Japanese Government Debt and Sustainability of Fiscal Policy*

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ABSTRACT

We construct quarterly series of the revenues, expenditures, and debt outstanding for Japan from 1980 to 2009, and analyze the sustainability of the fiscal policy. We consider two alternative coverage of the government sector: the general government sector that includes the social security funds and the central/local governments that does not include the social security funds. We pursue three alternative but complementary approaches to examine the sustainability. First, we calculate the minimum tax rate to stabilize the debt to GDP ratio for a given path of future government expenditures. Using 2010 as the base year we find that the general government revenue to GDP rate must be raised permanently to 40% to 47% (from the current 33%) to bring down the debt to GDP ratio back to its 2010 level by 2100. Second, we estimate how the primary surplus responds to the debt outstanding. We allow the relationship to fluctuate between two "regimes" using a Markov switching model. For both the general government and the central/local governments, the primary surplus to GDP ratio respond negatively to debt in one regime and does not respond in the other regime, which suggests the process is explosive. Finally, we estimate a fiscal policy function and a monetary policy function with Markov switching that Davig and Leeper (2007) estimate for the U.S. For both the general government sector and the central/local governments, we find that the fiscal policy is "active" in the sense that the tax revenues do not tend to rise when the debt increases, and the monetary policy is "passive" in the sense that the interest rate does not react to the inflation rate sufficiently, in both regimes. All these results point to the same conclusion: the current fiscal situation for the Japanese government is not sustainable. It takes unprecedented magnitude of fiscal consolidation and/or inflation to stabilize the debt.

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1. Introduction

Mounting government debt is a serious issue in many countries in Europe, the U.S., and Japan. The concern on sustainability of increasing government debt already put Greece and Ireland into serious crises. Many other countries have come up with fiscal consolidation plans one by one. We also started to see some movements toward more conservative fiscal policy in the U.S. as well.

Japan also suffers from a serious problem of the government debt. Indeed Japan's problem seems more serious when we look at the (gross) debt to GDP ratio. The OECD figure for 2010 shows that Japan's debt to GDP ratio was 198%, which is much higher than the U.S. (93%), the U.K. (81%), France (92%), Germany (80%), and even Greece (129%).

Japan's debt is a result of continued deficits of many more years than the U.S. or Europe. The start of the increasing government debt goes back to the fiscal stimulus packages in the early 1990s, when the Japanese economy suffered from the collapse of asset prices. There have been a couple of attempts of fiscal consolidation, but neither of them lasted long enough to achieve the initial goals, and the debt has continued to increase.

This paper examines the sustainability of Japan's fiscal policy. There are two contributions that the paper makes to the discussion of fiscal sustainability for Japan. First, the paper presents reliable quarterly data for the budget deficit and the government debt of Japan from 1980 to 2009. The data are comprehensive in that the coverage includes both central and local governments and almost all the government accounts including the social security fund. We also create the data series for only the central/local governments, excluding the social security account.

Second, the paper takes three complementary approaches to examine the sustainability. The first approach is that of Broda and Weinstein (2005) and Doi (2009). Here the question is how much the government needs to raise the tax revenue to stabilize the debt to income ratio in the long run *given* the future government expenditures and transfers. The second approach is an extension of Bohn (1998), and considers the dynamic feedback from the level of government debt to future government surpluses. The third approach considers the responses of tax revenues to the level of debt as well as the fluctuations in the government expenditures, following Davig and Leeper (2007).

The paper is organized as follows. In the next section, we briefly trace the evolution of the Japan's government debt over the last 20 years. Section 3 explains how we construct the quarterly data series of budget deficit and government debt that we use for the empirical analysis. In Section 4, we update the analyses of Broda and Weinstein (2005) and Doi (2009), and calculate the minimum tax rate that Japan needs to stabilize the debt to GDP ratio. Section 5 estimates a feedback rule from the level of government debt to the primary surplus à la Bohn (1998) to see if we observe stabilizing response of fiscal surpluses as the government debt increases in Japan. We consider the possibility that such a feedback rule has fluctuated between two different regimes over time. Section 6 estimates the fiscal policy function that models the tax revenues as a function of the government debt, output gap, and the government expenditure.

