Inflation and Output in Armenia: the Threshold Effect Revisited

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Prepared for the Third International AIPRG conference on Armenia

January 15-16, 2005
World Bank
Washington, D.C.

Keywords: Armenia; inflation; growth; threshold effect; total factor productivity
JPE Classification: E31; O40

[†] Author would like to thank Nerses Yeritsyan from AIRPG Yerevan office and Vache Gabrielyan from Central Bank of Armenia for their valuable comments and suggestions. Author also extends his gratitude to Dr. Jeffrey Wooldridge, distinguished professor, and Ana María Herrera, assistant professor, at Michigan State University for their invaluable lectures on econometrics, as well as Tania M. Balci from Financial Markets International, Inc. for continuous help and support in editing this paper.

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Abstract

This paper examines the relationship between inflation and output growth in Armenia. The purpose is to test for a threshold level of inflation at which the effect of inflation on growth changes from negative to positive, as inflation passes that level. The threshold level of inflation is calculated using specific econometric technique, which though was primarily used for panel data models, is applicable to time series models as well. The paper starts with a review of the literature and research available on the relationship between inflation and output, and links the two together. After setting up and calculating the model, endogeneity issues are addressed. Policy implications follow for Armenian economy arguing that targeting a level of inflation higher than current but not exceeding calculated threshold level might be beneficial for Armenia.

INTRODUCTION

Low inflation and sustainable output growth – that is what all the countries would wish for themselves. Not surprisingly extensive research on the relationship between inflation and output has been conducted. Is it negative, positive or neutral? Does the causality run from inflation to growth or from growth to inflation? These are the global issues addressed.

In the sixties, models of inflation and growth were dominated by the portfolio substitution mechanism, which said higher inflation makes capital more attractive than money, which induces per capita investments and brings higher growth. Economic studies of the 50s and 60s did not show any significant negative relationship between inflation and growth. Rather, a slight positive correlation was found.

In the 1970s and 80s, empirical models that demonstrated a negative correlation between inflation and growth were proposed. As Fischer (1983) pointed out, higher inflation is associated with lower growth because lower real balances reduce efficiency of factors of production, which leads to lower output growth.

Fischer (1993) was one of the pioneers to present the idea of a nonlinear relationship between inflation and output growth. He identified that although there is a negative relationship between the two, at some low levels of inflation one can find positive correlation with output growth. This idea gave birth to a number of studies devoted to finding the threshold rate of inflation at which the impact of inflation on output growth changes it sign. Particularly, papers by Sarel (1996) and Khan and Senhadji (2000) are noteworthy.

In this paper I try to find such a non-linear relationship between inflation and growth for Armenia using quarterly data from 1996-2004.

Thus this paper asks the following questions:

- Is there a non-linear relationship between inflation and output growth in Armenia?
- If yes, what is the threshold level of inflation for Armenia?
- Is it significantly different from zero?

The paper is organized in the following manner: Section I is a literature review, with an emphasis on possible linkage mechanisms between inflation and output. It also includes economic trends in Armenia during last decade. In Section II, econometric modeling and data issues are addressed. After interpreting estimation results, sensitivity analysis will be performed on the estimated model in Section III. Policy implications and conclusions will follow.

I. LINKING INFLATION AND OUTPUT

It is now widely accepted that for sustainable economic growth, a sound macroeconomic framework is needed. Fischer (1993), for a cross-section of data, shows that output growth is negatively correlated with inflation and positively correlated with good fiscal performance and a well behaved foreign exchange market. In this paper I follow World Bank (1990) in defining a stable macroeconomic framework as an economy where "…inflation is low and predictable, real interest rates are appropriate, fiscal policy is stable and sustainable, the real exchange rate is competitive and predictable, and the balance of payments situation is perceived as viable". Out of this definition, I would like to focus on "low and predictable inflation", because as we will see later, even though low inflation is not sufficient for fostering growth, it is still necessary condition.

Fischer (1983) outlines the following economic mechanisms that link inflation with output and growth:

(i) The portfolio substitution effect described in Sidaurski (1967), which is discussed below;

(ii) As mentioned in Feldstein (1976), if taxes are not adjusted to the inflation rates it can result in decreasing real returns to capital as inflation rises. This might reduce steady state per capita intensity, which might bring to lower growth rates.

(iii) A negative supply shock leads to a rise in the inflation rate; the growth rate of output simultaneously declines in the short-run, or stays same; long-run level of output decreases.

(iv) If government uses inflation tax, and finances part of its spending by printing money, then a negative supply shock, which will reduce the demand for real money balances, will force government to increase the growth rate of money, which in its turn will result in higher inflation;

(v) Higher inflation rates will lead to lower real balances, which make transactions inefficient in the sense of real resources. More generally, higher inflation creates inefficiency on the price system, and therefore reduces factor productivity;

(vi) The short-run Phillips curve implies negative association of unanticipated inflation rate and output.

As mentioned in introduction, models presented in sixties were based on the hypothesis that inflation is positively associated with the growth of economy, since inflation makes investments more attractive compared to cash, which is loosing its value faster than investments as prices rise. This hypothesis was tested based on data from the 40s and 50s. In some cases this positive relation was found, though it was not always significant. Sidrauski (1967) presented his view of the relationship between money, inflation and growth, and emphasized the portfolio substitution effect as the leading factor of growth in an inflationary environment. He proposed that an increase in the growth rate of money brings higher rates of expected inflation, which in its turn leads to decrease of demand for real balances. With the savings rate given, a higher portion of savings takes the form of physical capital. This leads to higher capital intensity and hence to a higher growth rate.

Sidaurski's proposition failed after stagflation (high inflation and recession) in 1970s. As the world economy entered the period of severe inflation and economic crises in the 70s and 80s, more data become available. Many empirical models showed a negative relationship between inflation and output growth, though evidence was still mixed. Models and empirical evidence of a negative relationship between inflation and output growth were found by Fischer (1983), stating that higher inflation is associated with lower growth since lower real balances reduce the efficiency of factors of production, and because there maybe a link between government purchases and the use of inflation tax. Kormendi and Meguire (1985) tested and proved the positive relationship between inflation and long-run growth for a cross-section of countries. Levine and Renelt (1992) checked the robustness of this and stated a negative effect of inflation again. Further findings belong to Fischer (1991) and Roubini and Sala-i-Martin (1991). De Gregorio (1991) investigated the effect of inflation and checked the evidence for a panel of Latin American countries. He found that decreasing growth is associated with the costs of reducing the inflation, when that activity causes diversion of resources from activities that would lead to higher rates of growth.

