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Working Paper

ESTIMATION OF SHORT RUN TRADE OFFS BETWEEN STABILITY AND OUTPUT

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Abstract

The views expressed in this Working Papers are those of the author and do not necessarily represent those of the Bank of Ghana. Working Papers describe research in progress by the author and are published to elicit comments and to further debate

The paper adopted all the three methods within the economic literature to estimate the size of the sacrifice ratio for Ghana. The first approach focused on historical episodes of disinflation and associated output losses during that period while the second approach estimated the sacrifice ratio from the structural vector auto regression framework. The third approach draws on the slope of the aggregate supply curves. The estimated sacrifice ratios indicated that in Ghana a permanent 1 per cent drop in inflation results in an output lose within the range of 0.001 to 5.1 per cent. The paper concluded that Ghana having experienced both macro stability and economic growth more recently, if a disinflation process persists and policies are consistent and credible, the economy may eventually adjust to the new monetary policy regime and output and employment losses may only be transitory. Therefore, discussions on this subject must take into account the sources of inflation, the monetary policy stance and the role of supply conditions.

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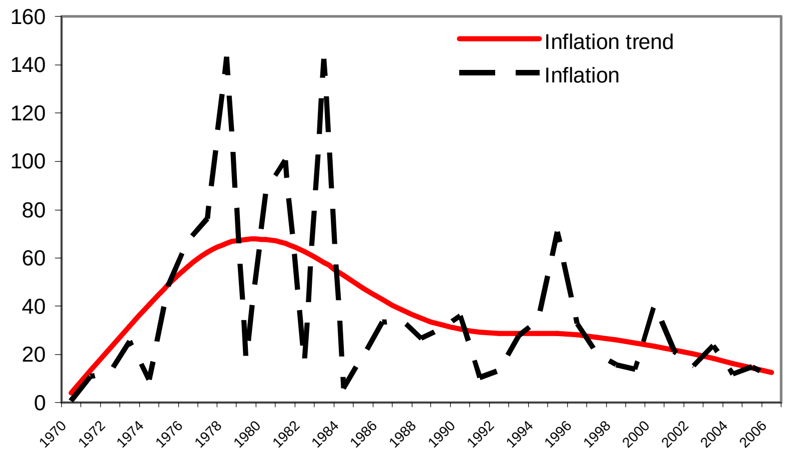
Section 1: Introduction

Stabilizing prices permanently has been generally agreed to create long run benefits to the society and helps increase trend growth rate of real output. However, there is a strong belief that bringing inflation down involves short-term costs associated with a corresponding loss in output, which is known in the literature as sacrifice ratio. It is defined as a ratio of the percentage loss of real output to the change in trend inflation. Thus, the sacrifice ratio is the cumulative output losses that an economy must endure to reduce average inflation, on a permanent basis, by one percentage point.

In Ghana, inflation has been on its downward trend over the past few years (Chart 1). In comparing the developments in the current monetary regime (MPC process) to the control regimes and the monetary targeting regimes, the inflation rate has been quite stable: it averaged 50.0 per cent per annum during the 1970s, 44.5 per cent during the 1980s and was 27.9 per cent during the 1990s and further down to 16.2 per cent in the last six years.

This favourable trend together with the gains in the general macroeconomic trends has renewed interest in the short run trade off between stability and growth particularly at the time that Ghana wants to raise the growth rates to the levels necessary to ensure the MDGs. Again, the recent announcement of the adoption of full fledge inflation targeting regime brings to fore the need to take into consideration the accompanying short run output costs of a further permanent reduction in inflation rate to the levels prevailing in most emerging economies.

Chart1: Inflationary Trends in Ghana: 1970 - 2006



Given these concerns and renewed interests in the policy discussions on the trade offs between stability and growth, estimation of the sacrifice ratio will serve as a pre requisite to inform discussions on the subject and also guide the policy maker to provide alternative policies to minimize any trade offs that may exist. This paper therefore seeks to address this issue as we try to estimate the magnitude of the output cost of disinflationary process in Ghana. The next section discusses the concept of the sacrifice ratio, followed by the brief review of the literature in section three and then the methodology and estimation in section four. The fifth section concludes.

Section 2: Concept of Sacrifice Ratio

The concept of the sacrifice ratio can be illustrated in an expectations augmented Phillips curve expressed as follows:

$\pi_t = \pi^e + a(y_t - y_t^*)$ é é é é é é é é é é é é é é é é é é é .é é é . (1)

Where, π_t, π^e, y_t and y_t^* denote actual inflation, expected inflation, actual and potential output respectively. The sacrifice ratio is based on the fact that given the potential output level; any attempt to reduce inflation requires either a reduction in expectations or a reduction in current period output. Available evidence strongly suggests that inflation expectations exhibit inertia, being largely adaptive (Mankiw 2001). Therefore a tight monetary policy can reduce inflation only by depressing economic activity that is to lower actual output which in this case is the y_t. Fuhrer (1995) provided reasons why inflation expectations exhibit inertia as:

- That inflation persistence may arise from the overlap and nonsynchronization of wage and price contracts in an economy as wages and prices adjust at different times to each other;

- Peopleœs inflation expectations may adjust slowly over time since it is based on some sort of adaptive mechanism;

- And finally if people do not believe that the monetary authority is truly committed to reducing inflation, then inflation will not fall as rapidly. That is, the credibility of the policymaker is important in determining the dynamics of inflation, with less credibility leading to more persistence.

Over time, as inflation starts falling and inflation expectations adjust downwards while the output approaches its potential level in the medium to the long run, monetary policy reduces inflation through a lowering of expectations.

On how to lessen this trade off, the discussions have mainly centred on the speed of disinflation and whether the Monetary Authority will have to adopt the gradualists approach or the cold turkey approach. Others have focused on identifying sources of inflation persistence and tackled them. We therefore extended discussions on the issue of the credibility/independence of the central bank and the speed of disinflation in this paper.

2.1 Central Bank Independence and Sacrifice Ratio

Discussions of the central banking independence and sacrifice ratio in an inflation-targeting framework have centred on the possibility of entrenched credibility and its impact on the output losses of disinflation. The issue has remained whether a credible central bank can lessen sacrifice ratio given that inflation expectations will adjust downwards. Underpinning this is that the public is expected to more readily believe the anti-inflationary pronouncements of an independent central bank and this, in turn, should lower output losses through downward adjustment in inflation expectations. Interestingly, the empirical evidences have not supported this theoretical assertion.

Debelle (1996) compared the experience of New Zealand (where the central bank was provided legal independence) with that of a control set (Australia and Canada, *i.e.*, countries with a similar inflation history but with the central banks not having explicit independence at the time of the study). The results suggest that costs of disinflation were not lower in New Zealand as compared with the control set. He again provided evidences that the sacrifice ratio increased from 0.3 in the 1980-83 disinflation episode (period before central bank reform) to 2.6 in the 1989-93 disinflation, which followed central bank reform.

Bernake and Mishkin, (1997) also provided evidence that the Deutsche Bundesbank and the Swiss National Bank, whose pursuit of low inflation over the last two decades has presumably given them maximum credibility, have been able to achieve inflation reductions only at high costs in output and employment lost.

