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Submitted by:

Dr. Muhammad Saifur Rahman Assistant Professor Finance & Economics

(Name of Junior Researcher) (Academic Rank) (Department) (Signature)

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(Name of Consultant, if any) (Academic Rank) (Department) (Signature)

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Department of: Finance & Economics

Chairman,
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Who Bears the Public Debt Burden? Understanding the Distributional Aspects of Government Debt Burden Using a Heterogeneous Agent Model.

Research Proposal
For
The Junior Faculty Grant

By

Muhammad Saifur Rahman, Ph.D.
Department of Finance & Economics
KFUPM

October 10, 2009

Summary

Traditionally, Dynamic Scoring calculations and debt financing experiments are carried out using representative agent based macroeconomic models. Existing literature does not provide any objection to this approach. In this paper, I plan develop a macroeconomic model with limited heterogeneity similar to the Saver-Spenders model of Mankiw(2000). But spenders in my model are merely credit constrained and not *Rule of thumb Consumers*. Both groups are intertemporal optimizers because of the existence of Internal Habit Persistence. I will use USA macroeconomic data for 1946 Q1-2008 Q4 data to calibrate my model to the USA economy. I will then carry out simulation experiments which will raise Public debt by alternative fiscal policies. Following Leeper and Yang (2006), I will assume alternative financing of the debt and analyze how the debt burden falls on the two income groups in my model. The study is expected to provide results which are interesting enough to be published in top macroeconomic or public economics journals. The project is expected to take 11 months and to cost SR43, 200.

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Introduction

Should we use heterogeneous agent based model to analyze aggregate change rather than representative agent model? More precisely, should we use models that have rich heterogeneity across their agents in terms of market participation, preference and labor supply decisions to analyze policy experiments such as dynamic scoring and debt financing that focus on the aggregate implications of alternative fiscal policies? The conventional wisdom among policy making agencies and to some extent, in the literature is the following; although heterogeneous agent based models are crucial for analyzing distributional policies, for standard dynamic fiscal policy analysis where the main focus is the aggregate effect such as debt financing and dynamic scoring, the representative agent based model, although subject to minor measurement error, could provide a reasonable approximation to macroeconomic response to various policy changes, and therefore could be used as a benchmark without any discretion. This paper attempts to refute this conventional wisdom and tries to answer these questions by adopting a heterogeneous agent based general equilibrium model to carry out two major fiscal policy experiments. The first one is the Dynamic scoring exercise undertaken by Joint Committee of Taxation(with the support from the Congressional Budget Office) and the second one is the traditional macroeconomic analysis of debt financing brought forth by alternative fiscal policy changes. I will systematically employ different layers of heterogeneity to the model to highlight the importance of various kinds of heterogeneity. The paper will show that heterogeneity can be very important not only for the distributional consequences but also for the aggregate implications. While most of the existing literature either puts less importance on the degree of heterogeneity or most of the times completely ignores it by using representative agent base models, this paper will argue that using representative agent based model dynamic scoring or debt financing or any other macroeconomic policy in general could be seriously misleading. This could lead to conclusions which are qualitatively and quantitatively different from a heterogeneous agent-based model's predictions.

The outcome of this paper could be very important for policy makers who regularly undertake policies that give rise to public debt. A clear contribution of this paper would be shed important insight into the distributional effect of debt under alternative fiscal policies which could lead to a more coherent policy prescription from the policy makers.

Literature Review

Dynamic scoring is the analysis of changes in tax revenue as a result of a proposed tax change by incorporating dynamic macroeconomic effects. It is therefore, an analysis of dynamic fiscal policy. Any fiscal policy that gives rise to debt would therefore be considered as a dynamic analysis of debt. The existing modern literature on dynamic fiscal policy is broadly divided into two groups in terms of modeling techniques and broad objectives. The first group of works focus on the distributional aspects of fiscal policy and use macroeconomic models that incorporate various kinds of heterogeneity such as age (Auerbach and Kotilikoff(1987),Jokisch and Kotlikoff(2007), Altig and others(2001)), income (Ventura, Guner and Kaygusuz(2008)),skill (Storesletten (2000)), size distribution (Ventura,Guner and Yi(2007)) , market imperfections (Heathcote(2005), Domeij and Heathcote(2004)), behavioral (Ventura,Guner and Kaygusuz(2008), Michel and Pestieau(2005))[1]. All the work in this group shares two common properties; they derive aggregate behavior of the economy from the disaggregate individuals and are analytically not tractable. The second group focuses on the aggregate implications of the economy and therefore uses representative agent based macroeconomic models to bypass the analysis of the distributional effect of the fiscal policy. This large group includes, but not limited to, fundamental contributions from Baxter and King(1993), King and Rebelo(2002), King and Rebelo(1990), McGrattan(1994) Leeper and Yang(2006) and important contributions from Trabandt and Uhlig(2005), Gordon and Leeper(2005), Novales and Ruiz(2002). All these papers use models that are analytically tractable and devoid of any distributional analysis. Recently, there has been exciting new development of a class of models that retains the tractable nature of the representative agent model while introduces some degree of heterogeneity across agents. This enables them to provide limited but important insight into the distributional or disaggregate effect of fiscal policy. Papers from this new and rapidly increasing pool includes Mankiw(2000), Mankiw and Weinzierl(2006), Gali, Salido and Valles(2004.a,JMCB and 2004.b), Erceg, Guerrieri and Gust(2005), Forni,Monforte and Sessa(2006), Colciago(2007) and Yang(2007). All these papers use a new kind of heterogenous agent based model first pioneered by Campbell and Makiw(1989). In this model, there are two kinds of agents. The first groups are called the Savers who have access to the credit market/or actually save by participating in the credit market. The second groups are called the Spenders who do not have any access to the credit market/or does not save. Therefore, this model has a unique combination of agents who follow life cycle hypothesis (savers) and agents who do not. This model draws support from several important empirical papers. First, Porteba(1988) found that anticipated tax change did not change consumption of some people. This, his argued, was an evidence of the Violation of LCH/PIH. Wolff (1998, 2001) looked at the Survey of credit finance data and found that almost 20% of the people surveyed had zero/negative wealth. Finally, Shapiro and Slemrod(1995) asked what people will do with the extra money from Bush's 1992 tax cut. 43% said they would spend the entire money. All these findings suggest that a hybrid model such as the Campbell and Mankiw(1989) would be a better approximation of the reality and could be used for more accurate policy analysis. Many empirical papers (Forni, Monforte, and