The model allows two regimes with different responses of the government revenues. We also estimate a monetary policy function that is also state contingent, and discuss the interactions between the fiscal policy regimes and the monetary policy regimes. Section 7 concludes.

2. Accumulation of Government Debt in Japan: 1991-2010

In the fiscal year 1990, the Japanese government believed that it had succeeded in containing the budget deficit problem that plagued them since the late 1970s, but it did not last long. To fight the recession following the collapse of asset price boom, the government turned to a series of fiscal stimulus during the first half of 1990s.[1] Figure 1 shows the deficit to GDP ratio and the debt to GDP ratio for the 1990s and the 2000s. The numbers are for the government sector as a whole, which includes the central as well as local governments and the social security funds. The numbers for 2010 and 2011 are for the initial budgets.

The figure shows that the government continued to run budget deficit throughout the last two decades. There have been some episodes when the budget deficit declined in proportion to GDP when the economy recovered and/or the government tried to reduce the deficits (1996, 2000, 2005-2007). The deficit to GDP ratio, however, increased from 2.5% in 1993 to about 8% by the end of the 1990s and most of the 2000s. Reflecting this trend in the deficits, the debt to GDP ratio steadily increased from 74% to 200% by the end of 2000s.

Figure 2 shows the budget surplus of eight OECD countries (G7 plus Greece) as % of GDP. Note a negative number means budget deficit. From 1997 to 2005, Japan's budget deficit to GDP ratio was the largest among G7 countries and even higher than that of Greece most of the time.

The gross debt to GDP ratios for the eight countries are shown in Figure 3. From 1999 on, Japan has the highest debt to GDP ratio among these countries. The ratio exceeded 200% after 2010. In terms of net debt, which subtracts the financial assets that the government sector owns from the gross debt, Japan looks slightly better. The Japanese government sector owns substantial financial assets (most notably in the social security funds), some of which are invested in the Japanese government bonds. For example, as of March 2009, the social security funds (reserves for government-run pension systems) had the net financial assets of about 200 trillion yen (about 40% of GDP). Figure 4 shows the net debt to GDP ratios for the eight countries. Even with this measure, however, the Japan's debt to GDP ratio has been the highest since 2008. The net debt to GDP ratio stood around 120% for Japan in 2010.

The Japanese government debt has been rising very rapidly. It is obvious that the debt to GDP ratio cannot continue growing forever. At one point, the debt to GDP must be stabilized (unless the Japanese government declares defaults). What are the conditions to stabilize the debt to GDP ratio at a certain level in the future? How much longer would the debt to GDP ratio continue rising before it starts to decline? How is such a policy change likely to happen in Japan given its past fiscal policy regimes? These are the questions that we ask in this paper.

[1] Doi and Ihori (2009, pp.24-31) summarizes major developments of Japanese fiscal policy from 1981 to 2007.

3. Data

The fiscal data used in the econometric analysis in Sections 5 and 6 are constructed from the national income accounting published by the Cabinet Office of the Japanese government. We create quarterly time series from the first quarter of 1980 to the first quarter of 2009 for government expenditure, revenue, primary deficit, and debt for two alternative definitions of the government sector: the central/local governments and the general government sector that also includes the social security funds. The total expenditure and revenue series for the general government are readily available in the national income accounting at quarterly frequency. The data by subsector and the debt outstanding are available only annually, so we construct the quarterly data by prorating and/or interpolating the original data.

