IMF Working Paper

Estimates of the Output Gap in Armenia with Applications to Monetary and Fiscal Policy

Asmaa El-Ganainy and Anke Weber

INTERNATIONAL MONETARY FUND

IMF Working Paper

Middle East and Central Asia Department; Fiscal Affairs Department

Estimates of the Output Gap in Armenia with Applications to Monetary and Fiscal Policy[1]

Prepared by Asmaa El-Ganainy and Anke Weber

Authorized for distribution by Joël Toujas-Bernaté

August 2010

Abstract

This paper employs several econometric techniques to estimate the Armenian output gap. The findings indicate that the output gap is significantly positive in 2007 and 2008 and decreased dramatically in 2009. The paper uses these results to estimate a New Keynesian Phillips curve for Armenia, suggesting a significant role of the output gap and inflation expectations in determining current inflation. Finally, the underlying fiscal stance over the period 2000–09 is assessed by estimating the cyclically-adjusted fiscal balance. Most of Armenia's fiscal deficit is found to be structural. Fiscal policy, while providing counter-cyclical support in 2009, has been largely pro-cyclical in the past.

---

[1] The authors would like to thank Emanuele Baldacci, Anna Bordon, Annalisa Fedelino, Mark Lewis, and Niklas Westelius for their helpful comments and suggestions. We are also grateful to seminar participants from the Ministry of Finance and the Central Bank of Armenia for their useful comments and discussion on an earlier draft of the paper. All remaining errors are ours.

Contents

Tables

I. INTRODUCTION

The objective of this paper is to provide a technical analysis of several time-series econometric techniques to estimate potential output and the output gap. Estimates of potential output serve as a useful indicator of business cycle developments. Moreover, there exist important applications of output gap estimates to monetary and fiscal policy issues, as demonstrated for the case of Armenia in this paper.

Armenia represents an interesting example, as it enjoyed a progressive strengthening of economic growth in 2006 and 2007 within a low inflation macroeconomic environment. However, these developments came to a sudden halt when Armenia was severely hit by the global economic crisis in 2008. The economy was confronted by a number of external shocks including large falls in remittances and capital inflows. GDP contracted by more than 14 percent in 2009 reflecting a collapse in the construction sector, which previously had been an engine of growth. The severe contraction of the Armenian economy raises the question of the effects of the financial crisis on potential output and the output gap. It is likely that the global economic crisis has reduced potential output in Armenia because it has led to slower capital inflows, higher government debt and thus a higher cost of capital. It is also likely to have severely reduced the capital stock through business failures and weak investment in light of unusual uncertainties and extreme tightness of credit.

The paper estimates potential output and the output gap for Armenia between 2000 and 2009. It also provides forecasts of potential output and the output gap up to end-2010, employing a Bayesian analysis to estimate by maximum likelihood a structural model of the Armenian economy. The findings show that the output gap is significantly positive in 2007 and 2008 and is falling dramatically in 2009. The projections indicate that the output gap returns into positive territory at the end of 2010. The results also point to a similar behavior of output gap estimates across different methods, although their magnitude varies depending on which method is used. Since real time data analysis demonstrates that Bayesian estimates are more robust to changes in the sample size, output gap estimates from the Bayesian methodology are used in the subsequent applications to monetary and fiscal policy issues.

First, we estimate both a closed economy and open economy version of the New Keynesian Phillips curve for the Armenian economy. The results indicate that the New Keynesian Phillips curve explains inflation in Armenia well, with a significant role of the output gap and inflation expectations in determining current inflation. These findings have important implications for the monetary policy framework in Armenia since they indicate that the central bank should closely monitor output gap developments and inflation expectations of the private sector.

Second, we assess the underlying fiscal stance by estimating the cyclically-adjusted fiscal balance for Armenia over the period 2000–09. The results indicate that Armenia's fiscal deficit is largely structural, while automatic stabilizers are weak. The results also suggest that while fiscal policy in the past was largely pro-cyclical even at periods of negative output gaps—a result that highlights the importance of fiscal discipline during good times—it was expansionary in 2009, providing a counter-cyclical support to the economy during the worst recession in years. These findings have important implications for fiscal policy formulation

going forward. More specifically, the government may consider measures to (i) strengthen fiscal rules to enhance fiscal discipline over the business cycle and limit pro-cyclicality of fiscal policy; and (ii) strengthen fiscal automatic stabilizers by enhancing revenue collection, increasing the progressivity of the tax system, and addressing Armenia's persistent institutional and governance weaknesses, particularly in tax administration.

The paper is structured as follows. In Section II estimation results from the non-Bayesian methods are provided. Section III presents the estimation methodology and results of the Bayesian method. In Section IV, a New Keynesian Phillips curve is estimated for Armenia. In Section V, the cyclically-adjusted fiscal balance is estimated and the underlying fiscal stance is assessed. Section VI concludes.

II. NON-BAYESIAN ESTIMATION

This section employs four different estimation methods to estimate potential output: the Hodrick and Prescott filter, the production function approach, an unobserved components model, and a multivariate Kalman filter approach. Non-Bayesian Estimation methods have been previously described in detail by several authors (see for example, Billmeier, 2004). Thus, a general overview of the different methods is provided in the Appendix. This section will instead focus on a discussion of the results. It should be noted that the logarithm of seasonally-adjusted quarterly real GDP multiplied by 100 is used in all estimations as a measure of real GDP. This specification has the advantage that the output gap is then given as the difference between the logarithm of seasonally-adjusted real GDP and the log of potential output.[2]

The paper first estimates potential output and the output gap by applying the HP filter to the quarterly real GDP series for 2000–09.[3] Two sets of estimates are provided with the restriction parameter (λ) set at 1600 and 400. The results are shown in Figure 1. There is a large positive swing in the output gap during 2007–08 when real GDP growth accelerated strongly. The negative output gap in 2006 narrows considerably in 2007 and turns positive in 2008. It then becomes significantly negative in 2009 in the face of the global economic crisis. In what follows, the restriction parameter (λ) is set at 400 to take into account the supply driven nature of shocks in Armenia. Estimates from the production function approach are broadly similar to those from the standard HP filter estimates as shown in Figure 2. The output gap is significantly positive in 2007 and 2008 and falling dramatically in 2009.

We then estimate the unobserved components (UC) model as outlined in the Appendix. The model assumes that the output gap follows an autoregressive process of order 2 while potential output is modeled as a random walk with drift. The results are shown in Figure 3 and the parameter estimates are depicted in Table 1. The results show that although the sign of the output gap in recent years is similar to that estimated by the HP filter, the magnitude of

---

[2] A detailed description of data used in this estimation is provided in Table 9 in the Appendix.

[3] Real quarterly GDP is adjusted seasonally using the Tramo/Seats program in EViews. Forecasts of real GDP for 2010 (IMF staff estimates) are used to partly overcome the end-point bias inherent to the HP filtering method.

output gap estimates is very different. In particular, the unobserved components model approach suggests that there is significantly less overheating of the economy in 2008 and that the fall in the output gap in 2009 is significantly smaller than under the HP filter approach. One possible explanation for this lies in the fact that the growth rate of real GDP has not been constant over time. The unobserved components model treats the growth rate of potential as time-varying and is thus able to extract cyclical fluctuations from the data.

Finally, output gap and potential output estimates are obtained using a multivariate Kalman filter in which an Okun's law relationship with static inflation expectations is added to the simple unobserved components model. It models the change in the growth rate of unit labor costs as a function of the output gap. The results, which are depicted in Figure 4, show significantly less overheating of the economy in 2008 than the simple HP filter. However, Table 2 shows that the coefficient on the output gap in the Okun's law equation is not significantly different from zero, which casts doubt on the usefulness of extending the simple UC model. This is surprising because including information on nominal unit wage growth should have captured interactions between output and labor market conditions. Since there have been little signs of wage pressures in the labor market in 2005 and 2007, the multivariate Kalman filtering approach, which includes an Okun's law equation, should have pointed to less overheating and a smaller output gap in those years. This contrasts the findings of Konuki (2008), who finds that including a structural equation with nominal unit labor costs as the dependent variable leads to fewer signs of overheating of the Slovenian economy. However, Konuki (2008) does not provide estimates of the Slovenian output gap using the simple UC model. The fact that the Kalman filtering approach generally leads to smaller output gap estimates during years of strong economic growth could simply be due to its treatment of the potential growth rate as time varying.

A comparison of results derived from non-Bayesian estimation techniques is provided in Figure 5. It can be seen that the different approaches yield similar results in terms of the sign of the output gap in recent years. However, the magnitude of estimates is very different depending on whether a Kalman filtering approach is used for estimation.

III. BAYESIAN ESTIMATION

Univariate filters have many shortcomings. Most importantly, they ignore relevant economic information, which can create large biases. For instance, estimates of potential output for 2009 using the HP filter, production function approach, or a simple Kalman filter ignore the significant decline in inflation that has been observed in early 2009 in Armenia. A possible definition of potential output would be the level of output that can be sustained indefinitely without creating a tendency for inflation to rise or fall (Benes et al., 2009). Thus, potential output should be estimated jointly with an inflation equation. Another important economic indicator is unemployment. Incorporating these economic variables into a UC model leads to a multivariate framework, which in principle could be estimated in the same way as the simple multivariate Kalman filter discussed above. However, with a number of state and measurement equations to estimate, the choice of initial conditions for the filter becomes even more important. Therefore, this section follows Benes et al. (2009) and estimates a structural macroeconomic model with Bayesian techniques. This methodology makes it

possible to define prior distributions that ensure that parameter values stay in sensical regions.

A. Model Specification

We follow Benes et al. (2009) and define three different gaps of the model. The output gap continues to be defined as the log difference between actual GDP and potential GDP:

$$z_t = y_t - y_t^p. \tag{1}$$

The unemployment gap, u_t, is defined as the difference between the equilibrium unemployment rate (NAIRU), $\overline{U}_t$, and the actual unemployment rate, U_t:

$$u_t = \overline{U}_t - U_t. \tag{2}$$

The capacity utilization gap, c_t, is the difference between the actual manufacturing utilization index, C_t, and its equilibrium level, $\overline{C}_t$:

$$c_t = C_t - \overline{C}_t. \tag{3}$$

The annual rate of current core inflation is assumed to be determined by the level and change in the output gap:

$$\pi_t = \pi_{t-1} + \beta z_t + \gamma(z_t - z_{t-1}) + \varepsilon_t^\pi. \tag{4}$$

Equation (12) depicts an intuitive relationship between inflation and the output gap since an increased output gap implies higher inflation. As Benes et al. (2009) argue, the lagged inflation can be interpreted as a simple proxy for backward looking inflation expectations.