All these findings were mainly outlining a negative relationship between high inflation and long-run output growth. Meanwhile in the early 90s, further studies showed a positive relationship of low inflation and high output growth. Particularly, Barro (1991), De Gregorio (1991), Fischer, Sahay and Vegh (1996) show that link for transition economies. It becomes obvious that if low inflation causes higher growth rates and higher inflation causes lower growth rate, some sort of inflexion point should exist, which would characterize change in direction of the effect that inflation causes on output growth. The possibility of such a non-linear relationship was first introduced by Fischer (1993). Sarel (1996) tested the existence of structural break in the relationship between inflation and output growth and found that such a break exists at an annual rate of 8 percent. He showed that below 8 percent the effect of inflation on output growth is slightly positive and very insignificant, meanwhile for inflation rates higher that 8 percent that relationship is significantly negative. Depending on the sample of countries, different authors find different threshold levels. For example Ghosh and Phillips (1998) found a threshold level of 2.5 percent, while Christoffersen and Doyle (1998) found it equal to 13 percent annual inflation rate. Khan and Senhadji (2000) re-examined the nature of the relationship between inflation and growth and particularly questioned whether the effect is different for developing and industrial countries. Accordingly, they found 11 percent annual inflation threshold for developing countries and 1 percent for industrial countries.

Figure 1 shows a scatter diagram for average rate of inflation and output growth for years 1996-2001 for CIS and Eastern Europe developing countries. The solid line on the graph depicts the fitted second order polynomial trendline. The hump-shaped line shows that for a cross-section of countries the higher rate of output growth corresponds to higher rate of annual inflation up to one point; beyond that, inflation is shown to hinder, rather than foster, growth.

All these findings argue for the existence of a threshold level of inflation, below which the effect of inflation is positive or flat, and above which the effect is negative. The flatness brings us back to the point where I mentioned that low inflation is not a sufficient condition of sustainable growth. But it is still necessary for the reasons explained above.

Of all the research conducted on threshold effects, none was done for a specific country using time series data. Rather, panel data was used for a sample of countries. From this point of view, this paper will be the first to apply the threshold model using time series data for a specific country.

However, does the negative relationship that was described above and shown by various economists in cross-section and panel data exist between inflation and output growth in Armenia in time dimension? The scatter diagram in Figure 2 incorporates a second order polynomial trend line, showing that for some low levels of inflation the relationship is positive, however after some point the graph inflects and we see decreasing trend line.

To better understand the economic growth trends prevailing in Armenia, let us introduce basic growth accounting by starting with a simple multiplicative production function with capital and labor:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta}, \text{ where} \qquad (1)$$

Y_t, K_t and L_t are output, capital stock and labor stock respectively, α and β are coefficients of elasticity for capital and labor respectively, and A_t is the efficiency factor by which capital and labor can be used. A_t includes not only level of technological advances, but also all other factors such as hidden employment, number of working hours, legislation, new capacity building, etc., that is all those factors that potentially effect productivity. *t* is the time index.

If we take the logarithms of both sides and take first time differences we come to the following equation:

$$\Delta \log Y_t = \Delta \log A_t + \alpha \Delta \log K_t + \beta \Delta \log L_t \text{, where} \quad (2)$$

α and β have the same interpretation as in (1). $\Delta \log A_t$ are called total factor productivity growth (TFP) or productivity residuals[1]. TFP growth is in fact the rate of efficiency or efficiency gains by which labor and capital are used. Explicitly TFP growth or productivity residuals can be calculated as the difference in output growth ($\Delta \log Y_t$) on one side and change in capital and labor ($\alpha \Delta \log K_t + \beta \Delta \log L_t$) on the other side, that is:

$$\Delta \log A_t = \Delta \log Y_t - \alpha \Delta \log K_t - \beta \Delta \log L_t \quad (3)$$

Depending on how many factors are included on the right hand side of equation (1) or (2) one can come to different values of productivity residuals. Fischer (1993) brings three alternatives of productivity residuals, namely *Bhalla* residuals, *Solow* residuals and *Mankiw-Romer-Weil* residuals. Solow residuals are calculated from a standard Cobb-Douglas production function with α = 0.4 and β = 0.6. Compared to other two types of residuals Solow residuals impose the highest share on capital in its production function which is so typical for developing, rather than developed countries. De Broeck and Koen (2000) calculated TFP growth with coefficients of elasticity for capital and labor set to 0.3 and 0.7 respectively, meanwhile IMF (2004) used 0.4. and 0.6. In this paper I use Solow residuals as our productivity residuals and therefore take α = 0.4 and β = 0.6 while calculating total factor productivity growth[2].

Finally, the calculation of rate of growth of capital remains. The problem is that there are no official statistics about the stock of capital in Armenia. The only way to calculate this number is by using a recursive formula linking capital stock with investments, which is:

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[1] See Prescott (1997) and Hulten (2000) for more on total factor productivity theory.

[2] In ideal case one should estimate production function and thus obtain appropriate shares of capital labor, that is the elasticity coefficients. However this falls out of the scope of research brought in this paper.

$$K_t = (1-\delta)K_{t-1} + I_t \text{, where} \qquad (4)^3$$

K_t is the capital stock at time t and I_t is the investments done during time t. δ is rate of depreciation of capital, that I take constant and equal to 4% a year (or 1% quarterly). With this I follow IMF (2004). But for the recursive equation (4) to be worthy one need to have initial stock of capital K_0. IMF (2004) suggests taking stock of capital in 1990 equal to 1.5 times GDP. Here I acknowledge that using this estimate of capital stock and using formula (4) keeping rate of depreciation constant is very rough. However Loukoianova and Unigovskaya (2004) calculate TFP for extremely high and extremely low depreciation rates and find similar patterns for TFP and capital stock for seven CIS countries including Armenia. And therefore I believe that this assumption would not distort the entire picture.

From 1994, after first stabilization program was introduced in Armenia and initial reforms took place, average capital productivities, calculated as ratio of output over capital and labor stocks respectively, started increasing. As seen from the Figure 3 labor productivity increased almost 2.5 times, meanwhile capital productivity increased by 1.5 times. Such a high increase in labor productivity might be a result of decrease in labor force by up to 400,000 people, by which higher output growth was performed.

Using data given in Table 11 in Loukoianova and Unigovskaya (2004), I put up a graph that depicts total factor productivity growth trends decomposed by sectors. As Figure 4 shows stable productivity growth was noticed in industry and construction, while transport and communication and trade and procurement had very volatile path of TFP growth. Agricultural sector, on the other hand had very high productivity growth in 1997, when intensive capital investments were done into that sector, however the growth almost stopped after that, and resumed only in 2000.