First, we divide expenditure and revenue of the general government into those of central and local governments and those of the social security funds. There are some expenditure or revenue items that are reported only by the social security funds and others by central and local governments only. For those items, we just take the quarterly series for the general government and apply those to the appropriate sector. For the other items, we first estimate the quarterly series for social security account by prorating the annual series. The expenditures and revenues related to financial transactions other than the interest payment, such as dividends received, rents paid and purchases of land, are estimated by dividing the annual amounts by four. The other items including the interest payment, the final consumption, the fixed capital formation, the current transfers are calculated by allocating the annual amount of each item to the social security funds and the central and local governments according to the relative proportion of annual flows for the year. We also adjust for temporary fluctuations by unusual events in the expenditures and the revenues that we know happened only in the central and local governments account.[2] Such special transfers between public corporation and the central and local governments are excluded from regular government expenditures and revenues. After we estimate the quarterly series for the social security account, we obtain the quarterly data for the central and local governments sector by subtracting the numbers for the social security account from those of the general government. The quarterly series of tax revenues for the central and local governments sector are estimated by prorating in accordance with actual tax revenues based on National Tax Agency “Annual Statistics Report” and Ministry of Internal Affairs and Communications “White Paper on Local Public Finance”

[2] These include transfers of liabilities from the Japanese National Railways Settlement Corporation and the Special Account for National Forest Service to the general account of the central government in 1998, returns of the public part of pension reserves from employee pension funds to the Welfare Insurances Special Account of the central government (so-called *daikō henjō*) for years from 2003 onward, transfers of assets and liabilities from the former Japan Highway Public Corporation and other three highway-related public corporations to the Japan Expressway Holding and Debt Repayment Agency, which took place in the privatization of these public corporations in 2005, transfers of funds from the Special Account for Fiscal Loan Program Funds to the Special Account for Government Bonds Consolidation Fund, which are based on the special law on issues of government bonds in 2006, transfers of funds from the Special Account for Fiscal Investment and Loan Program to the Special Account for Government Bonds Consolidation Fund and the General Account, which are based on the act on Special Accounts, and the special law on the issues of transfers of funds from the Special Account for Fiscal Investment and Loan Program in 2008.

Next we estimate the amount of debt in each sector at quarterly frequency. We get the amount of debt outstanding at the end of every calendar year (end of the fourth quarter) and fiscal year (end of the first quarter) from the official statistics since 1980. Because the quarterly series for the debt in each subsector of the public sector is available for the period after the fourth quarter in 1997 in the flow of funds data published by the Bank of Japan, we use that to interpolate the series. More specifically, we estimate the amounts of the debt for the second and third quarters so that the time series pattern of growth matches that of the flow of funds series. For the period before the fourth quarter of 1997, we estimate the second and third quarters numbers by linearly interpolating the series.

We construct the budget surplus (called net lending / net borrowing in the official statistics) and primary surplus at quarterly frequency from the revenues and expenditures series. The budget surplus (or deficit) number is generally not equal to of the increase in the net government asset (or debt), because the latter includes the capital gains (and losses) and other changes in the value of government assets and liabilities. So we define reconciliation term as follows:

Net debt at the end of this year = net debt at the end of previous year
– "net lending /net borrowing"
+ special factor term + reconciliation term

As the measure of debt for our analysis, we used the "adjusted net debt" proposed by Doi (2008), which is defined as the gross debt of the government sector minus the financial assets owned by the government sector that are readily disposable. This differs from the standard definition of the net debt in that some financial assets at the central and local governments such as the fiscal adjustment funds of the local governments are not subtracted from the gross debt. These financial assets are held as a buffer for unexpected losses and not expected to be drawn down to redeem the debt.

Figure 5 shows gross debt, net debt, and adjusted net debt as percentage of GDP for the general government sector. To remove the seasonality, the figure shows the four quarters moving averages. The time series patterns of the series are quite similar. The adjusted net debt that we use for the empirical analysis is closer to the net debt than to the gross debt in its level. The adjusted net debt to GDP ratio for the general government sector rose rapidly starting in the mid 1990s and reached around 130% by 2009.

Similarly, the debt to GDP ratio series for the central/local governments is shown in Figure 6. Note that the gross debt for the central/local governments is exactly the same as the gross debt for the general government as a whole, because the social security account so far holds net assets. The adjusted net debt series is also very close to the gross debt, suggesting most of the difference between the gross debt and the adjusted net debt in Figure 5 comes from the social security funds. The adjusted net debt to GDP ratio for the central/local governments also started to rise sharply in the mid 1990s and reached around 170% by 2009.

