Estimating the Output Cost of Disinflation: An Application to Jamaica and Trinidad & Tobago

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Abstract

The trade off between growth and inflation stabilization is one of the key test of monetary policy, particularly in small developing economies. It is generally accepted that price stability is an essential perquisite of sustained long term growth. Therefore if one accepts the view that there is no trade-off between employment and inflation in the long run then monetary policy should focus on price stability. However, the policy choice facing central banks in developing countries are not always clear-cut, particularly in the short run. Against this background this paper estimates the output cost of disinflation i.e. sacrifice ratio in selected Caribbean states using nonparametric and parametric models. Using episode-specific and a SVAR model the paper finds very low sacrifice ratio for Jamaica and Trinidad & Tobago. Specifically, during periods of disinflation, the sacrifice ratio for Jamaica was, on average, 0.029 percentage points loss in output for every 1.0 percentage point decline in inflation, while the ratio on average was 0.113 per cent for Trinidad & Tobago. The Phillips curve for Jamaica is found to be convex implying that the cost of fighting inflation falls with the strength of the economy. Trinidad & Tobago inflation is found to be insensitive to the strength of the economy.

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1.0   Introduction

The trade-off between inflation and output growth is a critical consideration of central bankers when formulating policy. During early stages of inflation, tighter monetary policy can slow the pace of economic activity. This output lost can be seen as the price paid for curtailing inflationary pressures. In this context, policy makers are keen in assessing the overall impact on the economy of disinflation policies. Against this background this paper estimates the output cost of disinflation i.e. sacrifice ratio in selected Caribbean states, namely Jamaica and Trinidad & Tobago.

The estimation of 'sacrifice ratios' is a common approach used in the literature to measure the costs of disinflation. Sacrifice ratios measures the quantity of output that is loss for each percentage point reduction in the inflation rate. Phillips curves have been used widely in the literature to estimate these sacrifice ratios. However, with new empirical evidence supporting a non-linear output-inflation relationship of the Phillips curve, episode-specific methods and nonlinear modelling using autoregression models have been used in more recent studies. Yavuz (2002) used an episode-specific model to calculate Turkey's sacrifice ratio. His results show that Turkey's disinflations are not characterized by huge losses in output and are significantly affected by positive supply shocks. Gordon and King (1982) used traditional and vector autoregressive techniques to estimate the size of the sacrifice ratio for the United States. They found a sacrifice ratio of 4.3 (5.8) when the relative import price variable was included (excluded). Filardo (1998) employed a nonlinear modelling technique to investigate the shape of the Phillip curves, in which the data is used to define the different regimes as well as determine the transition process between the regimes.

This paper uses an episode-specific model (non-parametric) as proposed by Ball (1994) and a structural autoregressive model (parametric) to calculate sacrifice ratios for Jamaica and Trinidad & Tobago. In addition, a nonlinear modelling technique used by Filardo (1998) is applied to Jamaica and Trinidad & Tobago to assess the sensitivity of inflation to the output gap. The paper finds very low sacrifice ratios for Jamaica and Trinidad & Tobago. Specifically, during periods of disinflation, the sacrifice ratio for Jamaica using

the episode-specific model (SVAR) on average is a 0.029 (0.040) percentage points loss in output for every 1.0 percentage point decline in inflation. For Trinidad & Tobago the ratio on average was 0.113 percentage points loss in output for every 1.0 percentage point decline in inflation. The Phillips curve for Jamaica is found to be convex indicating that a linear Philips curve estimate of the sacrifice ratio would not be appropriate and that the cost of fighting inflation decrease with the strength of the economy. Trinidad & Tobago inflation is found to be insensitive to the strength of the economy.

The rest of the paper is organized as follows. Section 2 looks at the concept of sacrifice ratio and the three techniques used to estimate this ratio. Section 3 outlines the paper data and the methods for estimation, while section 4 presents the results. This section also examines the policy implications from the results. The conclusion is presented in the final section.

2.0   What are Sacrifice Ratios?

The discussion, on whether price stability should be the sole focus of monetary policy has strengthened in recent years, more so with inflation targeting regimes. Supporters of price stability maintain that monetary policy has only a transitory effect on real variables.[1] In this regard policy makers should make price stability their focal point to realise the benefits from a stable and predictable price trajectory. On the other hand, opponents of price stability highlights that the existence of rigidities in the economy could result in those policies generating a recession in the economy. In this context the costs could exceed the benefits of controlling inflation.

According to Neely and Waller (1997), a country's sacrifice ratio is the cumulative loss of output during a disinflation episode as a percentage of initial output divided by the cumulative reduction in the inflation rate. For example, a sacrifice ratio of two implies that a one percentage point reduction in the trend inflation rate is associated with a loss of 2 percentage points of output. The sacrifice ratio is often loosely referred to, by

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[1] Output or unemployment

economists as the (inverse) slope of the aggregate supply curve. Consider the following aggregate supply (AS) and aggregate demand (AD) model depicted in figures 1A and 1B.

Figure 1A
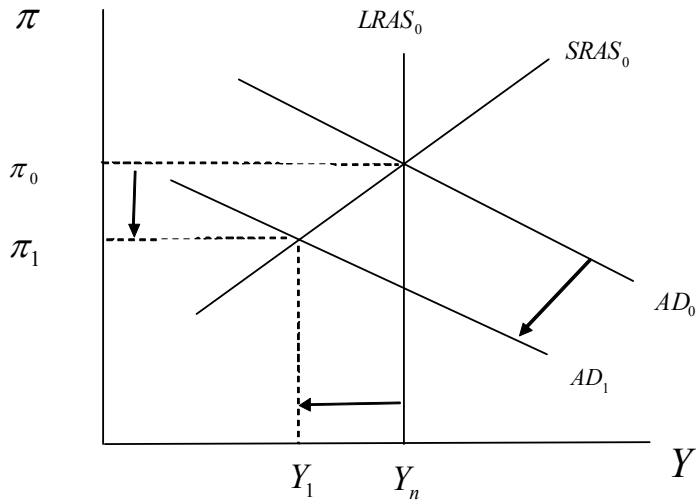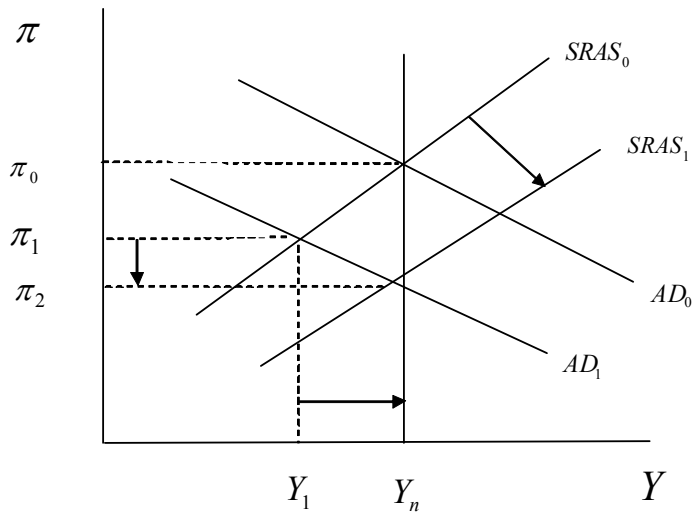Sacrifice Ratios in an Aggregate Demand-Aggregate Supply Framework