2.2 Speed of Disinflation

Speed of disinflation has also featured strongly in the discussion of the sacrifice ratio. The dominant issue here is whether the gradualists approach or cold turkey approach lessens the sacrifice ratio. Taylor 1983, stressed that gradualism is preferable so that wages and prices, which exhibit an inertial behaviour, can adjust smoothly to the tighter monetary policy. However, those who oppose the gradualists approach believe that gradualism raises the probability of future reversals and may have no favourable impact on inflationary expectations. On this basis they proposed a cold turkey approach which is less costly because expectations adjust sharply (Sargent 1983). Ball, 1993 and Zhang, 2001 have provided evidences to support the cold turkey approach. (Zhang 2001) indicated that for G-7 Countries, 0.25 percentage point reduction in a quarter lead to sacrifice ratio of 3.8 while 0.5 percentage points for the same period results in a sacrifice ratio of 1.8.

<u>Section 3: Literature on Sacrifice Ratio</u>

Okun first estimated the relationship between output and inflation using Philips curve models for U.S in 1978. Okun (1978) provided evidence that 1 per cent reduction in the basic inflation rate is 10 per cent of a yearös Gross National Product with a range of 6-18 per cent. Gordon and king (1982) followed Okunös methodology but used the Vector Autoregression Models within the framework of a linear Philips curve model and provided evidence of a range of 0 ï 8 per cent sacrifice ratio.

Ball (1994) however deviated from the earlier methodology which is derived from the linear Philips curve models asserting strongly that the sacrifice ratio derived from the Philipös curve constraints the output inflation trade off to be the same during disinflation as well as in the period of increased trend inflation and temporary fluctuations in demand. Subsequently, Ball in 1994 provided an alternative, which is based on an episode specific analysis. This approach seeks to identify disinflation episodes and measures the sacrifice ratio as the sum of output losses over the episode divided by the change in trend inflation. Many economists have followed this approach including Bernake et al (1999), Boschen and Werise (1999), and Zhang (2001).

Cecchetti and Rich 2001, on the other hand, explained that Ballös standard method could only be acceptable if there were a well-established asymmetry in the impact of monetary policy on output and prices. Following this, Cecchetti and Rich (2001) applied a generalized Philips curve relationship using structural VAR models to provide estimates of the sacrifice ratio.

More recently, Kapur and Petra (2002) used the slope of aggregate supply curve adjusting for the supply shocks to estimate the sacrifice ratio. Kapur and Petra (2002) argued strongly that this method avoids *ad hoc* assumptions of output returning to trend in some specified quarters (Ballös approach) and can control for supply shocks. Again, the sacrifice ratios obtained from structural VARs are highly sensitive to the size of the model and the identification restrictions. Table 1 below summarizes the empirical evidences of the estimation of sacrifice ratio from the various methods review:

Table1: Summary of Estimated Sacrifice Ratio

Study	**Methodology**	**Coverage and Study Period**	**Estimates of Sacrifice Ratio(%) 9%**
Okun (1978)	Aggregate supply curve	USA	6-18
Ball (1993)	Actual developments in output & inflation	19 industrial Countries (1960-92)	Average 5.8% for quarterly data and 3.1% for annual
Debelle (1996)	Actual developments in output & inflation	Australia, New Zealand & Canada	0.4-3.5
Anderson and Wascher(1999)	Aggregate supply curve; structural wage & price equations; actual dev'ts in output & inflation	19 OECD countries; 1965-98	Average of 1.5 (1965-85) and 2.5 (1985-98)
Turner and Seghezza (1999)	Aggregate supply curve	21 OECD countries; 1963-97	Average of 3.2 with a range of 1.6 (Japan, Italy &Netherlands) ,7.0(Norway)
Hutchison and Walsh (1998)	Aggregate supply curve	New Zealand;1983:2-1994:4	4.5-6.0 for the entire sample
Zhang (2001)	Actual developments in output & inflation	G-7; 1960:1-1999:4	1.4 (without any long-lived effects); 2.5(with long-lived effects)
Cecchetti and Rich (2001)	Structural VAR models	US;1959:1-1997:4	1-10
RBI (2002)	Aggregate supply curve	India;1971 - 2000	2.0
Kapur & Petra (2002)	Aggregate supply curve: alternative specifications	India; 1971 - 2001	0.3-4.7
A. Cetinkaya and D.Yavuz (2002)	Actual developments in output & inflation	1987-2001; monthly & quarterly	0.09-0.16

From the literature, three methodologies have generally been used to calculate the sacrifice ratio. One approach focuses on historical episodes of disinflation and calculates the sacrifice ratio as the output losses during that particular episode (Ball 1994; Zhang 2001). The second approach derives estimates of sacrifice ratios from a vector autoregression framework (Cecchetti and Rich, 2001); and the third approach estimates sacrifice ratios from the slope of the aggregate supply curve, *i.e.,* the Phillips curve which controls for supply shocks. We therefore follow these three methodologies to derive sacrifice ratios for Ghana using both the monthly and quarterly data for the analyses.

Section 4: Methodology and Estimations

4.1 The Episode Specific Approach

This approach uses the specific episode method to measure output losses occurred during individual disinflation episodes. It allows for comparison of different economic policies in terms of output losses and therefore does not constrain the sacrifice ratio to be the same for all disinflation episodes. Ball defines the sacrifice ratio for a specific episode of disinflationary period as:

$SR = \Delta Y / \Delta\pi$ é .. (2)

Where SR is sacrifice ratio, æY is change in real output and æ´ is the change in inflation.

Ball (1994) identified the time range between an inflation peak and an inflation trough to be disinflation episode. The sacrifice ratio in the given period is then defined as the total deviation in output from its trend over the change in the trend inflation as follows:

$SR = \sum(y_t - y_t{*})/(\pi_t - \pi_{t-1})$ é .. (3)

Ball (1994) made the following assumptions:

- Trend inflation is a centred four periods moving average of actual inflation. Trend inflation in time (t) is then average of inflation rate between (t-4) and (t+4);
- Inflation peak as a point in time where trend inflation is higher than the preceding and the four periods ahead;
- Inflation trough is a point where trend inflation is lower than the previous and the next four periods;

- The disinflation episode as the time range that starts with an inflation peak and ends at an inflation trough.

On the measure of output gap, Ball (1994) made these assumptions as an alternative to standard statistical filters such as HP filter:

- Output is at its natural level at the start of a disinflation episode or the inflation peak;
- Output returns to its potential level four periods after the end of an episode (four quarters after inflation trough);
- Potential output grows log-linearly between the two points when actual and potential outputs are equal.

Following this approach we estimated sacrifice ratio for Ghana using monthly data from 1999 to 2007 and Quarterly data from 1987 to 2006 but made slight changes to reflect Ghanaôs situation.

Before we proceed on our estimation, one issue in the literature which remains unresolved is the estimation of the potential output and therefore becomes necessary to settle on which method to be used to derive the potential output. Ballôs measure of potential output was widely used by many economists including Bernake et al (1999) and Boschen (1999). However, this has not come without criticisms as some economists (Ceechita and Rich, 2001) could not reach consensus on his assumption that potential output return to its potential level four periods after the episode and cited the issue of the long-lived persistence effect.

The ópersistenceô hypothesis holds that the economy may take a fairly long time to return to its potential output path; in the extreme case, disinflation may have a permanent effect on output and the economy may display óhysteresisô, *i.e.,* the potential output path may itself undergo a parallel downward shift (Blanchard and Summers, 1986). Under this circumstance, Ballôs assumption that the output returns to potential after a trough over a specified period may thus underestimate the sacrifice ratio.