[1] There are two other groups of work on fiscal policy that have flourished recently. The first one is the literature on optimal fiscal policy and the second one is the analysis of fiscal policy in an endogenous growth environment. Both of them are unrelated to the present paper.

Sessa (2006), Erceg, Guerrieri and Gust (2005)) have used this model to carry econometric works and found success.

Outside the academic work, policy institutions such as the Joint Committee of Taxation and the Congressional Budget Office carry out analysis of dynamic fiscal policy. Surprisingly, in almost all instances, their modeling choice involves using representative agent based models or simple overlapping generations models that only capture Intergenerational heterogeneity[2]. Papers that are aligned with policy institutions also use representative agent based models (for example, Mankiw and Weinzierl(2006), Bruce and Turnovsky (1999)).

The use of simple representative agent based modeling for important fiscal policy analysis has raised concern among academics and policy makers. It is strongly argued that the aggregate predictions from disaggregate heterogeneous based models are different from predictions made by aggregate representative agent based models, as was summarized by Heathcote(2005) . This however, is not without criticism. Auerbach(2000) and Mankiw(2000) argue that it is imperative to use heterogeneous agent based models for dynamic fiscal policy analysis such as dynamic scoring because they can provide additional distributional results for the policy makers. But the former is very skeptical about the possibility of different aggregate implications from these models. Finally, Mankiw and Weinzierl(2006) reports that using a heterogeneous models such as the saver-spender model does not change the prediction of the representative agent models. Despite that, Joint Committee of Taxation (2006) has introduced the saver-spender model in its dynamic scoring analysis.

The present paper will develop a modified version of the savers-spenders model. I argue that the use of standard saver-spender model in the dynamic fiscal policy analysis has been fruitless so far because of some inherent limitations of the model which are rather unrealistic. All the previous papers have used three crucial assumptions in their saver-spender model, which to my view, dampens the relative importance of the heterogeneity in their models. First, the spenders do not have access to the credit market. Second, these models assume that the spenders are *Rule of Thumb Consumers* in the sense that they do not participate in the labor market and take the wage bargained by the saver as given. Third, the spenders are not intertemporal optimizers. The only paper that challenges these assumptions is Yang (2007) who assumes the first two assumptions but models spenders as intra-temporal optimizers. Yet she still gets results very similar to the Mankiw and Weinzierl(2006). In my paper, I argue that the spenders could be credit constrained and at the same time intertemporal optimizers. I impose the assumption of Internal Habit Persistence on the preference of both the saver and the spender. This forces everyone in the economy to think at the intertemporal margins. I will show that the impulse response of all the major macro and fiscal variables for various tax shocks look quite different and sometimes contrasting to the representative agent based model.

In addition to looking at the impulse response functions and calculating the dynamic scores for various fiscal policies, the present paper will also make contributions to the dynamic analysis of debt

[2] To this date, Joint Committee of Taxation uses four models for their fiscal policy analysis; Joint Committee macroeconomic equilibrium growth model (MEG), the overlapping generations lifecycle model (OLG), Global Insight econometric model (GI) and a dynamic stochastic general equilibrium neoclassical growth model with infinitely lived agents (DSGE). The Congressional Budget Office uses different versions of the OLG model, the Ramsey model, the GI model and a "Macroadvisers' Model" which is also a representative agent based model. For a detailed description of each of these models, see Joint Committee of Taxation(2005a, b) and Dennis and Page(2003).

financing/sustainability. This area has been enriched by recent empirical and theoretical work on debt financing. For example, Henning (1998) finds that debt/GDP ratio is a positive function of primary surplus. Chung and Leeper(2007) finds similar results in their theoretical work. They also report a more significant role for the discount factor in debt financing in their empirical work but could not replicate it in their theoretical work using a representative agent based model. Lustig, Sleet and Sevin(2007) also finds significant and positive role of discount factor in debt financing generated by increase in government expenditure, which they argue is an evidence of fiscal hedging. I will show that my saver-spender model with other layers of heterogeneity could derive theoretical results similar to the above mentioned empirical works. Second, there has been recent discussion on the true nature of debt/tax burden imposed on individual groups. For example, Auerbach(2005) challenges the conventional wisdom of tax burden analysis carried out in classical literature such as Harberger(1962) by arguing that once dynamic tax burden rather than the conventional static burden is considered by adopting a fully developed general equilibrium analysis and introducing various kinds of heterogeneity , conclusions about the progressivity of the US tax(specially capital tax) could change. Indeed, in an empirical paper, Piketty and Saez(2007) shows that if we consider the recent changes in the labor and capital tax together and factor in the demographic transition along with changes in the payroll tax and social security payments, US tax system appears to be less progressive than what policy makers would like to claim. There has not been any significant theoretical work on the dynamic tax burden.