Despite the various bumps in the road, Armenia has, on the whole, experienced strong growth since 1994, the first year of positive real GDP growth. Average real GDP growth has been 7% per year between 1998 and 2003, compared with 4.9% in Georgia, 3.6% in the Kyrgyz Republic, and 2.1% in Moldova during the same period. However, growth in Armenia since 1998 has been driven primarily by the expansion of exports and investments in export-oriented sectors, not by consumption. This is evidenced by an increase in exports as a percentage of GDP from 20% in 1997 to 30% in 2002. As Figures A1 and A2 in Appendix A show net exports were fastest to grow, meanwhile, consumption and government expenditures grew with moderately low pace. From January to September 2004, real GDP grew by 10.3% compared to January-September 2003. This growth is mainly attributed to growth in services, agriculture, and construction.

[3] See Sachs and Larrain (1993) for more.

Prices in Armenia have been stable since 1995, following the exchange rate stabilization. This is because price developments have largely mirrored exchange rate activity, as opposed to reacting to interest rates, credit or wage pressures. Grigorian, Khatchatryan and Sargsyan (2004) attribute this peculiarity to five conditions:

- A narrow credit base, low financial intermediation, and underdeveloped financial and debt markets that render the interest rate and credit channels weak.
- Large inflows of external financing that reduce the demand for CBA reserves, sustain high dollarization, and affect price formation mechanisms. Because a large portion of these flows are driven by external budgetary financing, they are less sensitive to interest rate fluctuations.
- Dollarization limits the scope for monetary policy implementation and effectiveness.
- A sizeable share of imported goods in the domestic consumer market still ensures that the exchange rate pass-through remains strong.
- The impact of monopolistic and administered prices is increasing.

As a result of these conditions, and restrictive aggregate demand policies, prices have remained stable.

II. MODEL SETUP

To test for the existence of the threshold effect, the following regression model is proposed, which is based on the models of estimating threshold effects that can be found in Sarel (1996) or Khan and Senhadji (2000):

$$\Delta \log(y_t) = c + \gamma_1 \pi_t + \gamma_2 d_t (\pi_t - \pi^*) + x_t \beta + u_t \text{, where} \quad (5)$$

y_t is the real GDP, π_t is the inflation rate, π_t^* is the threshold level of inflation, x_t is the vector of significant control variables that can be encountered in growth literature[4]. Dummy variable d_t is chosen such that

[4] Various variables that could be found in Sala-i-Martin (2002), Sarel (1996), Khan and Senhadji (2001) and Iradian (2003) were used. However only those which were significant are kept and reported in the model, although I will mention about them later in the paper.

$$d_t = \begin{cases} 1 \ if \ \ \pi_t > \pi^* \\ 0 \ if \ \ \pi_t \leq \pi^* \end{cases} \quad (6)$$

That is, $\gamma_2 d_t(\pi_t - \pi^*)$ is equal to zero if inflation is below or equal to the threshold level and 1 otherwise. Therefore the effect of inflation will be γ_1 if inflation is less than threshold level, and $\gamma_1 + \gamma_2$ if inflation is higher than threshold level.

In contrast to models presented in Sarel (1996) or Khan and Senhadji (2000), where inflation was presented in logarithmic terms to achieve some sort of non-linearity between inflation and growth rate of GDP, I have to constrain myself by taking levels rather than log transformation of inflation, since Armenia encountered a few periods of deflations, and thus producing some negative values of inflation.

To find the threshold level of inflation equation (5) is estimated for various values of annual inflation rates from the set of [-2, 10], or for quarterly values, since I use quarterly data, for values of inflation in the range [-0.5, 2.5]. Hansen (1999) proposed to identify the threshold level of inflation at the minimum value of the sum of squared residuals for a panel data model, which is valid also for a cross-section and time series models. Since the sum of squared residuals and R^2 are functionally dependent[5], the procedure can be brought to seeking for the maximum of R^2, or *adjusted-*R^2, if number of variables is more than one excluding the constant term.

Besides inflation three other control variables are included in the model, namely investments as share of GDP (*igdp*), budget deficit (*bdef*) and growth rate of total factor productivity (*pr*es). As was already mentioned, the latter is sometimes referred to productivity residuals or just efficiency gains. We will come back to this variable in a more detail after we interpret the first two.

Investments as share of GDP had always been one of the most significant factors correlated with the output growth. As mentioned in Sala-i-Martin (2002) countries that invest more tend to grow faster, than those countries that save and invest less. Some African countries which had low growth rates counted only 10% of investments in GDP, meanwhile in such Asian countries as Singapore investments achieved up to 50% of gross domestic product. During 1996-2004 investments in Armenia counted 20% of GDP on average varying from as low as 17.7% to as high as 22.6% in recent years. Here I do not distinguish between FDI and domestic investments. As was already mentioned, investments were one of the main sources for growth in Armenia and therefore I expect to get positive significant effect for *igdp*.

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[5] Since $R^2 = 1 - \frac{\text{sum of squared residuals}}{\text{total sum of squares}}$, then the maximum of R^2 will be achieved at the minimum of sum of squared residuals.

Budget deficit is another significant variable influencing output growth rate. This variable is especially significant for such developing countries such as Armenia, where fiscal discipline plays very important role. In general very high levels of fiscal deficit may undermine economic growth. However if the budget deficit is low, stable and sustainable, as is the case with Armenia, it may be interpreted as an increased demand for goods and services[6]. And if the economy is below its equilibrium on Keynesian cross, higher fiscal deficit, that is increased government expenditures, should stimulate growth. Hence I expect to get positive relationship with output growth.

Total factor productivity was included in the model, because all other factors, that include market depth and various measures of trade openness, taken individually, were not significant or had small contribution. However, all these factors effect growth through their impact on total factor productivity. And therefore controlling for TFP would eliminate the need to control for other variables. A natural question that arises is, why then do I control for investments and fiscal deficit? As it will be shown in the next section, these two variables are included into the model without inducing multicollinearity, because (a) investments induce growth through higher demand, not productivity, and (b) fiscal deficit will have its negative effect on productivity if it will count a high portion of GDP. In summary, I am expecting a positive one-to-one relationship between productivity residuals and output growth, since efficiency gains in the use of production factors brings to higher rates of output growth. One-to-one relationship is a result of an equal to unity sum of factor elasticities.

Thus, the basic model to be estimated is as follows:

$$\Delta \log(y_t) = c + \gamma_1 \pi_t + \gamma_2 d_t (\pi_t - \pi^*) + \beta_1 igdp_t + \beta_2 bdef_t + \beta_3 pres_t + u_t \qquad (7)$$

Used time series range from the first quarter of 1996 to the second quarter of 2004. The starting point of 1996 was chosen mainly because more or less strict statistical data was available from that date. The second quarter of 2004 was chosen because of the data availability to the date when this research was conducted.

