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Estimating India's Fiscal Reaction Function*

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Abstract:

In the 1970s-1980s, monetary authorities were usually more active than their fiscal counterparts. After some crises, fiscal policy is currently regaining its role in implementing economic policies. As a sequel to estimating the Indian monetary reaction function, this paper models and estimates a fiscal reaction function for India as a part of a macro model for India. Unlike other papers about fiscal reaction functions which are mainly empirical-based, this paper first establishes the theoretical foundations for the empirical estimation. In estimating India's fiscal reaction function, data stationary problems are found and unbalanced regressions are employed. This paper finds that India's fiscal policy depends on debt, output gap, and interest rate levels. Apart from debt and output gap which were mentioned in other papers, the interest rate is the new element in the function and should be important in any borrowing action. The estimated fiscal reaction function tracks the actual reaction function very closely.

JEL classification: E62, E63, H63

Keywords India's fiscal reaction function, ARDL model, unbalanced regression

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1. Introduction

Several decades ago, there was a debate between Keynesians and Monetarists about the role of monetary and fiscal policies in supporting economic growth. In general, the Keynesians argued that monetary policy is less important than fiscal policy while Monetarists argued oppositely. In the 1970s-1980s, fiscal policy assumed a passive role in stabilizing the economy while monetary policy was more active. Today, both monetary and fiscal policies are recognized for the roles they play in supporting economic growth. Both the monetary and fiscal reaction functions are estimated to help relevant authorities to adjust their activities following certain rules.

However, fiscal policy has recently received more attention. For instance, there was a special issue of *The Oxford Review of Economic Policy* (2005) on fiscal policies with contribution from Robert Solow, Paul Krugman, Ross Garnaut and other outstanding economists. Solow (2005) argues that monetary policy is useful as a sole instrument only if modern macroeconomic assumptions that the economy is self-adjusting around an equilibrium path, that aggregate supply develops smoothly by long-term forces such as productivity changes, and that aggregate supply will catch up with aggregate demand are true. However, there are always various shocks that cause medium-term problems that are needed to correct. In such instances, fiscal policy is the best option for dealing with these shocks. This is because fiscal policy directly affects demand and fills the gap between saving and investment, while monetary policy indirectly affects supply and demand chiefly through price adjustment and this policy usually has some lagged effect. Therefore, fiscal policy is at least as important as monetary policy and should continue to play an active role in any government's macroeconomic policies.

Apart from monetarism, there is another theory that puts fiscal policy in the back seat. The well-known Ricardian equivalence hypothesis establishes that any movement in fiscal policy will not lead to changes in output because economic agents can anticipate the fiscal policy likely to be used in the future and can react accordingly. Solow (2005) points out that the Ricardian equivalence cannot be applied to the US data and that the fiscal policy still needs more research. Leeper (1991) with the Fiscal Theory of the Price Level also points out that fiscal policy may have its role.

Krugman (2005), investigating the liquidity trap of Japan in the 1990s and the current US economic situation, argues that we have experienced a period of monetary optimism with unusually effective monetary policy. However, monetary policy has become ineffective in some places and it is time to think of using fiscal policy again. Garnaut (2005) cites the case of Australia where a good combination of monetary, exchange rate, and fiscal policies can help stabilize growth. In an alternative, Kirsanova et al. (2005) focus on the interaction between monetary and fiscal policies in a dynamic setting model where fiscal policy may have a positive impact if there is fiscal leadership. Leith and Wren-Lewis (2005) alternatively consolidate the role of fiscal policy by providing a micro-based model showing that fiscal policy would have an impact on the economy, even when Ricardian equivalence holds.

Hence, there is a reemergence of fiscal policy. In fact, sound public finance plays a crucial role in facilitating central banks to maintain price stability, adjusting investment and saving to an optimal level, thus stimulates economic growth. The fiscal reaction function has been estimated by Bohn (1998), De Mello (2005), Davig and Leeper (2006), Budina and Wijnbergen (2008), and Burger et al. (2011), among others. In the context of this paper, I begin by looking at how scholars study India's fiscal policy.

2. Literature Review

2.1. Origin and Definition

In general, a fiscal reaction function is a rule that helps governments forecast and prepare to react against some macroeconomic changes. Having a right fiscal reaction function makes fiscal policy and public finance sound and stable. The origin of the fiscal reaction function is not as complicated as the origin of the monetary reaction function. Most fiscal reaction functions originate from the government intertemporal budget constraint:

$$G_t + (1 + i_{t-1})B_{t-1} = T_t + B_t \tag{1}$$

or the simpler form as used in Bohn (1998):

$$D_{t+1} = (D_t - S_t)(1 + R_{t+1}) \tag{2}$$

The meaning of the first equation is that the government's total receipts including tax (T_t) and borrowing (B_t) of the current period should equal the government's total spending (G_t) plus debt service (including the principal from the previous period B_{t-1} and interest payment $i_{t-1}B_{t-1}$). The second equation exploits the relationship among debt (D_t), primary surplus (S_t), which equals tax revenue minus non-interest spending, and an interest factor R_{t+1}. Researchers can iterate the government intertemporal budget constraint to produce different fiscal reaction functions suiting specific conditions of their research.

From the government intertemporal budget constraint, there are two approaches to study fiscal policies. In the first approach, the fiscal reaction functions are more model-based and are achieved by iterating the government budget constraint. Recent papers following this approach include Penalver and Thwaites (2006) and Budina and Wijnbergen (2008).

In fact, most research on the fiscal reaction function follow the second approach, which is more empirically-based. In the second approach, researchers use econometric methods to study the relationship between the dependent variable, which is usually the budget balance, and the independent variables including main macroeconomic series taken from the government's budget constraint and other political, institutional or business cycle variables. In this approach, the fiscal reaction function is derived from the government budget constraint as in the first approach. Then, some additional variables are considered. These variables are added to the model on the basis of empirical research and the argument that they may have explicit effects in specific cases. Papers following this approach include Bohn (1998), de Mello (2005), Adedeji and Williams (2007), Khalid et al. (2007), Turrini (2008), Afonso and Hauptmeier (2009), Egert (2010), Stoica and Leonte (2011), and Burger et al. (2011). However, because this paper is about the India, an open economy, the literature review for the fiscal reaction function will be divided in two categories: the fiscal reaction function for open and for closed economies.

2.2. Fiscal Reaction Function for Closed Economy

The first research this paper refers to is the influential paper by Bohn (1998) about the U.S. public debt. In general, the U.S. economy is considered a closed economy. In fact, a great number of closed economy models are proved to be suitable to the US. In this paper, Bohn (1998) uses the simple fiscal reaction function:

$$s_t = \rho.d_t + \alpha_0 + \varepsilon_t \tag{3}$$

In this equation, d_t and s_t stand for the Debt/Output and Primary Surplus/Output ratios. This function is used to study the US fiscal policy in the period from 1916 to 1995 with s_t as the dependent variable and d_t as the independent variable. However, Bohn (1998) argued that there might be omitted problems in this simple theoretical regression, and the empirical research should base on a more practical model. Therefore, Bohn used Barro's (1979) tax-smoothing model to expand this simple fiscal reaction function. The result is that the temporary government spending *(GVAR)* and business indicator *(YVAR)* are included in the model. Bohn's (1998) extended model is:

$$s_t = \rho.d_t + \alpha_0 + \alpha_G GVAR_t + \alpha_y YVAR_t + \varepsilon_t \tag{4}$$

The estimation results from Bohn (1998) show that the model fits the US data well and the fiscal policy of the US up to 1995 is stable. Following suit, Khalid et al. (2007) estimates the fiscal reaction function for Pakistan using VAR technique with three main variables including fiscal deficit, output gap, and inflation. Turrini (2008) estimates the fiscal reaction function for the European Zone in good and bad times with a business-cycle adjusted fiscal balance as the dependent variable, and lag of the business-cycle adjusted fiscal balance, debt, output gap, and some political and dummy variables as independent variables. Afonso and Hauptmeier (2009) follow this method to estimate the fiscal reaction function for the European Union with the two main variables are the Primary balance/GDP ratio *(s_t)* and Debt/GDP ratio *(d_t)*. The additional variables in Afonso and Hauptmeier (2009) are output gap, fiscal rule indicator, institutional, political and other control variables. The most recent research following this line is Egert (2010) where the business-cycle variable is added to the function as an independent variable.

Besides the fiscal reaction functions originated from Bohn (1998) there is fiscal reaction functions relating to the role of money. De Mello (2005) estimates a fiscal reaction function for Brazil in the 1990s. In his model, besides the primary balance and debt variables from the simple government intertemporal budget constraint, de Mello (2005) considers a monetary factor. This method makes use of the argument in Gali and Perotti (2003) about the fiscal-monetary relationship. With the monetary factor, the fiscal reaction function in de Mello (2005) has the following form:

$$pb_t + (r_t - \eta_t)d_{t-1} = \Delta d_t + \Delta m_t + (\pi_t + \eta_t)m_{t-1} \tag{5}$$

In this equation, pb_t is the Primary Balance/GDP ratio (similar to s_t in Bohn (1998)), d_t is the Debt/GDP ratio, η_t is the real GDP growth rate, r_t is the real interest rate, and m_t is the monetary base to GDP ratio. De Mello (2005) then assumes Δm =0 and no Ponzi game to estimate an empirical model:

$$pb_t = a_0 + a_1 pb_{t-1} + a_2 d_{t-1} + a_3 C_t + u_t \tag{6}$$

where C_t is a set of control variables. In general, this fiscal reaction function has the same objective as the function in Bohn (1998) which studies the relationship between the fiscal balance *(pb_t)* and the debt level *(d_t),* but now monetary factor is controlled. The estimation shows a statistical significant role of the lags of primary balance and debt in the fiscal reaction function. However, other variables including lag of output gap and inflation do not show the same statistical significance in the test. De Mello (2005) continues the paper with a cointegration test to confirm the relationship among major variables. A good cointegrating relationship among variables will show the stability of the Brazilian fiscal policy. The test provided good results confirming the relationship.