Project Objectives

The study will show that my analysis of debt financing exercises could shed some light on the relative distribution of tax/ debt burden between the two groups of people in my model.

Description of the Proposed Model

Following Mankiw (2000), Yang (2007) and Joint Committee on Taxation (2006),the economy has two types of infinitely-lived agents: savers and non-savers, competitive firms, and a government. Both the population and the total amount of time an agent is endowed with are normalized to 1. A fraction F of the agents are savers and the remaining $(1-F)$ are spenders.

Optimization of the Saver

The savers consume, save and work in this model. The representative saver chooses Consumption(C_t^a), Investment(I_t^a), Capital(K_t^a), Government issued one period bonds(B_t^a), and Labour(L_t^a) to maximize utility over consumption and leisure($1-L_t^a$):

$$\underset{\{C_t^a, K_t^a, L_t^a\}}{Max:} E_t \sum_{t=0}^{\infty} \beta_1^t \left[\frac{(C_t^{*a})^{1-\gamma_1} - 1}{1-\gamma_1} + \chi^a \frac{(1-L_t^a)^{1-\theta_1}}{1-\theta_1} \right] \tag{1}$$

subject to the budget constraint:

$$C_t^a + I_t^a + B_t^a \leq (1-\tau_t^k) r_t K_{t-1}^a + (1-\tau_t^{L_a}) W_t L_t^a + R_{t-1}^b B_{t-1}^a + tr_t^a \tag{2}$$

$$C_t^{*a} = C_t^a - b_1 C_{t-1}^a \tag{3}$$

The law of motion for capital has the following form:

$$K_t^a = (1-\delta) K_{t-1}^a + I_t^a \tag{4}$$

The superscript a and p indicate variables associated with the saver and the non-saver.$\beta_1$is the subjective discount factor for the saver. The elasticity of intertemporal substitution(IES) for the consumption and leisure for the saver are $\frac{1}{\gamma_1}$ and $\frac{1}{\theta_1}$ respectively($\gamma_1 > 0, \theta_1 \geq 0$). The Frisch elasticity of leisure is defined as $\frac{(1-L_t^a)}{\theta_1 L_t^a}$. r_t and W_t are respectively the rental rate of capital and the wage rate. τ_t^k,$\tau_t^{L_a}$are tax rate on capital and labour income of the saver. δ is the economic depreciation rate of capita . $\chi^a$is the weight that saver places on leisure. $b_1$indicates the degree of *internal habit persistence* for the saver.

The Lagrangian function for the optimization problem after combining (2) and (4) is written as follows:

$$\pounds = E_t \sum_{t=0}^{\infty} \beta_1^t \left[\begin{array}{c} \frac{(C_t^{*a})^{1-\gamma_1}-1}{1-\gamma_1} + \chi^a \frac{(1-L_t^a)^{1-\theta_1}}{1-\theta_1} \\ +\lambda_t^a \left\{ \begin{array}{c} (1-\tau_t^k) r_t K_{t-1}^a + (1-\tau_t^{L_a}) W_t L_t^a + R_{t-1}^b B_{t-1}^a \\ +tr_t^a - C_t^a - K_t^a - B_t^a + (1-\delta) K_t^a \end{array} \right\} \end{array} \right] \tag{5}$$

The first order conditions are as follows:

$$(C_t^{*a})^{-\gamma_1} - E_t \beta_1 b_1 \left(C_{t+1}^{*a}\right)^{-\gamma_1} = \lambda_t^a \tag{6}$$

$$\chi^a (1-L_t^a)^{-\theta_1} = \lambda_t^a (1-\tau_t^{L_a}) W_t \tag{7}$$

$$\lambda_t^a = E_t \beta_1 \lambda_{t+1}^a \left\{ (1-\tau_{t+1}^k) r_{t+1} + (1-\delta) \right\} \tag{8}$$

$$\lambda_t^a = E_t \beta_1 \lambda_{t+1}^a R_t^b \tag{9}$$

Define,

$$R_t^k = (1 - \tau_t^k) r_t + (1 - \delta) \tag{10}$$

Therefore, equation (8) could be re-written as:

$$\lambda_t^a = E_t \beta_1 \lambda_{t+1}^a R_{t+1}^k \tag{11}$$

Combining (6) and (7) and substituting (3), we get:

$$\chi^a (1 - L_t^a)^{-\theta_1} = \left\{ \left(C_t^a - b_1 C_{t-1}^a \right)^{-\gamma_1} - E_t \beta_1 b_1 \left(C_{t+1}^a - b_1 C_t^a \right)^{-\gamma_1} \right\} (1 - \tau_t^{L_a}) W_t \tag{11.a}$$

Equation(11.a) shows that the labor supply decisions of the saver depends on the intertemporal consumption decisions.

Optimization of the Spender

The spenders consume and work in this model. The representative spender chooses Consumption(C_t^p) and Labour(L_t^p) to maximize utility over consumption and leisure($1 - L_t^p$):

$$\underset{\left\{C_t^p, L_t^p\right\}}{Max:} \; E_t \sum_{t=0}^{\infty} \beta_2^t \left[\frac{(C_t^{*p})^{1-\gamma_2} - 1}{1 - \gamma_2} + \chi^p \frac{(1 - L_t^p)^{1-\theta_2}}{1 - \theta_2} \right] \tag{12}$$

subject to the budget constraint:

$$C_t^p \leq (1 - \tau_t^{L_p}) W_t L_t^p + tr_t^p \tag{13}$$

$$C_t^{*p} = C_t^p - b_2 C_{t-1}^p \tag{14}$$

Here γ_2,b_2, τ_t^{Lp},χ^p has the usual interpretation for the spender.