The output gap is determined by its past level and the difference between inflation in the last period and inflation expectations for that period (π_{t-1}^{LTE}):

$$z_t = \rho_1 z_{t-1} - \rho_2(\pi_{t-1} - \pi_{t-1}^{LTE}) + \varepsilon_t^y. \tag{5}$$

where inflation expectations evolve as follows:

$$\pi_t^{LTE} = \pi_{t-1}^{LTE} + \varepsilon_t^{\pi E}.$$

The output gap is furthermore related to the unemployment gap by Okun's law. However, it is assumed that changes in the output gap affect the unemployment gap with a lag:

$$u_t = \mu_1 u_{t-1} + \mu_2 z_t + \varepsilon_t^u. \tag{6}$$

Benes et al. (2009) assume a similar relationship to that of the unemployment gap for the capacity utilization gap:

$$c_t = \delta_1 c_{t-1} + \delta_2 z_t + \varepsilon_t^c. \tag{7}$$

Equilibrium unemployment is given as follows:

$$\overline{U}_t = \overline{U}_{t-1} + G_t^{\overline{U}} - \omega z_t - \frac{\alpha}{100}\left(\overline{U}_{t-1} - U^{SS}\right) + \varepsilon_t^{\overline{U}}. \tag{8}$$

Thus, the equilibrium unemployment rate (NAIRU) is a function of the lagged equilibrium unemployment rate, a persistent shock ($G_t^{\overline{U}}$), and the difference between last period's equilibrium unemployment rate and the steady state unemployment rate, which is assumed to be fixed in the long run.

The persistent shock to the NAIRU is assumed to follow an autoregressive process:

$$G_t^{\overline{U}} = G_{t-1}^{\overline{U}} + \varepsilon_t^{G^{\overline{U}}}. \tag{9}$$

Potential output on the other hand depends on the underlying trend growth rate of potential (G_t^y) and on changes in the NAIRU:

$$y_t^p = y_{t-1}^p - \theta\left(\overline{U}_t - \overline{U}_{t-1}\right) - \frac{(1-\theta)(\overline{U}_{t-1} - \overline{U}_{t-20})}{19} + G_t^y \tag{10}$$

where
$$G_t^y = \tau G_{SS}^y + (1 - \tau)G_{t-1}^y + \varepsilon_t^{G^y}. \tag{11}$$

The difference between the current and lagged NAIRU captures the impact of changes in the NAIRU on the growth of potential output via a Cobb-Douglas production function in which θ is the labor share. The 19-quarter difference captures the effect of induced changes in the capital stock. Therefore if $\overline{U}_t$ increases by one percent this leads to a decline in potential output of θ percent. A negative effect continues for a further 19 quarters, thus the long run decline in the level of potential output is 1 percent.

Similarly to potential output and the equilibrium unemployment rate, equilibrium capacity utilization is described by the following stochastic process:

$$\overline{C}_t = \overline{C}_{t-1} + G_t^{\overline{C}} + \varepsilon_t^{\overline{C}} \tag{12}$$

where $G_t^{\overline{C}} = (1 - \delta)G_{t-1}^{\overline{C}} + \varepsilon_t^{G^{\overline{C}}}$.

B. Methodology

The above model is estimated by regularized maximum likelihood using Iris, a toolbox for estimating macroeconomic models based on Matlab.[4] This estimation procedure obtains the most likely estimates of the output gap given our initial priors on parameters. It interprets the data on headline and core inflation, the unemployment rate and real seasonally-adjusted GDP through the lens of the model outlined above. The regularized maximum likelihood procedure will thus find the best estimates conditional on the above model. The posterior estimates of parameters are then a combination of the initial priors and an adjustment to make those priors more consistent with the model.

The following assumptions were made in the estimation: First, the steady state growth rate was set to 4 percent, the steady state unemployment rate was set as the average of unemployment rates from 1998–2009. The priors of model parameters were those derived from estimating the model for the U.S. economy. We also estimated the model with different steady state and prior assumptions and found that the results were not very sensitive to those. Since capacity utilization data and long-term inflation expectations were not available for Armenia, these variables were treated as unobservable and estimated as states.[5] Furthermore, it is helpful to incorporate GDP projections into the estimation. IMF staff projections for real quarterly GDP for 2010 were used.

C. Results and Discussion

Figure 6 shows the results for potential output, the unemployment gap, and inflation. The output gap estimates up to 2009Q4 are very similar to those of the multivariate Kalman filter of the previous section. The toolkit for the Bayesian estimation also provides forecasts of the output and unemployment gaps together with confidence intervals as shaded areas in the charts. Figure 6 shows that the output gap does not return into slightly positive territory before mid 2010.

It is difficult to compare the performance of the Bayesian estimation method with other estimation methods, since the output gap is an unobservable variable. However, it is possible to construct real time estimates, which are estimates of the output gap if only data up to a certain year were available. The outcome is shown in Figures 7 and 8. It can be seen that for the Bayesian approach, new data necessitate smaller revisions to current quarter estimates than when using the HP filter to estimate the output gap. Thus, the Bayesian estimation methodology is clearly preferable to the HP filter, which nevertheless is most frequently used in the literature, presumably because it is very straightforward to implement and has very limited data requirements.

---

[4] The toolbox and codes to estimate the model were kindly provided by the IMF Research Department. We particularly thank Petar Manchev for his instructions on how to use this toolbox.

[5] Estimating the model without capacity utilization and inflation expectations yielded similar results.

The next section will apply the results of the Bayesian analysis to estimate a New Keynesian Phillips curve, an important ingredient of monetary policy.

IV.   ESTIMATING A NEW KEYNESIAN PHILLIPS CURVE FOR ARMENIA

A.   Overview

The New Keynesian Phillips curve represents an important ingredient in modern monetary policy models. The new theoretical work on inflation dynamics emphasizes nominal rigidities in wage and price-setting by forward looking economic agents. These models of staggered price setting result in a forward-looking version of the traditional Phillips curve. The New Keynesian Phillips curve implies that the output gap—the deviation of the actual output from its natural level due to nominal rigidities—drives the dynamics of inflation relative to expected inflation:

$$\pi_t = \alpha E_t \pi_{t+1} + \gamma z_t + \varepsilon_t \qquad (13)$$

where π_t denotes year-on-year inflation, z_t denotes the output gap (using the results from the Bayesian analysis), $E_t \pi_{t+1}$ denotes inflation expectations for the next period and ε_t is a disturbance term, which may be serially correlated. The key feature of the above New Keynesian Phillips curve is that expected future inflation is a major determinant of current inflation. This contrasts the traditional backward looking Phillips curve, which can be written as follows:

$$\pi_t = \beta_1 \pi_{t-1} + \beta_2 \pi_{t-2} + \gamma z_{t-1} + \varepsilon_t. \qquad (14)$$

The empirical work that has estimated the New Keynesian Phillips curve typically finds that the fit improves if a lagged inflation term is added (for an excellent summary of this work, see for example, Linde, 2005). Thus the following equation is estimated:

$$\pi_t = \alpha E_t \pi_{t+1} + \beta \pi_{t-1} + \gamma y_t + \varepsilon_t. \qquad (15)$$

There are several methods by which the above can be estimated. Gali and Gertler (1999) estimate a so-called hybrid version of the New Keynesian Phillips curve, with both forward and backward looking components with Generalized Methods of Moments (GMM). They find that the above specification is a good approximation of inflation dynamics in Europe and the U.S. Thus, in order to estimate a New Keynesian Phillips curve for Armenia, the paper follows Gali and Gertler (1999) and Gali et al. (2005) and assumes that inflation expectations are rational:

$$E_t \pi_{t+1} = \pi_{t+1} + \varphi_{t+1}. \qquad (16)$$

Substituting for $E_t \pi_{t+1}$ in the above equation, it is then possible to estimate equation (15) by GMM using dependent variables dated *t-1* and earlier as instruments.

Armenia can be considered as a small open economy, and therefore, it is important to also assess the relevance of external and domestic determinants of CPI inflation dynamics. The

paper estimates an open-economy New Keynesian Phillips curve as derived in Gali and Monacelli (2005). According to the Gali and Monacelli (2005) model, the open-economy New Keynesian Phillips curve can be written as follows:

$$\pi_t = \alpha E_t \pi_{H,t+1} + \beta \pi_{t-1} + \gamma y_t + \theta \Delta s_t + \varepsilon_t \tag{17}$$

where $E_t \pi_{H,t+1}$ denotes expected domestic inflation and Δs_t the change in the terms of trade. Gali and Monacelli (2005) moreover show that inflation can be decomposed into domestic inflation and the change in the terms of trade:

$$\pi_t = \pi_{H,t} + \theta \Delta s_t \; . \tag{18}$$

Using equation (18), equation (17) can alternatively be expressed as:

$$\pi_t = \alpha E_t \pi_{t+1} + \beta \pi_{t-1} + \gamma y_t + \theta(\Delta s_t - \alpha E_t \Delta s_{t+1}) + \varepsilon_t. \tag{19}$$

According to equation (19), domestic CPI inflation is driven by expected next-period CPI inflation, the domestic output gap and the expected discounted change in the terms of trade relative to the past-to-current change in the terms of trade. Intuitively, one would expect that if $\Delta s_t > \beta E_t \Delta s_{t+1}$ this will increase current demand for domestic goods since their price is relatively lower than what is expected in the future. This increased demand should then exert upward pressure on current inflation.

B. Results and Discussion

First, we estimate the backward looking Phillips curve by OLS. The estimation results are as follows:[6]

$$\pi_t = 1.079\, \pi_{t-1} - 0.188\, \pi_{t-2} + 0.206\, y_{t-1} + \varepsilon_t$$
$$\quad (0.129) \qquad (0.105) \qquad (0.073)$$
$$\quad\;\; [0.000] \qquad\; [0.083] \qquad\; [0.008] \qquad R^2 = 0.83 \qquad DW = 1.74$$

where terms in brackets denote standard errors and in parentheses denote *p-values*. It should be noted that core inflation (year-on-year) and the output gap estimates from the Bayesian multivariate Kalman filter are used for the above estimation. More detailed results can be found in Table 4 in the Appendix. All coefficients have the expected signs. Inflation is highly persistent as indicated by the significant large coefficient on past inflation. Furthermore, an increase in the output gap will lead to an increase in inflation. Thus, past inflation rates and the output gap are significant in explaining current inflation. However, there may also be a role of inflation expectations in explaining current inflation. We therefore estimate the New Keynesian Phillips curve by GMM to overcome the endogeneity problems inherent in the forward looking specification. As it is standard in the literature, lagged values of dependent variables are used as instruments. The specific lag structure of the estimation is chosen

---

[6] Standard errors are robust to heteroscedasticity and autocorrelation.

according to these two criteria and the *J-test* is used to test the validity of the overidentifying restrictions. The following results are obtained:

$$\pi_t = 0.304\, E_t\pi_{t+1} + 0.665\, \pi_{t-1} + 0.166 y_t + \varepsilon_t$$
$$\quad\quad (0.088) \quad\quad\quad\; (0.087) \quad\;\; (0.045)$$
$$\quad\quad [0.0015] \quad\quad\; [0.0000] \quad\; [0.0008] \quad\quad R^2 = 0.91 \quad\quad DW = 2.22 \quad\quad p(J) = 0.37$$

where terms in brackets denote standard errors that are robust to heteroscedasticity and autocorrelation and terms in parentheses denote *p-values*. It can be seen that the fit of the New Phillips curve equation in Armenia is better than for the traditional Phillips curve, as indicated by a higher *R-Squared* value. Furthermore, according to the *p-value* of the *J-test* statistic, the null of the validity of the overidentifying restrictions cannot be rejected at standard levels of significance. The effect of a change in the output gap on current inflation is roughly the same as in the traditional Phillips curve. However, expected inflation for the next period now plays a significant role in explaining current inflation as a 1 percent increase in inflation expectations leads to a 0.3 percent increase in current inflation. More detailed estimation results can be found in Table 5 in the Appendix.

