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Abstract: This article examines fiscal policy shocks in the UK through using a Bayesian Vector Autoregression (BVAR) model which applies Mountford and Uhlig (2009) type sign-restriction. It investigates the impact of three fiscal policy experiments on macroeconomic variable. Specifically, the Deficit-Financed Spending Increase (DFSI), the Deficit-Financed Tax Cut (DFTC), and the Balanced-Budget Spending Increase (BBSI). The results show that, the policy conclusion differs according to the period under investigation.

Keywords: Fiscal policy, Bayesian VAR analysis, policy experiment.

JEL Classifications: E60, E62, H60.

1. Introduction

A substantial part of the empirical literature investigates the impact of shocks to monetary policy on macroeconomic variables using Vector Autoregression (VAR) or Structural Vector Autoregression (SVAR) models (e.g. Leeper *et al.*, 1996; Bagliano and Favero, 1998; Christiano *et al*., 1998; Favero, 2001; Uhlig, 2005). On the other hand, there is no intensive investigation of the impact of shocks to fiscal policy on output, private consumption, private investment, wages, prices and interest rates.

Many studies investigated the effects of fiscal policy using a basic *neoclassical* model, (e.g. Aiyagari, *et al.*, (1992); Baxter and King (1993); Ramey and Shapiro (1998)). According to this perspective, households behave in a Ricardian manner. In addition: goods, labor and capital markets work without any frictions and an increase in government spending is financed by non-distortionary taxes. This implies a negative wealth effect for the household,

which reduces private consumption and increases labour supply. Hence, total output increases but marginal labor productivity and real wages decline. Furthermore, marginal productivity of capital may rise as well due to the increase in employment. This, in turn, would lead to an increase in private investment.

As a revolutionary step in the economic thoughts, many authors commenced in introducing frictions to the standard model and assuming non-Ricardian behaviour of the household. This paved the way towards the *New Keynesian* models and the *Dynamic stochastic General Equilibrium* (DSGE) Models which became the workhorse in the recent literature. Those models were used in different studies (e.g. Rotemberg and Woodford, 1992) analyzed a model with imperfect competition and countercyclical markups, Devereux *et al.* (1996) incorporated monopolistic competition in the intermediate goods sector to obtain demand effects from government spending changes. Those two papers resulted in a very important remark that a model with imperfect competition and increasing returns to scale can explain the impact of the government spending more appropriately and an increase in government spending raises private consumption and real wages. Private investment also increases because of the large increase in labor supply due to the increase in the real wages.

On the other hand, most of the empirical analysis is done using US data. There is no equivalent research for developed economies, and particularly for the UK. Despite this fact, there remains a lack of consensus among economists about the exact impact of fiscal policy shocks even in the American economy.

This can be attributed to the use of different identification strategies of shocks in the estimated VARs or SVARs. More specifically, there are four main approaches: Firstly, the Event-Study approach, introduced by Ramey and Shapiro (1998), which studies the effects of large, unexpected increases in the American government defence spending and has been extended by Edelberg *et al*. (1999), Burnside *et al.* (2004), Eichenbaum and Fisher (2004) and Perotti (2007). Concerning government revenues shock, Romer and Romer (2007) have utilized this approach and concluded that tax increases are highly contractionary in the US. Secondly, the recursive approach by Fatás and Mihov (2001) which studies the effects of fiscal policy shocks on consumption and employment. Thirdly, the Blanchard-Perotti (2002) approach, which represents a mix of a SVAR model and the event study approach. Finally, the sign-restrictions approach which is utilized by Mountford and Uhlig (2009) in fiscal policy analysis.

According to investigation of the existing literature, there is no study applied the sign-restriction approach for fiscal policy analysis using UK data. This article provides some outcomes in this regard.

2. Existing Evidence for the UK

The number of contributions regarding the impact of fiscal policy for Europe and the UK is limited. Nevertheless, we think that there will be a deep investigation of fiscal policy in those countries, especially after the 2008 financial crunch. This section highlights the relevant literature for the UK fiscal policy shocks.