In Ghana, output persistence has been proven in some studies (EMOD & Opoku-Afari et al, 2005). Again, due to unavailable data on monthly and quarterly output we have to resort to interpolating the annual data into higher frequencies (monthly & quarterly), ending up with a more smoothened higher frequency data. Calculating potential output from Ballôs approach could be misleading. Following this, the study adopted standard HP filter approach (Method1) and an improved version of the Ballôs approach by Zhang (2001) (Method 2).

Zhangôs method for potential output operates as follows:

- Output was assumed to be at its potential at the beginning of the disinflation episode;
- HP filter was used to predict potential output. HP filter of the log real GDP was calculated first and growth rates of HP filter were found next;
- The potential output was assumed to grow at the rate estimated by HP filter at the beginning of the episode.

On the calculation of the inflation trend, we followed Ballôs approach but used seven quarter's moving averages in the case of the quarterly analysis and nine months moving averages for the monthly data.

4.1.1 Results of the Episode Specific Approach

4.1.1.1 Monthly Analysis

The disinflation episodes and the estimated sacrifice ratio in Ghana from the episode specific approach for the monthly analysis are presented below in table 2 & 3:

Table 2: Disinflation Episodes for Ghana (Monthly Data: 1999:2 ï 2007:6)

Episode	**Start**	**End**	**Duration**	**Trend Inflation Decline**
1	Jan 2001	Jul 2002	18	48.3
2	Aug 2003	Mar 2007	43	21.8

Table 3: Calculation of Sacrifice Ratio (Monthly Data: 1999:2 ï 2007:6)

Episode	Trend Inflation Decline	Output Gap (% of Potential GDP)		Sacrifice Ratio	
		Method 1	Method 2	Method 1	Method 2
1	48.34	0.1	-3.01	0.002	-0.06
2	21.67	0.05	-9.55	0.002	-0.44

Employing method 1, we recorded small but the same magnitude of the output losses from the disinflationary trend. It provided evidences of a sacrifice ratio of 0.002 per cent loss of output for one per cent decline in trend inflation. In the second method, it did not provide evidence of sacrifice ratios indicating that there were no output losses. This is expected given that the potential output derived from the second method resulted in the actual output permanently staying above its potential levels throughout the disinflationary period (Issue of hysteresis).

4.1.1.2 Quarterly Analysis

The disinflation episodes and the estimated sacrifice ratios in Ghana from the episode specific approach for the quarterly analysis are presented below in table 4 & 5:

Table 4: Disinflation Episodes for Ghana (Quarterly Data: 1987:1 ï 2006:4)

Episode	Start	End	Duration	Trend Inflation Decline
1	Jun 1987	Mar 1989	8 (2 years)	13.5
2	Jun 1990	Mar 1992	8 (2 years)	26.2
3	Dec. 1995	Sep 1999	16 (4 years)	50.1
4	Mar 2001	Jun 2002	6 (1-1/2 years)	20.1
5	Jun 2003	Dec 2006	15 (3-1/2 years)	14.7

For the quarterly analysis, with the exception of the third and fifth episodes, all the other episodes recorded some amount of output losses from the disinflationary trends in method 1. One interesting finding is that when we had a very long disinflationary trend we realized no output losses from disinflation as in the case of the episode 3 and episode 5. This may reflect the significant improvement in supply conditions during these periods than our control over strong demand pressures. The second method did not provide evidences of output losses.

Table 5: Calculation of Sacrifice Ratio (Quarterly Data: 1987:1 ï 2006:4)

Episode	Trend Inflation Decline	Output Gap (% of Potential GDP)		Sacrifice Ratio	
		Method 1	Method 2	Method 1	Method 2
1	13.5	0.14	-4.28	0.01	-0.32
2	26.2	0.17	-3.57	0.01	-0.13
3	50.1	-0.014	8.16	-0.003	-0.16
4	20.1	0.35	-2.49	0.02	-0.12
5	14.7	-0.039	9.9	-0.003	-0.68

4.2 Structural VAR Models (Two and Three Equation Models)

The second approach derives estimates of sacrifice ratios from a structural vector autoregression framework. This approach decomposes monetary policy into a systematic and a random component. The systematic component can be thought of as a reaction function and describes the historical response of the monetary authority to movements in a set of key economic variables. The random component signifies actions on the part of the monetary authority that cannot be explained by the reaction function and is labeled as ñmonetary policy shocksò.

Following the methodology by Cecchetti (1994) and (Cecchetti and Rich, 2001), we consider a simple structural VAR model to illustrate how the sacrifice ratio is derived. This is expressed as:

$$\Delta y_t = \sum_{i=1}^{n} b_{11}^{i} \Delta y_{t-i} + b_{12}^{0} \Delta \pi_t + \sum_{i=1}^{n} b_{12}^{i} \Delta \pi_{t-i} + \in_t^{y}$$

$$\Delta y_t = b_{21}^{0} \Delta y_t + \sum_{i=1}^{n} b_{21}^{i} \Delta y_{t-i} + \sum_{i=1}^{n} b_{22}^{i} \Delta \pi_{t-i} + \in_t^{\pi} \qquad \text{é é é é ..(4)}$$

Where y_t is the log of real output at time t, π_t is the inflation rate, and $\in_t^y, \in_t^\pi$ is a vector of innovation process representing the respective shocks to aggregate supply and aggregate demand. This is assumed to have zero mean and that the shocks are uncorrelated and have unitary variance.

It is important to indicate here that the principal focus of the remaining analysis is the impact of the structural shocks on inflation and output over time and ultimately allow us to answer questions concerning the quantitative impact of monetary policy on output and prices. Using vector moving averages representation (Ceechitta, 1994), which provide impulse responses of the system to the shocks, we capture the impact of the structural shocks on output and inflation and expressed as follows:

$$\begin{aligned}\Delta y_t &= A_{11}(L)\in_{t-i}^y + A_{12}(L)\in_{t-i}^\pi = \sum_{i=0}^{\infty} a_{11}^i \in_{t-1}^y + \sum_{i=0}^{\infty} a_{12}^i \in_{t-1}^\pi \\ \Delta\pi_t &= A_{21}(L)\in_{t-i}^y + A_{22}(L)\in_{t-i}^\pi = \sum_{i=0}^{\infty} a_{21}^i \in_{t-1}^y + \sum_{i=0}^{\infty} a_{22}^i \in_{t-1}^\pi\end{aligned} \quad \text{é é é (5)}$$

where $A_{ij}(L)$ is a polynomial in the lag operator L. If we initially use aggregate demand shocks to identify shifts in monetary policy, then the above equation provides a particularly convenient representation to assess the dynamic impact of a monetary policy shock on output and inflation. An estimate of the sacrifice ratio can then be computed based on the structural impulse response functions from the above equation. Here the sum of the coefficients in A_{22} (L) measures the effect of monetary policy shocks on the level of inflation while the A_{21} (L) measures the effect on output level but this considers the cumulative effect. In this case the sacrifice ratio is expressed as follows:

$$SR_{\in^\pi} = \sum_{j=0}^{\tau} \left(\frac{dy_{t+j}}{d\in_t^\pi}\right) / \left(\frac{d\pi_{t+\tau}}{d\in_t^\pi}\right) \quad \text{é é é é é é é é é é (6)}$$

For a disinflationary monetary strategy undertaken at time t, the numerator measures the cumulative output loss through the first τ periods, while the denominator is the difference in the level of inflation τ periods later.

