

Restatement of the problem

At the 2008 US presidential elections, one important point of the debate is focused on the national debt, since the level of the national debt is an important indicator of government's financial condition. A good management of the national debt will help to improve the federal government's financial health as well as the economy of the nation. The change in national debt depends on several factors including the current economy condition and the government policy. Our objective is to provide a model to get a clear understand of the national debt and to use the model to qualify the impacts of different policies on the national debt.

Assumption

1. US government uses national debt as a method to overcome deficit.
2. US government's public debt plan is based on the economy condition of the nation.
3. The control on national debt is successful and helped the government run smoothly in the past 58 years.

Variables

1. G = Current-year GDP

Explanation: Since current year's GDP is one of the measures of national income and output for a given country's economy, it is one of the most direct indexes to evaluate the nation's economy condition at the moment.

2. D' = Last year's national debt \times (Current-year GDP/Last-year GDP)

Explanation: During the data analysis, we found a close relationship between D' and current-year national debt. (See figure1 in appendix)

3. SD = US government's deficit or surplus in the current year
= Total receipt - Total outlay

Explanation: According to assumption, US government use national debt as a method to overcome deficit.

Our approach

To solve this problem, we choose one of the most reliable models in statistics approach-----linear model, to analysis and predict the national debt.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$$

Y represents the amount of national debt of the current year.

$x_1 = G$

$x_2 = D'$

$x_3 = SD$

We first divide the GDP and national debt by current year's inflation index to make sure all of the data reflect the real value. Then using Matlab (See appendix), we fit the model to the data of the past 58 years and get the following function:

$$Y = -85.684291 - 0.90124x_1 + 0.00087x_2 + 0.99784x_3$$

(Figure of the functions can be found in appendix)

This function reflects a general relationship between three variables and national debt. Since the control on national debt helped the government run smoothly (according to assumption3), the relationship between the variables and national debt can be seen as healthy. Thus the function can provide a fair way to manage national debt.

Moreover, in order to attain more accuracy, we separate the 58 years (from 1950 to 2007) into four periods according to both historical events and the trend of national debt/GDP (See figure2 in appendix):

1.1950-1980

After World War II, government's national-debt/GDP rate climbed to 93.2%. It was a symbol that the national debt had already become a huge burden of the financial condition of the government and the federal government had to reduce the debt/GDP rate or the national debt would harm the economy of the nation. It is obvious that during this session, national debt/GDP rate was continuously falling, which also reflected a anxious concern of the government to the huge quantity of national debt.

2.1981-1996

During 1981 and 1982, the nation endured a deep recession. President at that moment, Reagan (1981-1989) based his economic program on the theory of supply-side economics, which advocated reducing tax rates so people could keep more of what they earned. At the same time, he successfully pushed for big increases in defense spending. As a result, the deficit of the federal budget swelled, so as the national debt. Because of outbreak of Gulf War followed by huge increasing in military spending, this trend was maintained until 1996.

3.1997-2000

During this period, nation's economy experienced a successful boom. The government was also under an impressive financial condition: in 1998, Clinton (1993-2001) and his cabinet managed to get the first budget surplus after 1970. The reduction of national-debt/GDP rate reflected government's focus on lightening the government's debt burden.

4.2001-2007

Because of the War in Afghanistan and the Iraq War, the deficit of the government soon swelled to 378 billion in 2004. And the national-debt/GDP started to climb up again.

Fitting the model to the data of each period, we get following functions:

1950-1980:

$$Y = 445.308 - 0.0065x_1 + 0.66x_2 - 1.007x_3$$

1981-1996:

$$Y = -849.9829 + 0.1643x_1 + 0.875x_2 - 1.35316x_3$$

1997-2000:

$$Y = -10505.8 + 0.0396x_1 + 2.73x_2 - 2.295x_3$$

2001-2007:

$$Y = -3964.72 + 0.92x_1 + 0.11x_2 - 0.74x_3$$

(Figure of the functions can be found in appendix)

The functions above are too specific to be used as predicting models. However, they provide valuable data to understand the national-debt policy held by the government in different period.

Model Testing

We use PMCC (Pearson product-moment correlation coefficient) to test our model's correlation to the data:

$$r = \frac{1}{n-1} \sum_{i=1}^n \left(\frac{X_i - \bar{X}}{s_X} \right) \left(\frac{Y_i - \bar{Y}}{s_Y} \right)$$

general: $r^2 = 0.999$

1950-1980: $r^2 = 0.9066$

1981-1996: $r^2 = 0.998$

1997-2000: $r^2 = 1$

2001-2007: $r^2 = 0.999$

r^2 of the four functions are all close to 1 which indicates the strength and direction of the linear relationship between function's output and the history data. So, the model can efficiently express the national debt in the past.