Figure 1B

The economy is at its initial long-run equilibrium at $AD_0 = SRAS_0 = LRAS_0$ (see Figure 1a).[2] The decision by policy makers to curb inflation to π_1, by reducing the trend growth rate of the money stock is likely to shift the AD curve downwards to AD_1. If wages and prices in the economy do not adjust to reflect this new level of aggregate demand, real wages will increase faster than expected as nominal wages grow. As such, employment falls, output contracts to Y_t, and the economy enters a recession. With time, private agents will adjust their wages to reflect the lower level of aggregate demand and the short-run AS will shift to the right reaching long-run equilibrium at $AD_1 = SRAS_1 = LRAS_0$ (see Figure 1B). At this stage, the economy's output will return to its long-run trend value as inflation drops to π_2. In this regard, the sacrifice ratio can be represented as:

$$Ratio = \left[(Y_n - Y_1)/Y_n\right]/(\pi_0 - \pi_2)$$

Flat AS curves characterize countries that have large estimated sacrifice ratios while countries with small estimated sacrifice ratios are known to have steep AS curves. In this context, variables that affects the slope of the short-run AS curve is also expected to influence the size of the sacrifice ratio.

Sacrifice ratios suffer from a number of limitations. Neely and Waller (1997) refer to sacrifice ratios as back-of-the-envelope calculations, which are subject to a great deal of uncertainty. Mayes and Chapple (1995) note three disadvantages of these ratios. Firstly, the authors note that the calculation of the ratios ignore the subsequent output benefits of a low inflation environment. They argue that by looking at the short-run, sacrifice ratios inevitably reveal that there is a cost to the economy. If there were no long-term gains, one would question the worth of disinflationary policies. In this context, sacrifice ratios measure gross cost of disinflation. The net cost, which includes the net benefits in the long-run, should be accounted for. Secondly, the authors state that the impact of other

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[2] Replacing the price level with the inflation rate on the vertical axis, in principle does not change the concept.

policies on both output and inflation is not measured. Thirdly, the calculation of trend output and the dating of the disinflation periods are inherently arbitrary.

2.1 Estimation of Sacrifice Ratios

2.11 *Linear Phillips Curve*

Sacrifice ratios are generally estimated using an expectation augmented Phillips curve approach, the slope of which encapsulates the trade-off between inflation and output. The Phillip curve can be expressed as follows:

$$Y_t - Y_t^* = \alpha(\pi_t - \pi_{t-1}) + \mu_t; \alpha > 0 \qquad (1)$$

Y_t and Y_t^* represent actual and potential output while $(\pi_t - \pi_{t-1})$ denotes the disinflation in time 't'. 'μ_t' represents the error term. The cost of disinflation gets larger as α grows. The primary drawback of this approach cited by researchers is that the estimated sacrifice ratio is not time varying. As such, this method restricts the output-inflation trade-off to be identical during periods of disinflation, periods of increases in trend inflation as well as in periods of temporary fluctuations in demand (Ball (1994)).

2.12 *Episode-Specific Models*

Episode-specific models have been proposed by Ball (1994) as an alternative to the linear Phillip's curve approach to calculate the output losses that emerge in separate disinflation episodes. This approach allows the sacrifice ratio to vary over time. This method also facilitates the comparison of different economic policies in terms of output loss. According to Ball (1994) methodology specific disinflation episodes have to be identified after which the inflation-output trade-off is calculated for each episode.

The disinflation episodes are characterized by a substantial fall in trend inflation, defined as a centred, nine quarter moving average of actual inflation. For example, trend inflation at time (t) is the average of inflation rates between (t-4) and (t+4). This approach is taken as quarterly inflation tends to fluctuate significantly over short periods of time. By smoothing the inflation rates, Ball (1994) extracts the longer-run movements.   The

inflation peak is a point in time when trend inflation is higher than the previous quarter inflation rate as well as higher than the subsequent four quarters inflation rates.   On the other hand, an inflation trough is a point in time when trend inflation is lower than the previous quarter's inflation and also lower than the subsequent four quarters inflation rates. From the above, the disinflation episode is then defined as the time range, starting with an inflation peak and ending with an inflation trough. However, the annual inflation over the disinflation episode must be at least two percentage points lower than the inflation rate at the episode's peak.   The disinflation episode is identified as the time range between an inflation peak and an inflation trough. The sacrifice ratio for each episode is calculated as is the norm as the total deviation in output from its trend divided by the change in trend inflation.

To estimate the output loss from the disinflation episode, a measure of trend/potential output is required. The measurement of potential output is complicated as it is not transparent whether output fluctuates around a stable linear trend, a changing trend, or whether its movements are purely random. Ball (1994) uses three basic assumptions to define potential output:

1) Actual output is at its trend value when trend inflation is at its peak. He justifies this by noting that potential output is known as that level of output for which inflation is neither rising nor falling, and that this stipulation is reached when trend inflation is at its peak.

2) Output returns to its potential level four periods after the end of the episode. This assumption is based on the fact that the economy will continue to adjust even after inflation reaches its new trend level.

3) Trend output is defined by the line connecting the actual level of output at the start of the disinflation with the actual level of output four quarters after inflation reaches its trough.

Based on the above, the total output loss, as a percentage of initial output during a disinflation episode, is the annualized sum of actual GDP each period subtracted from its estimated trend value.

Ball's potential output assumptions have been criticized by many researchers. While the first assumption is widely acceptable, the second, of output returning to its potential level four quarters after the trough is questionable. In this regard, scholars are unsure how long the effects from the recession will last. It is possible that it could be greater than four quarters.

A possible solution to this problem was put forward by Zhang (2001). He notes that Ball's second assumption could result in an understatement of the cost of disinflation episode due to persistence effects lasting longer than four quarters. His proposed method for calculating potential output assumes that recessions have long-lived effects and as such makes no assumptions regarding the degree of persistence. Zhang (2001) assumes the following:

1) Actual output is at its trend level when trend inflation is at its peak.
2) Potential output calculated as a HP filter of the actual GDP series. Potential GDP growth derived from HP filter series.
3) Potential output grows at the rate estimated by the HP filter at the start of the episode.