These findings are very interesting and it is worthwhile to compare them to estimation results by Gali et al. (2005) for Europe and the U.S. Gali et al. (2005) find that the effect of expected inflation on current inflation is about twice as large as the effect of lagged inflation, whereas for Armenia, it is exactly the other way around. There are several potential explanations for this. Inflation expectations affect current inflation through wage and price setting and it may be the case that the information transmission in Armenia is much slower than in advanced economies, so that it takes longer for inflation expectations to adjust in response to external shocks.

We also estimate an open-economy version of the above New Keynesian Phillips curve in order to evaluate the robustness of the results. The paper follows the work of Mihailov et al. (2009) and estimates this equation by GMM using lagged values of the dependent variables as instruments. The following estimation results are found:

$$\pi_t = 0.405 E_t\pi_{t+1} + 0.587\pi_{t-1} + 0.198 y_t + 0.065(\Delta s_t - 0.405 E_t\Delta s_{t+1}) + \varepsilon_t$$
$$\quad\; (0.055) \qu\quad\quad (0.055) \ququad\;\; (0.033) \qu\;\; (0.027) \ququad\quad (0.055)$$
$$\quad\; [0.0000] \ququad\quad [0.0000] \ququad\; [0.0000] \qu\; [0.0257] \ququad\quad [0.0000]$$
$$\quad\quad R^2 = 0.93 \ququad DW = 2.45 \ququad p(J) = 0.44$$

where terms in brackets denote standard errors, which are robust to heteroscedasticity and autocorrelation, and terms in parentheses denote *p-values*. The *p-value* of the *J-statistic* is found to be 0.44, so that the null of the validity of the overidentifying restrictions cannot be rejected at standard levels of significance. More detailed results can be found in Table 6. The output gap still has a significant effect on current inflation. The effect of expected inflation is now even greater than in the closed-economy New Keynesian Phillips curve estimation. In addition, external factors appear to be relevant for CPI inflation in Armenia, which is indicated by a significant positive coefficient on the difference between the expected change and the observed past-to-current change in the terms of trade.

There are several policy implications of the above findings: Since the output gap is highly significant in explaining current inflation, it should be closely monitored by monetary authorities as should inflation expectations. Furthermore, given that the New Keynesian Phillips curve fits inflation behavior well in Armenia, this has implications for optimal monetary policy. If inflation expectations play a significant part in determining current inflation, then monetary policy essentially becomes the art of managing and steering private sector expectations in the desired direction (Woodford, 2003). This has important implications for the communication and transparency practices of the central bank.

The next section will employ the results of the output gap based on the Bayesian analysis to estimate the cyclically-adjusted fiscal balance, an important indicator to assess the underlying fiscal stance.

V. ESTIMATING THE CYCLICALLY-ADJUSTED FISCAL BALANCE FOR ARMENIA

A. Overview

Variations in the budget deficit can give a misleading picture of the underlying fiscal stance. This is especially true during upswings, when an improvement of the fiscal balance may mask a deterioration in the underlying position of public finances (the traditional problem of "bad policies in good times"), but also during downturns when a deterioration in the fiscal balance may overstate the deterioration in the underlying fiscal position. This is why budget balances are adjusted to the business cycle to filter the impact of cyclical movements on fiscal variables. This allows policymakers to distinguish between the automatic response of the budget to cyclical developments and discretionary policy actions; and ultimately to assess the underlying fiscal stance.

The literature has identified the cyclically-adjusted balance (CAB) as the key indicator to assess the underlying fiscal stance (Blanchard (1990) and Gramlich (1990)). The CAB measures the fiscal position net of temporary factors that can be expected to even out over time. The CAB is in fact used for several purposes, including (i) to decompose a given change in the headline deficit into a discretionary fiscal component and a cyclical component; (ii) to assess how fiscal policy responds to macroeconomic conditions, i.e., to assess the fiscal impulse; and (iii) to examine the sustainability of fiscal policy—an issue that is currently at the heart of the policy debate in Armenia and worldwide.

The role of the CAB has gained more prominence since the beginning of the global economic crisis that started in 2008 and led to a significant deterioration in public finances. In Armenia, revenues fell sharply, while expenditures were largely maintained as planned to support economic activity and protect vulnerable groups. These factors have resulted in a significant deterioration of the fiscal position: the budget deficit widened by about 6 percentage points of GDP between 2008 and 2009, while the ratio of public debt-to-GDP more than doubled. In this environment, it is useful to examine how fiscal policy responded to the crisis, and how much of the change in the primary balance was due to automatic factors driven by the cycle versus discretionary actions.

The range of methodologies for computing the CAB in the literature boils down to two alternative approaches. The first, developed by Blanchard (1990) consists of estimating cyclically-adjusted measures of expenditures and revenues directly from regression-based analysis. More recent applications of this approach make use of structural VAR methodologies and unobserved component models.[7] The second approach is a two-stage procedure: a cyclical component is first estimated and subsequently subtracted from the nominal budget balance. The second approach is the one generally used by national governments and IFIs, including the IMF, the European Commission, the ECB, and the OECD for the purpose of budgetary surveillance, and it is also the one used in this paper.

The aim of this section is to estimate the CAB in Armenia over the period 2000–09, employing various estimates of the output gap developed in the paper. To the best of our knowledge this paper provides the first attempt to do so.[8] We also compute the size of automatic stabilizers and fiscal impulse focusing on the more recent events to assess the government's response to the global economic crisis of 2008–09.

B. Methodology[9]

The cyclically-adjusted primary balance (PB_{CA}, expressed in nominal terms)[10] is obtained by subtracting the cyclical primary component (PB_C) from the actual budget balance (B):

$$PB_{CA} = B - PB_C \tag{20}$$

The cyclical component is computed by applying cyclical adjustment to both revenues and expenditures as follows:

$$R^{CA} = R \left(\frac{Y^*}{Y}\right)^{\varepsilon_R} \tag{21}$$

$$G^{CA} = G \left(\frac{Y^*}{Y}\right)^{\varepsilon_G} \tag{22}$$

where R^{CA} is the cyclically-adjusted revenue, R is nominal revenue, Y^* is potential output, Y is actual output, ε_R is the elasticity of revenue with respect to the output gap, G^{CA} is the cyclically-adjusted primary expenditure, G is nominal primary expenditure and ε_R is the elasticity of primary expenditure with respect to the output gap.

---

[7] See Dalsgaard and Serres (1999) for more details on estimating the CAB using the SVAR methodology.

[8] Gracia (2008) estimated the CAB for Armenia over the period 1998-2007 employing Hodrick-Prescott filter to estimate the output gap and a range of elasticities for tax revenues. The author concluded that fiscal policy since 2004 was pro-cyclical.

[9] The methodology is drawn from Fedelino et al. (2009).

[10] Since changes in interest payments affect the overall balance but are largely not a reflection of the government's discretionary policy, we opted to assess the underlying fiscal stance based on the primary balance. For further details, see Fedelino et al. (2009).

The output gap is defined as follows:

$$gap = \left(\frac{Y - Y^*}{Y^*}\right) \tag{23}$$

From (21) and (22), the PB_{CA} is:

$$PB_{CA} = R\left(\frac{Y^*}{Y}\right)^{\varepsilon_R} - G\left(\frac{Y^*}{Y}\right)^{\varepsilon_G} \tag{24}$$

Equation (24) implies that each component of the budget is adjusted proportionally to the ratio of potential to actual output, as determined by its elasticity with respect to the output gap.[11] The OECD computes revenue elasticities for separate individual revenue categories, with respect to their corresponding bases.[12] These categories are usually assumed to display a cyclical pattern and are thus subject to cyclical adjustment. They include indirect taxes, direct taxes on households and firms, and social contributions. On the expenditure side, unemployment-related outlays, such as unemployment benefits, are the only items corrected for the cycle taking into account changes over time in the trend of the unemployment rate.

The revenue elasticity applied by the European Commission is calculated as a weighted average of the respective elasticities of each of the revenue groups (calculated by the OECD), with the weights being the share of each of these categories in total revenue.[13] The ensuing aggregated revenue elasticity is close to 1, whereas that of expenditures is close to zero.

Elasticity parameters are generally derived from regression analysis.[14] However, in the absence of data on individual tax bases in Armenia, regression analysis of budgetary elasticities is not feasible. Therefore, we will use the aggregated constant unitary elasticity of revenue with respect to the output gap, which implies that revenues are perfectly correlated with the cycle; and zero elasticity of expenditures, which implies that expenditures do not respond to the cycle.[15] While an approximation, these elasticity assumptions are in line with those estimated for OECD countries.

Using these elasticity assumptions in (24), the PB_{CA} becomes:

$$PB_{CA} = R\left(\frac{Y^*}{Y}\right)^{\varepsilon_R} - G \tag{25}$$

The cyclical primary balance then computed as the residual:

---

[11] For more details on this approach, see Giorno et al. (1995).

[12] For further details on the OECD methodology for computing CABs, see Girouard and Andre (2005).

[13] For more details on the European Commission method, see EU Commission (2005).

[14] Useful references for the estimation of tax elasticities are: P. Van den Noord (2000), and G. Wolswijk (2007).

[15] In fact, unemployment benefits are very small in Armenia (less than 0.4 percent of current expenditures in 2008–09), and hence their impact is negligible.

$$PB_C = B - PB_{CA} = (R - G) - \left[R\left(\frac{Y^*}{Y}\right)^{\varepsilon_R} - G\right] = \left(\frac{R}{Y}\right)(Y^*)(gap) \qquad (26)$$

Equation (26) implies that if the expenditure elasticity is equal to zero, then the PB_C is a function of the tax-to-GDP ratio, potential output, and the output gap.