Since the structural shocks are not observable, we obtain estimates of the structural impulse response by using the reduced form VAR representation in equation (4) with other restrictions. We assume that the aggregate demand shocks have no permanent effect on the level of output. This implies that our term $A_{12}(L) \in_{t-1}^{\pi} = 0$ in equation (5). The estimated sacrifice ratio from the two sector model is provided in section 4.2.1.

In the two sector model, the system may fail to identify separate components of the aggregate demand shock and therefore makes it difficult to discern whether the monetary policy shock is as a result of the policy shift, or related to government expenditure or shifts in consumption or investment function. This has provided the basis for the estimation of a more detailed system which seeks to decompose the aggregate demand shock into individual components as done by Ceechitta and Rich (2001), Shapiro and Watson (1988) and Gali (1992). This is represented in the following model:

$$\begin{bmatrix} \Delta y_t \\ \Delta \pi_t \\ (i-\pi)_t \end{bmatrix} = A(L) \begin{bmatrix} \in_t^{y} \\ \in_t^{LM} \\ \in_t^{IS} \end{bmatrix} \text{é é é é é é é é é é é é é é é é .} (7)$$

Where i_t is a short-term nominal interest rate and $(i_t - \pi_t)$ is an ex-post real interest rate and $A(L)$ is a 3 x 3 matrix polynomial lags. Based on this model the three structural shocks were identified as $\in_t^{y}, \in_t^{LM}$ *and* $\in_t^{IS}$, where $\in_t^{y}$ continues to represent aggregate supply shock while aggregate demand shock decomposed into an LM and IS shocks represented by $\in_t^{LM}$ *and* $\in_t^{IS}$. For the estimation to derive the sacrifice ratio we identify the monetary policy shifts with the IS shocks instead of the LM shocks for the case of Ceechita and Rich (2001).

4.2.1 Empirical Results From the VAR Models

We therefore used the monthly and quarterly data over the respective sample period of 1999:2 to 2007:6 and 1987:Q1 to 2006:Q4 to estimate the reduced form VAR, using year-on-year changes in consumer price index as inflation, interpolated annual real GDP into monthly and quarterly frequency and 91 day interest equivalent treasury bill rate as the proxy for the short term interest rate and included some dummies to take account of the possible structural breaks in the data. It is also important to mention that in estimating the reduced form VAR we took into consideration the data quality analysis to inform the model specifications (the unit root analysis). The results of the estimated sacrifice ratio for both monthly and quarterly analysis have been presented in table 6 & 7 below:

Table 6: Estimated Sacrifice Ratio from Structural VAR (Monthly Data: 1999:2 ï 2007:6)

Model	Cumulative one year output loss
Two Variable System	0.0010
Three Variable System	0.00216

The above table shows the estimated sacrifice ratios from the two and three equation VAR model for the monthly analysis. It indicates the cumulated output loss associated with a permanent one-percentage fall in inflation rate. While the two-equation model recorded an output loss of 0.001 per cent from one per cent disinflationary process , the three variable equation model indicated an output lose of 0.0022 per cent from a one per cent permanent decline in inflation. This result represents higher output losses than the two sector model and the same as the sacrifice ratio from the episode specific approach.

For the quarterly analysis, much larger sacrifice ratios were recorded. It was 0.05 and 0.08 for the two and three sector models respectively.

Table 7: Estimated Sacrifice Ratio from Structural VAR (Quarterly Data: 1987:1 ï 2006:4)

Model	Cumulative one year output loss
Two Variable System	0.05
Three Variable System	0.08

4.3 Expectations Augmented Philips Curve Approach

The paper further looked at the third approach, which is an expected augmented Philipôs curve. Following the methodology by Kapur et al (2001) we estimated the reduced form specification of the aggregate supply curve. Within this framework an alternative specification based on different underlying theoretical model can be estimated.

Kapur and Petra (2001) used a simple expectations augmented Phillips Curve equation but reformulated to include supply shocks and adaptive expectations to obtain the ótriangle model of inflationô. The phrase ótriangleô stresses that inflation depends on a tripartite set of basic determinants: inertia (in inflation), demand and supply shocks and presented as follows:

$\pi_t = a(L)\ \pi_{t-1} + b(L)Dt + c(L)\ zt$ é é é é é é é é é é é é é é é é é é (8)

where, π_t Dt, and zt denote inflation, a measure of excess demand (unemployment gap or output gap) and supply shocks (proxied by imported inflation), respectively and L is the lag operator. We followed the same approach but used the domestic oil prices as a proxy of supply shocks. The potential output is estimated from the Hodrick Prescott filtering approach.

Following the evidences of unit root in the inflation and domestic oil prices we modified the above equation to take the first difference form as estimated by Turner and Seghezza (1999) and Kapur et al (2002). The model to be estimated is expressed as follows:

$$\Delta p_t = A(L)\Delta p_{t-1} + b^* \lg ap_{t-1} + C(L)\Delta oilp \quad \text{é é é é é é é é é é é} \ .(9)$$

Where, △ is the difference operator, *lgap* is the output gap and *oilp* is inflation due to supply shocks. The specification implies no long-run trade-off between the level of output and the level of inflation: a temporary increase in the output gap will lead to a permanent increase in inflation. As indicated in equation (1), given the potential output, and assuming adaptive expectations, any policy to reduce inflation in the short run will come from lowering output. The sacrifice ratio is then computed as [(1-coefficients of lagged inflation)/coefficient of output gap].

The alternative model state that the inflation-output trade off can be obtained from the decomposition of changes in nominal income and its impact on inflation and real output. This is based on the Lucas framework. Following Hutchison and Walsh (1998), the aggregate short-run supply curve can be formulated as:

$$\Delta p_t = \alpha \ pE_{t-1} + \beta\chi \ \lg ap_{t-1} + \delta \ oilp + \phi \ dnnt \quad \text{é é é é é é é} \ .(10)$$

Where ***dnnt*** is growth rate of nominal output and other variables are as defined before. We used the lagged inflation given that there is no data on inflationary expectations. Under this circumstance the coefficient of the nominal GDP measures the proportion of the changes in nominal aggregate demand that affects inflation in the short run, given expected inflation, the state of business cycle represented by the deviation of the actual output from its potential trend and supply shocks. Since the coefficient of the growth rate in nominal output measures the changes in prices, therefore subtracting one from this coefficient captures the effect of the change in nominal demand on real output. Therefore the sacrifice ratio is estimated as:

$$SA = \left[(1-\phi)/\phi\right] \quad \text{é é} \ (11)$$

We therefore estimated the equation (9 & 10) above with both monthly and quarterly time series and derived the sacrifice ratios which are presented in tables 8 - 11 below:

Table 8: Sacrifice Ratio from Philips Curve (Monthly Data: 1999:2 ï 2007:6)

Coefficient of:			
Lag Inflation	**Lag output gap**	**(1- coefficient of Lag Inflation)**	**Sacrifice Ratio**
0.573651	0.083783	0.426349	5.1

Table 9: Sacrifice Ratio from Philips Curve (Quarterly Data: 1987:1 ï 2006:4)

Coefficient of:			
Lag Inflation	**Lag output gap**	**(1- coefficient of Lag Inflation)**	**Sacrifice Ratio**
0.497589	0.098626	0.502411	5.1

Table10: Sacrifice Ratio from Philips Curve (Monthly Data: 1999:2 ï 2007:6)

Coefficient of DNNT	(1- Coefficient of DNNT)	Sacrifice Ratio
0.40	0.60	1.49

Table11: Sacrifice Ratio from Philips Curve (Quarterly Data: 1999:2 ï 2007:6)

Coefficient of DNNT	(1- Coefficient of DNNT)	Sacrifice Ratio
0.271764	0.728236	2.6

The two estimations from which the sacrifice ratios were calculated as well as the results of the diagnostic tests in both monthly and quarterly time series have been presented in the appendix 1&2. It is important to mention that the R^2 for the two estimations were satisfactory given that the dependent variable entered the equation in a first difference. The estimations again satisfy all the diagnostics tests as the equations passed the serial correlation, normality and the specification (reset) tests.