Budina and Wijnbergen (2008) also consider a simple fiscal model with the role of money for the closed economy. In this model, the role of issuing money is considered. Budina and Wijnbergen (2008) assume that seigniorage, the difference between the value of issued money and the cost of printing money, is a source of income for governments, thus, it should play a role in the government budget constraint. Therefore, the model in Budina and Wijnbergen (2008) has the form:

$$b_t = b_{t-1}(1+i) - (ps_t + se_t) \tag{7}$$

where b_t, ps_t, i, and se_t are the debt level or bonds, primary surplus, interest rate, and seigniorage. From this budget constraint, Budina and Wijnbergen (2008) derive the initial sustainable debt level:

$$b_0 + \sum_1^{\infty} \frac{g_i}{(1+i)^i} = \sum_1^{\infty} \frac{t_i + se_i}{(1+i)^i} \quad \text{or} \quad b_0 = \sum_1^{\infty} \frac{ps_i + se_i}{(1+i)^i} \tag{8}$$

The two equations in (8) show that the initial debt (b_0) plus the present value of government spending (g_i) of all periods should equal the present value of all future tax revenue and seigniorage value. In the end, the initial debt should equal all the discounted primary surplus and seigniorage in future. The two papers with the monetary factors provide good estimation results.

Most recently, Burger et al. (2011) return to the simplest government intertemporal budget constraint $D_t = D_{t-1} + iD_{t-1} - PB_t$ for the case of South Africa. In this equation, D_t stands for public debt, PB_t for primary balance, and i for nominal interest rate. Going forward one period and substituting back to the budget constraint, then dividing both sides by GDP (Y_t) and iterating the equation give the base line model:

$$(PB/Y)_t = ((r-\eta)/(1+\eta))(D/Y)_{t-1} \tag{9}$$

In equation (9), r is the real interest rate and η is the real economic growth rate. Departing from this expression, Burger et al. (2011) follow de Mello (2005) and Bohn (1998) to extend the model with the lag of $(B/Y)_t$ and output gap $\hat{y}$. The base-line model becomes:

$$(PB/Y)_t = \alpha_1 + \alpha_2 (B/Y)_{t-1} + \alpha_3 (D/Y)_{t-1} + \alpha_4 (\hat{y})_t + \varepsilon_t \tag{10}$$

Burger et al. (2011) estimate this fiscal reaction function with various methods including the OLS, TAR, VAR, GMM, VECM, and State-Space methods. The estimation from the research provides good policy recommendation for South Africa.

2.3. Fiscal Reaction Function for Open Economy

The literature about the fiscal reaction function shows that most models are for closed economies. The possible reason is that governments may want to address the fiscal problem independently and avoid depending on foreign resources. However, there have been a number of papers studying the fiscal reaction function in an open economy context. Penalver and Thwaites (2006) propose a simple government intertemporal budget constraint:

$$D_t = (1 + r_t) D_{t-1} - PB_t \tag{11}$$

This equation only considers the real debt *(D_t)*, the real primary budget surplus *(PB_t)*, and the real interest rate *(r_t)*. Assuming that debt may include domestic and foreign debt with a share ratio of ϕ, dividing both sides of the budget constraint equation by real GDP gives

$$d_t = (1 + (1 - \phi_t) r_t^d + \phi_t (r_t^f + \Delta s_t) - g_t) d_{t-1} - pb_t \tag{12}$$

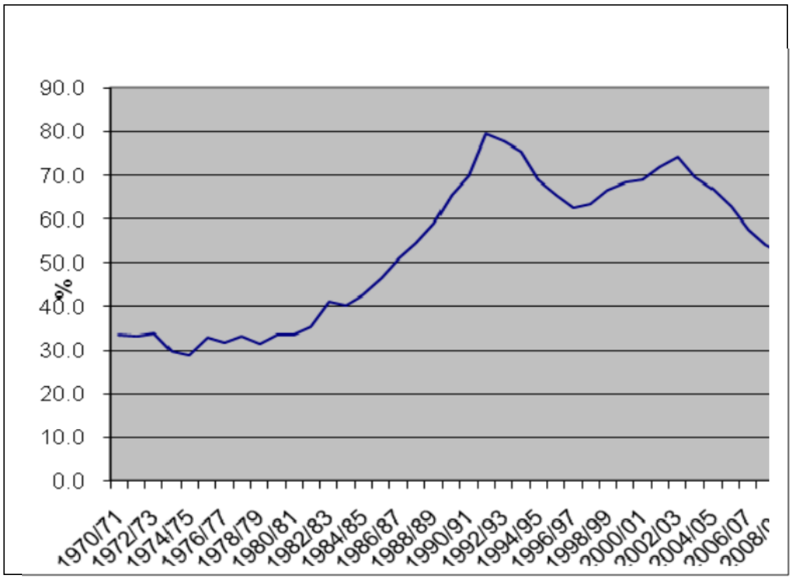
where Δs_t, r_t^f and r_t^d are the change in the foreign real exchange rate, foreign and domestic interest rates. With quarterly data from Brazil from 1999 to 2005, Penalver and Thwaites (2006) use VAR method to find the role of interest rate, exchange rate, and output growth in the process of debt management. After Penalver and Thwaites (2006), Adedeji and Williams (2007) estimate a fiscal reaction function for the CFA franc zone in West and Central Africa with the presence of terms of trade in the function. However, these two papers show mixed results about the role of terms of trade.

Comparing the open and closed economy versions of the fiscal reaction function shows that the closed economy version is superior to the open one in term of precision and availability. The closed fiscal reaction function always fits better. However, there is common things among these fiscal reaction function. Firstly, econometric methods are dominant in estimating the functions. Most variables are the ratios of the factors of the government budget constraint over GDP. All of these variables are usually statistically significant.

3. India's Fiscal Context

For a long time, governments have been assigned great responsibilities in helping socio-economic growth by providing public goods and services that require large scale production and management which cannot be supplied by a single private firm. This was especially true for India when it gained independence from Britain and began to develop its economy from a low starting position. To spur growth, besides providing public goods and services, the Indian government has operated many important industries including those related to steel and fertilizer production, electricity generation, and public transport, and providing various types of subsidies as a shield for its vulnerable poor population. As the rest of the world, a strong government was fashionable in India for some decades. However, this economic model showed some weakness. India's ineffective public sector and tax system led to higher deficit and debt levels overtime. Higher debt and deficit levels, coupled with some shocks, caused India's balance of payment crisis in 1991. As a result of the 1991 crisis, several reforms have been carried out. However, difficulties remain. A large fiscal deficit has re-emerged, adding pressure to the high public debt level. As shown in Graph 1, the total liability of both central and state governments has arising trend overtime. It reached its peak of 79.4% in the balance of payment crisis of 1991/92, fell to 62.6% in 1996/97, and then increased again to 74.3% in 2002/03. With these figures, fiscal stability can be a problem, especially in a period of economic downturn. In this context, the Indian government received criticisms for weak fiscal management from researchers around the world. Singh and Srinivasan (2004), Kochhar (2004), Rajaraman (2004), Roubini and Hemming (2004), Hausmann and Purfield (2004), and Heller (2004) provided details of India's fiscal situation at that time and called for immediate and effective actions to deal with the dangerous fiscal imbalance. The government of India has recognized these criticisms and has implemented corrective measures. As a result, India's fiscal condition has become less severe recently. As shown in Graph 1, after reaching a dangerous level in 2002/2003, India's public debt has been falling gradually and has only increased mildly as a result of the stimulus package in the context of the global financial crisis which began in the end of 2007. However, it has had a clear downward trend since 1991.

Graph 1: India's Total Debt over GDP



Source: Buiter and Patel (2010)

4. Baseline model

As briefly reviewed above, most fiscal reaction functions originate from the simple government intertemporal budget constraint and are empirically based, meaning that there is not a single form for the fiscal reaction function. The fiscal reaction function also varies depending on researchers' arguments. Some fiscal reaction functions follow Bohn's (1998) model and estimates the primary surplus/GDP as the dependent variable and debt/GDP, government spending, and output gap etc. as independent variables:

$$s_t = \rho.d_t + \alpha_0 + \alpha_G GVAR_t + \alpha_y YVAR_t + \varepsilon_t$$

Khalid et al. (2007), Turrini (2008), Afonso and Hauptmeier (2009), and Egert (2010) modify Bohn's (1998) method by controlling more factors. Besides primary surplus and debt, business cycle, output gap, inflation, and some political, institutional variables are considered. Investigating the relationship between the first difference of primary balance and debt, Afonso and Jalles (2011) apply Pooled OLS and Panel VAR for OECD countries to prove fiscal authorities do care about fiscal sustainability. However, except for Khalid et al. (2007) that acknowledges the relationship between monetary and fiscal policies, this type of fiscal reaction function is independent of monetary policy. This may be a problem in the context when monetary and fiscal policies are always interrelated. Moreover, this type of fiscal reaction function is empirically based, or at least, a solid theoretical base has not been indicated. Therefore, I prefer the fiscal reaction function type which originates from theoretical models. This fiscal reaction function is used by Davig and Leeper (2006) and estimates a function with tax/GDP as the dependent variable and debt/GDP, government spending/GDP, and output gap as independent variables (Equation 13).

$$\tau_t = \gamma_0 + \gamma_b b_{t-1} + \gamma_x y_t + \gamma_g g_t + \varepsilon_t \tag{13}$$

In fact, there is an approximation between Bohn's (1998) and Davig and Leeper's (2006) fiscal reaction functions. In Equation (13), if government spending is moved to the left hand side, we will have a new variable similar to Bohn's (1998) primary surplus. Follow Davig and Leeper (2006), I derive a new fiscal reaction function from the government intertemporal budget constraint and the IS curves originated from the Neoclassical and the Davig and Leeper (2011) model.