The first order conditions are as follows:

$$(C_t^{*p})^{-\gamma_2} - E_t \beta_2 b_2 \left(C_{t+1}^{*p} \right)^{-\gamma_2} = \lambda_t^p \tag{15}$$

$$\chi^p (1 - L_t^p)^{-\theta_2} = \lambda_t^p (1 - \tau_t^{L_p}) W_t \tag{16}$$

Combining (15) and (16) and substituting (14), we get:

$$\chi^p (1 - L_t^p)^{-\theta_2} = \left\{ \left(C_t^p - b_2 C_{t-1}^p \right)^{-\gamma_2} - E_t \beta_2 b_2 \left(C_{t+1}^p - b_2 C_t^p \right)^{-\gamma_2} \right\} (1 - \tau_t^{L_p}) W_t \tag{16.a}$$

There are several interesting feature of the spender's preference structure. First habit persistence makes consumption non-separable in time for agents. Therefore, intertemporal consumption decisions force agents to make intertemporal labor decisions, even for spenders. This becomes clear if we look at (16.a). Suppose there is an expected increase in C_{t+1}^{*p}. This would reduce marginal utility of consumption at $t+1$. According to equation(16.a), this would increase the RHS. In order to maintain equality, the LHS of the equation has to go up, which would

require L_t^p to increase . Since the labor supply today depends on consumption tomorrow, the spenders are neither *Rule-of-Thumb* consumers, nor are they *intra-temporal* optimizers. They are simply credit constrained. This is a direct contrast from Mankiw(2000), Mankiw-Weinzierl (2005) and Yang(2007).

Optimization of the firm

The firms maximize their profit by choosing amount of aggregate capital and labor K_t and L_t

$$\underset{\{K_t,L_t\}}{Max} : K_t^{\alpha} L_t^{1-\alpha} - W_t L_t - r_t K_{t-1} \tag{17}$$

$$Y_t = K_{t-1}^{\alpha} L_t^{1-\alpha} \tag{18}$$

The first order conditions for the firm determines the wage and the rental rate:

$$W_t = (1-\alpha)\frac{Y_t}{L_t} \tag{19}$$

$$r_t = \alpha \frac{Y_t}{K_{t-1}} \tag{19.a}$$

The government

The government collects taxes from the savers and the spenders, issues bonds,provides transfers and consumes part of the goods as government spending which is completely wasted or thrown away in the ocean. The government budget constraint looks like:

$$R_{t-1}^b B_{t-1} + TR_t + G_t = T_t + B_t \tag{20}$$

Where T_t is the total tax collected defined as:

$$T_t = T_t^l + T_t^k \tag{21}$$

$$T_t^l = F * \tau_t^{L_a} W_t L_t^a + (1-F) * \tau_t^{L_p} W_t L_t^p \tag{22}$$

$$T_t^k = \tau_t^k r_t K_{t-1} \tag{23}$$

Finally,the total transfer in the economy, TR_t looks like:

$$TR_t = TR_t^a + TR_t^p \tag{24}$$

Where TR_t^a, $TR_t^p$are aggregate transfers to the savers and the spenders, to be defined shortly.

The government also has to maintain intertemporal fiscal solvency. This will be achieved by using two conditions. First, any equilibrium must satisfy the Transversality conditions for the debt and capital accumulation:

$$E_t \lim_{T \longrightarrow \infty} \beta_1^{t+T} u' \left(C_{t+T}^{*a}\right) B_{t+T} = 0 \tag{25}$$

$$E_t \lim_{T \longrightarrow \infty} \beta_1^{t+T} u' \left(C_{t+T}^{*a}\right) K_{t+T-1} = 0 \tag{26}$$

Imposing the TVC on the flow budget constraint of the government, we derive the intertemporal budget constraint for the government:

$$\frac{B_t}{Y_t} = s_t^B = \sum_{j=0}^{\infty} d_{t,t+j} \left[\begin{array}{c} (1-\alpha)\,\tau_{t+j}^{L_a} \frac{FL_{t+j}^a}{L_{t+j}} + (1-\alpha)\,\tau_{t+j}^{L_p} \frac{(1-F)L_{t+j}^p}{L_{t+j}} \\ +\alpha\tau_{t+j}^k - s_{t+j}^G - s_{t+j}^{TR} \end{array} \right] \tag{27}$$

Where $L_t$is the aggregate labor supply in the economy, to be defined later and $d_{t,t+j} = \Pi_{i=o}^{j-1} R_{t+i}^{-1} \frac{Y_{t+i+1}}{Y_{t+i}}$. Equation(26) implies that the TVC condition for debt is satisfied.