Data comes mainly from the internal database of Central Bank of Armenia, but I also used statistics from International Financial Statistics (IFS), as well as World Development Indicators (WDI) for global data on inflation and GDP growth rate.

[6] Average budget deficit during 1996-2003 was 4.5% of GDP.

III. ESTIMATION AND RESULTS

Basic model estimation and interpretation

Before I pass on to interpretation of estimation results of equation (7), I first make sure our estimates are going to be consistent. That is, I run unit root tests for variables included in the equation. Table 1 shows number of lags included in the Augmented Dickey-Fuller test on unit root, as well as *p-values* at which the hypothesis of unit root existence in the series is rejected. As seen from the table all the variables, included in the model, are integrated of the first order.

As was already mentioned, to find the threshold level of inflation (7) is estimated for various quarterly levels of π^* in the range of [-0.5, 2.5]. After each estimation, corresponding values of *adjusted-*R^2 are collected, and the optimal threshold is identified as

$$\pi^* = \arg\max_{\pi}\{adjR^2(\pi), \pi = -0.5,...,2.5, \text{with step of } 0.5\}, \text{ where} \tag{8}$$

adj-$R^2(\pi)$ depends on the chosen threshold level of inflation.

Table 2 shows the final estimation output, with threshold level of inflation identified at 4.5% annually. The *adjusted-*R^2 statistic reached its maximum at the level of π^* = 4.5%. The Figure 5 shows the behavior of the values of *adjusted-*R^2 at different values of threshold levels of inflation.

The threshold level of inflation at 4.5% means that this level of inflation is the break-even level of inflation, above which inflation has a negative impact on the growth rate of output. On average, for the sample period for inflation rates higher than 4.5%, annually growth rate was hindered on average by 1.2% quarterly ($\gamma_1 + \gamma_2$), or to speak annually – approximately 1 % higher than a threshold level of inflation annually will result in 0.3% decrease in output growth annually. However we need to use this interpretation with one caveat. Our model does not take into account the fact that for extremely high levels of inflation, say 15% or 20% this would result in steeper decreases in output growth. Therefore this interpretation is valid for modest levels of inflation.

Before starting to interpret the magnitude and sign of other coefficients, we first need to be sure that the threshold effect which is represented by $d_t(\pi_t - \pi^*)$ is significant, that is to test null of $\gamma_2 = 0$. Unfortunately, under the null π^* might not be identified so the distribution of the coefficient estimator $\hat{\gamma}_2$ might not have *t*-distribution, and therefore classical *t*-test might not be appropriate. However we can bootstrap the distribution using standard bootstrap procedure with replacement. Appendix B shows the bootstrapped histogram of $\hat{\gamma}_2$, the OLS estimator for γ_2. The solid line depicts a normal distribution PDF graph with the same mean and standard error as the bootstrapped distribution. As easily seen the empirical distribution is not much skewed from normal distribution. Therefore I conclude that *t*-test given in Table 2 is a valid test for the significance of threshold level of inflation at 4.5%.

Thus, the results show that inflation rate of 4.5% annually is the optimal level of inflation in Armenia based on the data spanning from 1996 to present, since inflation rates higher than calculated threshold level negatively affect output growth, meanwhile for inflation rates less than the threshold level, inflation does not hinder growth, and has an insignificant effect on growth of the economy. This finding is in accordance with the findings of Khan and Senhadji (2000) for a panel of developing countries[7]: for inflation levels less than optimal the effect is insignificant, but as inflation passes the threshold, the effect becomes strongly significant and negative.

The rest of the variables have very significant and meaningful slope coefficients. According to the estimation results holding other things fixed one percent increase of share of investments in GDP into the economy will result in 1.4% output growth rate quarterly. Meanwhile worsening of fiscal deficit by additional 1 percent, and again *ceteris paribus*, will contribute to output growth by 1.1% quarterly. The coefficient on productivity residuals is close to unity, reflecting the fact that I used coefficients of elasticities for capital and growth summing to one. All these findings totally correspond to theoretical and empirical findings of economic growth literature of previous decades.

Endogeneity, multicollinearity and sensitivity to additional variables

Endogeneity. One would naturally think that for such high frequency time series of inflation and output growth the causality can run not the way it is presented in model (7), but the other way around, that is from growth to inflation. If this is the case, then the magnitude of the effect that inflation has on growth is biased. Another idea might be that investments also appear endogenous, since investments rise when the economy performs sustainable output growth, since it makes country more attractive for investments. And at last, budget deficit may also be endogenous. Any kind of shock that may reduce the growth at a given level of government spending will increase the budget deficit.

Table 3 shows the results of regressions using instrumental variables technique. The first three columns of the table show the results for two-stage least squares regression with the assumption that respectively inflation, investments in GDP and budget deficit

[7] They found that the optimal level of inflation for developing countries is 11% for an average country from the panel, which included such low level inflation countries as Ukraine and high inflation level countries as Bulgaria. Since Armenia was a low inflation country during last 8 years our findings can still support findings brought in Khan and Senhadji (2000).

are endogenous in the model. The last column shows the results of 2SLS regressions where all three mentioned variables are assumed to be endogenous. The set of instruments include first two lags of instrumented variables, first two lags of output growth, first two lags of money supply growth, measured as percentage change of broad money M2, as well as variability of terms of trade[8]. *P-values* of respective *t-statistics* are given in parenthesis under each estimated coefficient to make understanding of significance more explicit.

Comparing Tables 2 and 3 one can see that the effect of inflation above the threshold level did not change much when inflation is instrumented separately or in a group with investments and budget deficit. At the same time, the magnitude and significance of other exogenous variables did not change much.

Multicollinearity. In the end, high inflation rates impact on output growth through decreases in investments and factor productivity. Particularly, high inflation rates can undermine investments and factor productivity, which in their turn will undermine output growth. It will then become quite difficult to interpret *ceteris paribus* effect of inflation on growth. And from this point of view it is quite natural to think about possible multicollinearity in the model between inflation, investments and productivity residuals. Table 4 shows the correlation coefficients of right-hand side variables.

As seen from the table the highest correlation of -0.71 is observed between inflation and productivity residuals. However the magnitude of coefficient is not that large to worry about multicollinearity in the model. One explanation can be that it takes time, more than a quarter, for the inflation to leave its effect on the productivity or investments. And since variables in our model appear contemporaneously, that effect can be neglected.