In the neoclassical model, an infinitive living individual maximizes his utility by choosing his consumption, labor, and capital *(C_t, l_t, and k_t):*

$$U_t = Max \sum_{t=0}^{\infty} \beta^t U(\frac{C_t^{1-\sigma}}{1-\sigma})$$

subject to $\sum_{t=0}^{\infty} p_t[C_t + k_{t+1} - (1-\delta)k_t] \leq \sum_{t=0}^{\infty} p_t(k_t r_t + w_t l_t)$

In the Davig and Leeper (2011) model, an individual optimizes his utility by choosing his level of consumption, labor, and money holding as given by the following utility function:

$$U_t = MaxE_t \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{L_t^{1+\eta}}{1+\eta} + \delta \frac{(\frac{M_t}{P_t})^{1-\kappa}}{1-\kappa} \right]$$

subject to: $\left(C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} + \tau_t\right) \leq \left(\frac{W_t}{P_t} L_t + \frac{M_{t-1}}{P_t} + \frac{(1-i_{t-1})B_{t-1}}{P_t} + pf_t\right)$

Details of deriving the IS curves are provided in see Appendix 1-2. This new fiscal reaction function is more suitable to my purpose of studying the interrelation between monetary and fiscal policies with the presence of interest rate, inflation as the representative for monetary policy, and debt and tax as the representative for fiscal policies. Details of constructing the fiscal reaction function are as follows:

From the government budget constraint $G_t + (1+i_{t-1})B_{t-1} = B_t + T_t$ we have:

$$\boldsymbol{G_t = T_t + B_t - (1 + i_{t-1})B_{t-1}} \tag{14}$$

Going forward a period gives

$$\boldsymbol{G_{t+1} = T_{t+1} + B_{t+1} - (1 + i_t)B_t} \tag{15}$$

Denoting g_t as the log of G_t, from (14) and (15) we have:

$$\boldsymbol{\Delta g_{t+1} = g_{t+1} - g_t = \log(T_{t+1} + B_{t+1} - (1 + i_t)B_t) - \log(T_t + B_t - (1 + i_{t-1})B_{t-1})} \quad (16)$$

From the IS curve under the Constant Relative Risk Aversion (CRRA) assumption for the Neoclassical model (see Appendix 1-2) we have:

$$y_t = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + E_t y_{t+1} + \frac{1}{\delta}\bar{r}_t - E_t\Delta g_{t+1} + \varepsilon_t$$

where $\bar{r}_t$ is constant and can join the error term, we have

$$\boldsymbol{\Delta g_{t+1} = y_{t+1} - y_t - \frac{1}{\delta} i_{t+1} + \frac{1}{\delta}\pi_{t+1}} \quad (17)$$

Combining (16) with (17) gives

$$T_{t+1} = f(y_{t+1}, y_t, i_{t+1}, i_t, i_{t-1}, \pi_{t+1}, B_{t+1}, B_t, B_{t-1}, T_t) \quad (18)$$

From the IS Curve under the CRRA assumption for Davig and Leeper's (2011) model (see Appendix 1-2) we have

$$y_t = -\frac{1}{\sigma}i_t + \frac{1}{\sigma}\pi_{t+1} + E_t y_{t+1} + \frac{1}{\sigma}\bar{r} - \Delta g_{t+1} + \varepsilon_t \quad (19)$$

Similarly we have:

$$\boldsymbol{\Delta g_{t+1} = y_{t+1} - y_t - \frac{1}{\delta} i_t + \frac{1}{\delta}\pi_{t+1}} \quad (20)$$

Combining (16) and (19), we get the identical fiscal reaction function as in Equation (18):

$$\boldsymbol{T_{t+1} = f(y_{t+1}, y_t, i_{t+1}, i_t, i_{t-1}, \pi_{t+1}, B_{t+1}, B_t, B_{t-1}, T_t)} \quad (21)$$

It turns out that when combining with the government intertemporal budget constraint, both the IS curves under the CRRA assumption give an identical empirical fiscal reaction function. With rational expectation, going backward one period gives the empirical fiscal reaction function that will be estimated in this paper; i.e.,

$$\boldsymbol{T_t = f(T_{t-1}, y_t, y_{t-1}, i_t, i_{t-1}, i_{t-2}, \pi_t, B_t, B_{t-1}, B_{t-2})} \quad (22)$$

This fiscal reaction function is different from other fiscal reaction functions mentioned in the literature review section. From the fiscal reaction function in (22), there is no government spending variable. However, from the government intertemporal budget constraint we have $B_t = G_t + (1 + i_{t-1})B_{t-1} - T_t$. This implies that government spending has already been considered indirectly in the model. And if we rearrange by moving B_t to the left hand side, we have the similar fiscal function used in many other research where primary balance is a function of its lag, output gap, debt, inflation rate, and interest rate.

This fiscal reaction function is somewhat a modified version of what used by Jha and Sharma (2004) to investigate the sustainability of the Indian government's budget. Jha and Sharma (2004) use the following model:

$$\tau_t = \alpha + \beta d_t + v_t$$

to test if the tax revenue (τ_t) and government total expenditure (d_t) are cointegrated. If government revenue and expenditure are cointegrated, India's fiscal policy is stable. With the presence of tax, debt, and expenditure, Jha and Sharma's (2004), Davig and Leeper (2006) models and the fiscal reaction function under this paper are heading to the same direction.

Solving Equation (22) is difficult. However, this equation gives us an idea of how the fiscal reaction function involves. At this stage, I follow other scholars to use the tax/GDP (τ_t) and debt/GDP (b_t) ratio as main variables in the new fiscal reaction function. Assuming that the empirical fiscal reaction function has a linear form, the fiscal reaction function to be estimated is:

$$\tau_t = \gamma_0 + \gamma_1\tau_{t-1} + \gamma_2 y_t + \gamma_3 y_{t-1} + \gamma_4 i_t + \gamma_5 i_{t-1} + \gamma_6 i_{t-2} + \gamma_7 \pi_t + \gamma_8 b_t + \gamma_9 b_{t-1} + \gamma_{10} b_{t-2}$$

From the intertemporal government budget constraint, B_{t-1} is a function of B_{t-2} and i_{t-2}. Thus, in this approximate empirical testing, b_{t-1} can represent b_{t-2} and i_{t-2}. Further, as mentioned below, I use total public liability which includes all outstanding debt and other liabilities in the current year as an instrument for B_t. Therefore, including b_t and b_{t-1} in the fiscal function is enough and b_{t-2} can be excluded. The fiscal reaction function now becomes:

$$\boldsymbol{\tau_t = \gamma_0 + \gamma_1\tau_{t-1} + \gamma_2 y_t + \gamma_3 y_{t-1} + \gamma_4 i_t + \gamma_5 i_{t-1} + \gamma_6 \pi_t + \gamma_7 b_t + \gamma_8 b_{t-1}} \qquad (23)$$

This theoretical fiscal function will be used as the base to develop an empirical fiscal function below. With this fiscal reaction function, the government implements fiscal policy based on the following hypothesis:

Hypothesis 1: Tax and the previous period's debt. From the government's intertemporal budget constraint, the government borrows and collects tax today to finance its current spending and service the previous period's debt. Assuming that the government wants to avoid the Ponzi scheme that borrowing today is not for servicing previous debt, tax receipts will be used to service the previous debt and should be *positively* correlated with previous debt. That means, if the previous period's public borrowing increases, the government should collect more tax to repay its debt.

Hypothesis 2: Tax and current debt. The government has a spending and borrowing plan for the current year. However, while it is difficult to change spending plan, there are reasons that a government has to change its borrowing plan this period, i.e. lower than expected tax collection may lead to higher borrowing which is used to finance planned government spending. In general, for a fixed amount of aggregate output, lower tax will be compensated for by higher public borrowing. In contrast, if the government imposes higher tax, households will save less and lend less to the government, thus lower public borrowing. Therefore, current tax and public borrowing are *negatively* correlated.

Hypothesis 3: Tax and output gap. For a developing economy, the correlation between tax and output gap is *uncertain*. Rationally, when output is under its natural level, the government should reduce tax and increase its spending to stimulate growth. When output is above its natural level, the government should increase tax to deflate the overheated economy. Therefore, the correlation between the two variables should be *positive*. However, if the output gap is above its natural level and the focus of a developing country like India is economic growth, it may still reduce tax and increase government spending, thus the correlation may be *negative*.

Hypothesis 4: Tax and the first lag of tax. There are two reasons that the lag of tax plays an important role in the fiscal reaction function. Firstly, there is an economic reason in that the government wants to avoid a tax shock to smooth economic growth. Secondly, there is a political reason in that the government will not raise tax suddenly as it wants to avoid the public's dissatisfaction, failing which there will be a chance for political opponents to win in the next election. Therefore, the lagged term of tax plays an important role in the fiscal reaction function and should be *positively* correlated.

Hypothesis 5: Tax and inflation. Inflation can be used as a type of tax to helps reduce the government debt's burden. Therefore inflation and tax should be *negatively* correlated. However, the inflation rate of the previous period should be considered since it affects the government debt's burden directly when the government repays the previous period debt in this current period.

Hypothesis 6: Tax and previous period's interest rate. Higher interest rate from the previous period increases the government's debt burden. Therefore, current tax and the previous interest rate should be *positively* correlated.

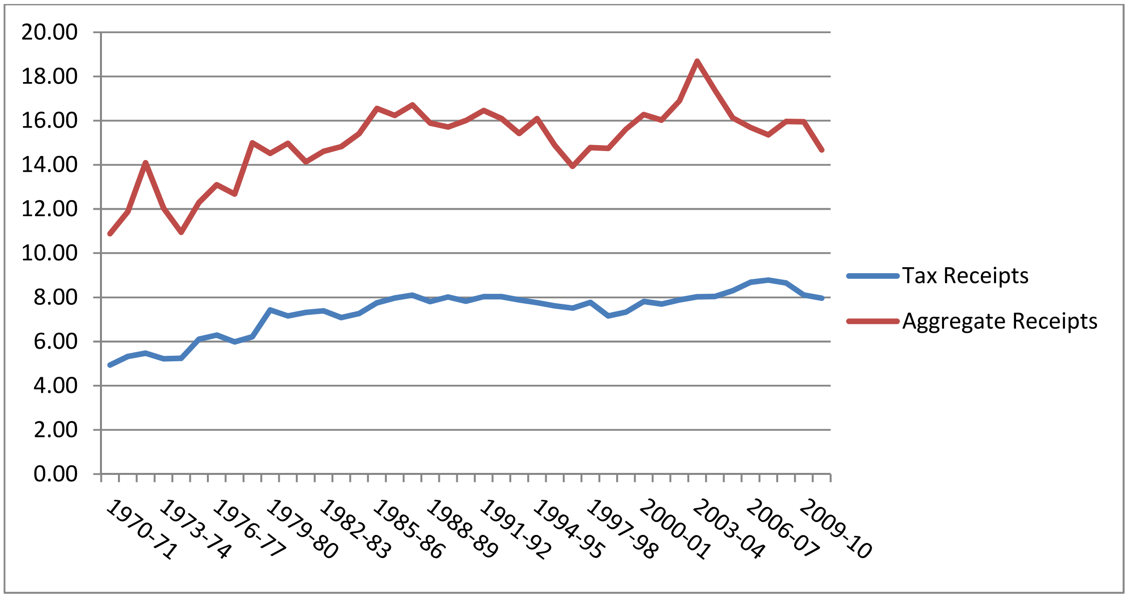
Before estimating the specific fiscal reaction function in (23), all variables will be checked to ensure they are stationary and cointegrated. This procedure confirms the validity of subsequent estimations.