Furthermore, following Leeper and Young(2006), the government uses different policy rules to adjust for any debt-financed tax cuts. The policy rules that the government uses are summarized as follows:

$$\ln\left(\frac{s_t^{TR^a}}{s^{TR^a}}\right) = q_{TR^a} \ln\left(\frac{s_{t-1}^B}{s^B}\right), q_{TR^a} \leq 0 \tag{28}$$

$$\ln\left(\frac{s_t^{TR^p}}{s^{TR^p}}\right) = q_{TR^p} \ln\left(\frac{s_{t-1}^B}{s^B}\right), q_{TR^p} \leq 0 \tag{29}$$

$$\ln\left(\frac{s_t^G}{s^G}\right) = q_G \ln\left(\frac{s_{t-1}^B}{s^B}\right), q_G \leq 0 \tag{30}$$

$$\ln\left(\frac{\tau_t^{L_a}}{\tau^{L_a}}\right) = q_{L_a} \ln\left(\frac{s_{t-1}^B}{s^B}\right), q_{L_a} \geq 0 \tag{31}$$

$$\ln\left(\frac{\tau_t^{L_p}}{\tau^{L_p}}\right) = q_{L_p} \ln\left(\frac{s_{t-1}^B}{s^B}\right), q_{L_p} \geq 0 \tag{32}$$

$$\ln\left(\frac{\tau_t^K}{\tau^K}\right) = q_K \left(\frac{s_{t-1}^B}{s^B}\right), q_K \geqslant 0 \tag{33}$$

Aggregation

The aggregate variables are defined as follows:

$$I_t = F * I_t^a \tag{34}$$

$$B_t = F * B_t^a \tag{35}$$

$$K_t = F * K_t^a \tag{36}$$

$$TR_t^a = F * tr_t^a \tag{37}$$

$$TR_t^p = (1-F) * tr_t^p \tag{38}$$

$$L_t = F * L_t^a + (1-F) * L_t^p \tag{39}$$

$$C_t = F * C_t^a + (1 - F) * C_t^p \tag{40}$$

The aggregate resource constraint looks like:

$$C_t + I_t + G_t = Y_t \tag{41}$$

In addition, we will define aggregate budget constraint for the savers and the spenders:

$$FC_t^a + I_t + B_t = (1 - \tau_t^k) r_t K_{t-1} + (1 - \tau_t^{L_a}) W_t F L_t^a + R_{t-1}^b B_{t-1} + TR_t^a \tag{42}$$

$$(1 - F) C_t^p = (1 - \tau_t^{L_p}) W_t (1 - F) L_t^p + TR_t^p \tag{43}$$

Definition of Competitive equilibrium

A competitive rational expectations equilibrium is defined as the agent's decisions, $\{C_t^{a,p}, L_t^{a,p}, K_t^a, B_t^a\}_{t=0}^{\infty}$, the firm's decisions, $\{ L_t, K_t\}_{t=0}^{\infty}$, prices, $\{W_t, r_t \}_{t=0}^{\infty}$ and policy variables, $\{B_t, G_t, \tau_t^K, \tau_t^{L_a}, \tau_t^{L_p}, TR_t \}_{t=0}^{\infty}$, such that, given initial levels of capital and debt, K_{t-1} and B_{t-1}, the optimality conditions for the different kinds of agents and firm's problems are solved; the goods, capital, labor and the bond markets clear; the transversality conditions for capital and debt hold; the government budget constraint and the policy rules(equations 28-33) and all the aggregate conditions(equations 34-43) are satisfied. We will only consider the ranges of the fiscal adjustment parameters- the q's- that are consistent with the existence of a rational expectations equilibrium.

Calibration and Solution Method

An analytical solution of the model is not available; the equilibrium conditions are log-linearized around the original steady state growth path and analyzed in terms of percentage deviations from that steady state. The model is solved using Sims's(2001) algorithm. The model is calibrated at an annual frequency. Table 1 reports the benchmark values of parameters and the steady state values of variables before a permanent tax rate change. These parameters need to be either calibrated or estimated using quarterly USA macroeconomic data.

Steady State of the system

Using (19), (19.a),the steady state system looks like:

$$(C^{*a})^{-\gamma_1} (1 - \beta_1 b_1) = \lambda^a \tag{44}$$

$$\chi^a (1 - L^a)^{-\theta_1} = \lambda^a (1 - \tau^{L_a}) \frac{Y}{L} \tag{45}$$

$$R^k = R^b = \frac{1}{\beta_1} \tag{46}$$

$$(C^{*p})^{-\gamma_2} (1 - \beta_2 b_2) = \lambda^p \tag{48}$$

$$\chi^p (1 - L^p)^{-\theta_2} = \lambda^p (1 - \tau^{L_p}) \frac{Y}{L} \tag{49}$$

In addition, we will need the following steady state version of the aggregate budget constraint for the spender and the aggregate resource constraint:

$$(1-F)C^p = (1-\tau^{L_p})\frac{(1-F)L^p}{L}Y + TR^p \tag{50}$$

$$C + \delta K + G = Y \tag{51}$$

Distribution of debt burden under alternative financing schemes

In this section, we will look at how the accumulation of debt caused by a tax cut gets financed under alternative tax financing schemes. This is theme that has recently been pursued by Leeper and Yang(2006), Chung and Leeper(2007) and Lustig, Sleet, and Yeltekin (2007). Following Chung and Leeper(2007), the log-linearized present value budget constraint can be written as:

$$\hat{b}_t = E_t \sum_{j=1}^{\infty} \beta^j \left(\frac{T^l}{B}\hat{T}^l_t + \frac{T^k}{B}\hat{T}^k_t - \frac{G}{B}\hat{g}_{t+j} - \frac{TR^a}{B}\hat{TR}^a_{t+j} - \frac{TR^p}{B}\hat{TR}^p_{t+j} - \frac{1}{\beta}\hat{R}_{t+j-1} \right) \tag{58}$$