Additional variables. As was mentioned earlier some other variables that can be found in growth literature, were included into the initial model, however were dropped after producing insignificant results. These variables include terms of trade (*tot*), variability of terms of trade (*totvar*) and real effective exchange rate (*reer*) as measures of openness of the economy, growth rate of broad money M2 ($\Delta\log(m2)$), ratio of broad money to GDP (*m2gdp*), growth rate of money multiplier ($\Delta\log(m2x)$) and share of credit given to the private sector (*md*) as measures of financial depth.

[8] Variability of terms of trade is calculated as standard deviation of terms of trade during last 4 quarters. Terms of trade is calculated as ratio of unit cost of imports over unit cost of exports.

IV. POLICY IMPLICATIONS AND CONCLUSIONS

The early 1990s in Armenia were marked with steep output decreases, unemployment and 1000-digit inflation. Not having a large stock of international reserves, Armenian was not able to fix its exchange rate and saddle hyperinflation. The first stabilization program, which was elaborated together with IMF, was introduced in 1994. By 1995, price inflation was down to 32%. During period of 1996-2003, the Armenian economy was growing on average 7.8%, while prices rose on average 5.5%. Although nowadays Central Bank of Armenia targets a level of inflation of around 3% annually and usually succeeds, gross domestic product is still below 1990 levels.

According to the results of the model presented above, an optimal level of inflation of 4.5% annually was calculated. So is an inflation level higher than 3%, which the CBA targets today, a "better deal?" Will the economy be better off or will it lose if CBA starts targeting a 4.5% increase of prices? To answer these questions, let's see what theory and the economic situation in Armenia dictates.

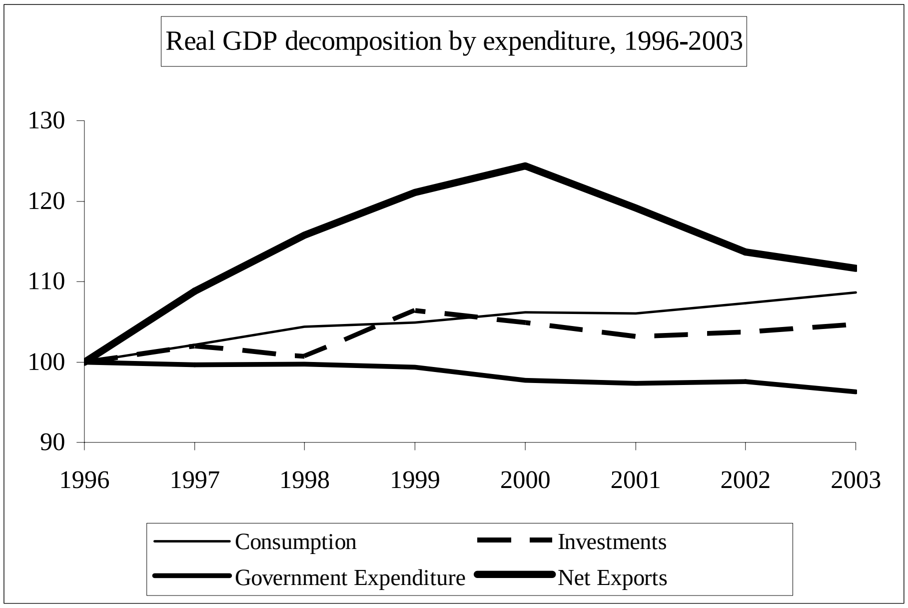
Firstly, firms are better off when prices rise. However a long term price increase will soon have its effect on households' pockets. If nominal wages in the economy are sticky, then it takes time for nominal wages to adjust to inflation. In Armenia, a world where union labors do not implement their main function and unemployment is high, the time to adjust to higher prices usually lasts longer than in developed countries, where union labors follow that contracts between employer and employee be indexed to price changes periodically. Secondly, because of imperfections in the market and weak financial intermediation, relative price adjustment usually takes longer period of time, and therefore the effect of inflation on the real sector of the economy lags. From this perspective, developing countries, such as Armenia, can accommodate to higher inflation more easily than developed countries[9]. And since the Armenian economy did not reach its "convergence point", higher inflation rates might result in higher growth rates of the economy without pushing the country into inflationary spiral. And here is why I think that an annual inflation rate of 4.5% might be justified and be preferred over 3% rate.

Thus this paper is reflecting the fact that in Armenia, as in any developing country, a stable low level of inflation is necessary, but not sufficient, for economic growth and prosperity. However because of the high rigidity of nominal wages and prices, Armenia can achieve a higher growth rates targeting somewhat higher level of inflation at a given stable and sustainable level of budget deficit and investments. Any inflation rate up to 4.5% will not hinder growth and sometimes even foster. However, trespassing the threshold level of inflation at 4.5% any additional inflation will hinder growth.

[9] By saying higher I mean rate of inflation higher than in developed countries, but up to reasonable limits.