5. Data

Departing from the government intertemporal budget constraint, I try to find the value of Debt (B_t) and Tax (T_t) variables in the *Handbook of Statistic on the India Economy* (2011). The series are available from 1981 to 2011. Next, the main variables of the empirical fiscal function, b_t and τ_t, are calculated by dividing the values of B_t and T_t to GDP at factor cost. The output gap is generated from the HP filter for India's GDP at factor cost. Interest rate is the call rate taken from Table 74 of the handbook of statistics. For inflation, I use the consumer price index for industrial worker (CPI) and wholesale price index (WPI) to compare the effect of CPI and WPI to fiscal policy. However, I only report the estimation using the inflation series generated from the WPI as this index is more general since it accounts for all commodities while the CPI for industrial worker is more specific and does not cover all India's consumers. The problem is how to select the value of Debt and Tax in the context of India.

There are some reasons that I should not use traditional data like tax revenue for T_t and yearly incurring debt value for B_t to estimate India's fiscal reaction function. From the government budget constraint, tax and bond represent the in-flow funds of a government are. In India, this is not enough. The Indian government owns many enterprises and collects huge amounts of fees and other income from these enterprises. For example, Indian Railways is one of the biggest firms of its kind in the world. Similarly, India Post Office also has the largest postal network in the world. Thus, fees and other receipts account for a large share of government income in India. Graph 2 shows the difference between tax receipts and aggregate receipts in India. In fact, aggregate receipts of India's government are nearly double tax receipts. Therefore, tax receipts should not be considered as a good representative for T_t. The aggregate receipts should not be considered as T_t either because they include both revenue receipts and capital receipts. From Table 102 of the RBI (2011), capital receipts include net market borrowings and external loans which should belong to B_t. Therefore, I use India's revenue receipts as an instrument for T_t. From now on, we understand that tax *(T_t)* in this model is revenue receipts. It is clear that revenue receipts presents better the in-flow fund of the government than tax receipts alone in the case of India.

Graph 2: India Aggregate Receipt and Tax Receipt



Source: Table 235 Handbook of Statistic on the Indian Economy

Similarly, for the debt series B_t, I use the total central and state governments' liabilities. In the government budget constraint, we assume that the government borrows for only one period then repays the loan in the next period. In fact, a loan usually has longer maturity and debt can pile up overtime. According to India Ministry of Finance (2012), as of March 2011, the portion of dated securities maturing in 10 years and above accounts for 36.9% of total debt. Therefore, a government should take care of total outstanding debt rather than debt arising yearly. In addition, the Indian central and state governments' aggregate liabilities, which include debt and other liabilities, are much higher than debt alone. For example, according to India Ministry of Finance (2012), the average public debt over GDP ratio was 38.2% in the period from 2006 to 2010 while the equivalent number for aggregate liability was 56.7%, (48.3% higher). Therefore, the government should address the total outstanding liability when implementing its fiscal policy. With the above argument, total central and state governments' liabilities over GDP at factor cost will be used as an instrument for b_t.

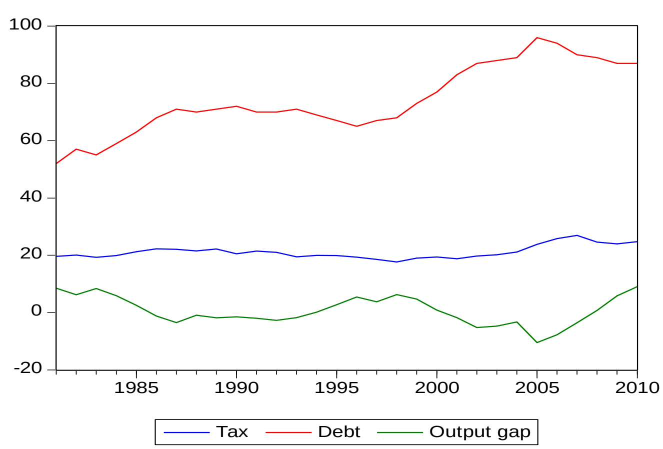
Using total liability as B_t also has one advantage. Total liability is composed of both central and state governments' liability. In turn, central government's liability is composed of domestic and foreign liability. Foreign liability is the amount of foreign debt in USD converted to Rupees through official exchange rate. Therefore, using total liability as B_t helps the model suit better to the case of India which should be considered in an open or semi-open economy context because both external debt and exchange rate are considered.

Besides selecting suitable data for empirical analysis, it is also worth exploring variable property before any testing. It is noted that macroeconomic variables such as debt and revenue levels usually have trend. However, in this paper, I use total liabilities/GDP *(b_t)* and revenue receipts/GDP *(τ_t)* that may already be detrended. Suppose that revenue receipts and GDP grow at a same rate then revenue receipts/GDP should not have a trend. Graph 3 shows that only b_t may have a sharp increasing trend. This is understandable in the context of India when total liabilities are building up overtime. However, τ_t is stable and just fluctuates between 20 per cent to 24 per cent. I expect that there is no trend in *(τ_t)* because tax cannot be rising forever and should settle down at an optimal level.

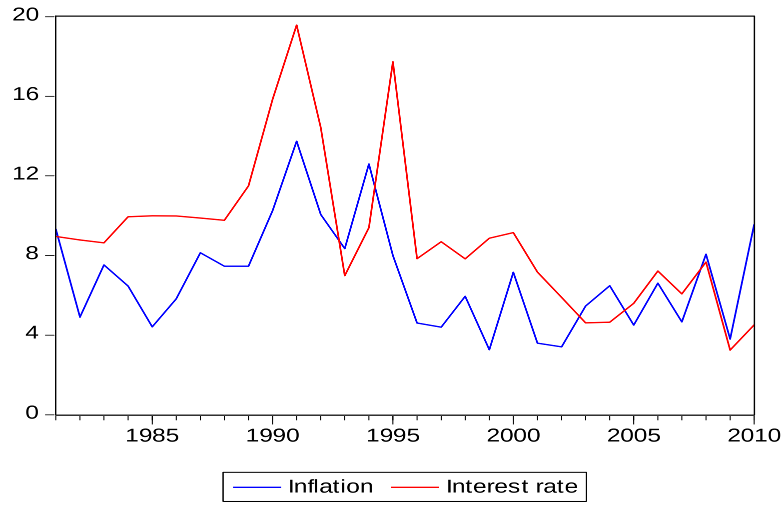
Output gap is a special variable in estimating India's fiscal reaction function. Normally, output gap fluctuates around zero and has no trend. If a government is quick in adjusting its macroeconomic policies to smooth output, output gap can be stationary. However, Graph 3 shows that the business cycle in India is quite long and it may take about a decade for India's output gap to change. With this movement pattern of India's output gap, I expect this variable not to be stationary.

Graph 4 provides a closer look at inflation and interest rate. In an optimum condition, inflation and interest rate should be I(0) and fluctuate around a centre point. However, with the moving pattern of inflation and interest rate as shown in Graph 4, inflation and interest rate are not I(0). Firstly, there was a sharp increase in 1991 and 1995. Then, interest rate has a downward trend and inflation has an upward trend.

Graph 3: Plot of variables used in India's Fiscal Reaction Function



Graph4: The correlation between interest rate and inflation rate



In general, all variables should exhibit no trend or are stationary under optimal condition. However, in the case of India, their moving patterns show the opposite. To solve this problem, the Augmented Dickey-Fuller (ADF) stationary tests incorporating both trend and non-trend should be considered. Besides the ADF test, I will conduct stationary tests for all variables using the Zivot and Andrews (1992) unit root test allowing for one structural break and the Clemente, Montanes, and Reyes (1998) allowing for two structural breaks. The main reason for choosing the tests incorporating structural breaks is the balance of payment crisis in India in 1991. After the crisis, there were reforms in both monetary and fiscal policies. India did not carry out the reforms aggressively but gradually and avoided the bitter lesson as seen in the East European socialist countries. From Graph 3, it is clear that the moving pattern of tax, debt, and output gap series are relatively smooth and there is no sudden change in data which may show a mean shift. For inflation and interest rate series, although there were two spikes in 1991 and 1995, these two series quickly returned to their normal levels. Therefore, I expected there was a trend break rather than an intercept break or a trend/intercept breaks around the 1991 balance of payment crisis. However, to be safe, I will carry out the structural break tests allowing both trend break and intercept and trend break tests. As presented below, the Zivot and Andrews (1992) test reports different break times. Besides the 1991 crisis, break times can be around 1996 and 1999 when the Asian financial crisis happened, and 2005 when India fiscal condition was in critical condition and was adjusted. The general Zivot and Andrews (1992) test as follows:

$$y_t = \alpha + \beta t + \gamma DU1_t + \omega DT1_t + \mu y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t$$

The Null hypothesis of the test is that there is Unit-Root in y_t. In this test, for t = [1,…T], $DU1_t$ is the dummy indicator for a mean or intercept shift and $DT1_t$ is the dummy indicator for a trend shift occurring at the time SB1. $DU1_t$ = 1 if t > SB1 and $DU1_t$ = 0 otherwise. $DT1_t$ = (t - SB1) if t > SB1 and $DT1_t$ = 0 otherwise. The structural break point SB1 can be any t in the set T = [1,…T] except for 1 and T. That means the beginning and the end of the period under the test cannot be the break. The number of lag of the first difference of y_t is important and is detected by grid search.