Zhang (2001) assumes the possibility of persistence effects and as such short-term and long-term output losses would not be equal as is the case in Ball (1994) approach. Of note, Ball (1994) and Zhang (2001) equally assumed the absence of hysteresis effects, which are very strong persistence effects. This occurs when the actions of a contractionary monetary policy affect the potential level of GDP. The notion of hysteresis was pioneered by Blanchard and Summers (1986) to explain the permanent effects of disinflation. It was later established by Romer and Romer (1989) that demand shifts could result in a permanent reduction in output.

2.13   *Non-Linear Models*
2.131 In light of studies suggesting the nonlinear nature of Phillips curve as well as empirical evidence supporting a variety of asymmetries in the output-inflation

relationship, vector autoregressive (VAR) models have been used to measure the output cost of inflation.[3] In the VAR framework the sacrifice ratios are measured as a ratio of the response of output relative to the response of inflation following an innovation to the policy rate.[4] Following Gordon and King (1982) the ratio is define relative to the following moving average representation of the estimated model:

$$y_t = A(L)v_t$$

$$\text{where} \quad A(L)_{i,j} = \sum_{j=1}^{J} a_{i,j} L^j \quad \text{for } i = \{gap, \pi, comm, tb\}$$

In the above equation, *gap*, *π*, *comm*, and *tb* represent the output gap, inflation, commodity prices and Treasury bill rate, respectively. Of note, innovations to the Treasury bill rate equation are used to proxy changes in monetary policy. The cumulative impact of the Treasury bill equation shock on output after 't' periods is measured by:

$$\frac{\Delta y_{gap}}{\Delta v_{tb}} = \sum_{i=1}^{t} a_{gap,tb}$$

while the cumulative impact of the Treasury bill equation shock on inflation is obtained from the following:

$$\frac{\Delta y_{\pi}}{\Delta v_{tb}} = \sum_{i=1}^{t} a_{\pi,tb}$$

The sacrifice ratio is then calculated as:

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[3] Ball (1994) and Jordon (1997) both have found that the output cost of inflation vary with the state of the economy for the majority of the OECS countries.
[4] The Treasury bill rate is used as the policy rate in this paper.

$$\frac{\Delta y_{gap}}{\Delta y_{\pi}} = \frac{\sum_{i=0}^{t} a_{gap,tb}}{\sum_{i=0}^{t} a_{\pi,tb}}$$

To identify the model long-run restrictions are imposed. It is assume that demand side shocks have no long-run effects on output. In addition, innovations in the system are assumed to be recursive which allows the use of the Choleski decomposition of the estimated variance-covariance matrix.

2.132 In an attempt to identify the shape of the Phillips curve as well as measure the sensitivity of inflation to the output gap, Filardo (1998) assumed a non-linear Phillips curve with the sacrifice ratios dependent on the stage of the business cycle (strength of the economy).[5] His methodology is based on the assumption that the different shapes of the non-linear Phillip's curve have dissimilar implications for the output cost of inflation. Given that the slope of the concave and convex Phillip's curve fluctuate systematically with the strength of the economy, it implies that the output cost of inflation changes with the strength of the economy.   According to Filardo (1998), concave Phillip's curve suggests that the cost of fighting inflation increases with the strength of the economy since as the economy strengthens its slope flattens.[6] On the other hand, the convex Phillip's curve implies that the cost of fighting inflation decrease with the strength of the economy as its slope steepens. Further, he noted that to deliberately disinflate the economy, policy makers have to slow the economy while to prevent inflation from rising, economic policies must pre-emptively forestall output from rising above trend.

Filardo (1998) design permits the inflation-output relationship to differ across three regimes. The regimes relate to economic periods when output is well below trend (weak), near trend (balanced) and well above trend (overheated).

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[5] Assuming linearity means that the output cost of fighting inflation does not vary with the strength of the economy.

[6] See Filardo (1998) for a complete analysis of the slopes of the Phillip's curve.

The nonlinear Phillip's curve is as follows:

$$\pi_t = \pi_t^e + \beta_{weak} * gap(during\ weak\ times)_{t-1}$$
$$+ \beta_{balanced} * gap(during\ balanced\ times)_{t-1}$$
$$+ \beta_{strong} * gap(during\ over\ heated\ times)_{t-1}$$
$$+ \varepsilon_t \qquad\qquad (1)$$

where π is inflation, π_t^e is inflation expectations and the *gap* represents the output gap, which is measured as real GDP minus its trend. ε_t represents a supply shock. The sensitivity of inflation to economic activity in the weak, balanced or overheated regimes is measure by the slope coefficients on the output gap.

Filardo (1998) estimates the regime dates by way of a threshold parameter 'α'. Using 'α'=0.9, Filardo (1998) notes that the balance-economy regime takes place when output is approximately a percentage point above or below trend. The weak-economy occurs when output is less than a percentage point below trend while the overheated regime arises when output is more than a percentage point above trend.

Inflation expectations take the following form:

$$\pi_t^e = \pi_0 + \pi_{t-1} + \delta\left(\pi_{t-1}^e - \pi_{t-1}\right) \qquad (2)$$

π_0 is a constant inflation premium which represents the average empirical deviation of survey inflation expectations from actual inflation. The next two terms of the equation reflects the empirical observation that changes in inflation are sluggish, as inflation expectations depends on the last period's inflation rate and the realized error in last period's expectation from the actual inflation rate.

Substituting equation (2) into equation (1) yields:

$$\pi_t - \pi_{t-1} = \pi_0 + \delta(\textit{last period's inflation forecast error})$$
$$+ \beta_{neg}\,(\textit{lagged output gap} \times I_{neg})$$
$$+ \beta_{balanced}\,(\textit{lagged output gap})$$
$$+ \beta_{pos}\,(\textit{lagged output gap} \times I_{pos}) + \varepsilon_t$$

$$= \pi_0 + \delta(\pi^e_{t-1} - \pi_{t-1})$$
$$+ \beta_{weak}\, \textit{gap(weak times)}_{t-1}$$
$$+ \beta_{balanced}\, \textit{gap(balanced times)}_{t-1}$$
$$+ \beta_{overheated}\, \textit{gap(overheated times)}_{t-1}$$

where *gap(weak times)*$_{t-1}$
$$= gap_{t-1}, \text{ if } gap_{t-1} \leq -\alpha$$
$$\textit{otherwise} = 0$$

gap(balanced times)$_{t-1}$
$$= gap_{t-1}, \text{ if } -\alpha < gap_{t-1} \leq \alpha$$
$$\textit{otherwise} = 0$$

gap(overheated times)$_{t-1}$
$$= gap_{t-1}, \text{ if } gap_{t-1} > \alpha$$
$$\textit{otherwise} = 0$$

In this set-up, the indicator functions 'I_{neg}' and 'I_{pos}' will take on a value of 1 if the output gap data come from the weak and overheated regimes, respectively. Otherwise the indicator functions are zero.