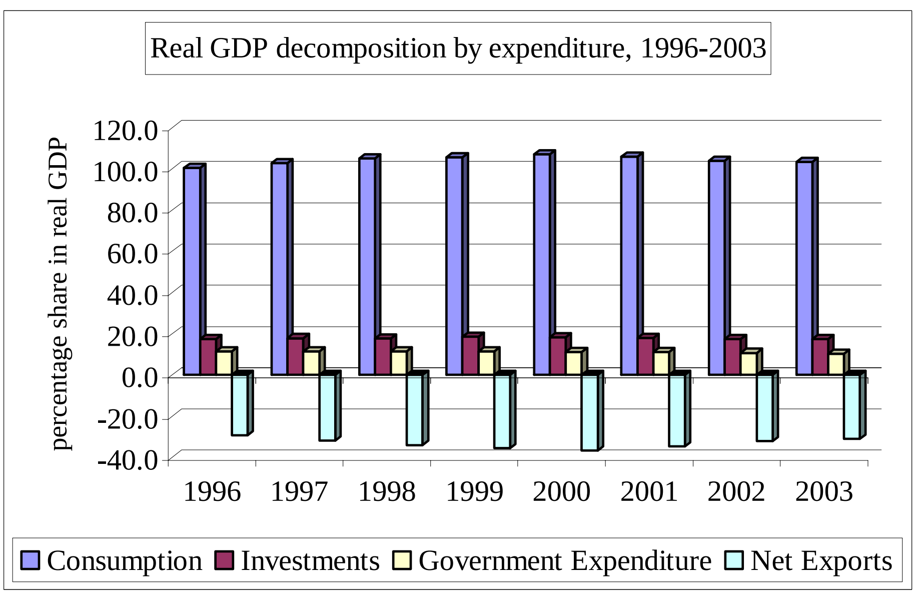
APPENDIX A

Figure A1. Evolution of real GDP expenditures during 1996-2003



source: CBA internal database and own calculations

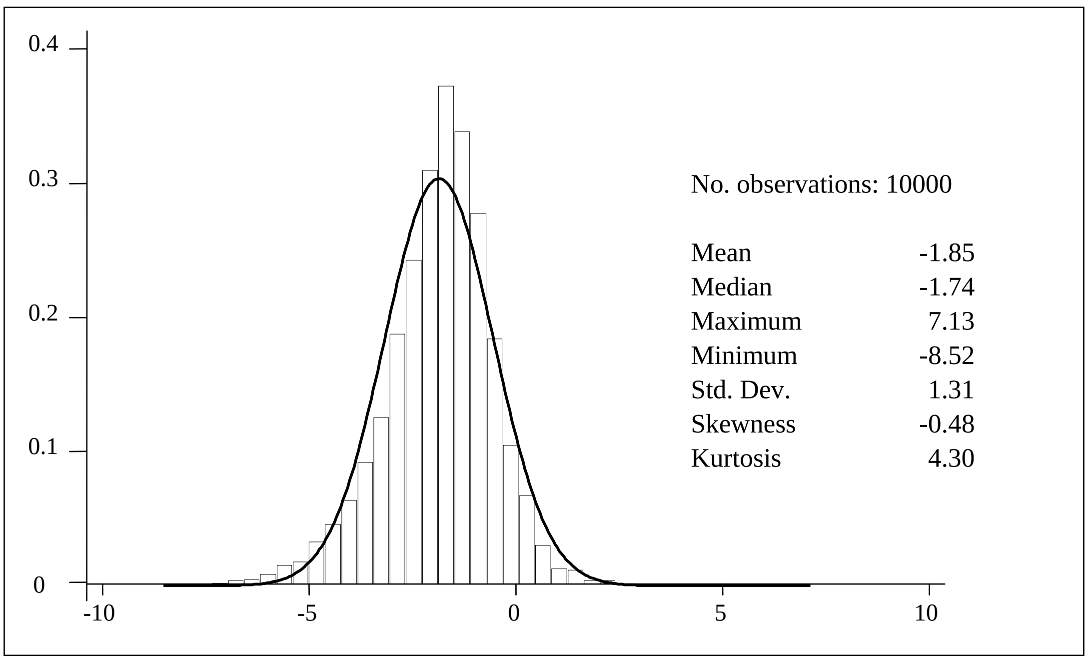
Figure A2. Contribution of Expenditures to Real GDP



source: CBA internal database and own calculations

APPENDIX B

Figure B1. Bootstrapped distribution for the estimator of the threshold effect



/1 10000 replications with replacement are done to get the empirical distribution for the estimator.

REFERENCES

1. Barro, R. , 1991, “Economic Growth in a Cross-Section of Countries,” Quarterly Journal of Economics, Vol. 106, No. 2, pp.407-43.

2. Christoffersen, P. and Doyle, Peter , 1998, “From Inflation to Growth: Eight Years of Transition”, IMF Working Paper 98/100, International Monetary Fund, Washington, D.C.

3. De Broeck, M., and V. Koen, , 2000, “The Great Contractions in Russia, the Baltics and the Other Countries of the Former Soviet Union: A View from the Supply Side,” IMF Working Paper 00/32, International Monetary Fund, Washington, D.C.

4. De Gregorio, José , 1991, “The Effect of Inflation on Economic Growth: Lessons from Latin America”, IMF Working Paper 91/95, International Monetary Fund, Washington, D.C.

5. Fischer, S., 1983, “Inflation and Growth”, NBER Working Paper No. 1235, NBER, MA.

6. Fischer, S., 1991, “Macroeconomics, Development, and Growth,” NBER Macroeconomics Annual, pp.329-364.

7. Fischer, S., 1993, “The Role of Macroeconomic factors in Growth”, Journal of Monetary Economics, Vol. 32, pp. 485-512.

8. Fischer, S., Sahay, R., Vegh C., 1996, “Stabilization and Growth in Transition Economics: The Early Experience”, Journal of Economic Perspectives, Vol. 10, No. 2.

9. Ghosh, A., and S. Phillips, “Warning: Inflation May Be Harmful to Your Growth,” IMF Staff Papers, International Monetary Fund, Vol. 45, No. 4, pp. 672-710

10. Grigorian, D., Khachatryan A., and G. Sargsyan, 2004, “Exchange Rate, Money, and Wages: What is Driving Prices in Armenia?” Armenian Journal of Public Policy, Vol. 1, 2, pp. 223-62.

11. Hansen, B., 1999, “Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference,” Journal of Econometrics, Vol. 93, No. 2, pp. 354-68.

12. Hulten, C., 2000, “Total Factor Productivity: A Short Biography,” NBER Working Paper No. 7471, NBER, MA.

13. IMF, 2005, “Republic of Armenia: Recent Economic Developments and Selected Country Issues,” Selected Issues Paper, (Unpublished: International Monetary Fund, Washington, D.C.)

14. Iradian, G., 2003, “Armenia: the Road to Sustained Rapid Growth,” Armenian Journal of Public Policy, Vol. 1, 1, pp. 35-56.

15. Khan, M., and Senhadji, A., 2000, “Threshold Effect in the Relationship Between Inflation and Growth”, IMF Working Paper 00/110, International Monetary Fund, Washington, D.C.

16. Kormendi, R., and P. Meguire, 1985, “Macroeconomic Determinants of Growth: Cross-Country Evidence,” Journal of Monetary Economics 16, pp. 141-164.

17. Levine, R., and Renelt, D., 1992, “A Sensitivity Analysis of Cross-Country Growth Regressions,” American Economic Review, Vol. 82 , May, pp. 942-63.

18. Loukoianova, E. and A. Unigovskaya, 2004, “Analysis of Recent Growth in Low-Income CIS Countries,” IMF Working Paper 04/151, International Monetary Fund, Washington, D.C.

19. Prescott, E.,1997, “Needed: A Theory of Total Factor Productivity,” Research Department Staff Report 242, Federal Reserve Bank of Minneapolis.

20. Roubini, N., and X. Sala-i-Martin, 1995, “A Growth Model of Inflation, Tax Evasion, and Financial Repression,” Journal of Monetary Economics, Vol. 35 (April), pp. 275-301.

21. Sachs, J., and F. Larrain, 1993, “Macroeconomics in the Global Economy,” (Prentice-Hall, Inc., Englewood Cliffs, NJ).

