019 |
| LOG(REER) | -30.21079 | 12.40146 | -2.436067 | 0.0230 |
| C | 88.66766 | 46.65685 | 1.900421 | 0.0700 |

*Source*. Author's calculations

Long run equation will look like this.

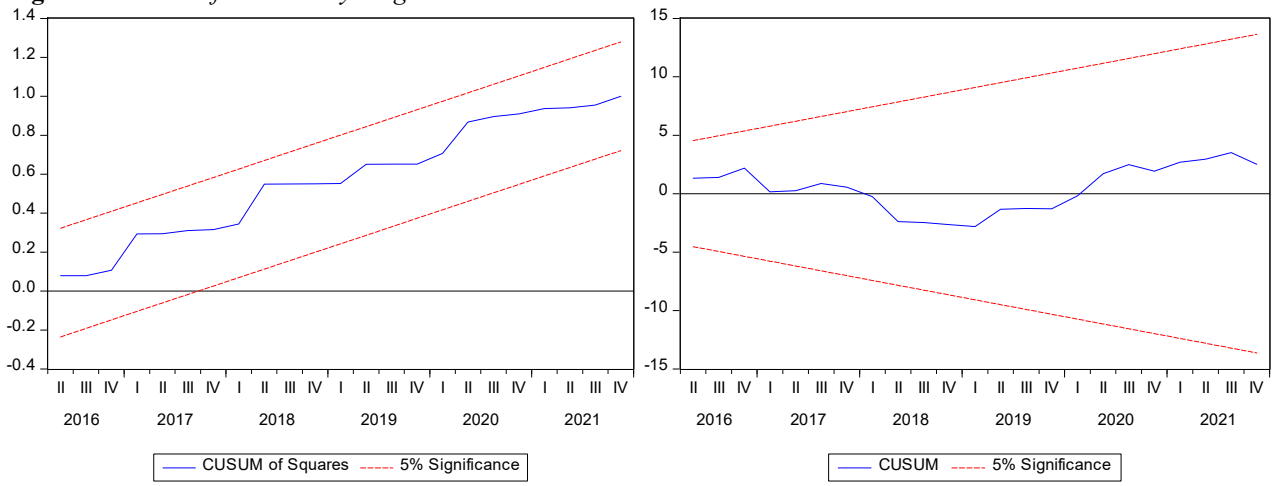
$$\widehat{INF} = 1.729 * GDP - 0.958 * R + 5.405 * LOG(CRD) - 30.21 * LOG(REER) + 88.667 \quad (3)$$

The obtained results indicate that the included variables are determining long-term inflation in Armenia, and the targeted management of these indicators can lead to inflation regulation. In particular, in the long run, one percentage point increase in the output gap leads to 1.72 percentage point increase in prices. The interest rate has a significant negative effect in the long run, one percentage point increase of which leads to 0.95 percentage point decrease in the price level.

Since in the model the volume of credits and the real effective exchange rate are presented in logarithmic form, and the dependent variable is in levels form, in that case, for interpreting the obtained coefficients, it is necessary to approximate it by the formula $\hat{\beta}/100$ [**3**, page 26].

In the long term, the increase in the volume of credits in the economy has a positive effect, a one percent increase in which leads to 0.054 percentage point increase in prices. One percent appreciation of the real effective exchange rate leads to 0.3 percentage point reduction in the price level.

**Figure 1**: *Results of the stability diagnostic tests*




*Source*. Author's calculations

The stability of the ARDL model was checked using CUSUM and CUSUMS tests. These tests are commonly used in econometrics and statistics to assess whether there are structural changes (or structural breaks) in a regression equation or not [**4**]. It graphically represents the hypothesis of stability of estimated coefficients, which is rejected when the graph crosses the 5 percent significance level. As it becomes clear from the test results, the model is stable, and the estimated coefficients are reliable.

The model (2) is designed to estimate the impact of monetary policy on the output gap in the long run. However, the null hypothesis of no cointegration cannot be rejected as seen from test results, which means that there is no long-run relationship between monetary policy indicators and the GDP gap.

**Table 6.** *Cointegration test results of model (2).*

F-Bounds Test — Null Hypothesis: No levels relationship

| Test Statistic | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|
| | | Asymptotic: n=1000 | | |
| F-statistic | 2.456488 | 10% | 2.2 | 3.09 |
| k | 4 | 5% | 2.56 | 3.49 |
| | | 2.5% | 2.88 | 3.87 |
| | | 1% | 3.29 | 4.37 |

*Source*. Author's calculations

It is now generally accepted that a low and predictable level of inflation is a necessary but not sufficient condition for sustainable economic growth. In this regard, the fluctuating behavior of inflation is also important. More volatile inflation leads to greater variation in real household wealth.

In this case, if the household avoids risk, then because of the increase in inflation volatility, consumption can be reduced, especially in conditions of unchanged wages [**9**, p. 486].

Several analyzes also document that there is a negative relationship not only between high inflation levels and economic growth, but also between inflation volatility and economic growth [**6**]. In this sense, the uncertainty or volatility of inflation is one of the transmission channels through which the effects of inflation are transmitted to economic growth. The results of empirical analysis also indicate that there is a negative relationship between inflation volatility and economic growth [**1**].