In the first estimated equation from the monthly analysis, inflation persistence variable was significant recording a coefficient of over 0.5 which explains the strong presence of inertia in Ghanaȏs inflationary process. The variable capturing the demand pressures indicated that if output increases above its potential level by 1 per cent inflation will increase by 0.08 per cent. The domestic oil prices which capture the supply shock also have significant impact on inflation. From this estimation we derived the sacrifice ratio to be 5.1.

In the second estimation from the monthly analysis we provided evidences of the presence of inflation inertia, significant impact of the growth rate of nominal GDP, demand pressures as well as supply shocks. Estimate of the sacrifice ratio from this equation is 1.5.

In terms of the quarterly analysis, both equations provided evidences of inflation inertia and also found that the growth rate of nominal GDP, demand pressures and supply shocks all have significant influences on inflation. From these estimations the sacrifices ratios of 1.5 and 2.6 were derived respectively.

To further ensure the robustness of our estimations we subjected the equations to some stability tests. This is in line with the concern in the literature that the coefficients from the estimated Philips curve are usually unstable. Chow test is the most popular test for the parameter stability but it requires a definite knowledge of the break point which is often difficult so we used the CUSUM and CUSUMSQ techniques which overcome this difficulty by detecting gradual changes based on the recursive residuals. The estimations passed the parameter stability tests as the results of the CUSUM and CUSUMSQ for all the estimations were within the boundary of stability. The results have been made available in the appendix.

Section 5: Conclusions

The paper has examined the short run trade off between stability and output. In doing this, we explored the various methodologies including the aggregate supply curve, actual developments in output and inflation as well as the structural VAR models. The estimates of the sacrifice ratios from these approaches show that a permanent one percentage reduction in inflation results in an output loss of 0.001 to 5.1 per cent. This wide range is very consistent with empirical studies on the subject.

It is worthy at this stage to mention that underpinning the sacrifice ratio is the cost of the disinflation policy ensued from a tight monetary policy stance. This in turn results in subduing the demand pressures or the economic activities which results in a short run output loss. Clearly, in a developing country like Ghana, the supply side issues can have significant effect on inflation. In this case, both demand and supply pressures during disinflation period can affect the size of the output losses and the change in inflation.

Since the MPC process, Ghana has experienced both macro stability and economic growth which support the arguments that if a disinflation process persists (as in the case of episode three and five above) and policies are consistent and credible, the economy may eventually adjust to the new monetary policy regime and output and employment losses may only be transitory. For this reason the discussions on this subject must take into account the sources of inflation, the monetary policy stance and the role of supply conditions.

APPENDIX

Appendix 1 Results of the Monthly Analysis

Table A: Estimation of Equation (9) – 1999:2 – 2007:7

Dependent Variable: DP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOILP(-1)	0.001867	0.000880	2.120834	0.0370
LGAP	0.083783	0.050090	1.672646	0.0982
DUM00	0.841599	1.085317	0.775441	0.4403
DUM01	-1.492989	2.213397	-0.674524	0.5019
DP(-1)	0.573651	0.085134	6.738190	0.0000

R-squared	0.410216	Mean dependent var	0.043922
Adjusted R-squared	0.381446	S.D. dependent var	3.581859
S.E. of regression	2.817067	Akaike info criterion	4.965023
Sum squared resid	650.7410	Schwarz criterion	5.106742
Log likelihood	-210.9785	Durbin-Watson stat	1.977419

Table B: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.209484	Prob. F(2,80)	0.811446
Obs*R-squared	0.417946	Prob. Chi-Square(2)	0.811417

Table C: Specification Test

Ramsey RESET Test:

F-statistic	0.109998	Prob. F(2,80)	0.895971
Log likelihood ratio	0.238918	Prob. Chi-Square(2)	0.887400

Chart A: Normality Test

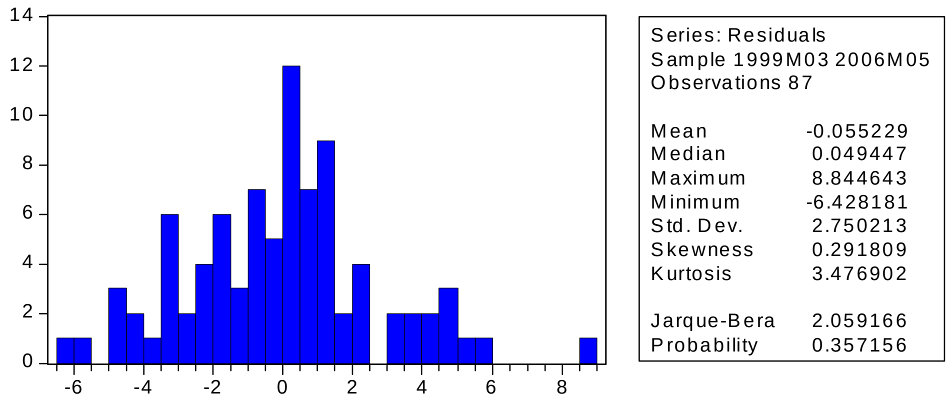


Chart B: CUSUM Test (Parameter Stability)

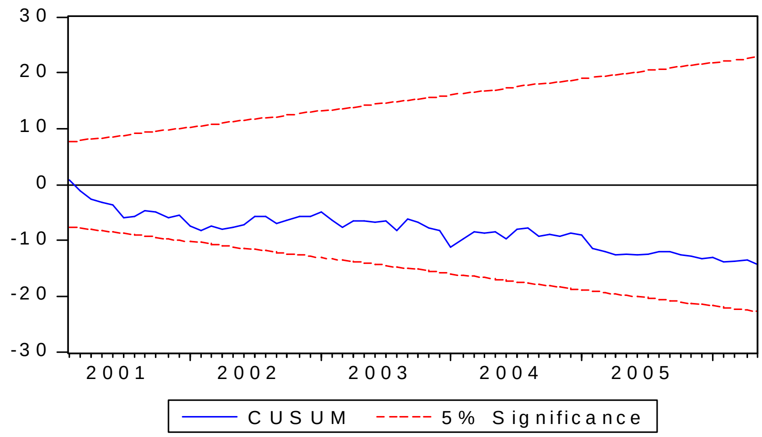


Chart C: CUSUMSQ Test (Parameter Stability)