There are two types of Clemente, Montanes, and Reyes (1998) test, one allows innovational outlier (gradual change) and one allows additive outlier (sudden change). The Clemente, Montanes, and Reyes (1998) test allowing innovational outlier is similar to the Zivot and Andrews (1992) except that now there are two breaks:

$$y_t = \mu + \rho y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t$$

The Clemente, Montanes, and Reyes (1998) test allowing additive outlier is different from the tests above. This test allows for two mean shifts which are presented as the additive outliner. There are two stages in the test. In the first stage, the deterministic part of the dependent variable is removed with the following equation:

$$y_t = \mu + d_1 DU_{1t} + d_2 DU_{2t} + \tilde{y}_t$$

In the second stage, the additive outlier test uses the same grid search method to decide the value of k and the times of break by searching for the minimal t-statistic for null hypothesis of unit-root to hold. The model is:

$$\tilde{y}_t = \rho \tilde{y}_{t-1} + \sum_{i=0}^{k} \omega_{1i} DTB_{1t-i} + \sum_{i=0}^{k} \omega_{2i} DTB_{2t-i} + \sum_{i=1}^{k} c_i \Delta\, \tilde{y}_{t-i} + e_t$$

Empirical results are presented in the next section.

6. Empirical Results

6.1. Stationary tests

Firstly, I use the Augmented Dickey-Fuller test to check if all the concerned variables are stationary or not. Table 1 reports the empirical results of the stationary test. Tax, output gap and interest rate are always I(1) whether there is trend or not. Debt and inflation are I(1) if there is trend in these variables. For debt, there is a clear upward trend as seen in the Graph 3, thus critical value with trend is used. For inflation, from 1980 to 1999, there is not a clear trend in the series. However, from 1999 to 2011, inflation exhibits a sharp upward trend. Assuming that inflation has a trend in India's context, the stationary test reports that inflation may be I(1). The critical values are reported in Verbeek (2008, p.283). It is clear that this result does not satisfy common arguments about these macro data. Possible reasons are structural breaks, thus other stationary tests should be considered.

Table 1: Augmented Dickey-Fuller Stationary Test

Variables	5% Critical value (25 obs – with trend)	5% critical value (25 obs- without trend)	t-statistics	Stationary
Debt (b_t)	-3.60	-3.00	-3.05	I(1)
Tax (τ_t)			-1.28	I(1)
Output Gap (y_t)			-2.12	I(1)
Inflation (π_t)			-3.40	I(1)
Interest rate (i_t)			-2.47	I(1)

In the next step, I apply the Zivot and Andrews (1992) unit root test allowing for one structural break and the Clemente, J., Montanes, A., Reyes, M., (1998) allowing two structural breaks to test if all variables are stationary. Table 2-3 and Table 4-5 report the empirical results for the tests respectively. The critical values presented in Table2 and Table3 are from Table 3 and Table 4 of Zivot and Andrews (1992). Table 2-3 reports that even if one trend break is considered, debt, tax, output, and inflation gap are still I(1) but interest rate is I(0). If a trend/intercept break is considered, only debt, tax, and output gap are I(1) but inflation and interest rate are now I(0). Assuming that India follows a certain monetary rule in which interest rate is a function of inflation, the unit root tests in Table 2-3 and Table 4-5 and the moving pattern of interest rate and inflation in Graph4 suggest that inflation and interest rate are I(0).

Table2: Zivot and Andrews (1992) unit root test allowing for one trend break

Variables	Critical value (5%)	t-statistic,	Date of Break	Stationary,
Debt (b_t)	-4.42	-2.12	1986	I(1)
Tax (τ_t)		-2.84	1999	I(1)
Output Gap (y_t)		-2.07	2006	I(1)
Inflation (π_t)		-4.03	1991	I(1)
Interest rate (i_t)		-4.65	1992	I(0)

Table3: Zivot and Andrews (1992) unit root test allowing for one trend and intercept break

Variables	Critical value (5%)	t-statistic	Date of Break	Stationary
Debt (b_t)	-5.08	-2.35	1991	I(1)
Tax (τ_t)		-2.94	2005	I(1)
Output Gap (y_t)		-2.86	2005	I(1)
Inflation (π_t)		-6.76	1996	I(0)
Interest rate (i_t)		-5.36	1993	I(0)

Table4: Clemente, Montanes, and Reyes (1998) innovational outlier

Variables	Critical value (5%)	t-statistic	Date of Break 1	Date of Break 2	Stationary
Debt (b_t)	-5.49	-4.794	1982	1997	I(1)
Tax (τ_t)		-4.381	1990	2003	I(1)
Output Gap (y_t)		-3.056	1982	1997	I(1)
Inflation (π_t)		-7.278	1989	1994	I(0)
Interest rate (i_t)		-4.503	1988	1997	I(1)

Table5: Clemente, Montanes, and Reyes (1998) additive outlier

Variables	Critical value (5%)	t-statistic	Date of Break 1	Date of Break 2	Stationary
Debt (b_t)	-5.49	-3.319	1987	2001	I(1)
Tax (τ_t)		-3.474	1994	2004	I(1)
Output Gap (y_t)		-4.419	1996	2003	I(1)
Inflation (π_t)		-6.308	1988	1994	I(0)
Interest rate (i_t)		-6.073	1989	1997	I(0)

In short, five stationary tests report different results. If a structural break is not considered, all the variables are I(1). It is against common thinking that inflation, interest rate, output gap should be stationary. However, if structural break is considered, interest rate and inflation are I(0) while the rests are I(1). Subsequent empirical testing should consider this problem.

6.2. Estimating the Fiscal Reaction Function

6.2.1. Differencing Estimation

Stationary testing reports that debt, tax, and output gap are I(1) while interest rate and inflation are I(0). Therefore, a cointegration relation among relevant variables cannot exist and we face an unbalanced regression. According to Banerjee et al. (1993, Ch.6), when we face an unbalanced model which incorporates both stationary and non-stationary variables, standard OLS tests are unreliable. To deal with this type of model, variables should be made stationary by differencing. When all the modified variables are stationary, it is possible to use standard tests again. Following the idea of Banerjee et al. (1993, Ch.6), the estimating procedure under this assumption is:

$$\Delta\tau_t = \gamma_0 + \gamma_1 \Delta y_t + \gamma_2 i_t + \gamma_3 i_{t-1} + \gamma_4 \pi_t + \boldsymbol{\gamma_5} \Delta b_t + \varepsilon_t$$

Detailed results are reported in Appendix 3.1. The coefficient of i_t is always statistically insignificant, thus i_t is excluded from the model. The estimated fiscal reaction function is as follows:

$\Delta\tau_t$=	2.71***	-0.51Δy_t***	-0.15i_{t-1}***	-0.09π_t	-0.41Δb_t***
	(0.75)	(0.13)	(0.05)	(0.07)	(0.14)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

With $\Delta\tau_t = \tau_t - \tau_{t-1}$ and similar for other variables, rearranging will transform this equation to the desired form as in Equation (23), we have the fiscal reaction function:

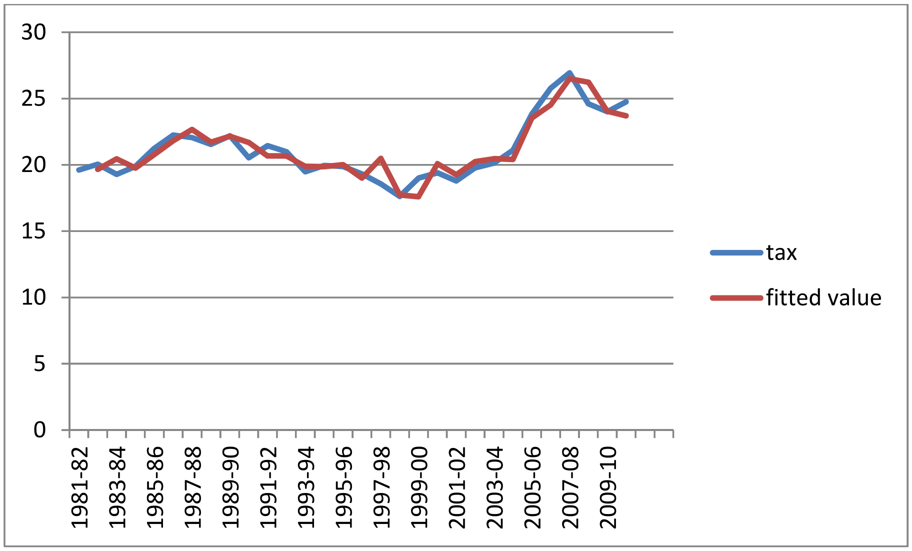
$$\tau_t = 2.71 + \tau_{t-1} - 0.51 y_t + 0.51 y_{t-1} - 0.15 i_{t-1} - 0.09 \pi_t - 0.41 b_t + 0.41 b_{t-1}$$

Using this fiscal function to generate the fitted series then plotting them against actual series show that the estimated fiscal function fits very well for the case of India (Graph5 and

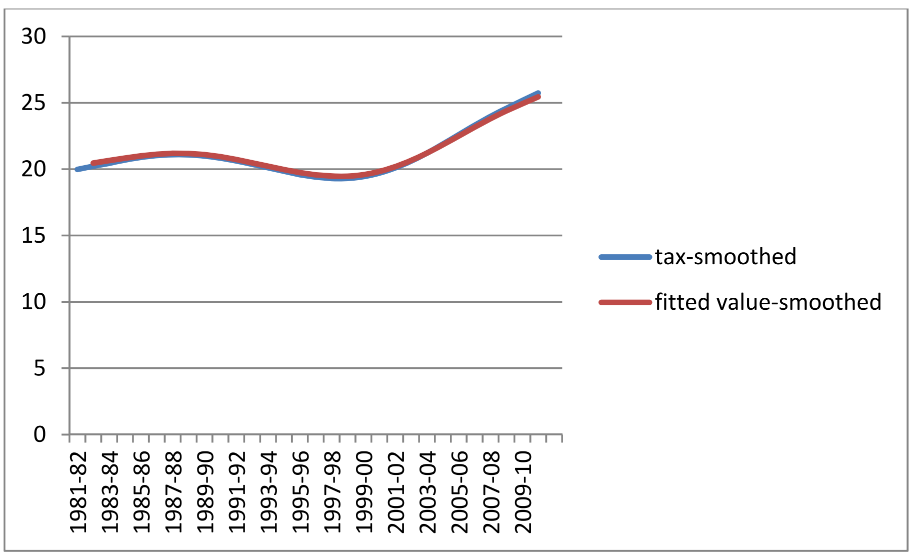
Graph6). However, this model has a weak point that the coefficients of some variables and their lag have opposite sign and absolute value, thus they usually cancel each other.