But since fiscal variables are typically expressed in ratios, the cyclically-adjusted primary balance as a ratio of potential GDP is:[16]

$$pb_{ca}^{y^*} = \frac{PB_{CA}}{Y^*} = \frac{R^{CA} - G^{CA}}{Y^*} = r(1 + gap)^{-(\varepsilon_R - 1)} - g(1 + gap)^{-(\varepsilon_G - 1)} \qquad (27)$$

where $pb_{ca}^{y^*}$ is the ratio of the cyclically-adjusted balance to potential GDP, and r and g are the ratios of revenue and primary expenditures to GDP, respectively. The cyclical primary balance is then computed as a residual.

Changes between two consecutive years (or with respect to a base year—typically when the output gap is zero) in the cyclically-adjusted primary balance (cyclical balance) measure the size of the fiscal impulse/discretionary policy (automatic stabilizers).

C. Results and Discussion

Employing various estimates of the output gap yields similar results for the cyclically-adjusted primary balance, as depicted in Figure 9. Therefore, the rest of this section will focus on the results based on the Bayesian methodology, which is the most sophisticated of all estimation techniques discussed in this paper.

A decomposition of the primary balance into its cyclical and cyclically-adjusted components suggests that Armenia's fiscal deficit is mainly structural, while GDP fluctuations affect the primary balance to a much lesser extent (Figure 10 and Table 7). The relative weakness of automatic stabilizers is largely explained by two factors. First, the tax burden is low in Armenia. This reflects several structural factors in the economy, including weak institutions, particularly tax administration, and the large shadow economy.[17] Accordingly, tax and expenditure ratios to GDP are small. The second factor is the proportionality of the tax system[18] and wide spread exemptions and tax holidays, which imply that the tax system is not sufficiently progressive, resulting in smaller cyclical revenue response to output changes.

---

[16] Potential GDP is the appropriate scaling variable since the cyclically-adjusted primary balance measures what the fiscal balance would have been if output had been at its potential.

[17] In a study by Davoodi and Grigorian (2007) that assessed the gap between the potential and actual tax collection in Armenia, the authors concluded that the gap could be as high as 6½ percent of GDP, and is largely due to institutional and governance weaknesses, and informality.

[18] For instance, both the bottom and top personal income tax rates of 10 and 20 percent, respectively apply at relatively moderate to low income levels suggesting that the tax system places a heavy tax burden on low income households with little revenue for the system.

Figure 11 and Table 8 show estimates of automatic stabilizers and the fiscal impulse. The results further confirm the large contribution of the fiscal impulse to the deterioration in the primary balance over the past decade. A closer examination of the relative deterioration in the primary balance between 2008 and 2009 (estimated at about 6 percent of GDP), suggests that about 80 percent of the deterioration is explained by discretionary policy, whereas only 20 percent is due to automatic stabilizers.

An assessment of the extent to which fiscal policy in Armenia has been used as a stabilizing tool over the past decade shows that fiscal policy has been largely pro-cyclical in the past with the exception of 2009 (Table 8). A period of fiscal adjustment from 2000–04 led to a gradual decline in the primary balance from about 6½ percent of GDP to around 2 percent, mainly due to a contractionary fiscal policy, which seems to have been adopted even at periods of negative output gaps, e.g., 2000–01. However, in 2007 the cyclically-adjusted primary balance deteriorated faster than the primary balance at a time when actual output was above potential. The fiscal impulse was estimated at about 1½ percent of potential GDP, while automatic stabilizers offset part of the deterioration in the primary balance by about ½ percent of potential GDP. Such pro-cyclicality of fiscal policy in Armenia could be explained by well-identified lags in the formulation and implementation of policy, institutional weaknesses—particularly in tax administration and governance—as well as limited financing sources. Political economy factors may also have contributed. They prevent savings in upturns due to rising spending pressures, which forces the government to engage in a pro-cyclical expansionary policy during economic booms. This limits the fiscal space to conduct a counter-cyclical fiscal policy when it is much needed during a downturn.

In 2009, the government responded to the crisis with an expansionary counter-cyclical policy. The results suggest that it was the largest fiscal impulse over the past decade (estimated at about 5 percent of potential GDP), while automatic stabilizers contributed about 1 ½ percent of potential GDP to the deterioration in the primary balance. Such a counter-cyclical stance, while supporting the economy during the worst recession in years, came at the expense of rapid debt accumulation.[19] Armenia's debt remains sustainable. However, the rapid pace of its accumulation and rising spending pressures related to the planned pension reforms underscore the importance of pursuing prudent fiscal policy to maintain debt sustainability over the medium-to-long term.

Clearly, there is some tension between ensuring sustainability and limiting pro-cyclicality in the design of fiscal policy. Therefore, ensuring fiscal prudence at good times is a key to alleviating some of this tension, as it would provide fiscal space to conduct a counter-cyclical policy when it is much needed.

Several options could be considered to improve the balance between sustainability and cyclicality concerns in the design of the fiscal framework in Armenia. First, fiscal rules are correlated with good fiscal performance and therefore it might be helpful to strengthen the

---

[19] The ratio of public debt-to-GDP rose from 16 percent at end-2008 to 39 percent at end-2009.

current fiscal rules under the Armenian Law.[20] For instance, the introduction of an annual target on the cyclically-adjusted primary balance complemented with expenditure rules would provide a straightforward mechanism for allowing flexibility to respond to output shocks, while limiting pro-cyclicality. Expenditure rules are not only directly under the control of the policymakers, but they are easy to monitor, and are linked to debt targets when combined with a budget balance rule.[21] Such a framework could also strengthen the link between the medium-term expenditure framework that Armenia has in place and the annual budget process.

Second, and given that automatic stabilizers ensure a prompter and self-correcting fiscal response, several options could be considered to strengthen automatic fiscal stabilizers without increasing the size of the government in Armenia.[22] These include increasing revenue collection through broadening the tax base, reducing the size of the informal economy, addressing persistent institutional and governance weaknesses, particularly in tax administration, and increasing the progressivity of the income tax system.

While targeting the cyclically-adjusted primary balance can potentially be used to avoid pro-cyclicality, a number of issues arise in calculating such a fiscal indicator. Therefore, caution should be used in precisely calibrating the fiscal stance. Estimating the output gap in an economy that has undergone considerable structural changes and experienced a number of shocks, as is the case in Armenia, is subject to large uncertainties. Second, the constant elasticity assumption employed in this study, while providing a reasonable approximation, may introduce distortions in the estimates of automatic stabilizers in case of changes in the composition of revenue.

VI. SUMMARY AND CONCLUSIONS

Recently there has been an increased interest in the implications of the global economic crisis for potential output and the output gap. Against this background, the present paper provides a comprehensive overview of several estimation techniques to estimate potential output and the output gap for Armenia between 2000 and 2009. The findings of the paper show that the output gap is significantly positive in 2007 and 2008 and is falling dramatically in 2009. The Bayesian estimation results indicate that the output gap may return into slightly positive territory at the end of 2010.

The paper then moves on to using those output gap estimation results to estimate both a closed and open-economy version of the New Keynesian Phillips curve for the Armenian economy. The results indicate that the New Keynesian Phillips curve explains inflation in

---

[20] Armenia adopted fiscal rules in 2008, under which the public debt may not exceed 60 percent of GDP in any given year, and if the ratio of public debt over the previous year's GDP is above 50 percent, the deficit in the following year should be lower than 3 percent of the average GDP of the previous three years.

[21] For a detailed discussion of fiscal rules, see Baldacci et al. (2009).

[22] For further details on how to strengthen automatic fiscal stabilizers, see Baunsgaard and Symansky (2009).

Armenia well, with a significant role of the output gap and inflation expectations in determining current inflation. Given that inflation expectations seem to play a significant role in determining current inflation, monetary policy becomes partly an art of managing those expectations. Thus, the findings of the paper have important implications for the communication and transparency practices of the Central Bank of Armenia.

Finally, the paper employs those output gap measures to assess the underlying fiscal stance by estimating the cyclically-adjusted fiscal balance for Armenia over the period 2000–09. The results indicate that Armenia's fiscal deficit is largely structural, while automatic stabilizers are weak. The results also suggest that, while fiscal policy was largely pro-cyclical in the past even at periods of negative output gaps—a result that highlights the importance of fiscal discipline during good times—it was expansionary in 2009, providing a counter-cyclical support to the economy during the worst recession in years. These findings have important implications for fiscal policy formulation going forward. The authorities should consider ways to strengthen fiscal rules in order to enhance fiscal discipline over the business cycle. Furthermore, it would be beneficial to introduce measures to strengthen automatic stabilizers by enhancing revenue collection and by addressing Armenia's persistent institutional and governance weaknesses, particularly in tax administration.

REFERENCES

Baldacci, E., M. Kumar, and A. Schaechter, 2009, "Fiscal Rules—Anchoring Expectations for Sustainable Public Finances," IMF Board Paper, SM/09/274.

Baunsgaard, T., and Steven Symansky, 2009, "Automatic Fiscal Stabilizers," IMF Staff Position Note, SPN/09/23, September 28, 2009.

Benes, J., K. Clinton, R. Garcia-Saltos, M. Johnson, D. Laxton, and T. Matheson, 2009, "The Global Financial Crisis and its Implications for Potential Output," forthcoming IMF Working Paper.

Benes, J., and Papa N'Diaye, 2004, "A Multivariate Filter for Measuring Potential Output and the NAIRU: Application to the Czech Republic," IMF Working Paper 04/45 (Washington: International Monetary Fund).

Billmeier, Andreas, 2004, "Ghostbusting: Which Output Gap Measure Really Matters?" IMF Working Paper 04/146 (Washington: International Monetary Fund).

Blanchard, Olivier, 1990, "Suggestions for a New Set of Fiscal Indicators," OECD Economics Department Working Paper, No. 79, OECD Publishing.

Clark, Peter, 1989, "Trend Reversion in Real Output and Unemployment," *Journal of Econometrics*, Vol. 40, pp. 15-32.

Davoodi, H., and David Grigorian, 2007, "Tax Potential vs. Tax Effort: A Cross-Country Analysis of Armenia's Stubbornly Low Tax Collection," IMF Working Paper 07/106 (Washington: International Monetary Fund).

Dalsgaard, T., and Alain de Serres, 1999, "Estimating Prudent Budgetary Margins for 11 EU Countries: A Simulated SVAR Model Approach," OECD Economics Department Working Papers No. 216, OECD Publishing.

European Commission, 2005, "New and Updated Budgetary Sensitivities for the EU Budgetary Surveillance," Information Note for the Economic and Policy Committee, European Commission, ECFIN/B/6(2005) REP54508, September 2005.