To estimate the impact of inflation volatility on economic growth, a panel linear regression model was conducted, which includes data of 39 countries. The data was collected from the statistics provided by the Organization of Economic Cooperation and Development. It includes quarterly data of inflation and real GDP for the period 2006-2021. Using these time series, the coefficients of standard deviation of the inflation and output gap were calculated for each country over the sample period.

The econometric view of the estimated model is as follows:

$$DEV(GDPGAP)_t = \alpha_1 + \alpha_2\, DEV(CPI)_t + \varepsilon_t, \quad t = \overline{1,39} \qquad (4)$$

Where: $DEV(GDPGAP)_t$ is the standard deviation of the output gap for the entire observed period in the selected countries, $DEV(CPI)_t$ is the standard deviation of inflation for the entire period observed in the selected countries, $\alpha_1$ - free parameter, $\varepsilon_t$ - error term, $t$ - number of observations.

**Table 7.** *Model (4) estimation results*

Dependent Variable: DEV(GDPGAP)

Method: Least Squares

Included observations: 39

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DEV(CPI) | 0.589594 | 0.117174 | 5.031781 | 0.0000 |
| C | 0.706308 | 0.240991 | 2.930847 | 0.0058 |

| | | | |
|---|---|---|---|
| R-squared | 0.406279 | Mean dependent var | 1.793137 |
| Adjusted R-squared | 0.390232 | S.D. dependent var | 0.854781 |
| S.E. of regression | 0.667478 | Akaike info criterion | 2.079301 |
| Sum squared resid | 16.48452 | Schwarz criterion | 2.164612 |
| Log likelihood | -38.54637 | Hannan-Quinn criter. | 2.109910 |
| F-statistic | 25.31882 | Durbin-Watson stat | 2.288927 |
| Prob(F-statistic) | 0.000013 | | |

*Source*. Author's calculations

The results of the model's estimation document that about 40 percent of output gap's volatility is explained by inflation volatility, and one percentage point increase in inflation volatility leads to a 0.58 percentage point increase in output gap's volatility. This implies that countries with a lower inflation volatility have a lower output gap's volatility, from which it can be concluded that economic growth is more stable in countries with lower inflation volatility.

As a summary, the following conclusions can be made.

- The analysis of the descriptive statistics of the time series proves that the inflation in Armenia corresponds to the targeted level of 4% in the long run, but it has a highly fluctuating behavior in the short run. The causes of volatility can be the external shocks, which Central Bank is not able to control.
- Cointegration analysis shows that the monetary policy has a significant impact on the inflation rate in the long run. The transmission mechanisms have a significant effect on inflation both in short and long run, which implies that the role of monetary policy in Armenia is high for controlling inflation.
- GDP growth also leads to an increase in the inflation rate both in the short run, and in the long run, so an increase in aggregate demand leads to an increase in the price level.

- 45.7 percent of inflation deviation from equilibrium is adjusted during one quarter, from which it follows that the deviation is almost completely adjusted in 7-8 quarters. This supports the results obtained from SVAR model, where is also shown that inflation recovers from its own shock in 7-8 quarters [**8**].
- In the long run, the output gap and the main monetary indicators are not cointegrated, this result is closer to the theory of neutrality of money, according to which changes in the money market do not have permanent effect on the real indicators of the economy in the long run.
- The results of the panel linear regression model's estimation prove that in the long term, the volatility of inflation is more important indicator describing countries economic development, which has a significant negative impact on economic growth and approximately 40 percent volatility of output gap can be explained by inflation volatility in observed countries.

**List of References**


1. **Al-Marhubi F.** "Cross-country evidence on the link between inflation volatility and growth", Applied Economics. 1998. Т. 30. №. 10. С. 1317-1326.
2. **Barro R. J.**, "Inflation and Economic Growth", Annals of Economics and Finance, Society for AEF, vol. 14(1), 2013, 85-109 pp.
3. **Benoit K.** "Linear regression models with logarithmic transformations." London School of Economics, London 22.1 (2011): 23-36.
4. **Dao, Phong B.** "A CUSUM-based approach for condition monitoring and fault diagnosis of wind turbines." Energies 14.11 (2021): 3236.
5. **Das A., Loxley J.** Non-linear relationship between inflation and growth in developing countries, Economic and political weekly 50 (37), Sep. 2015, 59-64 pp.
6. **Judson, R., Orphanides A.** "Inflation, volatility and growth." international Finance 2.1 (1999): 117-138.
7. **King, Robert G., and Watson Mark W.** "Testing long run neutrality." (1992). 28 pages.
8. **Levonyan S.**, Estimation of Monetary Policy transmission channels efficiency in Armenia. An SVAR approach. Armenian Economic Journal N1, 2022
9. **Okun A. M.**, "The Mirage of Steady Inflation", Brookings Paper on Economic Activity, Issue 2, 1971, 485-498 pp
10. **Pesaran, H. M. and Pesaran B.**, 1997. "Working With Microfit 4.0: An introduction to econometrics", Oxford University Press, London.
11. **Taylor, John B.** "How should monetary policy respond to shocks while maintaining long-run price stability? –Conceptual issues." Achieving Price Stability (1996): 181-195.
12. www.armstat.am
13. www.cba.am
14. www.stats.oecd.org



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