In their early contributions, Benjamin and Kochin (1984); Barro (1986) have analyzed the economic effect of government expenditure using data from the outset of the eighteenth century through World War I. They have pointed out that temporary government purchases affect the term structure of real interest rates. Specifically, the government spending shock has bad positive effects on long term interest rates.

Recently, Perotti's (2005) [1] results for the UK suggest that government spending shocks have significant effects on the real short interest rate. Also, net tax shocks have very small effects on prices. Furthermore, positive shocks to government spending and negative shocks to taxes tend to elicit negative responses in output, private consumption, and private investment for the post-1980 period.

Monacelli and Perotti (2006) have found that following a positive government spending shock, output and private consumption increase, trade balance deteriorates and real exchange rate depreciates. Ravn *et al.* (2007) have obtained similar results, however their analysis included a panel VAR rather than a country-based estimated VAR.

Afonso and Sousa (2009) have evaluated the effect of fiscal policy on economic activity identifying the shocks using a recursive identification scheme in a Bayesian Structural Vector Autoregression model. According to their results, private consumption is not affected by the government spending shock. The effect on private investment is negative and very persistent. Wages tend to be positive. In addition, private investment reacts positively to the government revenue shocks.

3. Data and Methodology

This article follows the sign-restriction identification approach which has been applied initially to monetary policy (e.g. Faust, 1998; Canova and De Nicoló, 2002; Uhlig, 2005; Peersman, 2005). Then, it has been extended by Mountford and Uhlig (2009) to identify fiscal policy shocks.

[1] Perotti (2005) estimated the effects of government expenditures and revenues for five OECD countries (specifically: the US, Germany, the UK, Canada, and Australia) applying the Blanchard-Perotti identification approach.

The data used in this article are obtained from three sources: The Office for National Statistics for the UK, the main economic indicators provided at the website of the Organization of Economic Cooperation and Development, and the International Monetary Fund.

The framework of the analysis is a BVAR model using quarterly data for the UK spanning from 1971:Q1 to 2009:Q2. The fiscal shocks are identified using the methodology of Mountford and Uhlig (2009).

The starting step is a standard reduced-from VAR:

$$Y_t = \sum_{i=1}^{L} B_i Y_{t-i} + u_t \qquad (1)$$

Where, Y_t is an m×1 vector of endogenous variables, L is the lag length of the estimated VAR, B_i is m×m coefficient matrices and u_t is the one step ahead prediction error with zero mean and a variance-covariance matrix: $E(u_t u_t') = \sum_u$.

The VAR includes twelve variables; the Gross Domestic Product (GDP), government expenditures, government revenues, GDP deflator, private consumption, private investment, monetary aggregates, real wages, producer price index, short-term interest rate, trade balance and the real effective exchange rates.

The government expenditure variable is defined as (government consumption on goods and services plus government investment). The government revenue variable is defined as total tax revenues minus transfers (including interest payments). All the components of national income are in real per capita terms. The VAR is estimated using levels of the logs of variables, with L=4.

The problem of identification in the VARs literature is to translate u_t into economically meaningful or fundamental shocks v_t. Hence, there are m fundamental shocks, which are orthogonal and normalized to be of variance one. Identification of these shocks amounts to identifying a matrix A, such that $u_t = Av_t$ and $AA' = \sum_u$.

In this section of the article, we are dealing with an impulse matrix $[a^{(1)}, a^{(2)}, a^{(3)}]$ of rank 3 rather than all of A. Where the first shock is a business cycle shock, the second shock is a monetary policy shock, and the third is the fiscal policy shock.

This impulse matrix can be written as the product $[a^{(1)}, a^{(2)}, a^{(3)}] = \tilde{A}Q$ of the lower triangular Cholesky factor $\tilde{A}$ of $\sum_u$.