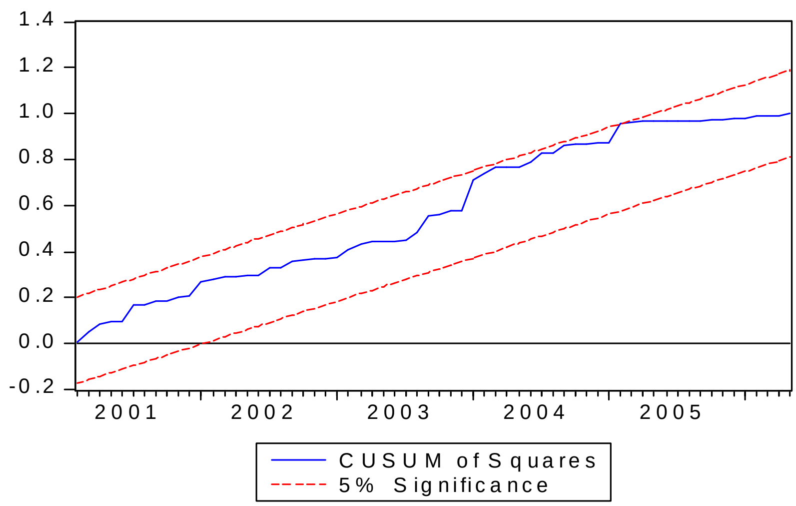


Chart D: Recursive Estimate Test

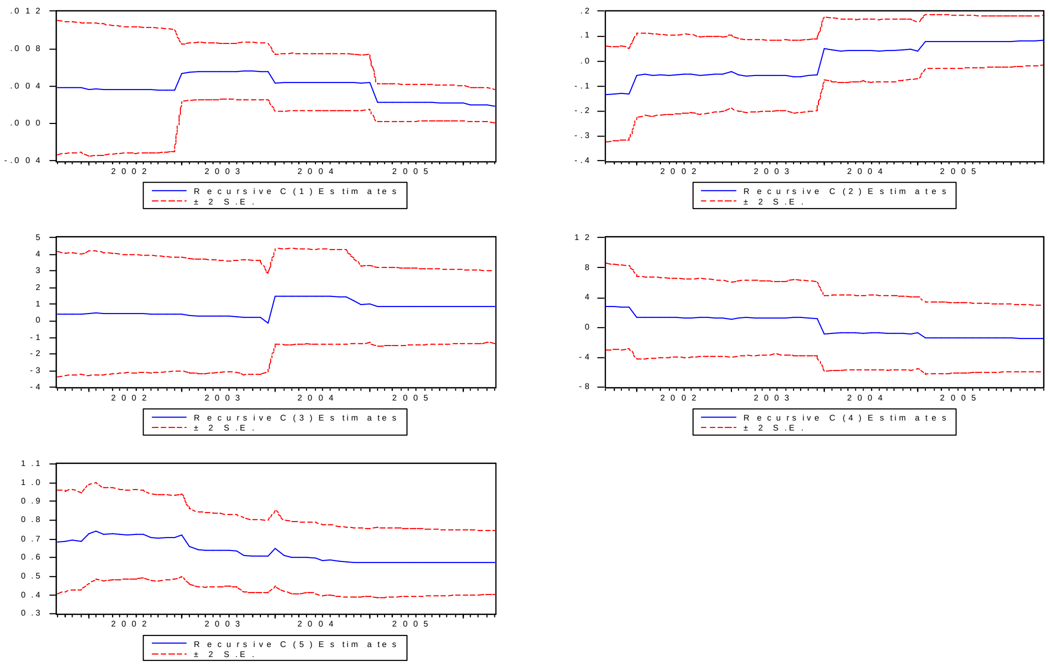


Table D: Estimation of Equation (10) – 1999:2 – 2007:7

Dependent Variable: DP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOILP(-1)	0.001712	0.000874	1.958452	0.0537
LGAP	0.102974	0.051344	2.005548	0.0483
DUM00	1.330019	1.109935	1.198286	0.2343
DUM01	-2.627242	2.257695	-1.163684	0.2480
DP(-1)	0.523375	0.089426	5.852578	0.0000
DNNT	0.401430	0.217626	1.844587	0.0688
DOILP	-0.001338	0.000923	-1.448915	0.1513

R-squared	0.438653	Mean dependent var	0.043922
Adjusted R-squared	0.396552	S.D. dependent var	3.581859
S.E. of regression	2.782457	Akaike info criterion	4.961584
Sum squared resid	619.3652	Schwarz criterion	5.159990
Log likelihood	-208.8289	Durbin-Watson stat	2.058193

Table E: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

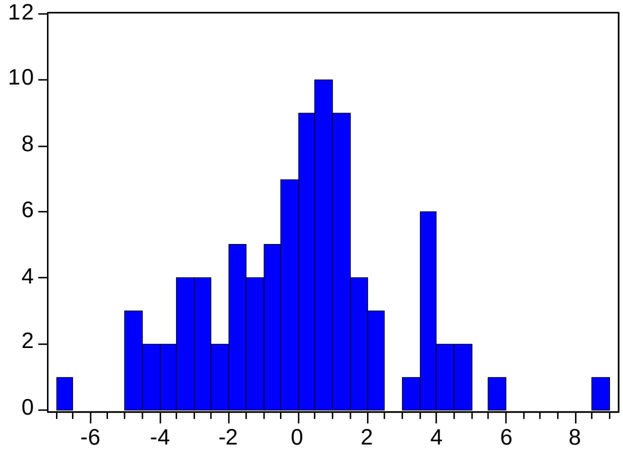
F-statistic	0.294810	Prob. F(2,78)	0.745499
Obs*R-squared	0.565323	Prob. Chi-Square(2)	0.753775

Table F: Specification Test

Ramsey RESET Test:

F-statistic	0.428766	Prob. F(2,78)	0.652838
Log likelihood ratio	0.951258	Prob. Chi-Square(2)	0.621494

Chart E: Normality Test



Series: Residuals
Sample 1999M03 2006M05
Observations 87

Mean	0.084843
Median	0.204991
Maximum	8.706639
Minimum	-6.560729
Std. Dev.	2.682282
Skewness	0.220178
Kurtosis	3.462969
Jarque-Bera	1.479917
Probability	0.477134

Chart F: CUSUM Test (Parameter Stability)

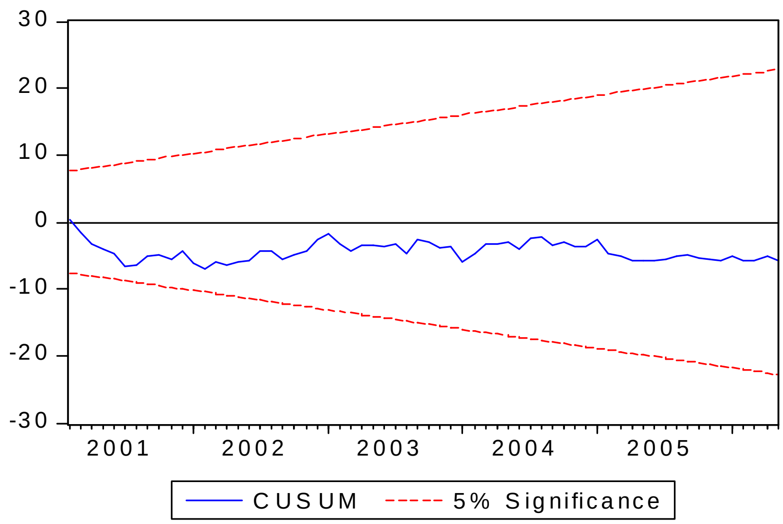


Chart G: CUSUMSQ Test (Parameter Stability)