When calculating sacrifice ratios, it is extremely important to make allowances for supply shocks. Supply shocks, for example a hurricane can reduces output without any

monetary authority actions. In this regard, sacrifice ratios can be deceptive if supply shocks are not separated from demand shocks.

3.0   Data and Estimation

This paper uses quarterly data from 1981:01 to 2008:02 for real Gross Domestic Product (GDP) and inflation.[7]   Both headline and core inflation is used in the analysis. All variables are in logs and seasonally adjusted, where appropriate. The variables used are consistent with that used by Filardo (1998), Zhang (2001) and Ball (1994).

The data series for Jamaica were obtained from the Statistical Institute of Jamaica while the series for Trinidad & Tobago was acquired from the IMF International Financial Statistics CD Rom as well as from the Trinidad and Tobago Central Bank's website.

Five methodologies[8]   are employed to calculate the sacrifice ratios for the episode-specific model. For the first two episode-specific models, the paper fully adopts Ball's (1994) and Zhang's (2001) procedures. So as to account for the uncertainty regarding the dating of the disinflation episodes, the paper adopts two additional approaches advanced by Neely and Waller (2001) who re-examine the assumption that monetary policy tends to work through an output gap channel. That is to say that a contraction in output precedes a fall in inflation. In this regard, they reestimate the sacrifice ratio by measuring the output loss beginning four quarters before the disinflation begins and stopping at the end of the disinflation episodes. The second timing adjustment made by Neely and Waller (2001) involves the assumption that output returns to its trend value by the end of the disinflation episode, instead of four quarters later. The fifth methodology calculates potential output using the Hodrick-Prescott filter.

Trend inflation is calculated according to Yavuz (2002) as the centred five-period moving average of inflation (see Figures 2 and 3 in the Appendix). By shorting the moving average procedure, the author found a less smoothened inflation trend in which

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[7] Inflation is calculated as the average inflation during the quarter.
[8] The different methodologies speak to the different approaches in calculating the deviation of output from its trend, as the calculation of trend inflation remains the same for all methodologies.

disinflation episodes were more evident. This procedure highlighted more clearly the disinflation episodes for Trinidad & Tobago.

The inflation peak and trough is defined according to Ball (1994). The disinflation episode is then identified as the time range starting with an inflation peak and ending with an inflation trough. Similar to Neely and Waller (2001), the paper examines disinflation greater than 1.0 per cent instead of 2.0 per cent as used by Ball (1994). The potential output calculation from methods 2 and 3 are shown in Figures 4 and 5 in the Appendix.

The SVAR model uses the output gap, core inflation, Treasury bill rate and commodity prices. Commodity prices for Jamaica and Trinidad & Tobago is proxy by Jamaica's terms of trade index and world commodity price index, respectively. Given that Jamaica and Trinidad & Tobago are small open economies, commodity prices are included as increases in these prices could significantly affect consumer price inflation. To identify the system it is assume that shocks to inflation and the proxy for the commodity price variable have no effect on the output gap in the long run.

The use of a nonlinear Phillip's curve as advanced by Filardo (1998) is used to define the shape of the Phillip curves in each country and the sensitivity of inflation to the output gap. The Phillips curve is estimated using a generalized method of moments (GMM) with '$\pi_t - \pi_{t-1}$' serving as a proxy for expected inflation, $(\pi^e_{t-1} - \pi_{t-1})$ captures the empirical observation that changes in inflation are sluggish. The Phillips curve is also estimated along with lagged values of the output gap in each stage of the economy and first differences of the exchange rate. The exchange rate is included to account for the openness of the economies being modeled. Lagged values of all the variables used are included as instruments in the estimation. A hurricane dummy is also included amongst the instrumental variables to capture the effects of supply shocks. The dummy included the seven most severe tropical storms and hurricanes between 1985 and 2008.[9]

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[9] Hurricane Kate, Hurricane Gilbert, Tropical Storm Gordon, Hurricane Lilly, Hurricane Ivan, Hurricane Dennis and Hurricane Dean.

4.0   Results

4.1   *Jamaica* / Episode-Specific Models

The results show 3 disinflation episodes for Jamaica using the two measures of core inflation and 4 disinflation episodes using headline inflation (see table1).[10]

Table 1: Disinflation Episodes for Jamaica Inflation Data

	Start	End	Duration (Quarters)	Trend Inflation Decline
(Centered 5-quarters moving average) CPIAF				
Episode 1	Dec-91	Mar-93	6	9.6 ppts
Episode 2	Mar-94	Mar-95	5	2.7 ppts
Episode 3	Dec-95	Sep-99	16	3.5 ppts
(Centered 5-quarters moving average) CPIA				
Episode 1	Dec-91	Mar-93	6	10.8 ppts
Episode 2	Mar-94	Mar-95	5	3.1 ppts
Episode 3	Dec-95	Jun-99	15	4.2 ppts
(Centered 5-quarters moving average) Headline				
Episode 1	Dec-84	Sep-87	12	5.0 ppts
Episode 2	Dec-91	Mar-93	6	11.7 ppts
Episode 3	Mar-94	Mar-95	5	3.7 ppts
Episode 4	Dec-95	Dec-98	13	4.6 ppts

For Jamaica, the inflationary episodes depicted by the two core measures are fairly identical and are also consistent with the episodes highlighted by the headline measure. The rise in inflation in 1984 coincided with the change in the crawling peg exchange rate regime and the introduction of the foreign exchange auction mechanism in March of that year, which saw a devaluation in the exchange rate of over 100.0 per cent by the year end. In 1991, inflation peaked, following the liberalization of the foreign exchange rate regime. Inflationary pressures in the mid 1990's can be attributed to post liberalization effects.

All measures of the sacrifice ratio show that for the period December 1991 to March 1993 a 1.0 percentage point decline in core inflation result, on average, in a 0.004

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[10] The core measures used are inflation excluding agriculture and fuel (CPIAF) and inflation excluding agriculture (CPIA).

percentage points loss in output (see table 2). For the second episode, March 1994 to March 1995, a relatively larger sacrifice ratio of 0.05 is derived. That is a 1.0 percentage point decline in core inflation result, on average, in a 0.05 percentage points loss in output. Based on the sacrifice ratio estimates for the third episode, monetary policy did not result in output loss as indicated by the negative sacrifice ratios across all methods.[11] The timing adjustments made to Ball's calculation show greater positive sacrifice ratios in the second episode for both core measures versus Ball's negative values. Similarly, in the third episode, the timing adjustments for both core measures show greater increases in output from a one percentage point fall in trend inflation. Based on the result, Jamaica's disinflation episodes are not characterize by critical losses in GDP as depicted by the relatively small sacrifice ratios. In this regard, the cost to move from 15.6 per cent inflation (annual average estimate for CPIAF for 2008) to 5.0 per cent (single digit) is approximately 0.53 percentage points of initial output (using a sacrifice ratio of 0.05).