Where Q is an orthonormal matrix with $QQ' = I$. This matrix plays the crucial role in this identification approach as it collects the identifying weights with each column of Q corresponding to a particular fundamental shock. Then, the penalty function approach is utilized to compute the individual elements of Q. It is applied through minimizing a criterion function, which penalizes impulse responses violating the sign restrictions, with respect to the identifying weights. In order to apply this step a function f on the real line is defined where *f(x)=100x* if *x* is greater than or equal to zero and *f(x) = x* if *x* is less than or equal to zero. Hence, the following minimization problem has to be solved:

$$a = \arg\min_{a=\tilde{A}q} \ \psi(a) \qquad (2)$$

Where, a and q are the corresponding elements of the matrices A and Q, respectively. The criterion function is given by:

$$\psi(a) = \sum_{j \in J_{s,+}} \sum_{k=0}^{3} f\left(-\frac{r_{ja}(k)}{S_j}\right) + \sum_{j \in J_{s,-}} \sum_{k=0}^{3} f\left(\frac{r_{ja}(k)}{S_j}\right) \qquad (3)$$

This function sums penalties over a year following the shock and over the indices of the variables with positive ($J_{s,+}$) and negative ($J_{s,-}$) sign restrictions. Then, the impulse responses r_{ja} of variable j at the time horizon k are normalized by the standards error S_j. The computations are performed using a Bayesian approach as we take 1000 draws from the posterior. The shocks are identified using the above criterion. Then, the impulse responses are computed and error bands are plotted. The computations are performed, using a Bayesian approach as in Mountford and Uhlig (2009), Uhlig (2005), Sims and Zha (1998).

We abstract from discussing the business cycle and monetary policy shocks. The analysis focuses mainly on fiscal policy shocks. Those shocks are identified through restricting the impulse responses of the fiscal variables to be orthogonal to business cycle and monetary policy shocks. This leads to two basic shocks, a government spending shock and a government revenue shock.

Then, the policy experiments are represented as linear combinations of the basic shocks.

The (DFSI) policy is defined as an increase in government spending by 1% for one year while taxes remain unchanged. The (DFTC) is defined as a fall in taxes by 1% for a year while government spending remains unchanged. Finally, the (BBSI) is defined as an increase of 1% in both government spending and revenues in one year following the shock.

4. Empirical Results

All the impulse responses are plotted with the median, 84th and 16th quartiles error bands. The following analysis depends on the median responses of the variables following the shock. The impulse responses for the (DFSI) policy are shown in figure 1. This policy stimulates output and private investment. However, the impact is very weak.

It reduces private consumption, monetary aggregates and real wages. On the other, it produces a counterintuitive response for prices and no immediate response from short-term interest rate. Moreover, it induces real exchange rate depreciation and a trade balance surplus.