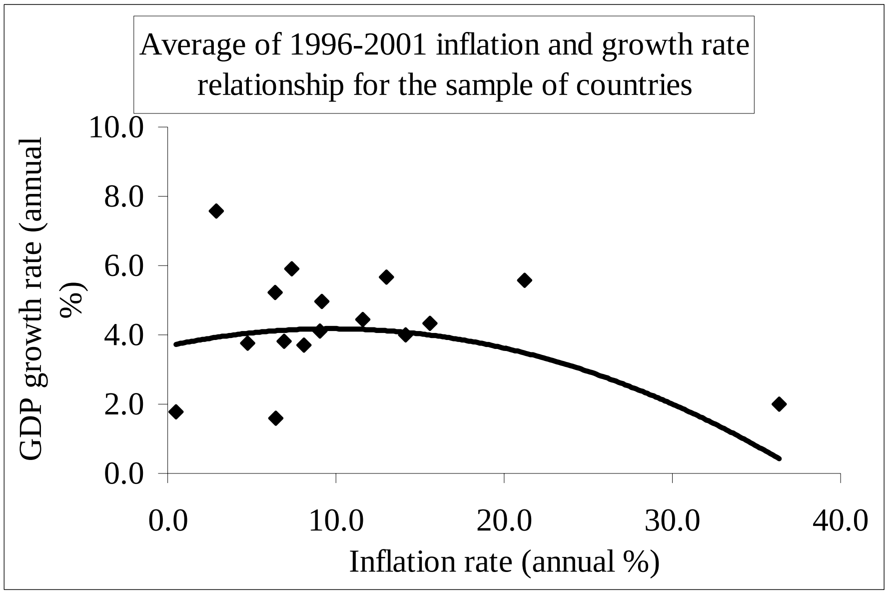
22. Sala-i-Martin, Xavier X., 2002, “Sources of Growth,” in: Khan M., and Nsouli, S., eds., Macroeconomic Management, Programs and Policies (IMF Institute), pp. 58-97.

23. Sarel, M., 1996, “Nonlinear Effects of Inflation on Economic Growth”, IMF Staff Papers, Vol. 43, No. 1, International Monetary fund, Washington, D.C.

24. Sidaurski, M., 1967, “Rational Choice and Patterns of Growth in a Monetary Economy,” American Economic Review, Vol. 57, No. 2.

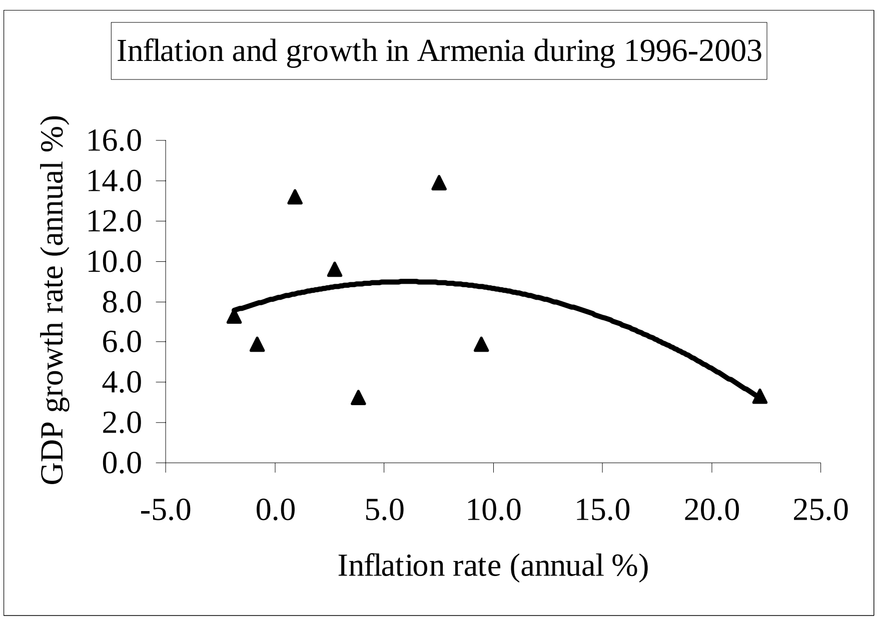
25. World Bank, 1990, “Adjustment Lending Policies for Sustainable Growth,” Policy and research series paper no. 14, World Bank, Washington, D.C.

Figure 1. Inflation and growth relationship



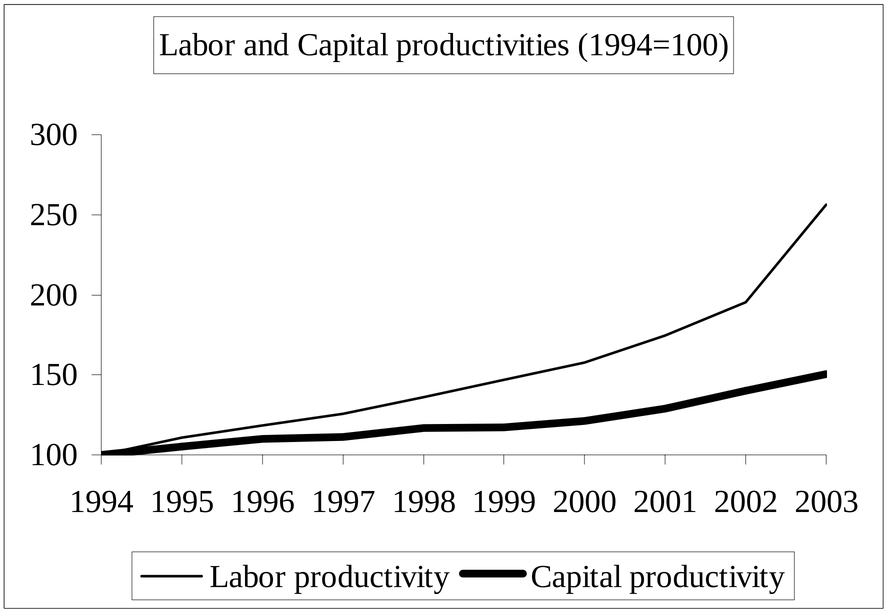
source: World Development Indicators and own calculation