Figure 7 shows expenditure and revenue as percentage of GDP for the general government sector. The seasonality has been removed by taking four quarters moving average again. The expenditure here does not include the interest payment, so that the difference between two series shows the primary balance. For the general government sector that includes the social security funds, the primary balance was in surplus in the late 1980s and the early 1990s. After the mid 1990s, however, the primary balance has been in red consistently.

The expenditure and revenue series for the central/local governments are shown in Figure 8. The time series patterns for both series look quite similar to those in Figure 7. After the mid-1990s, the primary balance has been in red consistently.

4. Minimum Tax Rate for Sustainable Fiscal Policy

This section calculates the minimum amount of taxes (in proportion to GDP) that makes the fiscal policy sustainable at a certain future date, given the future paths for government expenditures, following the method used by Broda and Weinstein (2005) and Doi (2008, 2009). This approach defines the sustainable fiscal policy to be the one that stabilize the debt to GDP ratio at the level in the base year, as proposed in Blanchard et al (1990). We start from a basic inter-temporal budget constraint for the government:

$$B_t - B_{t-1} = G_t - T_t + iB_{t-1} \tag{1}$$

where B_t stands for the amount of government debt outstanding at the end of period t, G_t and T_t are the government expenditure (including transfers) and the tax revenues respectively during the period t, and i is the interest rate that is assumed to be constant. Dividing the both side of the equation by GDP for the period t, Y_t, and rearranging it, we get:

$$\frac{B_t}{Y_t} = \frac{G_t - T_t}{Y_t} + \frac{1+i}{1+\eta}\frac{B_{t-1}}{Y_{t-1}} \quad \text{or} \tag{2}$$

$$b_t = g_t - \tau_t + \frac{1+i}{1+\eta} b_{t-1} \tag{3}$$

where b_t, g_t, and τ_t denote the government debt, the government expenditure, and the tax revenues respectively divided by GDP, and η is the growth rate of GDP, which is also assumed to be constant. We assume $i \geq \eta$. If the long-run growth rate of GDP exceeded the long-run interest rate, sustainability of fiscal policy would not be an issue.

Rearranging the terms, we can express the debt to GDP ratio as a function of the future debt to GDP ratio and the future primary surplus:

$$b_{t-1} = \frac{1+\eta}{1+i} b_t + \frac{1+\eta}{1+i}(\tau_t - g_t) \tag{4}$$

Solving the equation forward, we get:

$$b_0 = \left(\frac{1+\eta}{1+i}\right)^n b_n + \sum_{t=1}^{n}\left(\frac{1+\eta}{1+i}\right)^t (\tau_t - g_t) \qquad (5)$$

The current debt to GDP ratio must be equal to the present discount value of the future debt to GDP ratio and the series of future primary surpluses.

The sustainability requires that the debt to GDP ratio at some distant future n comes back to the level at the period zero. We can calculate the constant tax rate τ^* that makes $b_0=b_n$ to be:

$$\tau^* = \begin{cases} \frac{i-\eta}{1+\eta}\left[b_0 + \left\{1-\left(\frac{1+\eta}{1+i}\right)^n\right\}^{-1} \sum_{t=1}^{n}\left(\frac{1+\eta}{1+i}\right)^t g_t\right] & \text{if } i > \eta \\ \sum_{t=1}^{n}\left(\frac{1+\eta}{1+i}\right)^t g_t & \text{if } i = \eta \end{cases} \qquad (6)$$

Broda and Weinstein (2005) calculated the number for Japan under some alternative scenarios. Looking at the formula, we see that the tax rate necessary to make the fiscal policy sustainable is high when (1) the initial debt to GDP ratio is high, (2) the levels of future government spending are high, (3) the interest rate is high, and (4) the growth rate is low.