Fedelino, A., M. Horton, and A. Ivanova, 2009, "Computing Cyclically-Adjusted Balances and Automatic Stabilizers," Technical Notes and Manuals 09/05 (Washington: International Monetary Fund).

Gali, J., M. Gertler, and J.D. Lopez-Salido, 2005, "Robustness of the Estimates of the Hybrid New Keynesian Phillips Curve," *Journal of Monetary Economics*, Vol. 52, pp. 1107-1118.

Gali, J. and Mark Gertler, 1999, "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics*, Vol. 44, pp. 195-222.

Gali, J. and Tommaso Monacelli, 2005, "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies*, Vol. 72, pp. 707-734.

Girouard, N., and Christophe André, 2005, "Measuring Cyclically-adjusted Budget Balances for OECD Countries," OECD Economics Department Working Papers, No. 434, OECD Publishing.

Giorno, C., P. Richardson, D. Roseveare, and P. van den Noord, 1995, "Estimating Potential Output, Output Gaps, and Structural Budget Balances," OECD, Economics Department Working Paper, Vol. 152.

Gracia, Borja, 2008, "Enhancing Fiscal Policy in Armenia," Selected Issues Paper, IMF Country Report No. 08/375 (Washington: International Monetary Fund).

Gramlich, E. M. 1990, "Fiscal Indicators," OECD Economics Department Working Papers, No. 80, OECD Publishing.

Konuki, Tesuya, 2008, "Estimating Potential Output and the Output Gap in Slovakia," IMF Working Paper 08/275 (Washington: International Monetary Fund).

Linde, Jesper, 2005, "Estimating New-Keynesian Phillips Curves: A Full Information Maximum Likelihood Approach," *Journal of Monetary Economics*, Vol. 52, pp. 1135-1149.

Mihailov, A., F. Rumler, and J. Scharler, 2009, "The Small Open-Ecoonmy New Keynesian Phillips Curve: Empirical Evidence and Implied Inflation Dynamics," *Open Economies Review*, 10.1007/s11079-009-9125-9.

Oomes, Nienke, and Oksana Dynnikova, 2006, "The Utilization-Adjusted Output Gap: Is the Russian Economy Overheating," IMF Working Paper 06/68 (Washington: International Monetary Fund).

Van den Noord, P., 2000, "The Size and Role of Automatic Fiscal Stabilizers in the 1990s and Beyond," OECD Working Paper, No. 230.

Watson, Mark, 1989, "Univariate Detrending Methods with Stochastic Trends," *Journal of Monetary Economics*, Vol. 18, pp. 49-75.

Wolswijk, G., 2007, "Short-And-Long-Run Tax Elasticities: The Case of the Netherlands," European Central Bank, Working Paper Series, No. 763 / June 2007.

Woodford, Michael, 2003, *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton: Princeton University Press).

APPENDIX

A. Non-Bayesian Estimation Techniques

A.1 Hodrick-Prescott Filter

This approach views the estimation problem as a statistical exercise in which actual output data are used to construct an estimate of potential output. Time series techniques are used to fit trend lines through the data and these trends provide measures of the underlying equilibrium values (Benes and N'Diaye, 2004).

When using this filter, one needs to apply some judgment as to how smooth the trend that is being fitted should be. As Benes and N'Diaye (2004) point out, if the shocks to the economy are primarily demand driven, then potential output does not move closely with actual data on output and a higher degree of smoothing in the filter should be used. The opposite applies when there are supply shocks with a lower degree of smoothing in this case being appropriate.

An important shortcoming of the HP filter is that estimates become relatively imprecise at the end of the sample since trends are estimated as two-sided moving averages of the data ("end-point bias"). Furthermore, whilst univariate filters are easy to implement, they provide no economic understanding of the sources of growth. They also do not exploit interactions among unemployment, output, and inflation. Nevertheless, these filters are used widely in the literature, presumably because often there are no data available to estimate more complicated economic models.

A.2 Production Function Approach

The production function approach is used widely in the literature and models potential output as a function of potential labor and capital inputs as well as total factor productivity (TFP). Thus, this approach exploits economic theory to estimate potential output. The production function is typically assumed to be of Cobb-Douglas form:

$$Y = A \times L^\alpha \times K^{(1-\alpha)} \tag{A.1}$$

where Y denotes output, A denotes total factor productivity growth and L and K refer to labor and capital inputs, respectively. The labor share is denoted by α. Thus potential output is assumed to evolve according to the following equation:

$$Y^* = A^* \times L^{*\alpha} \times K^{*(1-\alpha)} \tag{A.2}$$

where Y^* denotes potential output, A^* denotes potential total factor productivity growth, and L^* and K^* refer to full employment labor and capital inputs, respectively. Hence, estimating potential output involves identifying full-employment capital and labor input levels, potential TFP and the labor share.

The production function approach makes use of microeconomic links between potential output and its inputs, and thereby, provides useful information on the determinants of potential output growth. Such information is of independent value as it may help guide policies to raise productivity. However, the estimates of the output gap depend crucially on the detrending method used for smoothing components of factor inputs (typically the HP filter). Thus, any shortcomings of the HP filter pointed out above will also affect the estimate of the output gap derived from the production function approach. There are alternatives to these traditional trend-fitting and filtering methods used to obtain potential labor and capital inputs. For example, Oomes and Dynnikova (2006) use survey data to estimate natural rates of capacity and labor utilization. However, such survey data are not available for Armenia. A related disadvantage of the production function approach in the case of Armenia arises from the need for high quality data on the capital stock and the labor force. In Armenia such data is likely to be subject to considerable measurement errors.

In order to obtain the full employment labor input, the HP filter ($\lambda=400$) is applied to the quarterly seasonally adjusted series of actual employment for the period 2000-2009. There is annual data available for the labor share in Armenia from 1995–2007 and the paper uses the average of these data points as an estimate of the labor share. The labor share is fixed at this average value of 0.44 throughout the estimation period of 2000–09. Following the previous literature (Billmeier, 2004), it is assumed that the full-employment capital stock equals the actual total capital stock. In order to estimate the actual capital stock, we first calculate the real capital stock for the first quarter of 2000 by dividing real gross capital formation by its average growth rate (g) and the annual depreciation rate (δ), which is assumed to equal 4 percent, a standard assumption in the previous literature (e.g. Billmeier, 2004, Konuki, 2008). In order to get the real capital stock after 2000Q1, the following formula is employed:

$$K_t = (1 - \delta)K_{t-1} + I_t \tag{A.3}$$

where K_t denotes the real capital stock and I_t is real gross fixed capital formation. Using the labor share, real GDP, actual employment, and the real capital stock, equation (A.1) can be used to calculate the TFP. The HP filter ($\lambda=400$) is then used to de-trend both the TFP and real capital stock series. Potential output can then be calculated using equation (A.2). After converting these estimates of potential output into logarithmic form, the output gap is given as the deviation of the log of potential output from the log of actual output.

A.3 Unobserved Components Model

Since the unobserved components (UC) model is less well known than the HP filter, a brief review of its specification, which follows Watson (1989) and Clark (1989) is presented. Let y_t, y_t^p and z_t denote the logarithms of actual and potential output and the output gap. In order to estimate the latter two variables; the following identity is used, which specifies output as the sum of potential output and the output gap:

$$y_t = y_t^p + z_t. \tag{A.4}$$

It is also assumed that potential output follows a random walk with drift,

$$y_t^p = \mu_{t-1} + y_{t-1}^p + \varepsilon_t \tag{A.5}$$

where $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$. The drift parameter, μ_t, follows a random walk,

$$\mu_t = \mu_{t-1} + \varepsilon_t^\mu \tag{A.6}$$

where $\varepsilon_t^\mu \sim N(0, \sigma_\mu^2)$. It should be noted that if $\sigma_\mu^2 = 0$, then the rate of growth is constant over time. Furthermore, the UC model assumes that the output gap evolves according to a second-order autoregressive process:

$$z_t = \varphi_1 z_{t-1} + \varphi_2 z_{t-2} + \epsilon_t^z \tag{A.7}$$

where $\epsilon_t^z \sim N(0, \sigma_z^2)$.

When using the UC approach, one important methodological issue is how to determine starting values for the Kalman filter. In addition, as was the case for the HP filter, the unobserved components model provides no economic understanding of the sources of growth. It also does not exploit interactions among unemployment, output and inflation. Furthermore, the parameter values, φ_1 and φ_2 are assumed to be time-invariant.

A.4 Multivariate Kalman Filter

This approach combines a time series model with structural economic information. One advantage of this approach is its ability to take into account the economic links between the output gap and other economic indicators. This method treats the filtering problem as a small system in which the estimates of potential output and some of the parameters of a dynamic system are treated simultaneously. This method has been used to estimate potential output in both Slovakia and the Czech Republic (Konuki, 2008; Benes and N'Diaye, 2004). Similarly to Armenia, both countries have seen a significant degree of structural change and volatile economic environments. For example, Benes and N'Diaye (2004) add to the standard UC framework a Phillips curve equation and an Okun's law equation that links movements in unemployment to those in the output gap. A possible extension to these previous studies would be to introduce time-varying parameters into the multivariate Kalman filtering framework with the hope of capturing much more of the volatility and structural change that characterize emerging market economies. As such, a multivariate extended Kalman filter has not yet been employed in the previous literature; this would be an interesting direction for further research.

One potential disadvantage of the multivariate Kalman filter approach is that the results may be sensitive to the choice of starting values. Furthermore, some judgment is needed when developing a small system of the economy. For example, is it reasonable to assume that the output gap follows a second-order autoregressive process or should a higher order autoregressive process be used? Which relationships between labor, prices and output should be incorporated into the model? Data availability might also be an issue for Armenia since fairly long time series are needed. Konuki (2008) uses quarterly data for 1996–2010 from the

IMF's Spring WEO (including forecasts). Benes and N'Diaye (2004) use quarterly data series from 1994-2004.

The paper estimates a simple multivariate Kalman filter model to which a Phillips curve relationship with static inflation expectations is added. This follows the analysis by Konuki (2008). In addition to equations (A.4)-(A.7), the following equation is estimated:

$$\Delta^2 \log(ULC_t) = \alpha + \beta z_t + \varepsilon_t^{ULC} \tag{A.8}$$

where $\varepsilon_t^{ULC} \sim N(0, \sigma_{ULC}^2)$. It should be noted that $\Delta^2 \log(ULC_t)$ denotes the change in the growth rate of the log of unit labor costs.

B. Figures and Tables

Figure 1: Output Gap Estimates Based on the HP Filter.