We also test the sensitivity of the model. While we change 1% of each variable, the model shows a clear response in the output.

Prediction

Assumption

- The economy environment in the 8 years is similar to that of 1950-2007 period.
- The impact of the current financial crisis maintains for 4 years. As a result, the GDP growth rate remains 1% in the first 4 years and climbed to 4% in the last 4 years.

Explanation: After the crisis, the country starts to recover.

Plan

- In the first 4 years, government remains a deficit of 300 billion dollars, and in the last 4 years, government has a constant surplus of 100 billion dollars.
- In the first year, government has a 400 billion deficit in order to support the tax cutting and market stimulation. With the economy thaws and the withdrawing of the soldiers in Iraq, the budget of federal government starts to surplus in 2014.

Result

- Plan1:

Year	Surplus or deficit	GDP	D'	National debt	National debt/GDP
2007	-135.5098	11432.5	7419.6925	7469.623427	64.9
2008	-336.4902	11744.2	7692.451	7922.564	65.5
2009	-300	11861.642	7769.37551	7450.0548	62.80795526
2010	-300	11980.25842	7524.555348	7903.626897	65.97209025
2011	-300	12100.061	7982.663166	7947.600996	65.68232171
2012	-300	12221.06161	8027.077006	7703.412843	63.03390888
2013	100	12709.90408	8011.549356	8160.635375	64.20689979
2014	100	13218.30024	8487.06079	8205.058553	62.07347694
2015	100	13747.03225	8533.260895	7829.493735	56.95406537
2016	100	14296.91354	8142.673485	8304.420369	58.08540665

- Plan2:

Year	Surplus or deficit	GDP	D'	National debt	National debt/GDP
2007	-135.5098	11432.5	7419.6925	7469.623427	64.9
2008	-336.4902	11744.2	7692.451	7922.564	65.5
2009	-400	11861.642	7769.37551	7450.0548	62.80795526
2010	-300	11980.25842	8179.608166	7903.626897	65.97209025
2011	-200	12100.061	7982.663166	8037.724996	66.42714441
2012	-100	12221.06161	8118.102246	8357.050746	68.38236325
2013	0	12709.90408	8691.332776	8070.511375	63.49781497
2014	50	13218.30024	8393.33183	8115.639178	61.3969953
2015	100	13747.03225	8440.264745	8597.932822	62.54391977
2016	150	14296.91354	8941.850135	8255.955864	57.74642086

Analysis

In the plans above, if government controls the national debt as the function give, both plan1 and plan2 can get a good control on the national debt in 2016 to achieve an about 57% national-debt/GDP rate (and is not likely to cause disorder in government's financial condition, since the function gives the healthy relation between the variables and national debt). Plan1 reduces the national debt step by step and shows a more stable financial health which is more feasible in the real world.

Letter to the new president

Dear Mr. president,

After the subprime mortgage crisis, the government's approach of tax cutting or economy stimulation may cause the deficit to swell. That required an accurate control on national debt to overcome the deficit as well as avoid the high national debt.

We create a model which determines the national debt that should be borrowed depending on government budget's surplus or deficit and current year's GDP and last year's national-debt/GDP rate. We base the model on the data collected from the past 58 years to make the model close to the real situation. Thus, the model can express a general relation between the variables and the national debt. It can be used as a reliable financial planning tool to calculate and manage national debt.

Also, despite the general model used to predict the future we built four specific model for four different period in 1950 to 2007. These four models can be used to study the different strategy which was used by former presidents and his cabinet.

We hope you could benefit from the model and make wise decisions in national-debt management.