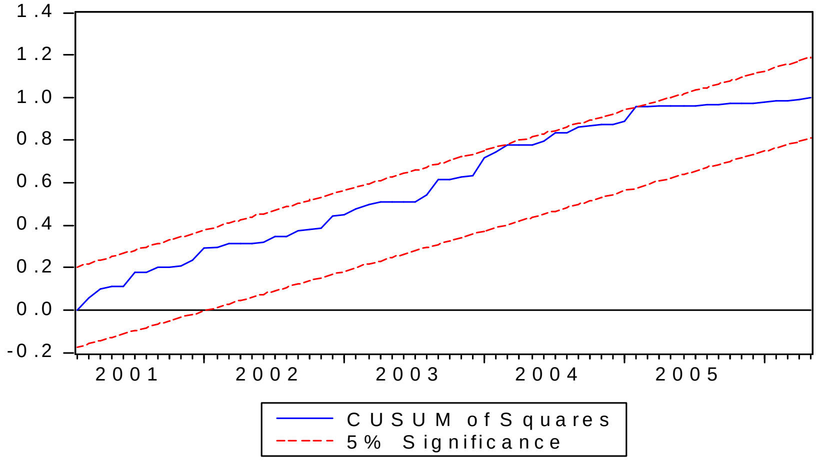
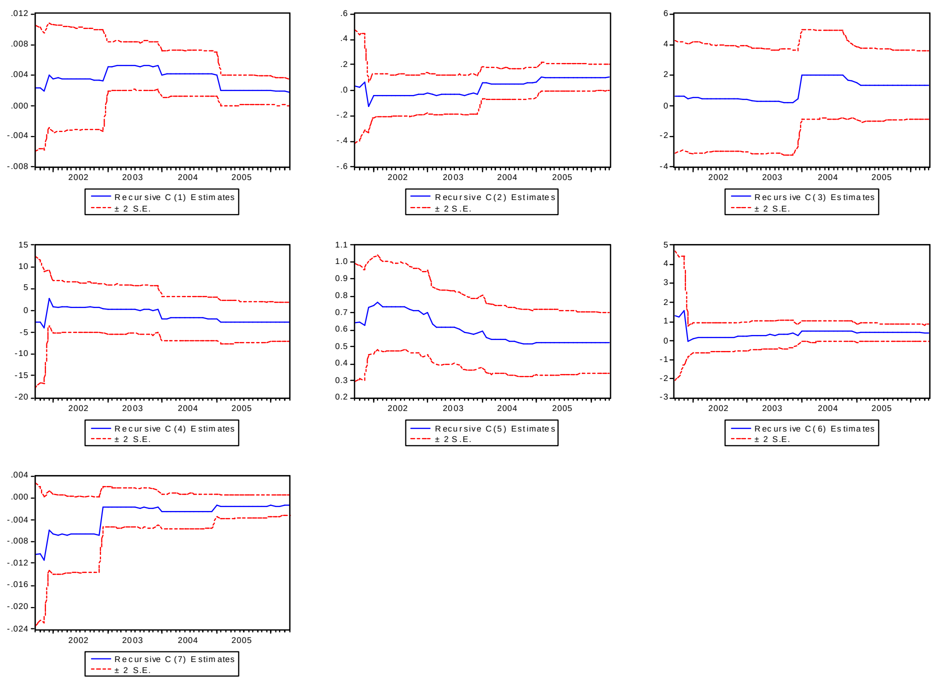


Chart H: Recursive Tests



Appendix 2: Results of the Quarterly Analysis

Table G: Estimated Equation (9) : 1987:1 – 2006:4

Dependent Variable: DP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOILP	0.004296	0.001514	2.836974	0.0059
DP(-1)	0.497589	0.089541	5.557096	0.0000
LYQGAPP(-1)	0.098626	0.050560	1.950676	0.0548
LYQGAPP(-2)	-0.097379	0.050402	-1.932054	0.0571
DUM01	1.798000	1.188713	1.512561	0.1346

R-squared	0.387363	Mean dependent var	0.285000
Adjusted R-squared	0.354689	S.D. dependent var	5.973022
S.E. of regression	4.798202	Akaike info criterion	6.034821
Sum squared resid	1726.706	Schwarz criterion	6.183698
Log likelihood	-236.3928	Durbin-Watson stat	1.795987

Chart I: Normality Test

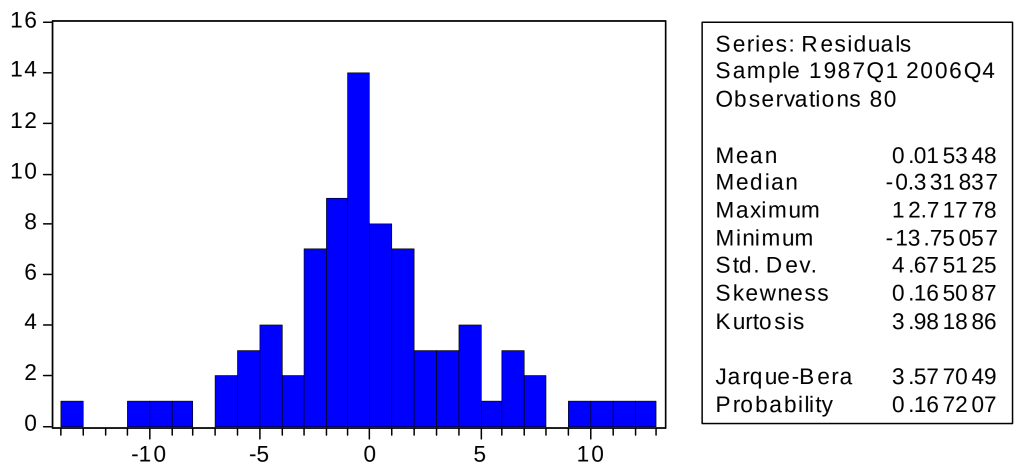


Table H: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.998711	Prob. F(2,73)	0.373330
Obs*R-squared	2.129807	Prob. Chi-Square(2)	0.344761

Table I: Specification Test

Ramsey RESET Test:

F-statistic	0.176359	Prob. F(2,73)	0.838673
Log likelihood ratio	0.385609	Prob. Chi-Square(2)	0.824643

Chart J: Parameter Stability Test (CUSUM)

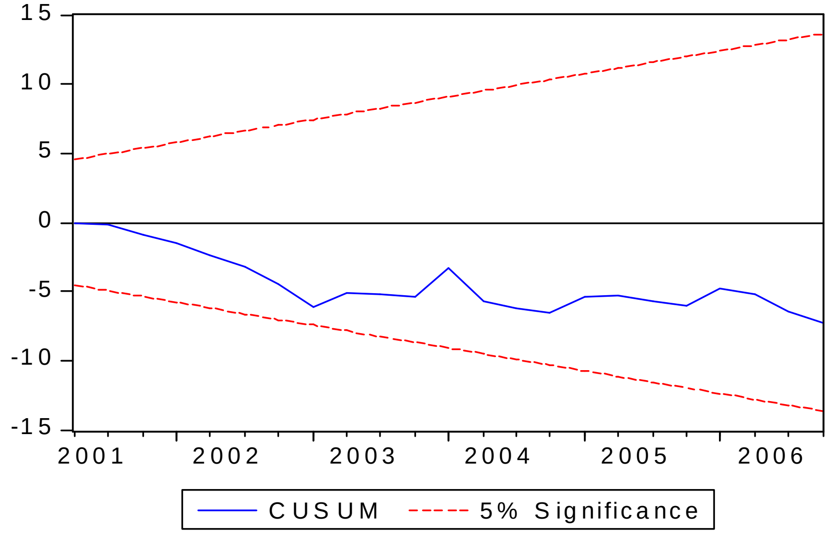


Chart K: Parameter Stability Test (CUSUMSQ)