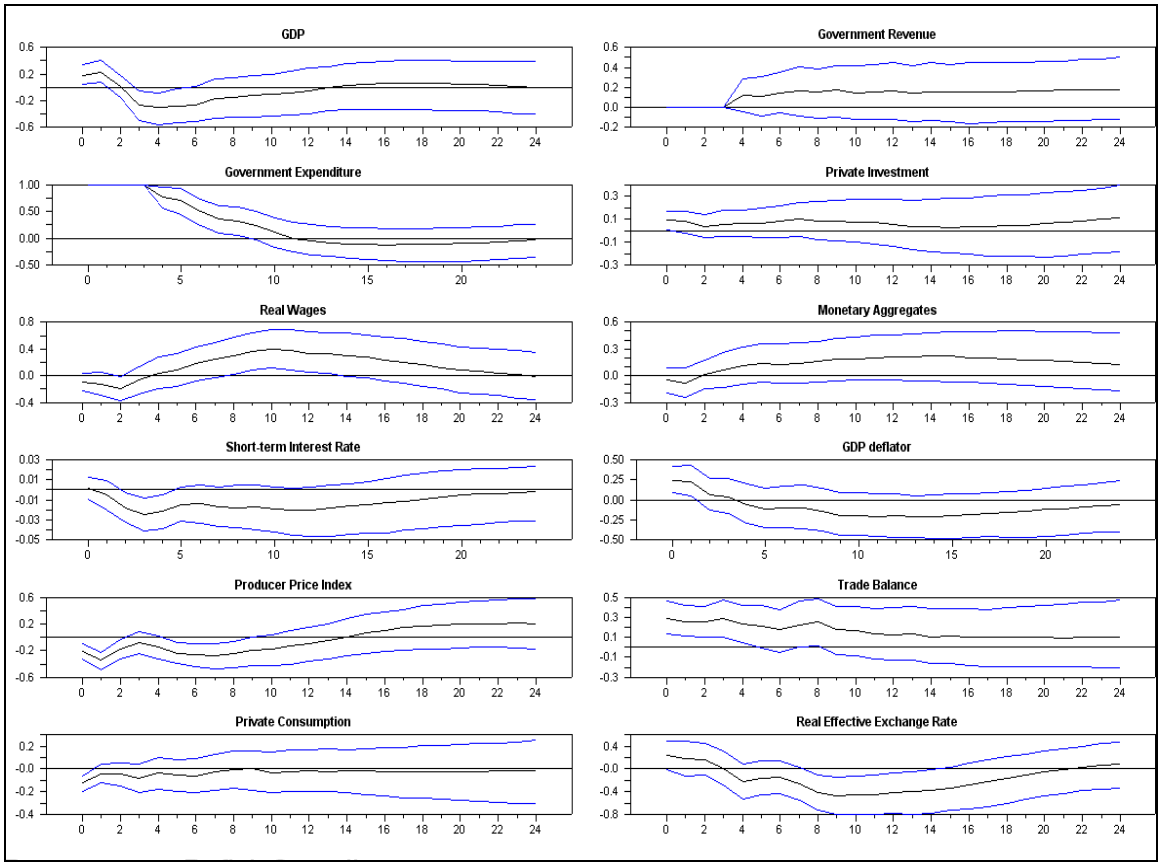


Figure (1): The responses to the (DFSI) policy.

The impulse responses for the (BBSI) policy are shown in figure 2. The results are different from those reported for the (DFSI) policy. The depressing effects of the tax increases in the (BBSI) policy dominate the government spending effects. Therefore, output, private consumption, private investment and real wages all decline immediately.

However, prices rise slightly. One interpretation of this result is that a rise in distortionary taxes is used by the fiscal authority to match the spending increase which has strong

disincentive effects. This empirical result is consistent with the standard neoclassical growth model. Where, output decrease if a spending increase is financed with distortionary taxes. Hence, this result reflects the importance of a deep understanding of the impact of shocks to different types of taxes on macroeconomic variables through using a Dynamic stochastic General Equilibrium (DSGE) model. In addition, this policy has an impact on the external sector variables similar to that of the (DFSI).