Table 2: Jamaica Calculation of Sacrifice Ratio for 5-Quarter Moving Average Inflation

	Method 1	Method 2	Method 3	Method 4	Method 5	Average*
	HP	*Ball*	*Ball & HP*	*Timing 1*	*Timing 2*	
Episode 1						
Sacrifice ratio: CPIAF	-0.002	0.002	0.013	0.003	0.002	0.004
: CPIA	-0.002	0.001	0.011	0.003	0.002	0.004
: Headline (2)	-0.002	0.001	0.011	0.003	0.002	0.003
Episode 2						
Sacrifice ratio: CPIAF	0.036	-0.06	0.132	0.038	0.008	0.054
: CPIA	0.032	-0.054	0.116	0.034	0.008	0.047
: Headline (3)	0.027	-0.045	0.098	0.028	0.006	0.040
Episode 3						
Sacrifice ratio: CPIAF	-0.027	-0.157	-0.030	-0.034	-0.111	-0.050
: CPIA	-0.022	-0.125	-0.023	-0.033	-0.099	-0.044
: Headline (4)	-0.021	-0.122	-0.019	-0.018	-0.080	-0.034

* Excludes method 2

4.2   *Trinidad & Tobago* / Episode-Specific Models

Table 3 illustrates 3 disinflation episodes for Trinidad & Tobago using both core and headline inflation. The disinflation episodes illustrate by the core measure is fairly similar to that depicted by the headline measure. In Trinidad & Tobago, inflationary pressures during 1993 reflected the first round effects of the abolition of the fixed peg exchange

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[11] Negative sacrifice ratios imply that output actual increases as trend inflation falls.

rate to the US Dollar and the removal of formal exchange controls. This resulted in an immediate depreciation of the domestic currency by 25.1 per cent.

Table 3: Disinflation Episodes for T&T Inflation Data

	Start	End	Duration (Quarters)	Trend Inflation Decline
(Centered 5-quarters moving average) Core				
Episode 1	Sep-83	Dec-85	10	2.7 ppts
Episode 2	Mar-89	Jun-91	10	1.9 ppts
Episode 3	Sep-93	Mar-96	11	2.2 ppts
(Centered 5-quarters moving average) Headline				
Episode 1	Sep-83	Sep-85	9	2.7 ppts
Episode 2	Dec-86	Dec-87	5	1.1 ppts
Episode 3	Jun-93	Mar-96	12	2.3 ppts

The sacrifice ratios for Trinidad & Tobago illustrate two episodes where disinflation resulted in a loss in output (see table 4). For episode two (three), a 1.0 percentage point decline in core inflation result, on average, in a 0.016 (0.209) percentage points loss in output. For the case of Trinidad & Tobago, the timing adjustments made to Ball's calculation illustrate, in all cases, smaller sacrifice ratios. This finding is similar to the results by Neely & Waller (2001) for the United States. Although, the sacrifice ratios for Trinidad & Tobago are relatively bigger than Jamaica's, disinflation episodes in Trinidad & Tobago were still not characterized by significant losses in GDP.

Table 4: Trinidad & Tobago Calculation of Sacrifice Ratio for 5-Quarter Moving Average Inflation

	Method 1 HP	Method 2 Ball	Method 3 Ball & HP	Method 4 Timing 1	Method 5 Timing 2	Average*
Episode 1						
Sacrifice ratio: Core	0.010	0.082	-0.287	-0.144	0.034	-0.097
: Headline	0.069	0.435	-2.292	-2.074	0.175	-1.031
Episode 2						
Sacrifice ratio: Core	0.006	0.044	0.200	-0.189	0.048	0.016
: Headline	-1.837	-0.735	-2.324	-0.475	-0.433	-1.267
Episode 3						
Sacrifice ratio: Core	-0.043	0.370	0.879	-0.157	0.157	0.209
: Headline	-0.739	0.706	5.636	-4.207	0.110	0.200

* Excludes method 2

Of the two countries, Trinidad & Tobago have the larger sacrifice ratios. In addition, the duration of the disinflation period in Trinidad & Tobago was, on average, longer at 10.3 quarters relative to Jamaica's duration of 9 quarters. From the results, none of the countries disinflation episodes were characterize by critical losses in GDP as indicate by the relatively small ratios.

4.3   SVAR

Figures 4 and 5 in the appendix show the accumulated impulse responses of the output gap and core inflation, after 10 quarters, to a one percentage point increase in the Treasury bill rate for Jamaica and Trinidad & Tobago, respectively. For Jamaica, the initial increase in the Treasury bill rate causes the output gap to decline steadily for the first 2 quarters before tapering off by the 7th quarter. As a result the accumulated responses remain negative for the ten-quarter period. In response to the Treasury bill rate shock, core inflation increase for the first two quarters before it's descend which lasted for approximately 8 quarters.

With respect to Trinidad & Tobago, the response of the output gap to the shock to the Treasury bill rate was similar to Jamaica's response. However, the response of core inflation was somewhat different. Core inflation increase steadily for the first two quarters, after that the rate of increase decline gradually up until the 7th quarter when the response tappers off. As a result, the accumulated responses remain positive for the ten-

quarter period. In this context the sacrifice ratios calculated for Trinidad & Tobago are all negative after 4,8 and 10 quarters after the Treasury bill shock, while positive ratios are found for Jamaica (see table 7)

Table 7: SVAR Sacrifice Ratio Results

	Jamaica	Trinidad & Tobago
Sacrifice Ratio		
4- Period After Shock	0.079	-0.044
8- Period After Shock	0.021	-0.049
10- Period After Shock	0.019	-0.050

For Jamaica the sacrifice ratio of 0.079 implies that the cost of disinflation is a loss in output of 0.079 percentage points after 4 quarters. This ratio is somewhat consistent with the result from the episode-specific model, in particular with the second episode's ratio of 0.054, a lower ratio of 0.004 is found during the first episode. The importance of the episode-specific model is borne out in this result in that the cost of disinflation is not the same over the sample period (i.e. it varies with time). The average duration of a disinflation episode in the episode-specific model was 9 quarters. Using 9 quarters in the SVAR analysis, gives a cost of disinflation of 0.020 percentage loss of output, which is relative similar to the average sacrifice ratio of 0.029 over the different episodes.