The estimating result shows that a change in tax is highly correlated to changes in output gap, debt, and interest rate. The coefficients of lag of tax, output gap, lag of output gap, debt, and lag of debt are as expected. However, inflation does not play any role in India's fiscal reaction function.

Graph5: India FRF with CRRA assumption (Benerjee et al. 1993 method)



Graph6: India FRF with CRRA assumption– smoothed (Benerjee et al. 1993 method)



6.2.2. Persaran et al. (2001) ARDL bound testing method.

The Autoregressive Distributed Lag Model (ARDL) is used widely in analyzing macroeconomic time series. It works well with stationary variables. When both left-hand side and right-hand side variables are I(0), the error term will be I(0) and there exists an error correction relation between regressand and regressors. However, when it comes to non-stationary variables, this is not applicable anymore. When relevant variables are I(1), the error term may be I(1) and the model becomes unreliable. There is a special case when both left-hand side and right-hand side variables are I(1) and cointegrated, the error correction mechanism exists again. For the case of unbalanced model with both I(0) and I(1) variables are present, the traditional ARDL model does not work. However, this case is quite popular.

Persaran and Shin (1997) and Persaran et al. (2001) revisit the role of ARDL model in detecting the long run relation between dependent and independent variables and find that their ARDL model can be utilized to detect the existence of the level relationship between relevant variables irrespective of whether they are purely I(0), I(1), or a mixture of both I(0) and I(1). Following Persaran et al. (2001), the ARDL model under consideration is:

$$\Delta\tau_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta\tau_{t-i} + \sum_{i=0}^{p} \theta_i \Delta b_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta y_{t-i} + \sum_{i=0}^{p} \varphi_i \Delta i_{t-i} + \sum_{i=0}^{p} \omega_i \Delta\pi_{t-i} + \delta_1 \tau_{t-1} + \delta_2 b_{t-1} + \delta_3 y_{t-1} + \delta_4 i_{t-1} + \delta_5 \pi_{t-1} + v_t$$

Persaran and Shin (1997) and Persaran et al. (2001) proved that this model is always consistent irrespective of whether relevant variables are stationary or not. This model also has an advantage of working well with small sample. The Persaran et al. (2001) cointegration test makes use of the usual F-statistic and t-statistic. The Null hypothesis that there not exist long-run relationship among all variables is H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ and the alternative hypothesis is H_0: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$. However, the Persaran et al. (2001) ARDL model does not use the standard critical values of the F-test and t-test. They provide two other sets of critical values. The first set is applied when all variables are I(0). This set is referred to as the lower bound. The second set is applied when all variables are I(1) and is referred to as the upper bound. These sets of critical values also depend on whether intercept and trend are considered. If the F-statistic is higher than the upper bounce then the Null hypothesis is rejected and we can conclude without knowing the stationary property of relevant variables that there exists a level relationship among variables. Similarly, if the F-statistic is lower than the lower bounce then the Null hypothesis is not rejected. However, if the F-statistic is in the middle between the lower and upper bounces, we need to know the stationary character of relevant variables before concluding. The Persaran et al. (2001) require minimum lag length $p=1$. The lag length will be selected by AIC. However, in the context of small sample size in India, it is impossible to run the model with lag length $p=2$ and above because there is not enough degree of freedom. Therefore, the only selection is $p=1$. Applying the Persaran et al. (2001) to India's data produces the following results:

Table 6: Persaran et al. (2001) Cointegration Test

Test	Value	Significant level	Bounce Critical Value (restricted intercept, no trend)	
			Lower Bounce	Upper Bounce
F-Statistic	1.86	1%	3.06	4.15
		5%	2.39	3.38
		10%	2.08	3.00

With such a low F-statistic, the Persaran et al. (2001) test shows that level relationship among relevant variables under this paper does not exist. This result supports the empirical results of no cointegration of previous sections. Because the Persaran et al. (2001) test is consistent, we can use the result from this test to consolidate those of previous tests. The test result from Appendix 3.2 shows that only Δy_t, Δb_t, and i_{t-1} are statistically significant. Table 7 compares the coefficients from two estimating methods. The coefficients from both models have the same size and are quite close. Both tests report that debt, output gap, and interest rate may play an important role in India's fiscal reaction function.

Table7: Comparing results from Banerjee et al. (1993) and Persaran et al. (2001) methods

Method	**Dependent variable**	Δy_t	Δb_t	i_{t-1}
Banerjee et al (1993)	$\Delta\tau_t$	-0.51*** (0.15)	-0.41*** (0.16)	-0.15*** (0.07)
Persaran (2001)	$\Delta\tau_t$	-0.53** (0.20)	-0.40* (0.21)	-0.31* (0.16)

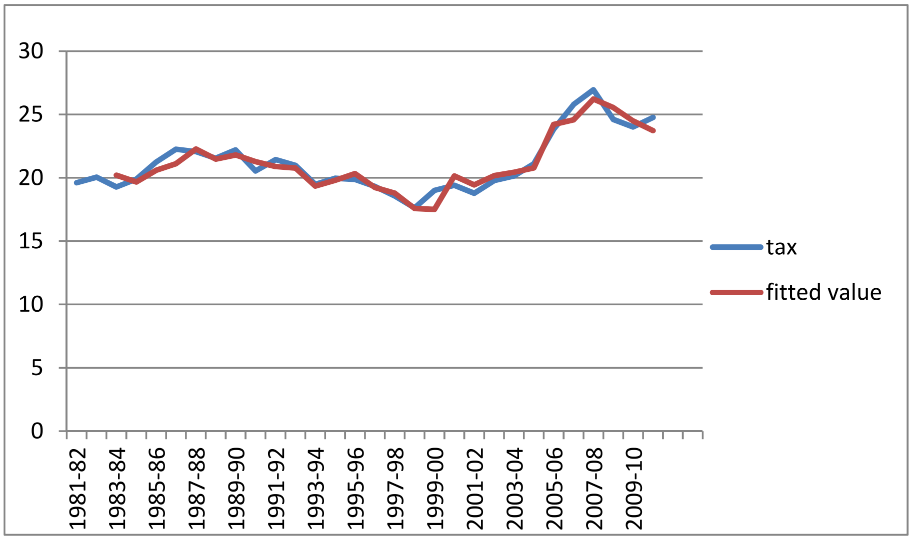
Following the regression result from Appendix 3.2, the fiscal reaction function estimated by Persaran et al. (2001) ARDL model is :

$$\tau_t = 2.73 + 0.88\tau_{t-1} + 0.03\tau_{t-2} - 0.53y_t + 0.57y_{t-1} - 0.01y_{t-2} - 0.08i_t - 0.11i_{t-1} - 0.13i_{t-2} + 0.15\pi_{t-1} + 0.02\pi_{t-2} - 0.4b_t + 0.46b_{t-1} - 0.04b_{t-2}$$

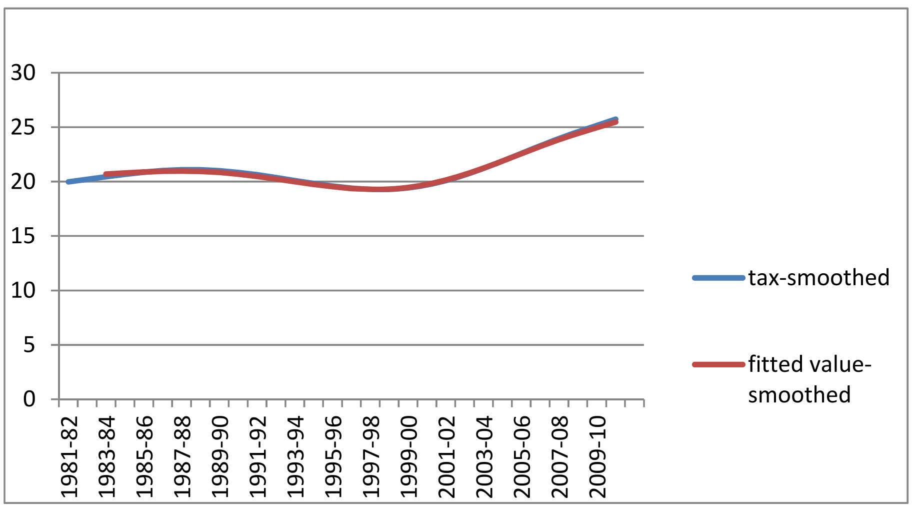
Using the fiscal reaction function estimated by Persaran el al. (2001) method to generate the fitted series then plotting them against actual series show that the estimated fiscal function fits very well for the case of India (Graph7 and

Graph8):

Graph7: India Fiscal Reaction Function (Persaran et al. 2001 method)



Graph8: India's Fiscal Reaction Function – Smoothed (Persaran et al. 2001 method)



Compare to previous fiscal reaction functions, the new fiscal reaction function estimated in this paper has some advantages. Firstly, it carefully examines the stationary property of all relevant variables and applies appropriate econometric methods. Secondly, it incorporates the interrelation between monetary and fiscal policies. Although inflation is not statistically significant in case of India, it may be statistically significant for other cases. Finally, the model confirms the role of interest rate in the new fiscal reaction function. This is reasonable when fiscal authority should take monetary policies into account while implementing fiscal policies.