Taking the fiscal year 2003 as the base year, Broda and Weinstein (2005) find that the Japan needs to raise the tax revenues to around 35% of GDP if the government expenditure is to grow at the rate of GDP, and to around 40% of GDP if the government expenditure is to grow at the rate of GDP per workers, in order to stabilize the net debt to GDP ratio. These numbers were compared to the tax rate of around 27%, the actual number for Japan in 2003 (including the social security contributions). The numbers required for sustainability are high but not extremely high, compared with the tax rates in other advanced economies. For example, the 35% number is comparable to the U.S. tax rate (including the social security contributions). The higher 40% number, which is required to sustain more generous government expenditures in the future, is comparable to many countries in EU.

Thus, the calculation led Broda and Weinstein (2005) to conclude that the fiscal situation in Japan is not as dire as some observers claimed. It is important to note, however, that the Japanese government debt increased further since the time they did this calculation. Doi (2009) performed a similar calculation using fiscal 2008 as the base year. He finds that the tax rate that makes the fiscal policy sustainable tends to be higher than those estimated by Broda and Weinstein. For example, if the government expenditure grows at the rate of GDP, the necessary tax rate is about 40% even under the scenarios with less generous government transfers. Thus, Doi finds that the sustaining fiscal policy became substantially difficult after five years. Japan needs to increase the tax rate to the levels comparable to many countries in EU just to sustain less generous growth in government expenditures.

In Doi (2009), a new population projection in December 2006 presented by the National Institute of Population and Social Security Research is used (Broda and Weinstein (2005) use the 2002 projection). In the 2006 projection, the fertility rate forecast for 2050 was lowered to about

1.2 from the 2002 projection value of 1.39. The revision reflects a growing tendency among Japanese women to get married and give birth later in life and increasing divorce rate. The average age for Japanese women to give birth to the first child was 29.1 years old in 2005, up from 27.5 years old in 1995, according to the Ministry of Health, Welfare and Labor (hereafter MHWL) statistics. Japan's falling fertility rate has made it one of the world's most rapidly aging countries, with 20.7 percent of the population aged 65 or older in 2006. According to the latest census data, the country's population peaked in 2004 at 127.790 million. The population fell by 22,000 in 2005.

After the publication of Broda and Weinstein (2005), newer sets of estimates of some future government expenditures became available. Thus, Doi (2009) used those, rather than assuming the expenditures grows at the rate of GDP (or GDP per worker) for those expenditures and transfers.

For the public expenditures on medical and long term care, the 2008 estimates published by the National Congress on Social Security known as the “simulation” were used. Because the study disclosed the detailed inputs for the simulation (unusually transparent for a study done by a Japanese government organization), one could tweak the numbers as one sees fit. The cost on medical and long term care reported in the “simulation” includes the co-pay of the people who receive the service. To conform to the national income accounting framework, the future estimates of co-pay burdens are subtracted from the projected costs to obtain the future stream of medical and long term care burdens for the public sector.

The “simulation” considers several alternative scenarios for the future reforms of the national healthcare and long term care system. Scenario A assumes that the current system will continue without any reforms. Scenario B assumes some reforms to address rapidly increasing demand for healthcare and long-term care, and includes some sub-scenarios with different levels of generosity of the reform. In this paper, we focus on Scenario B1 with the least generous benefits stream and Scenario B3 which is the most generous.

For the public pension related expenditures, the 2009 pension prediction released by the MHLW in February 2009 is used. The prediction provides the forecasts for the future social security expenditures every five years. The basic inputs for the simulation are carefully documented and published, so one can modify those to fit the purposes of the analysis. Both the “simulation” and the pension prediction report different forecasts based on different macroeconomic assumptions. We take the baseline case, which assumes the nominal growth rate of 2.0%, the nominal rate of return of the pension system of 4.1%, and the inflation rate of 1.0%.

The government expenditure items other than healthcare, long-term care and pension related ones are assumed to increase at the growth rate of GDP per worker.

In this section, we extend the analysis of Doi (2009) using 2010 as the base year. The initial adjusted net government debt to GDP ratio is 152.8 percent. In Doi (2009), the adjusted net government debt to GDP ratio at the end of 2010 is estimated to be 144.0 percent. Thus, the deficit situation has already worsened substantially over the past year.