Here, B, G, TR^a, TR^p, are the steady state value of the respective variables while T^l, T^k are the steady state value of the labor and capital tax revenue.β is the constant discount factor. Imposing the equilibrium law of motion, the above equation of infinite sum could be written as[1]:

$$\hat{b}_t = f_t \left(I - \beta A\right)^{-1} \left[\left(\frac{T^l}{B}C_{T^l} + \frac{T^k}{B}C_{T^k} - \frac{G}{B}C_G - \frac{TR^a}{B}C_{Z^a} - \frac{TR^p}{B}C_{Z^p} \right) \beta A - C_R \right] \tag{59}$$

If we denote an innovation in x_t by $\delta x_t = x_t - E_{t-1}x_t$, then

$$\hat{\delta b}_t = \delta f_t \left(I - \beta A\right)^{-1} \left[\left(\frac{T^l}{B}C_{T^l} + \frac{T^k}{B}C_{T^k} - \frac{G}{B}C_G - \frac{TR^a}{B}C_{Z^a} - \frac{TR^p}{B}C_{Z^p} \right) \beta A - C_R \right] \tag{60}$$

Equation (60) shows what fraction of the innovation in debt is financed by various components of the budget constraint on the right hand side. We want to further decompose the debt financing by the labor tax rate and the labor tax base for the two groups. To do this, lets define the tax base for labor tax to be:

$$TB^{L_a}_t = \frac{(1-\alpha)\,FL^a_t}{L_t} \tag{61}$$

$$TB^{L_p}_t = \frac{(1-\alpha)\,(1-F)L^p_t}{L_t} \tag{62}$$

Substituting equation (61) and (62) into (60) gives us a further decomposition of the debt innovation in terms of tax rate and tax base for the labor tax as follows:

$$\hat{\delta b}_t = \delta f_t \left(I - \beta A\right)^{-1} \left[\begin{pmatrix} \frac{\tau^{L_a} * TB^{L_a}}{B}C_{TB^{L_a}} + \frac{\tau^{L_a} * TB^{L_a}}{B}C_{\tau^{L_a}} \\ + \frac{\tau^{L_p} * TB^{L_p}}{B}C_{TB^{L_p}} + \frac{\tau^{L_p} * TB^{L_p}}{B}C_{\tau^{L_p}} \\ + \frac{T^k}{B}C_{T^k} - \frac{G}{B}C_G \\ - \frac{TR^a}{B}C_{Z^a} - \frac{TR^p}{B}C_{Z^p} \end{pmatrix} \beta A - C_R \right] \tag{63}$$

[1]For a more elaborate discussion about the derivations, please see Chung and Leeper(2007), page 6.

Parameter	**Value**	**Parameter**	**Value**	**Parameter**	**Value**
α		S^{TR}		L	
$\beta_1 = \beta_2$		S^{TR_a}	$0.7 * S^{TR}$	τ^{L_a}	
V		S^{TR_p}	$0.3 * S^{TR}$	τ^{L_p}	
$\gamma_1 = \gamma_2$		S^G		τ^K	
$b_1 = b_2$		S^C		F	
θ_1		S^B		χ^a	
θ_1		δ		χ^p	

Table 1: Benchmark Parameter values

We will compare our results between different versions of the Savers-Spenders(SS from now) model and a modified version of Leeper and Young (2006, MLY from now) where we will hold the assumption of a representative agent but add internal habit persistence to his behavior. The different versions of the SS model will help us to identify the role of different kinds of heterogeneity on the dynamic behavior of the model.

Scheduling & Design

The theme of the study is shaped generally in this proposal. There are two major steps that need to be undertaken. First, I need to collect macroeconomic data for the USA. Second, I will run simulations based on actual policy scenarios that have been undertaken in the USA which have lead to debt accumulation. The final shape of the study may take more than 12 months, but the core task should be done according to the following schedule:

	Months										
TASK	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Data Collection and Preparation											
Conduct Methodology											
Run Simulations											
Compare Results and write the Paper											

Deliverables

The research activity will come up with results that will shed light on the macroeconomic importance of the heterogeneity in the analysis of dynamic fiscal policy such as the analysis of debt burden. Policy makers would benefit from paper.

Personnel Requirement

The Junior Researcher: Dr. Muhammad Saifur Rahman will collect the data and conduct the empirical analysis using standard calibration technique as well as using Generalized Methods of Moments (GMM) method. He will also run various simulations and write the report with involvement of (100% of academic year and summer).

Monitoring and Evaluation

Project findings will be discussed with peers and outside researchers with expertise in the subject matter.

Utilization Plan

The research activity will come up a paper that will provide evidence on the role of income and behavioral heterogeneity in the analysis of dynamic fiscal policy. Overall, the paper will argue that the need to use heterogeneous agent based model in dynamic fiscal calculations is not only desirable but also essential.

Budget

PROJECT TITLE: Who Bears the Public Debt? Understanding the Distributional Aspect of Government Debt Burden using a Heterogeneous Agent Model.