7. Conclusion and Policy Recommendation

Estimating the fiscal reaction function for India shows that the Indian government follows a fiscal rule strictly. Firstly, this rule prevents any sudden shock that could be harmful for economic growth. This idea can be understood in two ways. First, tax and other fee reduction may boost economic growth. However, India is currently facing high public debt, thus a sudden drop in tax and fee collection will be unfavourable because this will result in higher debt level. Second, a sudden increase in tax revenue and fee collection should also be avoided. Without a reform of the tax system, the only way to raise tax revenue is to increase the tax rate. A higher tax rate may curb output growth. Similarly, raise public goods and service price will impact growth negatively. Thus, a sudden increase in tax and fee collection in India may not be popular.

Another good point about this rule is it shows how the India government reacts to debt. According to this rule, the correlation between tax plus fee collection and the previous period's debt is positive implying that the Indian government does care about debt repayment. If the previous period's debt level rises, the Indian government will try to collect more tax to repay the debt.

Graph 7 and 8 suggest that the improvement in India's fiscal status may be due to a gradual increase in tax/GDP ratio from 1991/1992 to 2010/11 as a result of the fiscal reform after the 1991 balance of payment crisis. This fiscal reform has done well to offer a reasonable and effective tax scheme that has stimulated strong economic growth while still increasing tax relative to the rate of growth. Tax revenue has had an upward trend since 2003 in response to the high debt level of that time. As a result, debt level has been going down since 2004. India's Ministry of Finance (2012) reports that India's debt/GDP was reduced from 40.2% in 2005/06 to a safer level of 36.3% in 2010/11.

However, the fiscal policy in India is not perfect and need some adjustments. Firstly, output gap and tax are negatively correlated. As pointed out in Hypothesis 3, this relationship implies that India may put more weight on economic growth. If too much weight is put on economic growth, there might be distortions somewhere else. In an optimum situation, output gap and tax should be positively correlated, which means fiscal policy may be used to deflate an overheated economy.

The second issue is the relationship between the previous period's interest rate and tax. Hypothesis 6 suggests that these two variables should be positively correlated. However, the estimation for India's fiscal reaction function shows that the relationship between two variables is in fact negative. This sometime can be explained that the high interest rate from previous period can be harmful for growth and the government reduce tax to support growth.

But this could mean India's government may not care about the interest amount arising from total debt. It is acceptable if the amount of interest payment is small and interest rate is low. However, if public debt is growing and interest rate is high, this should be corrected. In fact, Jha and Sharma (2004) conclude that India's public debt is sustainable, but just a possible problem is that at that time more than one third of government expenditure was reserved for interest payment on past loans. With current public debt building up and if the estimated fiscal reaction function is correct, the Indian government should addresses the correlation between tax revenue and past interest rate.

References

Adedeji, O & Williams, O 2007, 'Fiscal Reaction functions in the CFA Zone: An analytical perspective', IMF Working Paper No. 07/232, Oct. 2007.

Afonso, A & Hauptmeier, S 2009, 'Fiscal behaviour in the European Union - rules, fiscal decentralization and government indebtedness', European Central Bank Working paper No. 1054/May 2009.

Afonso, A. and Jalles, J. T., 2011, 'Appraising fiscal reaction functions', Technical University of Lisbon Working paper No.23/2011/DE/UECE.

Banerjee, R, Dolado, JJ, Galbraith, JW, & Hendry, D 1993, *Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data,* Oxford University Press.

Bohn, H 1998, 'The Behavior of U.S. Public Debt and Deficits', *The Quarterly Journal of Economics,* vol. 113, no.3, pp. 949-963.

Budina, N & Wijnbergen, SV 2008, 'Quantitative Approaches to Fiscal Sustainability Analysis: A Case Study of Turkey since the Crisis of 2001', *World Bank Economic Review,* vol. 23, no.1, pp.119-140.

Burger, P, Stuart, I, Jooste, C, & Cuevas, A 2011, 'Fiscal sustainability and the fiscal reaction function for South Africa', IMF Working Paper No. 11/69, Mar.2011,

Buiter WH & Patel UR 2010, 'Fiscal Rules in India: Are They Effective?' National Bureau of Economic Research Working Paper No. 15934.

Clemente, J, Montanes, A & Reyes, M 1998, 'Testing for a unit root in variables with a double change in the mean', *Economics Letters,* vol. 59, no.2, pp.175-182.

Davig, T & Leeper, EM 2006, 'Fluctuating Macro Policies and the Fiscal Theory' , *NBER Macroeconomics Annual,* vol. 21, pp. 247-316.

Davig, T and Leeper, EM 2011, 'Monetary-fiscal policy interactions and fiscal stimulus', *European Economic Review,* vol. 55, no.2, pp.211-227.

de Mello, L 2005, 'Estimating a Fiscal Reaction Function: The Case of Debt Sustainability in Brazil', OECD Publishing.

Égert, B 2010, 'Fiscal Policy Reaction to the Cycle in the OECD: Pro- or Counter-cyclical?', OECD Economics Department Working Paper No. 763, OECD Publishing.

Garnaut, R 2005, 'Is Macroeconomics Dead? Monetary and Fiscal Policy in Historical Context', *Oxford Review of Economic Policy*, vol. 21, no. 4.

Hausmann, R & Purfield, C 2004, 'The Challenge of Fiscal Adjustment in a Democracy: The Case of India', in *NIPFP-IMF Conference Paper,* 16-17 January 2004, New Delhi, India.

Heller, P 2004, 'India: Today's Fiscal Policy Imperatives Seen in the Context of Longer-Term Challenges and Risks', in *NIPFP-IMF Conference Paper,* 16-17 January 2004, New Delhi, India.

Kochhar, K 2004, 'Macroeconomic Implications of the Fiscal Imbalances', in *NIPFP-IMF*

Conference Paper, 16-17 January 2004, New Delhi, India.

Kirsanova, T, Stehn, SJ, & Vines, D 2005, 'The Interactions between Fiscal Policy and Monetary Policy', *Oxford Review of Economic Policy*, vol. 21, no.4.

Khalid, M, Malik, WS, & Sattar, A 2007, 'The Fiscal Reaction Function and the Transmission Mechanism for Pakistan', *The Pakistan Development Review,* vol. 46, no. 4, pp. 435-447.

Krugman, P 2005, 'Is Fiscal Policy Poised for a ComeBack?', *Oxford Review of Economic Policy*, vol. 21, no. 4.

India Ministry of Finance 2012, *Government Debt – Status Paper*, India Ministry of Finance, viewed on March 2012, http://finmin.nic.in/reports/govt_debt_2012.pdf

Jha, R & Sharma, A 2004, 'Structural breaks, unit roots, and cointegration: a further test of the sustainability of the India fiscal deficit', *Public Finance Review*, vol. 32, pp. 196-219.

Joshi, V & Little, IM 1996, *India's Economic Reforms 1991-2001,* Oxford University Press, New York.

Leeper, EM 1991, 'Equilibria under 'active' and 'passive' monetary and fiscal policies', *Journal of Monetary Economics,* vol. 27, pp. 129-147.

Leeper, EM 1993, 'The Policy Tango: Toward a Holistic View of Monetary and Fiscal Effects', *Federal Reserve Bank of Atlanta's Economic Review,* July/August 1993.

Leeper, EM & Yun, T 2005, 'Monetary-Fiscal Policy Interactions and the Price Level: Background and Beyond', NBER Working Paper No. 11646.

Leith, C & Wren-Lewis, S 2005, 'Fiscal Stabilization Policy and Fiscal Institutions', *Oxford Review of Economic Policy*, vol. 21, no. 4.

Mohan, R 2008, 'The Role of Fiscal and Monetary Policies in Sustaining Growth With Stability in India', *Asian Economic Policy Review*, vol. 3, pp. 209-236.

Penalver, A & Thwaites, G 2006, 'Fiscal rules for debt sustainability in emerging markets: the impact of volatility and default risk', Bank of England Working Paper No. 307.

Persaran, MH & Shin, Y 1997, 'An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis', Cambridge Working Papers in Economics No. 9514, Faculty of Economics, University of Cambridge.

Persaran, MH, Shin, Y, & Smith RJ 2001, 'Bounds Testing Approaches to the Analysis of Level Relationship', *Journal of Applied Econometrics,* vol. 16, no. 3, pp. 289-326.

Rajaraman, I 2004, 'Fiscal Developments and Outlook in India', in *NIPFP-IMF Conference Paper*, 16-17 January 2004, New Delhi, India.

RBI 2011, *Handbook of Statistics on the Indian Economy*, Reserve Bank of India, viewed on 8/02/2012, http://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20Economy

Roubini, N & Hemming, R 2004, 'A Balance Sheet Crisis in India?', in *IMF/NIPFP Conference on Fiscal Policy in India*, 16-17 January 2004, New Delhi, India.

Sims, CA 1994, 'A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy', *Economic Theory,* vol. 4, no. 3, pp.381-99.

Singh, N & Srinivasan, TN 2004, 'Fiscal Policy in India: Lessons and Priorities', in *IMF/NIPFP Conference on Fiscal Policy in India*, 16-17 January 2004, New Delhi, India.

Solow, RM 2005, 'Rethinking Fiscal Policy', *Oxford Review of Economic Policy*, vol. 21, no.4.

Turrini, A 2008, 'Fiscal policy and the cycle in the Euro Area: The role of government revenue and expenditure', *Directorate General Economic and Monetary Affairs*, European Commission.

Verbeek, M 2008, *A Guide to Modern Econometrics*, 3rd edition, John Wiley & Sons Ltd, West Sussex, England.

Zivot, E & Andrews, DWK 1992, 'Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis ', *Journal of Business & Economic Statistics,* vol. 20, no. 1, pp. 25-44.