Estimates of Potential (in logs)
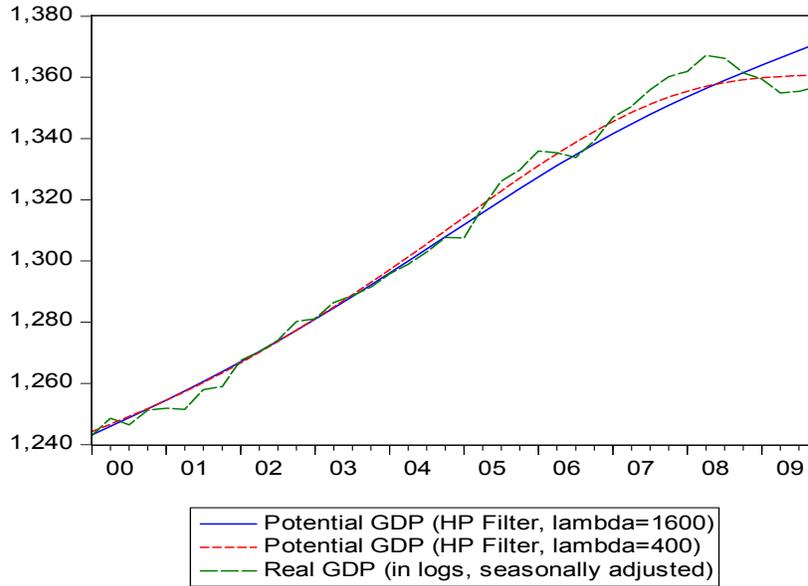
Output Gap Estimates (in percent)
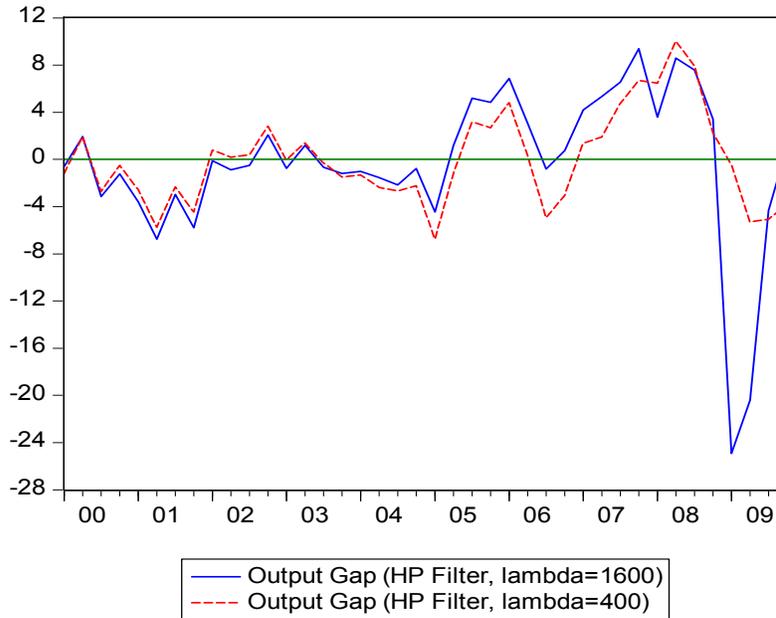
Figure 2: Output Gap Estimates Based on the Production Function Estimates of Potential (in logs)
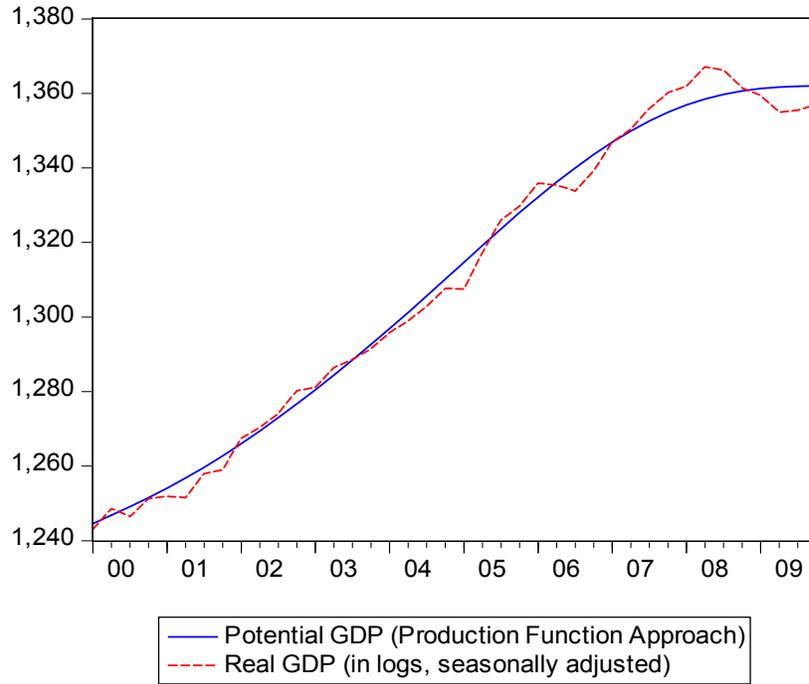
Output Gap Estimates (in percent)
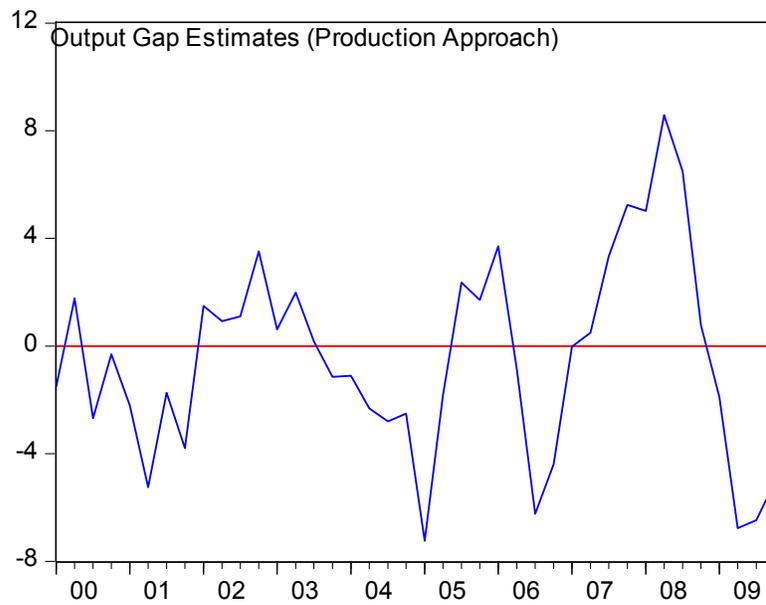
Figure 3: Output gap estimates based on the Univariate Kalman Filter Estimates of Potential (in logs)
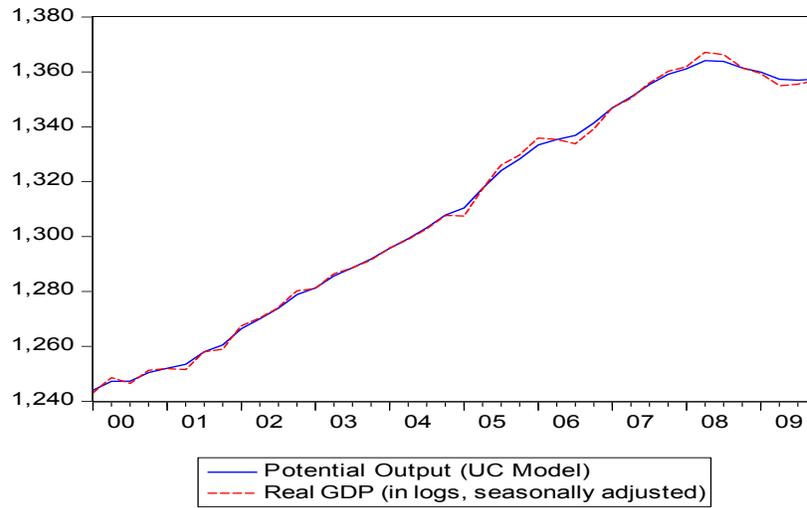
Output Gap Estimates (in percent)
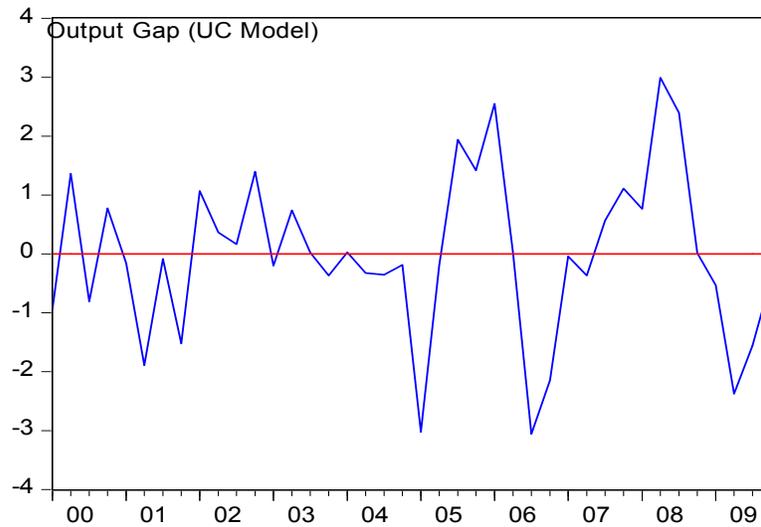
Figure 4: Output Gap Estimates Based on a Simple Multivariate Kalman Filter Estimates of Potential (in logs)
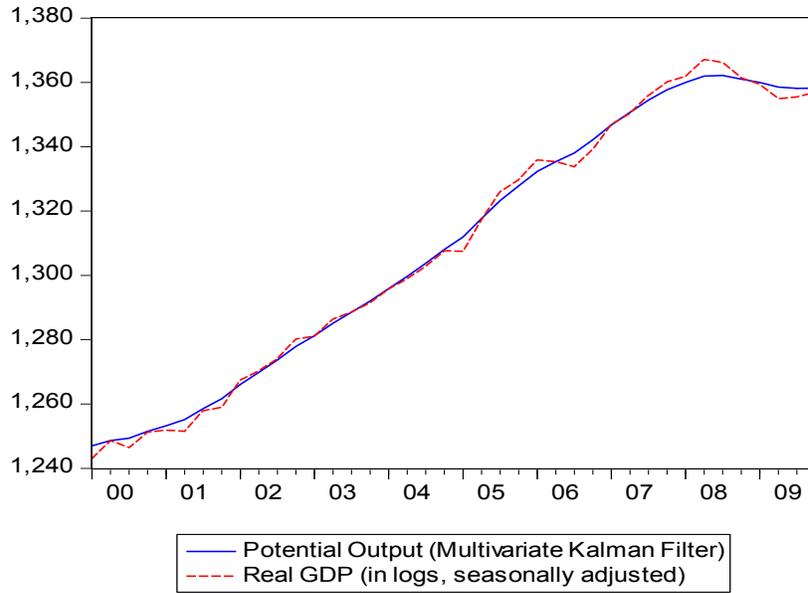
Output Gap Estimates (in percent)
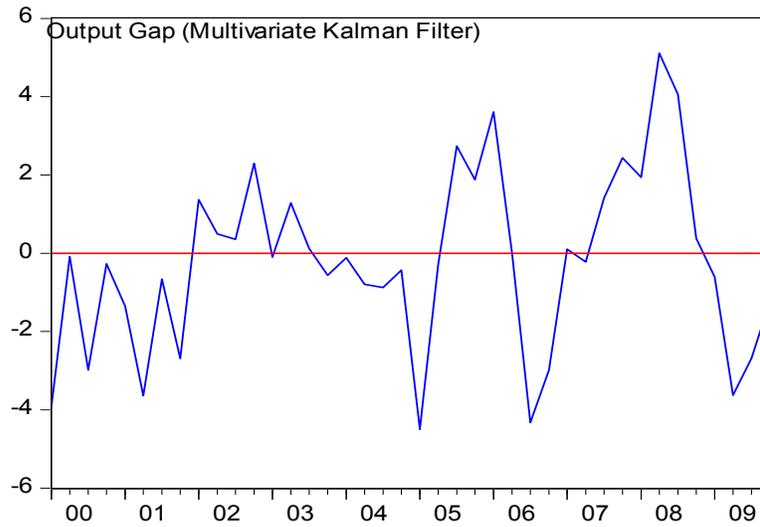
Figure 5: Output Gap Estimates: A Comparison Among Non-Bayesian Estimation Methods (in percent)
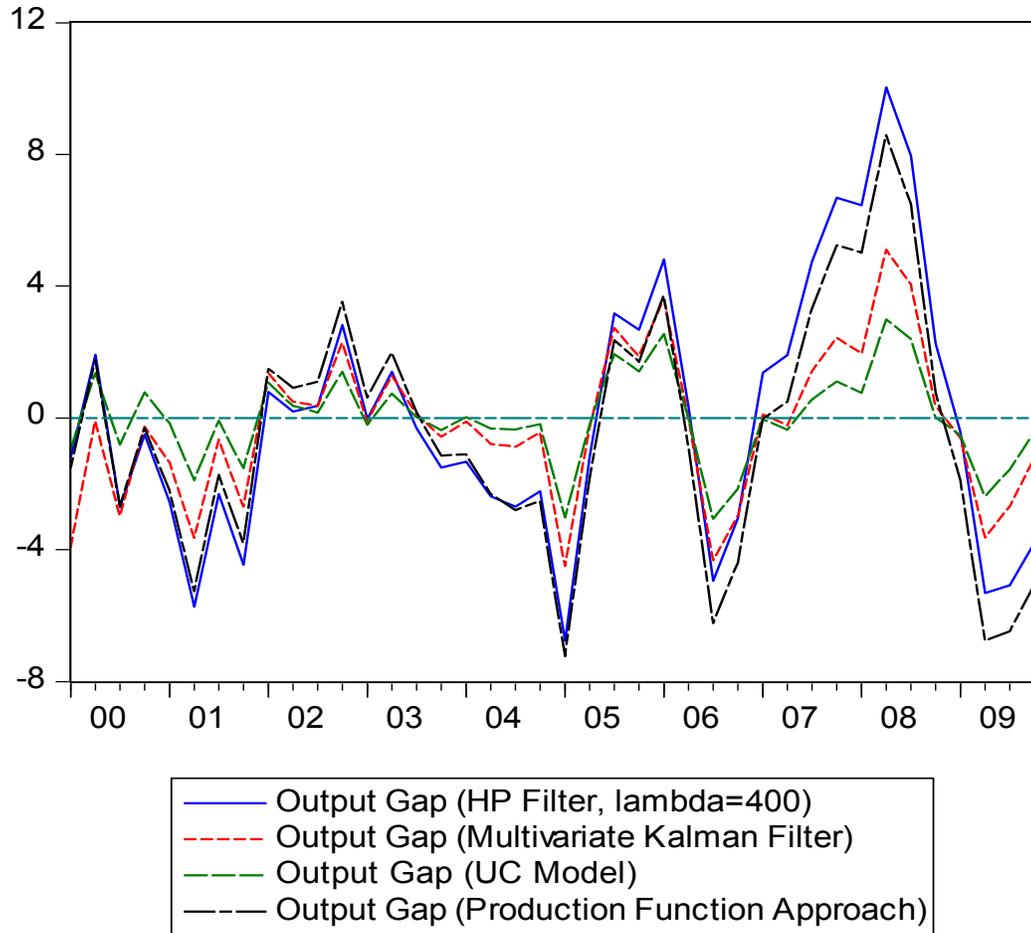
Figure 6: Bayesian Estimation Results (in percent)