In regards to Trinidad & Tobago disinflation did not result in a loss in output as indicated by the negative ratio. This result is consistent with the sacrifice ratio from the 1st disinflation episode of its episode-specific model. However, positive ratios are shown for the other two episodes.

4.4   *Nonlinear Phillip's Curve*

Table 8 contains the result of the regime-dependent sensitivity of inflation to output. Of note, the larger the slope coefficient, the greater the inflation sensitivity will be to the output gap.   The slope coefficients are all statistically significant, with the exception of the balanced-regime coefficient for Trinidad & Tobago. Tests of the hypothesis that the slope coefficients in the different regimes are equal for each country is rejected at the 5

per cent level for Jamaica but could not be rejected for Trinidad and Tobago. The J-statistics of 0.20 and 0.17 for Jamaica and Trinidad & Tobago, respectively, both imply that the null hypothesis of the model not over-identified can not be rejected. The term $(\pi^e_{t-1} - \pi_{t-1})$ was also found to be statistically significant in both countries models.

Table 8: Estimates of Nonlinear Philip's Curve: Sensitivity of Inflation to the Output Gap

Dependent Variable	Three Regimes			ER	Beta
	Weak Economy β_{weak}	Balanced Economy $\beta_{balanced}$	Overheated Economy $\beta_{overheated}$		Equality
Inflation Expectation (Jamaica)	0.14* (0.0691)	0.26* (0.1180)	0.35* (0.0339)	0.02 (0.0097)*	Stat. Diff
Inflation Expectation (Trinidad & Tobago)	0.39* (0.0799)	-0.55 (0.5142)	0.31* (0.0786)	0.01 (0.0095)	Not Stat. Diff

Statistically Significant at the 5% level.
Standard Errors in Parentheses

The Jarque-Bera test for normality indicates that the residuals from both Jamaica's and Trinidad & Tobago's Phillips curve estimates are normal.

The estimates of the slope coefficients for Jamaica show the nonlinear nature of the Phillip's curve. For Jamaica, inflation increases in all regimes, but at a different rate. At the point when output is below trend, Jamaica's Phillip's curve tends to be convex as the slope rises from 0.14 to 0.26. Similarly, when output is above trend, the Phillip's curve is convex as the slope steepens from 0.26 to 0.35. Based on these result, Jamaica's Phillip's curve is likely convex in shape. A convex Phillip's curve is an upward sloping curve that steepens as output rises relative to trend. This means that inflation is increasingly sensitive to changes in output as the economy strengthens. That is, a given change in inflation would require a progressively smaller output adjustment. This type of Phillip's curve is normally associated with an economy subject to capacity constraints. In this case, as the economy strengthens, firms' capability to expand will be limited and as such an increase in demand is likely to translate into higher prices than higher output. On the

other hand when the economy is weak and there is less capacity constraints, inflation would be less sensitive to output fluctuations.

For Trinidad, the beta coefficients are found to be statistically the same. This means that inflation is not sensitive to the strength of the economy.

4.5   Policy Implications

The output cost of disinflation depends on the shape of the Phillip's curve, which can vary according to the state of the economy. A convex Phillip's curve, as in the case of Jamaica, means that the cost of fighting inflation falls with the strength of the economy. In this regard, monetary policy which seeks to deliberate disinflate the economy is likely to be more costly than one to pre-emptively defend a parallel rise in inflation. As to deliberately disinflate the economy, policies makers slow the economy. Would a cold turkey strategy benefits Jamaica?[12]   Given that Jamaica's estimated Phillips curve is convex when output is below trend; the cold turkey strategy would not be the best option.[13] According to King (1996), gradualism would be the lowest cost strategy when the Phillips curve is convex.[14]

5.0   Conclusion

Sacrifice ratios measures the quantity of output that is lost for each percentage point reduction in the inflation rate. Using episode-specific and SVAR models, this paper estimates sacrifice ratio in selected Caribbean states. The paper finds very low sacrifice ratio for Jamaica and Trinidad & Tobago. Specifically, during periods of disinflation, the sacrifice ratio for Jamaica was a 0.029 percentage points loss in output for every 1.0 percentage point decline in inflation, while the ratio on average was 0.113 for Trinidad & Tobago.

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[12] It is believed that a rapid disinflation could enhance the monetary authorities' credibility, thereby lowering the cost of disinflation.
[13] That is a rapid decline in inflation.
[14] Cold turkey would be the preferred strategy if the curve is concave.

The estimated shape of the Phillips curve show that inflation and output are related in a complicated nonlinear fashion. The curve for Jamaica is found to be convex implying that the cost of fighting inflation in Jamaica falls with the strength of the economy. For Trinidad & Tobago inflation is not sensitive to the strength of the economy.

The main policy implication from this research is that the relative small sacrifice ratio makes it beneficial for policy makers to attempt to reduce inflation to single digit without fear of contracting output significantly. In Jamaica gradualism is found to be the best policy to disinflate the economy.

Calculation of the sacrifice ratios seek to measure the costs of disinflation policies. However, given that shifts in aggregate supply can also affect inflation, it is likely that supply as well as demand shifts occur during some of the inflation episodes. As such supply shocks could have affected the sizes of the output loss and inflation movements. In this regard, the sacrifice ratios in these episodes can be seen as a noisy measure of the effects of the demand contraction, as highlighted by Ball 1994.

Possible extensions to the paper include the calculation of benefit ratios for the economy, that is, the benefits from disinflation. Economists have long argued that society benefits from reducing the inflation rate. The most prominent point is that eliminating inflation leads to a more efficient allocation of resources and better decision-making by private consumers, workers and investors that can lead to increase total output.

Bibliography

Ball, Laurence, 1994, "What Determines the Sacrifice Ratio?" in N. Gregory Mankiw, ed., *Monetary Policy*. National Bureau of Economic Research Studies in Business Cycles, vol. 29. Chicago: The University of Chicago Press.

Blanchard, O., and L. Summers, 1986. "Hysteresis and the European Unemployment Problem," NBER Macroeconomics Annual 1. edited by Stanley Fisher.

Clark, P., and D. Laxton, 1997. "Phillips Curves, Phillips Lines, and the Unemployment Costs of Overheating," International Monetary Fund, Research Working Paper 97-17, February.

Filardo, Andrew, 1998, "New Evidence on the Output Cost of Fighting Inflation," Federal Reserve Bank of New York, Staff Papers.

Gordon, R., and S. King, 1982. "The Output Cost of Disinflation in Traditional and Vector Autoregressive Models," *Brookings Paper on Economic Activity*, Vol. 1982, no. 1, pp. 205-244.

Huh, Hyeon-seung, 2002. "Estimating Asymmetric Output Cost of Lowering Inflation for Australia," *Southern Economic Journal*, 68(3), 600-616.