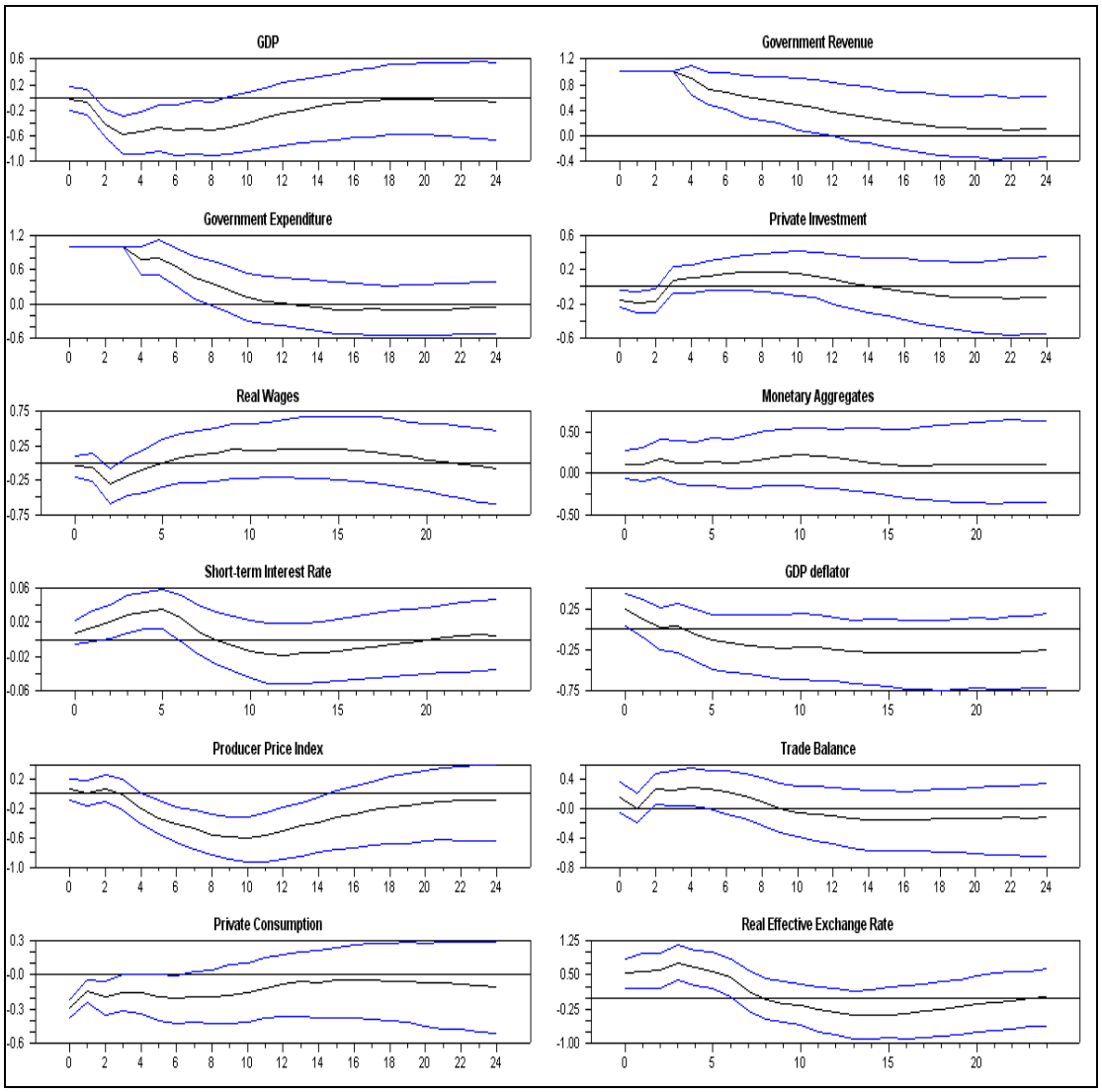


Figure (2): The responses to the (BBSI) policy.

The impulse responses for the (DFTC) policy are shown in figure 3. This policy simulates output, private consumption and private investment while the real wage falls. Also, it produces a counterintuitive response from prices and there is a decline in monetary variables. Concerning the external sector variables, the policy leads to a surplus in the trade balance and appreciation in the real exchange rate. Furthermore, the above results indicate that the (BBSI)

scenario has a crowding-out effect on private investment. On the other hand, the (DFTC) and (DFSI) policies have a crowding-in impact.