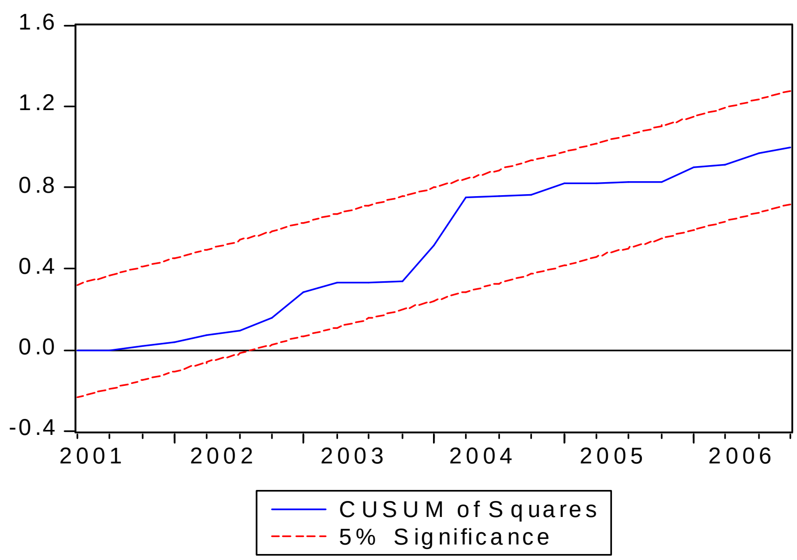


Table J: Estimation of Equation (10) : 1987:1 – 2006:4

Dependent Variable: DP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LYQGAPP(-1)	0.087700	0.051390	1.706546	0.0920
DP(-1)	0.536682	0.090606	5.923238	0.0000
DNNT	0.271764	0.162601	1.671355	0.0988
LYQGAPP(-2)	-0.117153	0.051730	-2.264711	0.0264
DOILP	0.003644	0.001426	2.554934	0.0126

R-squared	0.391345	Mean dependent var	0.285000
Adjusted R-squared	0.358883	S.D. dependent var	5.973022
S.E. of regression	4.782585	Akaike info criterion	6.028301
Sum squared resid	1715.484	Schwarz criterion	6.177177
Log likelihood	-236.1320	Durbin-Watson stat	1.905315

Chart L: Normality Test

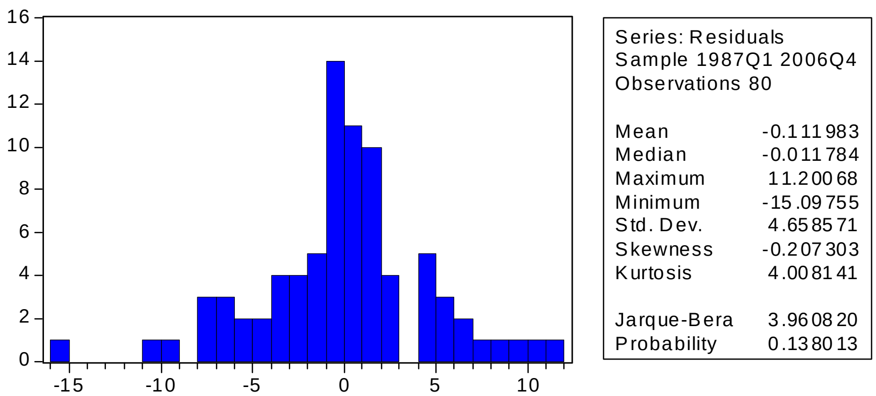


Table K: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.611820	Prob. F(2,73)	0.545120
Obs*R-squared	1.272829	Prob. Chi-Square(2)	0.529186

Table L: Specification Test

Ramsey RESET Test:

F-statistic	0.439642	Prob. F(2,73)	0.645961
Log likelihood ratio	0.957842	Prob. Chi-Square(2)	0.619451

Chart M: Parameter Stability Test (CUSUM)

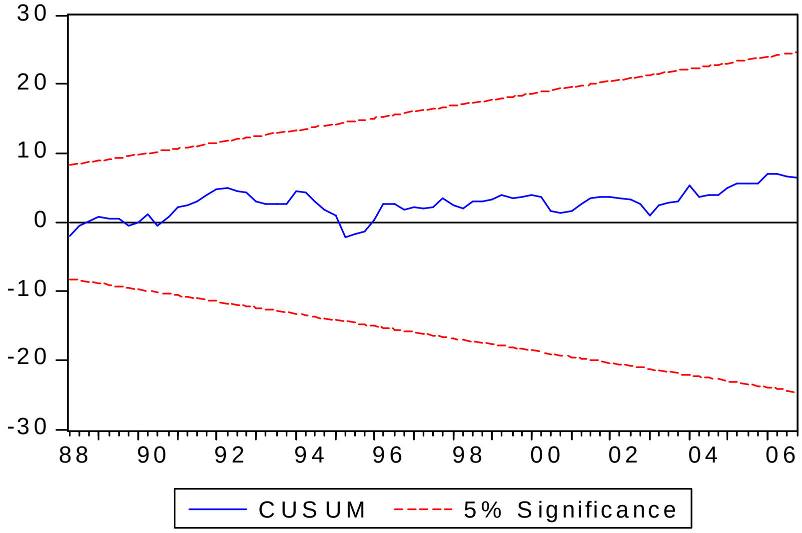
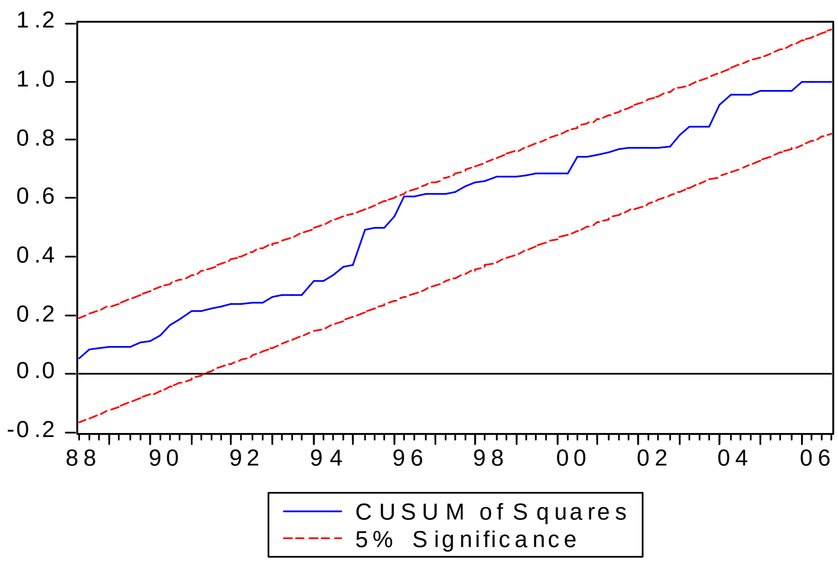


Chart N: Parameter Stability Test (CUSUMSQ)



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