King, Mervyn, 1996. "How Should Central Banks Reduce Inflation? Conceptual Issues," in *Achieving Price Stability*. Kansas City: Federal Reserve Bank of Kansas City.

Mayes, D. and B. Chapple, 1994. "The Costs and Benefits of Disinflation: A Critique of the Sacrifice Ratio," *Reserve Bank Bulletin*, vol. 57, no. 4.

Neely, C., and C. Waller, 1997. "A Benefit-Cost Analysis of Disinflation," *Contemporary Economic Policy*, January.

Okun, Arthur M., 1978. "Efficient Disinflation Policies," *American Economic Review*, May.

Romer, C., and D. Romer, 1989. "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," NBER Macroeconomics Annual 4: 121-170

Stiglitz, Joseph E. 1997. "Reflection on the Natural Rate," *Journal of Economic Perspective*, Winter.

Yavuz, Devrim, 2002. "Calculation of Output-Inflation Sacrifice Ratio: The Case of Turkey," The Central Bank of the Republic of Turkey, Research Department.

Zhang, Lawrence Huiyan, 2001, "Sacrifice Ratios with Long-Lived Effects," The Johns Hopkins University, Department of Economics.
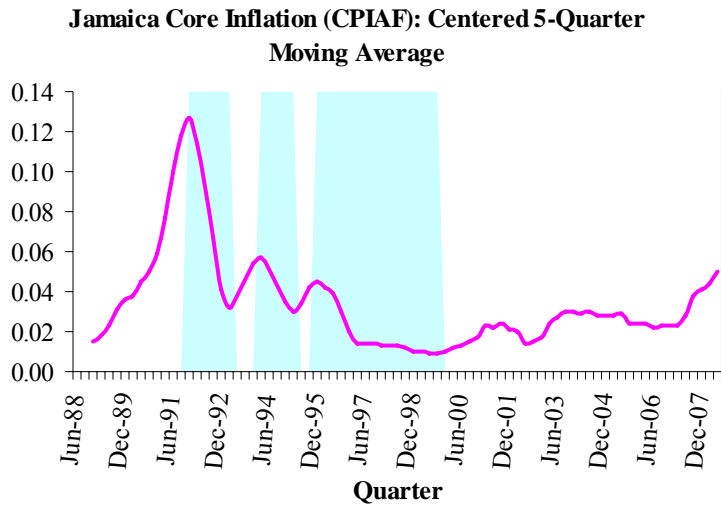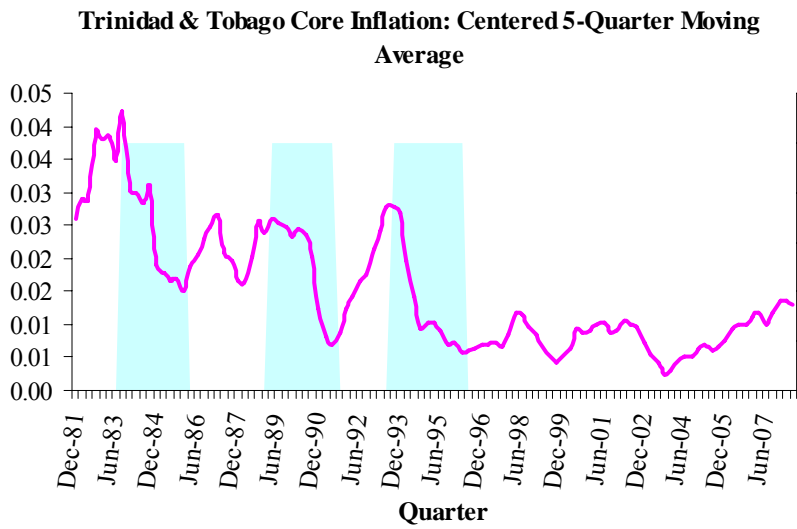
APPENDIX

Figure 2

Jamaica Core Inflation (CPIAF): Centered 5-Quarter Moving Average

Figure 3

Trinidad & Tobago Core Inflation: Centered 5-Quarter Moving Average

Figure 4: Real GDP and Potential Output (Method 2)

Jamaica: Seasonally Adjusted GDP & Potential GDP

Trinidad & Tobago Seasonally Adjusted GDP and Potential GDP
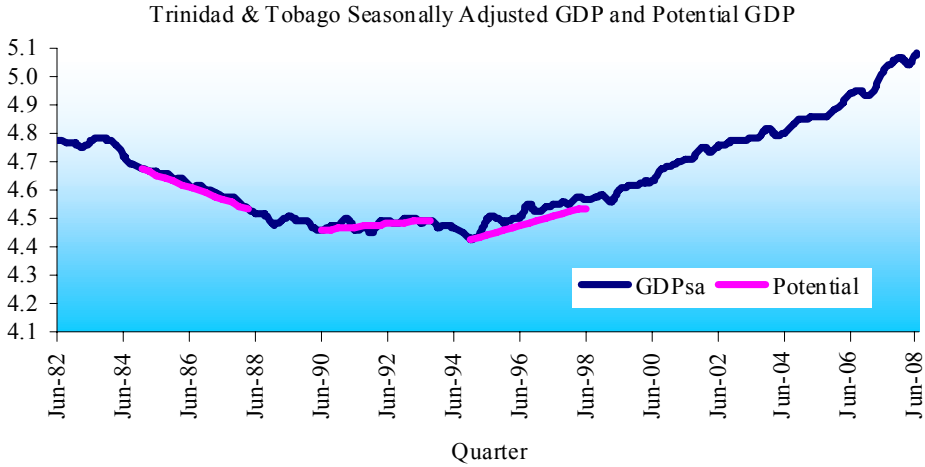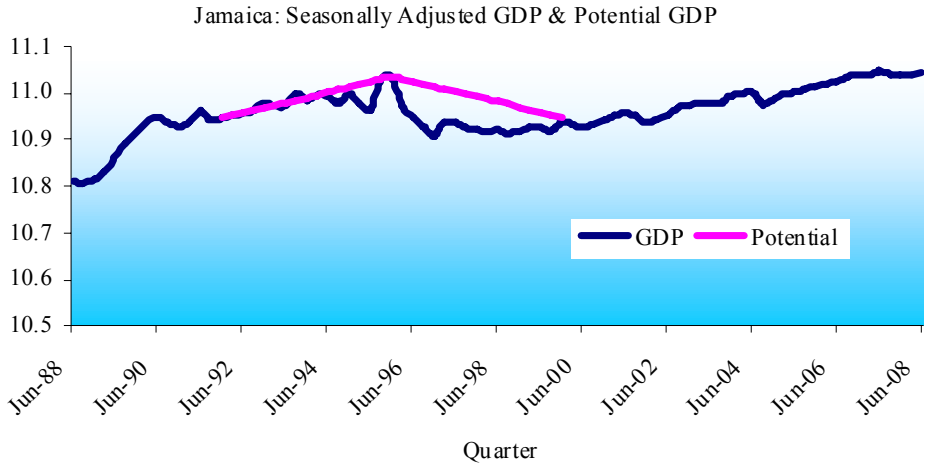
Figure 5: Real GDP and Potential Output (Method 3)