Name of Junior Researcher: Muhammad Saifur Rahman **Name of Consultant**

His ID #: 7090971 **His ID #:**

TOTAL BUDGET	**SR. 43,200**	**STARTING DATE**	**November 1st,2009**
DURATION	**11 Months**	**COMPLETION DATE**	**September 31,2010**

Head #	**Budget Item**	**Budget (SR)**	**Remarks**
1.	**Manpower:** 1- Investigator (12,00x 10 months) Dr. Muhammad Saifur Rahman (ID#7090971)	12,000	
	2- One month summer compensation	13,000	
	3-Research Assistant (600 x 3 months)	1,800	
	4-Technician (400 x 2 months)	800	
	5-Secretary	1,000	
	4-Consultant	0000	
	Sub-Total	**SR 28,600**	

2.	**Equipment, Equipment Maintenance & Materials** 1- Scanner and Printer 2-multi-Prossecor desktop **Sub-Total**	 5,500 6,700 **SR 12,200**	 To use State/MP the investigator needs a 2-processor computer with large RAM.
3.	**Supplies** 1-stationary/phtocopies **Sub-Total**	 1,400 **SR1,400**	
4.	**Miscellaneous**	**SR1,000**	Includes shipping costs and fees to download important papers and data not available through our library.
5.	**GRAND TOTAL**	**SR43,200**	

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Piketty, Thomas. and Saez, Emmanuel (2007): "How Progressive is the U.S. Federal Tax System? A historical and International Perspective", Journal of Economic Perspectives, Volume 21, Number 1, Winter 2007, Pages 3--24.

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Wolff, Nathan, Edward. (1998): "Recent Trends in the Size Distribution of Household Wealth", Journal of Economic Perspectives, Vol. 12, No. 3, Summer 1998, pp. 131-150

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Muhammad Saifur Rahman
Curriculum Vitae
October 10, 2009

Office Address
Department of Finance and Economics
King Fahd University of Petroleum and Minerals
Home Phone: 966-03-860-5641
Mobile: 0565895564
Homepage: http://mypage.iu.edu/~murahman

Home Address
Apt No#5341, Ferdous Court
Dhahran 31261, Saudi Arabia

Email: murahman@kfupm.edu.sa

EDUCATION

Ph. D. in Economics, Indiana University, Bloomington August, 2009
Dissertation Title: Essays on Dynamic Fiscal Policy: Theory and Empirics

- **Dissertation Committee:** Eric M. Leeper (Chair), Gerhard Glomm**,** Michael Kaganovich, Brian Peterson,

M. A. in Economics, University of Iowa, Iowa City 2001-2004

- M. A. Thesis Pending

M.S.S in Economics, University of Dhaka, Bangladesh 1999
First Class Third Position
Thesis Title: Structural Adjustment in Bangladesh: An Analytical Overview

B.S.S in Economics, University of Dhaka, Bangladesh 1997
First Class Second Position

FIELDS OF SPECIALIZATION

Primary Fields: Macroeconomics, Monetary Economics, Open Economy Macroeconomics
Secondary Fields: Development Macroeconomics, Public Economics, Growth Theory
Supporting Field: Econometrics

RESEARCH INTERESTS

- Macro econometrics with focus on structural estimation of DSGE models using Classical (such as VAR) and Bayesian techniques.
- Distributional aspects of fiscal policy and other macroeconomic aspects of public economics.
- Interaction between fiscal and monetary policy.

WORKING PAPERS

- (**Job Market Paper**) "Government Spending and Consumption in the Presence of Borrowing Constraints"

- "Should Dynamic Scoring be Done with Heterogeneous Agent-Based Models? Challenging the Conventional Wisdom," CAEPR Working Paper No. 2008-024
  (Submitted to *Journal of Public Economics*)

- "Demographic Uncertainty and Welfare in a Life-cycle Model under Alternative Public Pension Systems," CAEPR Working Paper No. 2008-025
  (Submitted to *European Economic Review*)

- "Strategic Quality Choice and Charter School: Some Comments," Mimeo, Indiana University
  (Submitted to *Journal of Public Economics*)

RESEARCH IN PROGRESS

- "Government Spending and Consumption in the Presence of Borrowing Constraints: An Estimation of the DSGE Model using Bayesian Technique"

- "Who Bears the Public Debt? Understanding the Distributional Aspect of Government Debt Burden using a Heterogeneous Agent Model"

- "Robustifying the Generalized Taylor Rule: Understanding the Role of Regime Spillovers"

- "Understanding the Factors behind Inflation Targeting: A Panel Logit Approach"

- "The Effect of Tax Policy under Alternative Fiscal Financing Schemes on Income Distribution and Growth: A Savers-Spenders Model Perspective"

- "What Determines Specific Schooling Decisions? Linking Theory with Data"

PUBLICATIONS

- "Medium-Term Outlook for Rice Production and Demand: Projections to 2020," with Paul Dorosh and Quazi Shahabuddin, IFPRI-FMRSP Working Paper No. 36, June 2001 (Reprinted as "Price Responsiveness of Food Grain Supply in Bangladesh and Projections 2020," The Bangladesh Development Studies,
  Volume XXVIII, March-June 2002, Nos. 1 & 2)

- "Bangladesh-EU Development Relationship: Major Features and Emerging Issues," with Mustafizur Rahman, CPD Occasional Paper Series, No. 5, Centre for Policy Dialogue, June 2000

- "Ageing in Bangladesh: Issues and Challenges," with Jakir Hossain, CPD Dialogue Reports No. 23, Centre for Policy Dialogue, May 2000

TEACHING EXPERIENCE

- E322: Intermediate Macroeconomics at Indiana University
  Summer 2005 at IUPUI Campus
  Summer 2006, 2007, and 2008 at Bloomington Campus
  Associate Instructor with full teaching responsibility.

- E202 : Introduction to Macroeconomics at Indiana University
  Fall 2006, Fall 2007, Spring 2008, Fall 2008
  Associate Instructor with full teaching responsibility.