Economic activity gaps
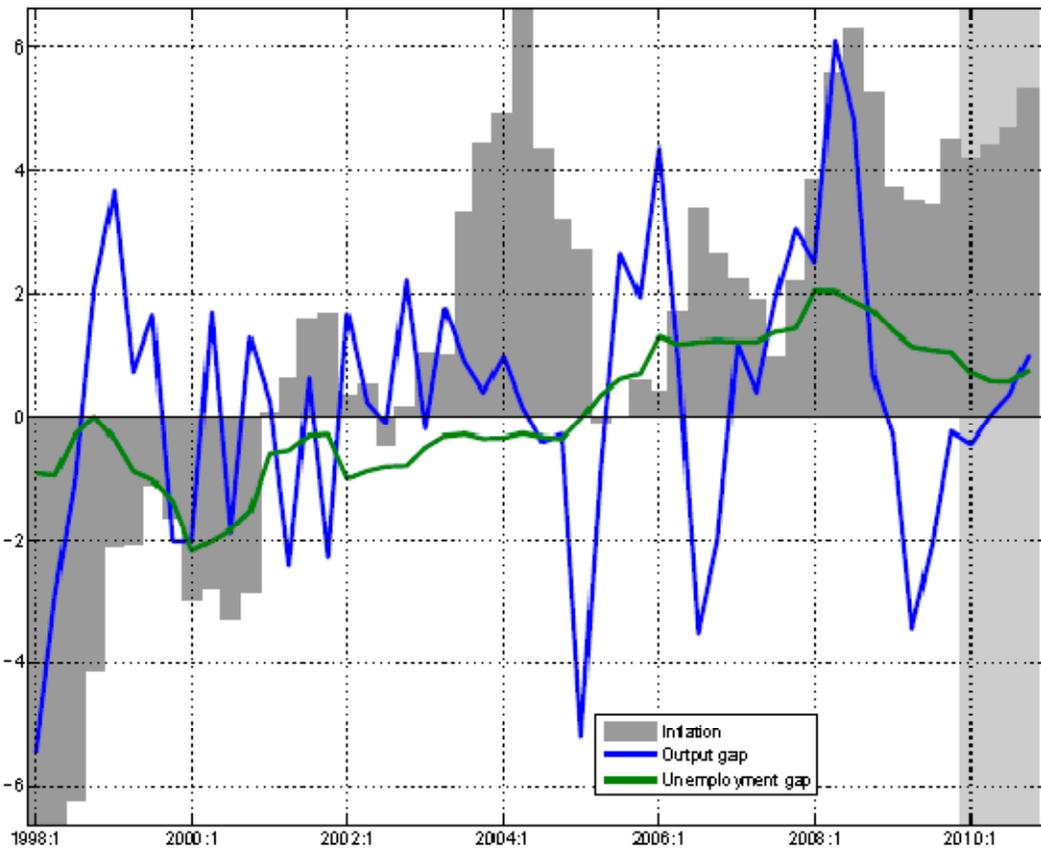
Figure 7: Real Time Estimates, HP Filter (in percent)

Real-time output gap (HP)
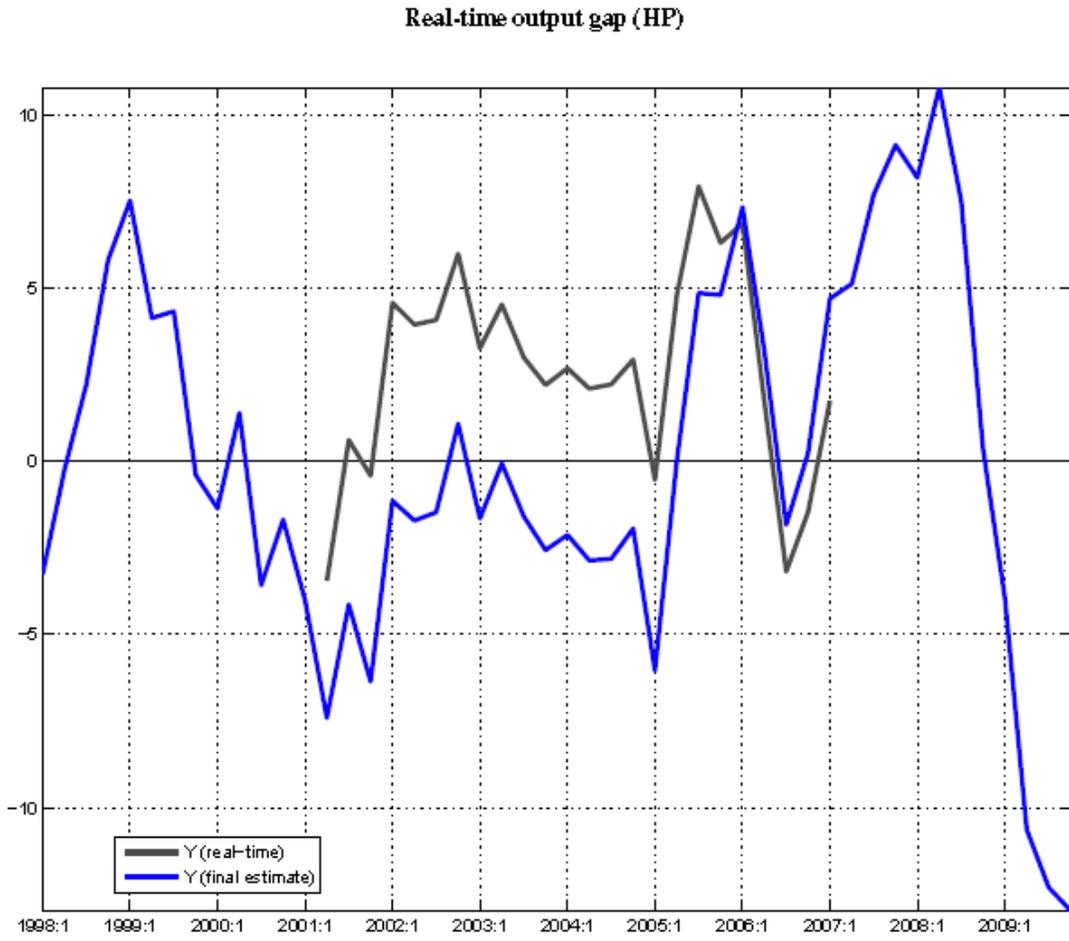
Figure 8: Real Time Estimates, Bayesian Estimation (in percent)

Real-time output gap (MV)

**Figure 9. Armenia: Cyclically-Adjusted Primary Balance
(2000-09, Percent of Potential GDP)**

Legend: Bayesian, Multivariate Kalman, Simple Kalman, Production Function, HP Filter

Figure 10. Armenia: Central Government Primary Balance and Its Cyclical and Cyclically-Adjusted Components (2000-09, Percent of Potential GDP)

Figure 11. Armenia: Contribution of Automatic Stabilizers and Fiscal Impluse to Changes in Primary Balance (2000-09, Percent of Potential GDP)

Table 1: Maximum Likelihood Estimates, UC Model

φ_1	0.6512
	(0.3301)
	[0.0485]
φ_2	-0.0947
	(0.1395)
	[0.4972]
σ_ε^2	1.3158
	(2.2794)
	[0.5638]
σ_μ^2	-0.0538
	(0.9286)
	[0.9668]
σ_z^2	1.3183
	(1.4970)
	[0.3785]
Log-Likelihood	-156.863

Note: Standard errors in parentheses and p-values in brackets.