Figure 2. Inflation and growth relationship in Armenia



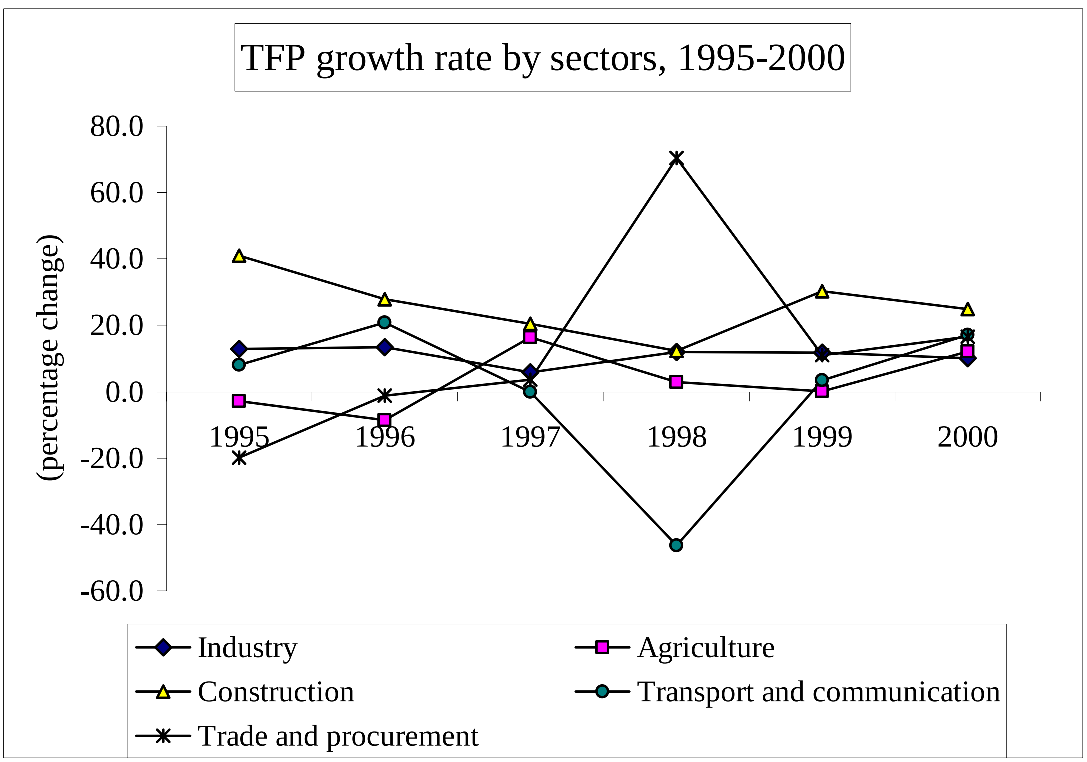
source: CBA internal database and author's calculation

Figure 3. Factor productivities



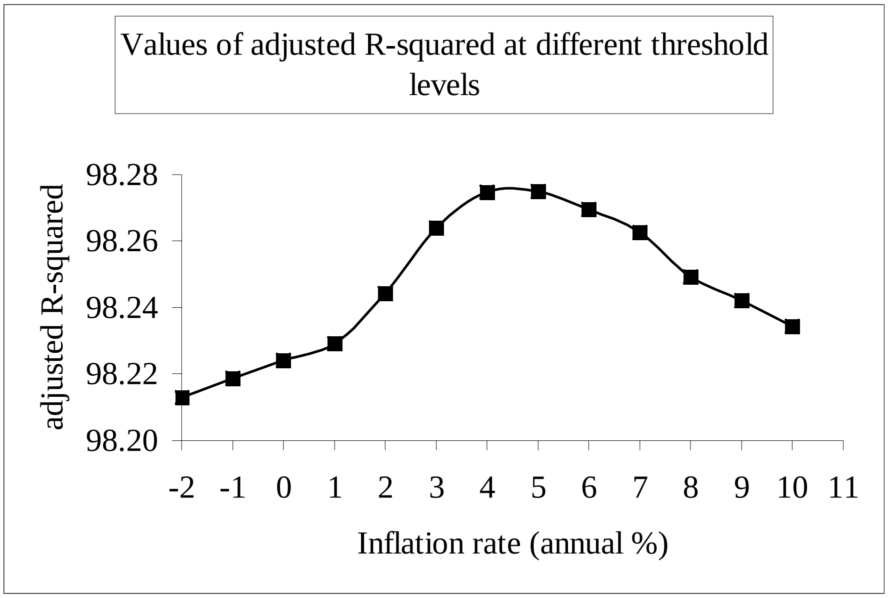
source: CBA internal database, IFS and own calculations

Figure 4. Total factor productivity growth rate by sectors.



source: Loukoianova and Unigovskaya (2004), pp.21

Figure 5. Relationship between π^* and adjusted-R^2.



source: author's calculations

Table 1. Stationarity tests

	included lags*	p-values
$\Delta\log(y)$	2	0.0001
π	1	0.0000
$d(\pi - \pi^*)$	3	0.0002
igdp	2	0.0039
bdef	0	0.0006
pres	0	0.0000

Table 2. Estimation results for the basic model

Dependent variable: $\Delta\log(y)$ /1
Threshold level π^*: 4.5% annually

Variable	*Coefficient*	*Std. Error*	*t-statistic*	*p-value*
π	0.627	0.543	1.155	0.2579
$d(\pi - \pi^*)$	-1.846	0.754	-2.446	0.0210
igdp	1.388	0.282	4.914	0.0000
bdef	1.121	0.385	2.913	0.0070
pres	1.031	0.037	27.913	0.0000
const	-0.447	0.066	-6.785	0.0000

Adjusted R-squared	0.9828
F-statistic	377
Prob(F-statistic)	0.0000
Durbin-Watson stat	2.00

Sample: 1996Q1 - 2004Q2
Number of observations: 34

/1 Newey-West HAC Standard Errors & Covariance (lag truncation=3)

* The optimal number of lags was chosen that maximizes the Schwartz criterion function.

Table 3. 2SLS estimation results.

Dependent variable is $\Delta\log(y)$ /1

	Instrumented variables			
	π	*igdp*	*bdef*	π *igdp* *bdef*
π	1.012	0.429	0.286	1.316
	(0.0736)	(0.4433)	(0.7451)	(0.0628)
$d(\pi-\pi^{*})$	-2.330	-1.247	-0.403	-2.717
	(0.0102)	(0.0645)	(0.8587)	(0.0508)
igdp	1.309	1.897	1.588	1.444
	(0.0005)	(0.0005)	(0.0039)	(0.0024)
bdef	1.070	1.208	2.628	1.387
	(0.0125)	(0.0109)	(0.0207)	(0.0551)
pres	1.041	1.020	1.034	1.048
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
const	-0.427	-0.555	-0.566	-0.462
	(0.0000)	(0.0000)	(0.0004)	(0.0002)
Adjusted R-squared	0.9825	0.9820	0.9757	0.9811
F-statistic	373	362	252	324
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000

Sample: 1996Q1 - 2004Q2
Number of observations: 34

/1 Newey-West HAC Standard Errors & Covariance (lag truncation=3)

Table 4. Correlations

	π	*igdp*	*bdef*	*pres*
π	1.00			
igdp	-0.44	1.00		
bdef	-0.09	0.01	1.00	
pres	-0.71	0.51	0.15	1.00