Following Doi (2009), we consider three different cases, which differ in the scenario for the healthcare and long-term care reform. Case 1 assumes no reforms (Scenario A). Cases 2 and 3 assume the least generous reform (Scenario B1) and the most generous reform (Scenario B3) respectively. Figure 9 shows the forecasts for the future government expenditures for each case. The ratio of the government expenditures to GDP never exceeds 40 percent in every case. This shows that the government projections for social security benefits and healthcare and long-term care expenses imply that those expenditures will be somehow contained even without additional reforms for healthcare and long-term care.

Table 1 shows the tax rate (τ^*) that is necessary to reduce the debt to GDP ratio in 2010 back to the level of 2010. The calculation is based on equation (6). For the length of horizon (n), we consider two cases: 95 years and 38 years. The 95 years horizon is roughly the same as the longer horizon considered by Broda and Weinstein (2005) (98 years) and the horizon considered by Doi (2009) (90 years). The 38 years horizon is exactly the same as the shorter horizon considered by Broda and Weinstein (2005). Panel A reports the results for the 95 years horizon and Panel B reports the results for the 38 years horizon.

Panel A shows that the tax rates that are necessary to stabilize the debt to GDP ratio in about 100 years are higher than those in Broda and Weinstein (2005) or Doi (2009) for similar assumptions on the growth rate and the interest rate. For example, if we assume the interest rate is higher than the growth rate by 2% and no further reform on the national healthcare and long-term care systems (Case 1), the tax revenue to GDP ratio must be raised to 44.1% immediately to achieve the sustainability. The ratio of the government revenues to GDP is forecasted to be 32.9% for 2010 (*OECD Economic Outlook*). Thus, our calculation suggests that the government increase the revenues by more than 11 percent of GDP through tax increases and increases in social security contributions by taxpayers. Panel B shows that the sustainable tax rates for the 38 years horizon in our Cases 1, 2, and 3 are only slightly higher than those for the 95 years horizon. This suggests that taking a longer horizon and spreading the cost over many generations would not reduce the tax burden of each generation very much.[3]

Figure 10 shows the path of the primary balance for each case. The figure shows that the primary balance of two to four percent of GDP has to be maintained for years. The primary balance reaches close to 10% of GDP toward the end. Even in the booming 1980s, Japan did not experience primary surplus continuing for a decade. Although such magnitude of primary surplus is possible, it is hard to imagine that voters would accept such sustained fiscal austerity without resistance.

[3] We also tried the calculation with simpler assumptions about the future government expenditures and transfers following Broda and Weinstein (2005). We considered their Case 2 where the government expenditure and transfer per person are expected to grow at the rate of GDP and their Case 3 where the government expenditure and transfer per person are expected to grow at the rate of GDP per worker. It turns out these scenarios provide more extreme versions of the future government expenditures and transfers than the scenarios that we consider. In their Case 2, the government expenditures to GDP ratio eventually start to decline more rapidly than any of our cases. In their Case 3, the government expenditures to GDP ratio continues to grow indefinitely. In either case, the qualitative result does not change. The tax rate that achieves sustainability is higher than that calculated by Broda and Weinstein (2005). For their Case 3, for example, a tax rate higher than 55% is necessary to stabilize the debt to GDP ratio in 95 years.

Even with the extremely high tax rates, the debt to GDP ratio is forecasted to rise substantially before it starts to come down. Figure 11 shows the implied path for the adjusted net debt to GDP ratio for each case. In all the cases that we consider, the debt to GDP ratio goes higher than 200 percent before it comes down. Noting that the total financial assets of the household sector currently amount to about 300 percent of GDP, the government may face substantial trouble refinancing the debt somewhere along this path.

Thus, the optimistic picture painted by Broda and Weinstein (2005) completely disappears when we update the analysis using more recent data. Fiscal expansion after the global financial crisis substantially worsened the conditions. To stabilize the debt by increasing the tax rate, the Japanese government would have to raise the revenue by 11% of GDP or more.