Appendix

Appendix 1: Deriving the New Keynesian IS curve from the basic neoclassic model

The Euler equation under the basic neoclassical model is:

$$C_t^{-\delta} = \beta E_t[C_{t+1}^{-\delta}(1+r_{t+1})] \tag{A.1}$$

Under steady state, the Euler equation becomes:

$$\overline{C}_t^{-\delta} = \beta E_t[\overline{C}_t^{-\delta}(1+\overline{r}_t)] \tag{A.2}$$

Dividing (A.1) by (A.2) gives the following identity:

$$\frac{C_t^{-\delta}}{\overline{C}_t^{-\delta}} = E_t\left[\left(\frac{C_{t+1}}{\overline{C}_t}\right)^{-\delta}\left(\frac{1+r_{t+1}}{1+\overline{r}_t}\right)\right] \tag{A.3}$$

Taking log of both sides of (A.3) and using the log approximation $\log(1+r_t) \approx r_t$ (the real interest rate r_t is usually smaller than 10%) give:

$$c_t - \overline{c}_t = -\frac{1}{\delta}E_t(r_{t+1} - \overline{r}_t) + E_t(c_{t+1} - \overline{c}_t) \qquad (c_t = logC_t) \tag{A.4}$$

Applying rational expectation, we assume that $\pi = \pi^e$. Using the Fisher equation $i = r + \pi^e$ or $i = r + \pi$ as assumed above and its steady state version $\overline{i} = \overline{r} + \overline{\pi}$, (A.4) becomes:

$$c_t - \overline{c}_t = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + \frac{1}{\delta}(\overline{r}_t) + E_t(c_{t+1} - \overline{c}_t) \tag{A.5}$$

In general, total output production equals total consumption. Assuming that the government and households consume all the produced goods, this relationship is described by the following equation:

$$Y_t = C_t + G_t \quad \text{or } e^{\log(Y_t)} = e^{\log(C_t)} + e^{\log(G_t)} \tag{A.6}$$

With any small x, we have the exponential approximation $e^x \approx 1 + x$. Therefore, equation (A.6) becomes $1 + \log(Y_t) \approx 1 + \log(C_t) + 1 + \log(G_t)$. Denote $\log(Y_t) = y_t^*$ and $\log(G_t) = g_t$, equation (A.6) becomes $c_t \approx y_t^* - g_t - 1$. In steady state, $\overline{g}_t = \overline{g}_{t+1}$, $\overline{y_t^*} = \overline{y}_{t+1}^*$ and $\overline{c}_t = \overline{c}_{t+1}$, the log-linearized equation (A.5) is rewritten as follow:

$$(y_t^* - g_t - 1) - (\overline{y}_t^* - \overline{g}_t - 1) = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + \frac{1}{\delta}\overline{r}_t + E_t(y_{t+1}^* - g_{t+1} - 1 - \overline{y}_{t+1}^* + \overline{g}_{t+1} + 1) \tag{A.7}$$

$$\text{or } (y_t^* - \overline{y}_t^*) - g_t = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + E_t((y_{t+1}^* - \overline{y}_{t+1}^*) - g_{t+1}) + \frac{1}{\delta}\overline{r}_t \tag{A.8}$$

Denote the output gap $y_t = y_t^* - \overline{y}_t^*$, equation (A.8) becomes:

$$y_t = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + E_t y_{t+1} + \frac{1}{\delta}\overline{r}_t - E_t\Delta g_{t+1} + \varepsilon_t \tag{A.9}$$

From equation (A.9), supposing that government expenditure is stabilized, we have the New Keynesian IS curve where output gap depends on the expected future output gap, real interest rate, and inflation:

$$y_t = -\frac{1}{\delta}(i_{t+1} - E_t\pi_{t+1}) + E_t y_{t+1} + v_t \tag{A.10}$$

Appendix 2: Deriving the New Keynesian IS curve under the Davig and Leeper (2011) model

The Euler equation under the Davig and Leeper (2011) model is:

$$C_t^{-\sigma} = \beta E_t C_{t+1}^{-\sigma} \frac{(1+i_t)}{(1+\pi_{t+1})} \tag{A.11}$$

In steady state, we have

$$\overline{C}^{-\sigma} = \beta \overline{C}^{-\sigma} \frac{(1+\bar{i})}{(1+\overline{\pi})} \tag{A.12}$$

Divide equation (A.11) by equation (A.12), we have:

$$\left(\frac{C_t}{\overline{C}}\right)^{-\sigma} = E_t\left(\frac{C_{t+1}}{\overline{C}}\right)^{-\sigma} \frac{(1+i_t)(1+\overline{\pi})}{(1+\bar{i})(1+\pi_{t+1})} \tag{A.13}$$

Take log of both sides and do the same procedures as described in Appendix 1 gives:

$$(c_t - \bar{c}) = E_t(c_{t+1} - \bar{c}) - \frac{1}{\sigma}(i_t - \bar{i}) - \frac{1}{\sigma}(\overline{\pi} - \pi_{t+1}) \tag{A.14}$$

With ($c_t = y_t^* - g_t - 1$) as shown above, equation (A.14) becomes

$$(y_t^* - \overline{y}_t^*) = -\frac{1}{\sigma}(i_t - \pi_{t+1}) + E_t(y_{t+1}^* - \overline{y}_{t+1}^*) - (g_{t+1} - g_t) + \frac{1}{\sigma}(\bar{i} - \overline{\pi}) \tag{A.15}$$

$$y_t = -\frac{1}{\sigma} i_t + \frac{1}{\sigma}\pi_{t+1} + E_t y_{t+1} + \frac{1}{\sigma}(\bar{i} - \overline{\pi}) - \Delta g_{t+1} \tag{A.16}$$

Equation (A.16) is the IS curve derived from Davig and Leeper (2011) model.

Appendix 3. Estimating India's Fiscal Reaction Function

Appendix 3.1: India's Fiscal Reaction Function – Banerjee et al. (1993)

Dependent Variable: DTAX
Method: Least Squares
Date: 11/02/12 Time: 13:38
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.837676	0.770830	2.384022	0.0254
DGAP	-0.465758	0.150303	-3.098788	0.0049
INTEREST	-0.100109	0.066050	-1.515639	0.1427
INFLATION	-0.049720	0.097627	-0.509281	0.6152
DDEBT	-0.340880	0.159041	-2.143347	0.0424

R-squared	0.357562	Mean dependent var	0.177586
Adjusted R-squared	0.250490	S.D. dependent var	1.123860
S.E. of regression	0.972974	Akaike info criterion	2.938666
Sum squared resid	22.72027	Schwarz criterion	3.174407
Log likelihood	-37.61066	Hannan-Quinn criter.	3.012497
F-statistic	3.339430	Durbin-Watson stat	1.814964
Prob(F-statistic)	0.026151		

Dependent Variable: DTAX
Method: Least Squares
Date: 03/20/13 Time: 12:08
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.731493	0.768929	3.552336	0.0017
DDEBT	-0.414379	0.145087	-2.856073	0.0089
DGAP	-0.518066	0.136015	-3.808893	0.0009
INTEREST	-0.015313	0.067319	-0.227468	0.8221
INTEREST(-1)	-0.147066	0.055806	-2.635331	0.0148
INFLATION	-0.082169	0.088264	-0.930948	0.3615

R-squared	0.506559	Mean dependent var	0.177586
Adjusted R-squared	0.399290	S.D. dependent var	1.123860
S.E. of regression	0.871054	Akaike info criterion	2.743765
Sum squared resid	17.45089	Schwarz criterion	3.026654
Log likelihood	-33.78459	Hannan-Quinn criter.	2.832362
F-statistic	4.722297	Durbin-Watson stat	2.178537
Prob(F-statistic)	0.004104		

Dependent Variable: DTAX
Method: Least Squares
Date: 03/20/13 Time: 12:08
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.713205	0.749455	3.620240	0.0014
DDEBT	-0.409430	0.140584	-2.912354	0.0076
DGAP	-0.509673	0.128303	-3.972424	0.0006
INTEREST(-1)	-0.153133	0.048040	-3.187613	0.0040
INFLATION	-0.092529	0.074097	-1.248755	0.2238

R-squared	0.505449	Mean dependent var	0.177586
Adjusted R-squared	0.423024	S.D. dependent var	1.123860
S.E. of regression	0.853672	Akaike info criterion	2.677046
Sum squared resid	17.49015	Schwarz criterion	2.912787
Log likelihood	-33.81717	Hannan-Quinn criter.	2.750877
F-statistic	6.132225	Durbin-Watson stat	2.172085
Prob(F-statistic)	0.001512		

Appendix 3.2: India's Fiscal Reaction function - Persaran (2001) ARDL

Dependent Variable: DTAX
Method: Least Squares
Date: 11/09/12 Time: 11:17
Sample (adjusted): 1983 2010
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.729547	4.543230	0.600794	0.5583
DTAX(-1)	-0.029050	0.318653	-0.091166	0.9288
DGAP	-0.528981	0.197044	-2.684582	0.0187
DGAP(-1)	0.008743	0.280950	0.031120	0.9756
DDEBT	-0.399468	0.208691	-1.914159	0.0779
DDEBT(-1)	0.041804	0.253918	0.164638	0.8718
DINFLATION	2.89E-05	0.114545	0.000252	0.9998
DINFLATION(-1)	-0.017977	0.121644	-0.147786	0.8848
DINTEREST	-0.075410	0.099558	-0.757444	0.4623
DINTEREST(-1)	0.129915	0.097883	1.327248	0.2073
TAX(-1)	-0.089810	0.135253	-0.664015	0.5183
OUTPUTGAP(-1)	0.026208	0.105115	0.249330	0.8070
INTERESTRATE(-1)	-0.314918	0.163316	-1.928270	0.0759
INFLATION(-1)	0.165500	0.191402	0.864668	0.4029
DEBT(-1)	0.020927	0.043276	0.483569	0.6367

R-squared	0.667216	Mean dependent var	0.168214
Adjusted R-squared	0.308834	S.D. dependent var	1.143329
S.E. of regression	0.950522	Akaike info criterion	3.040563
Sum squared resid	11.74540	Schwarz criterion	3.754244
Log likelihood	-27.56788	Hannan-Quinn criter.	3.258742
F-statistic	1.861745	Durbin-Watson stat	2.017818
Prob(F-statistic)	0.135551		