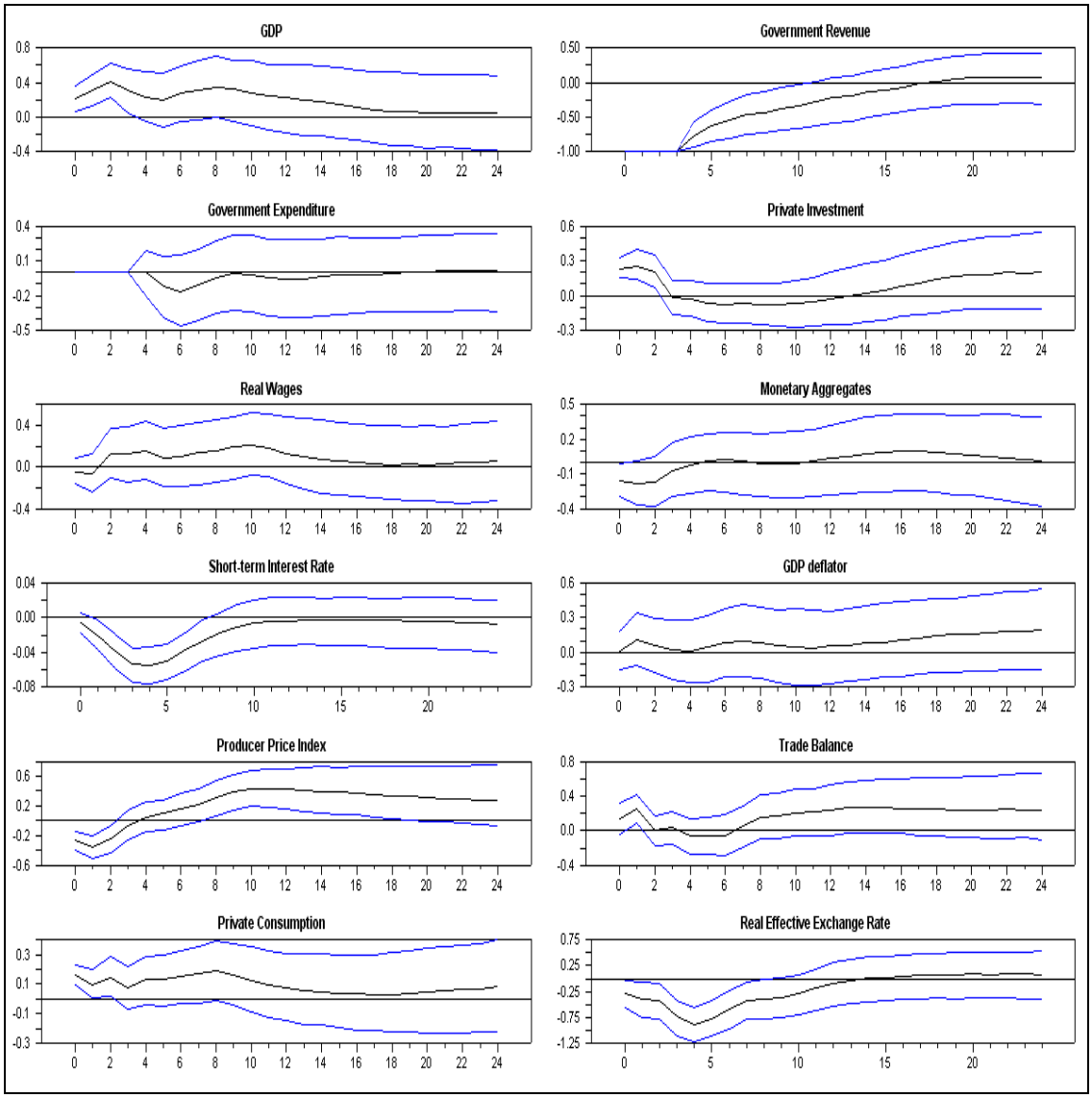


Figure (3): The responses to the (DFTC) policy.

In order to determine the impact of each policy experiment along the path of responses the following multiplier statistic is calculated:

$$\text{The present va lue multiplier at lag k} = \frac{\sum_{j=0}^{k}(1+i)^{-j}\,y_j}{\sum_{j=0}^{k}(1+i)^{-j}\,f_j}\,\frac{1}{f/y} \qquad (4)$$

Where y_j is the response of GDP at period j, f_j is the response of the fiscal variable at period j, i is the average interest rate over the sample, and f/y is the average share of the fiscal variable in GDP over the sample. From the data, the average interest rate is 0.93. While, the average

shares of fiscal variable was 0.31 in the (DFTC) scenario, and 0.62 in both the (DFSI) and (BBSI) scenarios. The following figure indicates the present value of the impulse responses of GDP to the three policy experiments under investigation.