To make the situation worse, the Great East Japan Earthquake struck on March 11, 2011. A large amount of additional government expenditure will be necessary for reconsruction of the affected areas. The cost for rebuilding the lost infrastructures is estimated to be around 16 to 25 trillion yen (about 200 or 300 billion dollars at the exchange rate of 80 yen per dollar) by the Japanese government. Some other estimates go as high as 40 trillion yen (about 500 billion dollars or about 8.3% of GDP in 2010).

How has the disaster and additional expenditures on the recovery efforts changed the fiscal sustainability? For simplicity, let us consider the case when the government immediately pays for the total reconstruction expenditure by issuing new bonds. This is the case when the reconstruction expenditure has the maximum impact for the sustainability calculation.

Following steps similar to the derivation above, one can show that the minimum tax rate for sustainability τ^* is given by:

$$\tau^* = \begin{cases} \dfrac{i-\eta}{1+\eta}\left[b_0 + \left\{ 1 - \left(\dfrac{1+\eta}{1+i}\right)^n \right\}^{-1} \left\{ d_0 + \sum_{t=1}^{n} \left(\dfrac{1+\eta}{1+i}\right)^t g_t \right\} \right] & \text{if } i > \eta \\ \dfrac{1}{n}\left\{ d_0 + \sum_{t=1}^{n} \left(\dfrac{1+\eta}{1+i}\right)^t g_t \right\} & \text{if } i = \eta \end{cases} \tag{7}$$

where d_0 denotes the ratio of the reconstruction expenditure to GDP. Comparing this to the equation (6), we see that the sustainable tax rate increases by

$$\frac{i-\eta}{1+\eta}\left\{ 1 - \left(\frac{1+\eta}{1+i}\right)^n \right\}^{-1} d_0 \quad \text{if } i > \eta \quad \text{or} \quad \frac{1}{n} d_0 \quad \text{if } i = \eta$$

Substituting d_0 with 8.3% (the maximum amount of estimated reconstruction that we can find), we see the increase in the sustainable tax rate is limited to 0.1 to 0.4 percentage points in the 95 years horizon cases. Thus, although the reconstruction cost may be substantial, its impact on the sustainability calculation is minimal because the cost can be spread over the long horizon.

5. Does the Japanese Government Increase the Primary Surplus as the Government Debt Grows?

Will the Japanese government raise the tax rate drastically to stabilize the debt to GDP ratio? One way to answer this question is to examine how the fiscal policy responded to rising government debt in the past. If we observe the tendency for the government to reduce the primary deficit sufficiently in response to increasing government debt, for example, we can infer that the government may increase the tax rate to stabilize the debt eventually. Thus, this and the next section examine the Japanese government's responses to rising government debts in the last 30 years to see if we are likely to see drastic tax increases in the near future.

This section applies the approach proposed by Bohn (1998) that examines the response of the primary surplus to the debt. To illustrate the approach, let x_t denote the ratio of primary surplus to GDP and suppose it is a linear function of the debt to GDP ratio in the (end of the) previous period:

$$x_t = \alpha + \beta b_{t-1} + \rho x_{t-1} + \gamma z_t + u_t \tag{8}$$

where z is a vector of stationary variables that influences the primary surplus and u is a white noise disturbance. In contrast to Bohn (1998), we allow the smoothed adjustment of primary surplus by including the AR(1) term.

In the following analysis, we use two variables for z. The first is GVAR, which is defined to be the temporary deviation from the trend level of government expenditure divided by GDP, namely $GVAR_t \equiv (G_t - G_t^*)/Y_t$, where G_t^* is the trend level of government expenditure calculated using the method proposed by Hodrick and Prescott (1997). The budget balance can worsen to finance a temporary surge in the government expenditure (such as a war) without jeopardizing the long-run sustainability. Thus, we expect to find the primary surplus respond negatively to this variable. The other stationary variable is GDP gap, which attempts to capture the fluctuations of the primary surplus coming from the automatic stabilizer function of the government budget.[4] GDP gap is measured as the deviation of the Hodrick-Prescott trend. The primary surplus is likely to fall during economic downturns, so we expect a positive coefficient on this variable.