Table 2: Maximum Likelihood Estimates, Multivariate Kalman Filter

α	0.0541
	(1.5682)
	[0.9725]
β	0.1408
	(0.6510)
	[0.8311]
σ^2_{ULC}	4.4407
	(0.1332)
	[0.0000]
φ_1	0.7429
	(0.1348)
	[0.0000]
φ_2	6.53E-06
	(0.2217)
	[0.9998]
σ^2_z	1.6885
	(0.3561)
	[0.0000]
Log-Likelihood	-338.746

Note: Standard errors in parentheses and p-values in brackets.

Table 3: Prior and Posterior Distributions

Maximum regularised likelihood

Parameter	Prior		Posterior	
	Mode	Dispersion	Mode	Dispersion
alpha	0.500	0.032	0.500	0.012
beta	0.400	0.063	0.369	0.024
omega	0.500	0.063	0.457	0.024
rho1	0.800	0.032	0.798	0.012
kappa1	0.100	0.126	0.100	0.048
phi1	0.800	0.032	0.801	0.012
phi2	0.300	0.032	0.294	0.012
tau	0.100	0.032	0.097	0.011
delta	0.500	0.032	0.500	0.012
kappa2	1.500	0.316	1.500	0.122
parhist	5.000	0.632	4.981	0.235
rho2	5.000	0.632	5.003	0.235
lambda	1.000	0.632	1.025	0.231
std_RES_Y	1.000	0.063	0.991	0.024
std_RES_G	1.000	0.063	1.008	0.024
std_RES_UNR_GAP	0.500	0.063	0.468	0.024
std_RES_UNR_BAR	0.100	0.032	0.098	0.012
std_RES_UNR_G	0.100	0.032	0.098	0.012
std_RES_CAPU_GAP	0.400	0.063	0.400	0.024
std_RES_CAPU_BAR	0.250	0.032	0.250	0.012
std_RES_CU_G	0.075	0.006	0.075	0.002
std_RES_PIE	0.500	0.063	0.535	0.022
std_RES_PIELTE	0.300	0.063	0.300	0.024

Table 4: OLS, Backward-Looking Phillips Curve

Dependent Variable: CPI_CQ
Method: Least Squares
Date: 04/19/10   Time: 19:04
Sample (adjusted): 1999Q3 2009Q4
Included observations: 42 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI_CQ(-1)	1.078537	0.128592	8.387267	0.0000
CPI_CQ(-2)	-0.187802	0.105393	-1.781919	0.0826
GAP(-1)	0.206376	0.073117	2.822536	0.0075
R-squared	0.826383	Mean dependent var		1.753431
Adjusted R-squared	0.817479	S.D. dependent var		2.527579
S.E. of regression	1.079843	Akaike info criterion		3.060258
Sum squared resid	45.47639	Schwarz criterion		3.184377
Log likelihood	-61.26541	Hannan-Quinn criter.		3.105752
Durbin-Watson stat	1.744425			

Table 5: GMM Estimates, New Keynesian Phillips Curve

Estimation Method: Generalized Method of Moments

Sample: 2000Q1 2009Q3
Included observations: 39
Total system (balanced) observations 39
White Covariance
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.303790	0.088327	3.439377	0.0015
C(2)	0.664551	0.087376	7.605644	0.0000
C(3)	0.165598	0.045189	3.664559	0.0008

Determinant residual covariance	0.538541
J-statistic	0.365197

Equation: CPI_CQ=C(1)*CPI_CQ(1)+C(2)*CPI_CQ(-1)+C(3)*GAP
Instruments: CPI_CQ(-1) CPI_CQ(-2) CPI_CQ(-3) CPI_CQ(-4) GAP(-1)
    GAP(-2) GAP(-3) GAP(-4) GAP(-5) GAP(-6) C
Observations: 39

R-squared	0.910443	Mean dependent var	1.843225
Adjusted R-squared	0.905468	S.D. dependent var	2.484281
S.E. of regression	0.763819	Sum squared resid	21.00312
Durbin-Watson stat	2.216613		

Table 6: GMM Estimates, Open Economy New Keynesian Phillips Curve

Estimation Method: Generalized Method of Moments

Sample: 2000Q1 2009Q3
Included observations: 39
Total system (balanced) observations 39
White Covariance
Iterate coefficients after one-step weighting matrix
Convergence achieved after: 1 weight matrix, 7 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.405174	0.054518	7.431937	0.0000
C(2)	0.586910	0.054931	10.68454	0.0000
C(3)	0.198147	0.033227	5.963417	0.0000
C(4)	0.064770	0.026731	2.422994	0.0207

Determinant residual covariance	0.423428
J-statistic	0.443380

Equation: CPI_CQ=C(1)*CPI_CQ(1)+C(2)*CPI_CQ(-1)+C(3)*GAP+C(4)
    *DTOT_CBA+C(4)*C(1)*DTOT_CBA(1)
Instruments: CPI_CQ(-1) CPI_CQ(-2) CPI_CQ(-3) CPI_CQ(-4) GAP(-1)
    GAP(-2) GAP(-3) GAP(-4) GAP(-5) GAP(-6) DTOT(-1) DTOT(-2) DTOT(
    -3) DTOT(-4) DTOT(-5) DTOT(-6) C
Observations: 39

R-squared	0.929586	Mean dependent var	1.843225
Adjusted R-squared	0.923551	S.D. dependent var	2.484281
S.E. of regression	0.686891	Sum squared resid	16.51369
Durbin-Watson stat	2.450555		

	Primary Balance	Cyclical Primary Balance	Cyclically-Adjusted Primary Balance	Share of Cyclical Component	Share of Cyclically-Adjusted Component
Table 7: Armenia: Primary Balance and its Composition (2000-09, Percent of Potential GDP)					
2000	-6.4	-0.1	-6.3	1	99
2001	-5.1	-0.2	-4.9	5	95
2002	-3.8	0.2	-3.9	-5	105
2003	-4.0	0.1	-4.1	-3	103
2004	-2.2	0.0	-2.2	0	100
2005	-2.4	0.0	-2.4	1	99
2006	-2.5	0.0	-2.5	0	100
2007	-3.5	0.4	-3.9	-13	113
2008	-2.3	0.8	-3.2	-37	137
2009	-8.5	-0.4	-8.0	5	95

Table 8: Armenia: Contribution of Automatic Stabilizers and Fiscal Impulse to Changes in the Primary Balance (2000-09, Percent of Potential GDP)					
	Output Gap (Percent deviation from potential output)	Change in the Primary Balance	Automatic Stabilizers	Fiscal Impulse	Fiscal Stance
2000	-0.4	2.1	-0.3	2.4	Pro-cyclical contractionary
2001	-1.2	1.3	-0.2	1.4	Pro-cyclical contractionary
2002	0.9	1.3	0.4	0.9	Counter-cyclical contractionary
2003	0.6	-0.2	-0.1	-0.2	Pro-cyclical expansionary
2004	0.0	1.9	-0.1	2.0	Contractionary
2005	-0.1	-0.2	0.0	-0.2	Neutral
2006	0.0	-0.1	0.0	-0.1	Neutral
2007	2.0	-1.0	0.4	-1.4	Pro-cyclical expansionary
2008	3.8	1.1	0.4	0.7	Counter-cyclical contractionary
2009	-1.6	-6.1	-1.3	-4.9	Counter-cyclical expansionary

Table 9: Data Sources

Variable	Description	Frequency	Sample	Source
Real GDP	in prices of the same quarter of the previous year, AMD millions	Quarterly	1998Q1-2009Q4	NSS
Core Inflation Index	Seasonally Adjusted	Monthly	1998M1-2009M12	NSS
Quarterly Core Inflation Index	Avg. of each quarter of monthly core inflation index	Quarterly	1998Q1-2009Q4	Own calculations
Current Account Balance	In percent of GDP	Annual	2000-2009	World Economic Outlook Database
Headline Inflation Index	Seasonally Adjusted	Monthly	1998M1-2009M12	NSS
Quarterly Headline Inflation Index	Avg. of each quarter of headline inflation index	Quarterly	1998Q1-2009Q4	Own calculations
Employment	thousands people	Quarterly	1998Q1-2009Q4	NSS
Avg. Nominal Wage	AMD	Quarterly	1998Q1-2009Q4	NSS
Nominal Unit Labor Cost	(Nominal Wage* Employment)/ Nominal GDP	Quarterly	1998Q1-2009Q4	Own calculations
Gross accumulation of fixed assets (Gross capital Formation)	in previous year constant prices, AMD millions	Quarterly	1998Q1-2009Q4	NSS
Unemployment	In percent	Quarterly	1998Q1-2009Q4	NSS
Labor share	Compensation of employees/ gross value added at current prices	Annual	1995-2007	Own calculations
Real Productivity	Real GDP (SA)/Employment	Quarterly	1998Q1-2009Q4	Own calculations
Avg. Real Wage	in prices of the same quarter of the previous year, AMD	Quarterly	1998Q1-2009Q4	Own calculations
Terms of Trade	Index	Quarterly	1998Q1-2009Q4	CBA
Revenues	Nominal revenue as a share of GDP	Annual	2000-2009	MOF
Expenditures	Nominal expenditures as a share of GDP	Annual	2000-2009	MOF
Primary expenditures	Nominal primary expenditures as a share of GDP	Annual	2000-2009	Own calculation