- E101: Introduction to Economics at Ivy tech Community College, Bloomington, Indiana.
  Fall 2006, Adjunct Instructor. Taught an in-class course with full teaching responsibility.
  Spring 2007, Adjunct Instructor. Taught two sections of an on-line course with full teaching responsibility.

- E202 : Introduction to Macroeconomics at Indiana University
  Spring 2005 (Honors Section), Teaching Assistant to Professor Eric Leeper
  Fall 2005, Teaching Assistant to Professor Willard Witte
  Spring 2006, Teaching Assistant (Head)
  Spring 2007, Teaching Assistant (Head)
  Taught courses with partial teaching responsibility.

- Econ 06E: 002 : Introduction to Macroeconomics at the University of Iowa
  Fall 2002, Spring 2003, Teaching Assistant
  Taught courses with full teaching responsibility except for designing examinations.

- Econ 06E: 001 : Introduction to Microeconomics at the University of Iowa
  Fall 2001, Spring 2002, Fall 2003, Spring 2004, Teaching Assistant
  Taught courses with full teaching responsibility except for designing examinations.

- Econ 101: Principles of Microeconomics at the Perdana College of Malaysia, Dhaka, Bangladesh.
  Econ 102: Principles of Macroeconomics at the Perdana College of Malaysia, Dhaka, Bangladesh.
  Fall 2000, Spring 2001: Adjunct Instructor with full teaching responsibility.

RESEARCH EXPERIENCE

Fall 2004 - Spring 2005	Research Assistant to Professor Gerhard Glomm, Department of Economics, Indiana University, Bloomington. Solving models, compilation of data and running simulations; data support.
Fall 2004	Research Assistant to Professor Eric Leeper, Department of Economics, Indiana University, Bloomington.
Summer 2002	Research Assistant to Professor John Geweke, Department of Economics, University of Iowa.
June 2000 - June 2001	Research Analyst, International Food Policy Research Institute (IFPRI)-FMRSP Project, Dhaka, Bangladesh. Model simulation, forecasting and data support, writing research papers.
January 2000 - June 2000	Research Associate, Centre for Policy Dialogue (CPD), Dhaka, Bangladesh. Writing dialogue reports, occasional papers, model simulation, forecasting and data support.
June 1998 - December 1998	Research Assistant, Dr. Nazmul Ehsan Fatmi, Professor, Department of Economics, University of Dhaka, Dhaka, Bangladesh. Designing survey for a “Socio-Economic Survey” for BEXIMCO group of industries (the largest group of industries in Bangladesh), conducting, compiling and publishing the survey results.

HONORS AND AWARDS

Spring 2008	Travel Grant, Department of Economics, Indiana University
Fall 2006-Spring 2008	Alumni Scholarship, Department of Economics, Indiana University, Bloomington
Fall 2004-Spring 2009	Graduate Assistantship, Department of Economics, Indiana University, Bloomington
Fall 1997-Spring 1999	Merit scholarship for Excellence in the BA/BSS examination in Economics, Department of Economics, University of Dhaka, Bangladesh

CONFERENCE AND SEMINAR PRESENTATIONS

- Midwest Macroeconomics Conference, May 2009
- 17th Annual Symposium of the Society for Non-linear Dynamics and Econometrics held at the Federal Reserve Bank of Atlanta, Georgia, April 16&17, 2009.
- Eighth Annual Missouri Economics Conference, University of Missouri-Columbia, March 2008
- Jordan River Conference, Indiana University, Bloomington, April 2008
- Selected for presentation at the Conference on Institutional and Social Dynamics of Growth and Distribution, Lucca, Italy, December 2007
- Selected for presentation at the First International Conference on Growth, Development and Poverty, Kathmandu, Nepal, December 2007
- Second Economics Graduate Students' Conference, Washington University at St. Louis, September 2007

COMPUTER PROFICIENCY

Matlab, Dynare, STATA, Eviews, Maple, C and C++, SAS (working knowledge)

LANGUAGE SKILLS

English (Fluent), Bengali (Native), Hindi and Urdu (Working Knowledge)

PROFESSIONAL SERVICES

- **Referee**: *B. E Journal of Macroeconomics*
- **Member**: The American Economic Association, The Econometric Society

REFERENCES

Research References

Eric M. Leeper
Professor
Department of Economics
Indiana University
100 S. Woodlawn
Bloomington, IN 47405-7104
Phone: (812) 855-9157
Email: eleeper@indiana.edu

Michael Kaganovich
Professor and Director of Graduate Studies
Department of Economics
Indiana University
100 S. Woodlawn
Bloomington, IN 47405-7104
Phone: (812) 855-6967
Email: mkaganov@indiana.edu

Gerhard Glomm
Professor and Chair
Department of Economics
Indiana University
100 S. Woodlawn
Bloomington, IN 47405-7104
Phone: (812) 855-7256
Email: gglomm@indiana.edu

Brian Peterson
Assistant Professor
Department of Economics
Indiana University
100 S. Woodlawn
Bloomington, IN 47405-7104
Phone: (812) 855-4828
Email: bripeter@indiana.edu

Teaching References

Willard E. Witte
Associate Professor
Department of Economics
Indiana University
100 S. Woodlawn
Bloomington, IN 47405-7104
Phone: (812) 855-2082
Email: witte@indiana.edu

Donald F Hall
Associate Professor and Programme Chair
Gen Education - Humanities
Ivy Tech College of Indiana
Bloomington Campus
200 Daniels Way, Bloomington, IN 47404
Phone: (812)330-6126
Email: dfhall@ivytech.edu