Model Building Team

Appendix

Figure 1

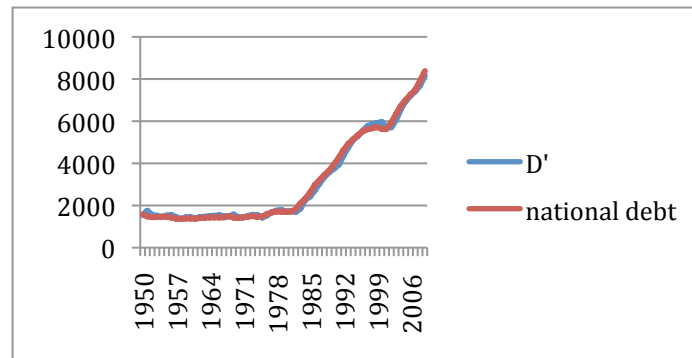
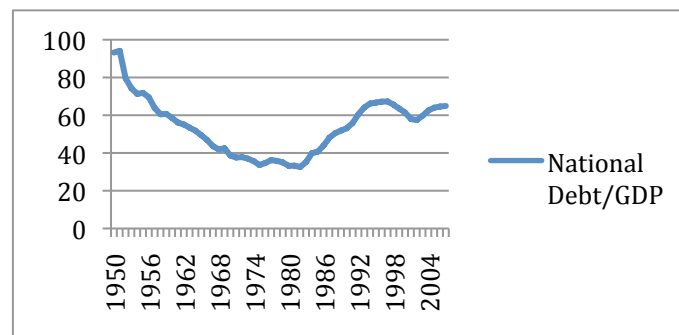
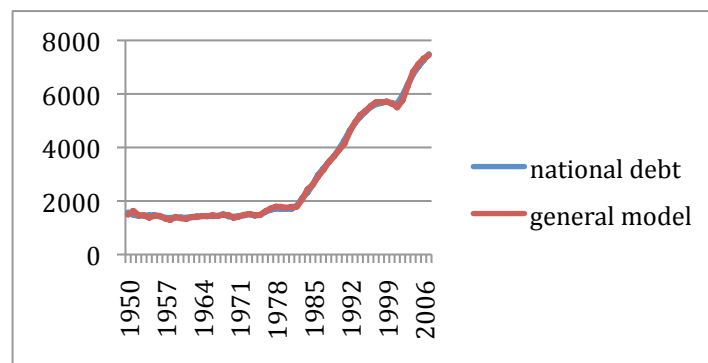


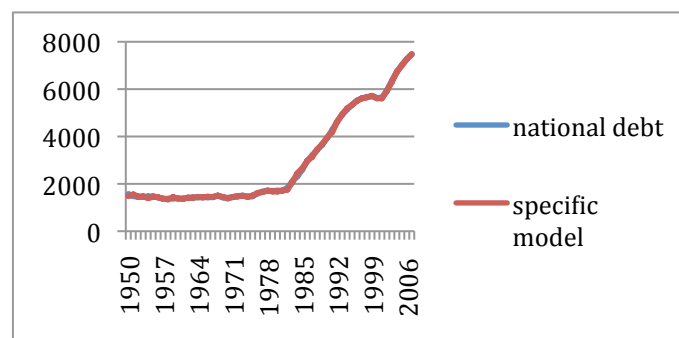
Figure 2



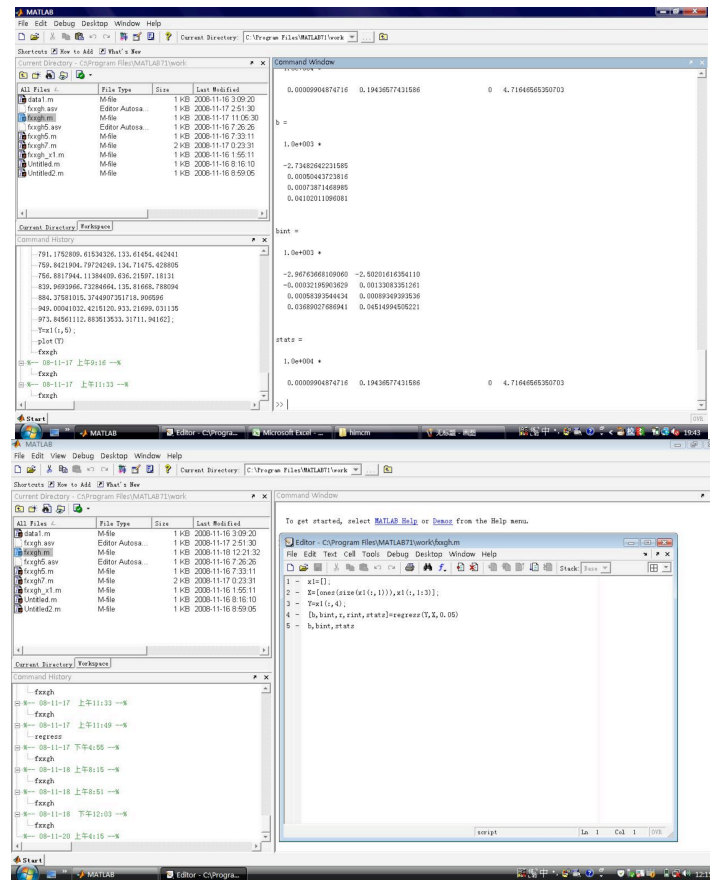
General model and real national debt



Specific model and national debt



Matlab



Reference

LINEAR MODELS-----An Integrated Approach

by Debasis Sengupta (Indian Statistical Institute, India)

& Sreenivasa Rao Jammalamadaka (University of California, Santa Barbara, USA)

http://en.wikipedia.org/wiki/National_debt_by_U.S._presidential_terms

http://en.wikipedia.org/wiki/National_debt

Budget of the United States Government, Fiscal Year 2009