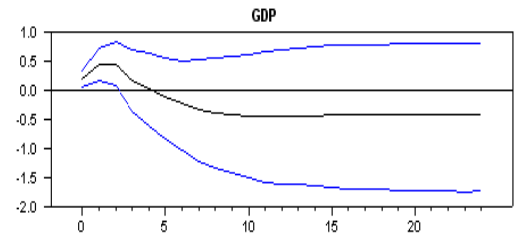
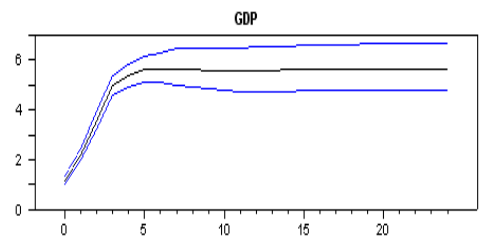
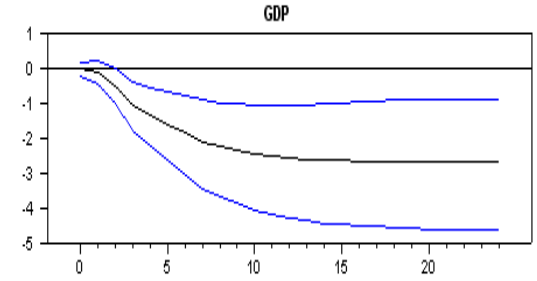
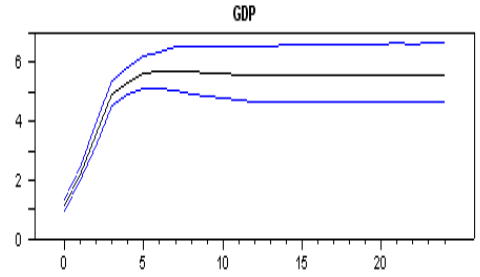
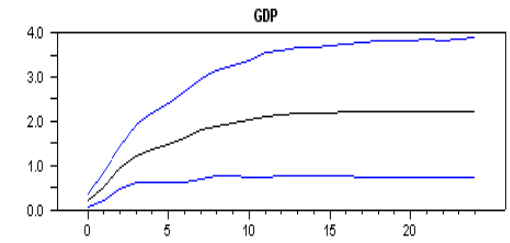
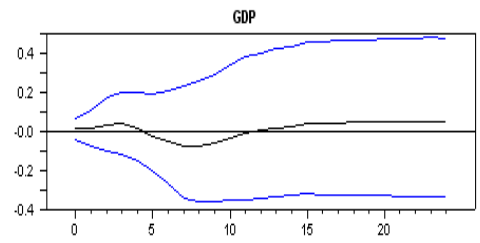
The (DFSI) policy		
The (BBSI) policy		
The (DFTC) policy		
	The period from 1971:Q1 to 2009:Q2	**The period from 1980:Q1 to 2009:Q2**

Figure (4): The present value of the impulse responses of GDP

The main finding is that, in present value terms the (DFTC) have a much greater effect on GDP than the (DFSI) policy for the period from 1971:Q1 to 2009:Q2. The present value of the GDP response to a (DFSI) scenario becomes insignificant after four quarters whereas that for the deficit financed tax cut is significantly positive throughout. On the contrary, the (BBSI) has a negative and undesirable impact on GDP

In order to check whether our policy conclusion is robust we use a different sample from 1980:Q1 to 2009:Q2. Interestingly, the present value of the GDP response to the (BBSI) and (DFSI) policy scenarios is positive and persistent whereas that for the (DFTC) scenario becomes insignificant after the fourth quarter. This indicates that the policy conclusion is different depending on the period under investigation.

5. Concluding Remarks

The above analysis shows that for the period from 1971:Q1 to 2009:Q2, the (DFSI) scenario has positive impact on output in the short-term, but the costs in the medium-term are higher compared to the positive impact of the (DFTC). Regarding the (BBSI) scenario, the negative effects of the tax increase outweighs the expansionary effects of the increased expenditure. Furthermore, while a (DFTC) scenario could be a desirable option for the fiscal authority to adopt from 1971:Q1 to 2009:Q2. It is indifferent between the (BBSI) and the (DFSI) scenarios for the period from 1980:Q1 to 2009:Q2.

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