Jamaica: Seasonally Adjusted GDP and Potential GDP
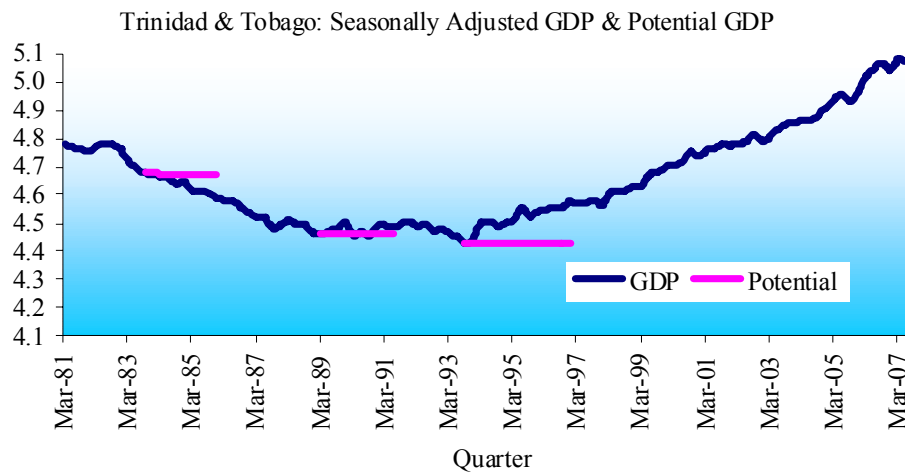

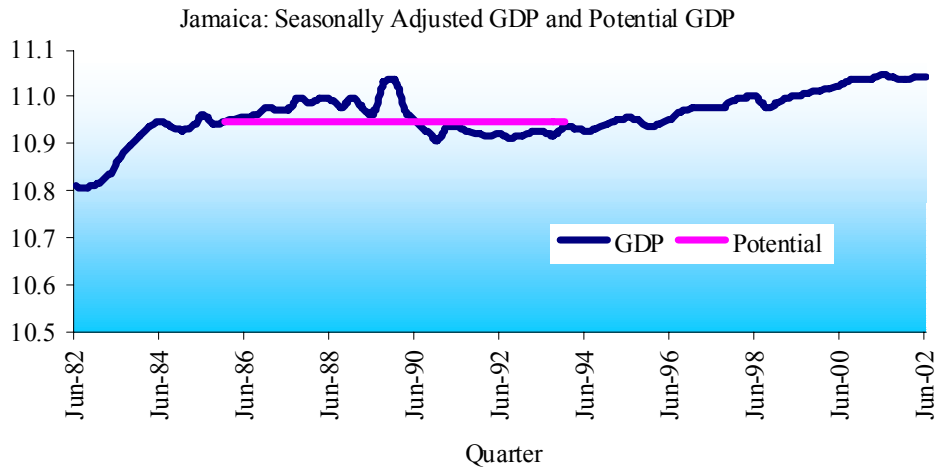Trinidad & Tobago: Seasonally Adjusted GDP & Potential GDP

Figure 6: Jamaica: Response of the Output Gap (GAP) and Core Inflation (DLCPIAFSA)
to a one Standard Deviation in the Treasury Bill Rate

Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.

Accumulated Response of GAP to DTB
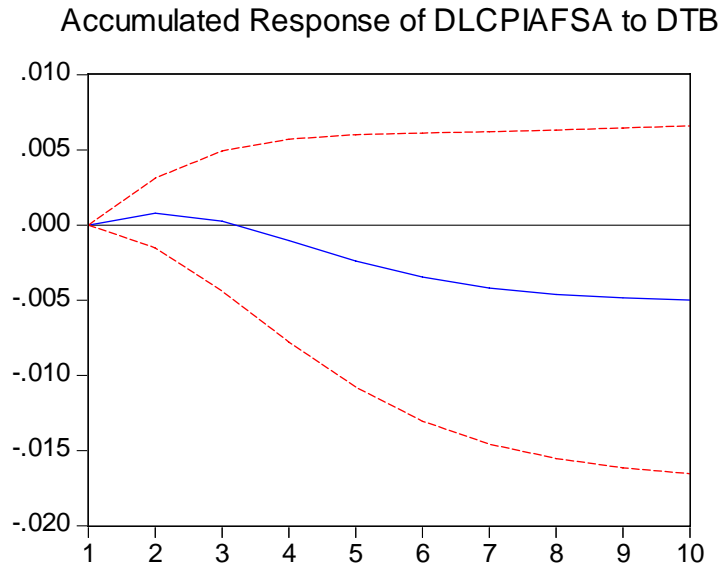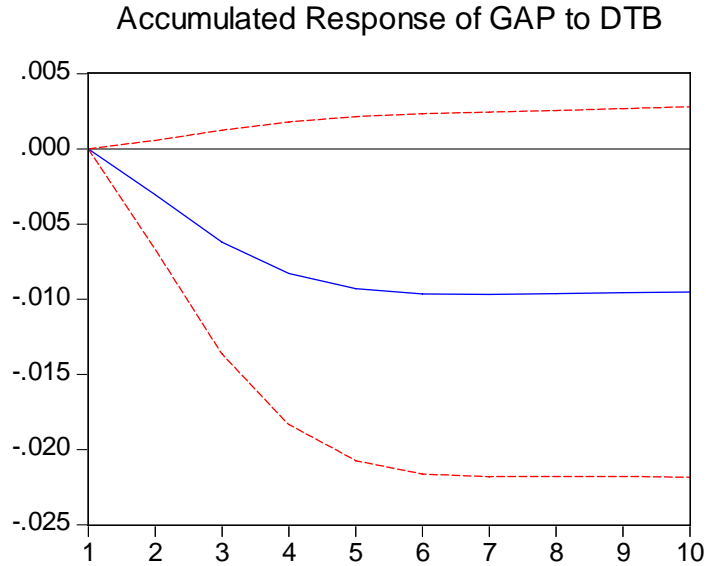
Accumulated Response of DLCPIAFSA to DTB

Figure 7: Trinidad & Tobago: Response of the Output Gap (GAP) and Core Inflation (DLCCPI) to a one Standard Deviation in the Treasury Bill Rate

Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.

Accumulated Response of GAP to DTB

Accumulated Response of DLCCPI to DTB