Note that the relation between the primary surplus and debt for a constant interest rate and a constant growth rate:

$$b_t = (1 + i - \eta) b_{t-1} - x_t \tag{9}$$

Substituting (8) into (9) obtains:

[4] Bohn uses the unemployment rate to capture the business cycle fluctuations. Instead of GDP gap, he uses *YVAR* which is defined as $YVAR_t \equiv (U_t - U^m)(G_t^* / Y_t)$, where U_t is the unemployment rate, U^m is the median unemployment rate for the sample. The choice of the variables follows Barro (1986).

$$b_t = (1+i-\eta-\beta)b_{t-1} - \rho x_{t-1} - \alpha - \gamma z_t - u_t \quad (10)$$

Noting that $x_{t-1} = (1+i-\eta)b_{t-2} - b_{t-1}$:

$$b_t = (1+i-\eta-\beta+\rho)b_{t-1} - \rho(1+i-\eta)b_{t-2} - \alpha - \gamma z_t - u_t \,. \quad (11)$$

Thus, b_t is expressed in the ADF regression form as:

$$\Delta b_t = \{(i-\eta)(1-\rho)-\beta)\}b_{t-1} + \rho(1+i-\eta)\Delta b_{t-1} - \alpha - \gamma z_t - u_t \quad (12)$$

Thus, b_t is stationary if $\beta \geq (i-\eta)(1-\rho)$. Thus, if the primary surplus responds substantially positively to an increase in the debt to GDP ratio (assuming that the interest rate is higher than the growth rate), the debt to GDP ratio tends to be stabilized in the long run.

Intuitively, the debt to GDP ratio grows over time at the rate of the interest rate minus the growth rate of GDP even if the primary balance is zero. In order for this ratio to be stabilized in the long run, the primary surplus must be at least as large. If the primary surplus follows the process specified in the equation (8), the long run level of the primary surplus to GDP ratio is given by $\beta/(1-\rho)$ times the debt to GDP ratio. Thus, if this is greater than the interest rate minus the growth rate, the government debt is sustainable.

If we allow the response of the primary surplus to the debt to GDP ratio to depend on the level of debt to GDP ratio, so that $\beta = f(b_{t-1})$, one can show that the debt process is sustainable if there exists b^* such that $f(b) \geq (i-\eta)(1-\rho)$ for all $b > b^*$.

Table 2 reports the estimation result of the equation (8) by maximum likelihood estimation (MLE) assuming the error term is normally distributed with mean 0 and variance σ^2. The definition of the government sector here is the general government that includes the social security funds. We use the average of the adjusted net debt to GDP ratio for the previous four quarters as b_{t-1}. All other variables are seasonally adjusted using X12-ARIMA, if the seasonally adjusted series are not available. The sample period used for this estimation is 1981Q1 to 2010Q1.

The table reports the results for two alternative specifications. Model 1 is a simple linear specification. Model 2 includes the quadratic term $(b_{t-1}-\bar{b})^2$, where $\bar{b}$ is the sample mean of b. This is a simple way to introduce the dependence of the size of response (β) on the debt to GDP ratio. In both specifications, the coefficients estimates on GVAR and GDP gap are both statistically significant and have the expected signs. In Model 1, the coefficient estimate on the debt to GDP ratio is negative and significant, which implies the process is explosive as long as the interest rate exceeds the growth rate.

Inclusion of the quadratic term in Model 2 slightly improves the fit of the model. This can be seen from the value of Markov switching criterion (MSC) proposed by Smith, Naik, and Tsai (2006), which can be used to compare regression models with and without Markov switching. The MSC of Model 2 is slightly lower than that of Model 1 but not much. The result on the sustainability is the same as that in Model 1. The coefficient estimates on the linear term and the quadratic term of the debt to GDP ratio are both negative, suggesting that the primary surplus responds negatively to an increase in the debt to GDP ratio. Thus, the debt dynamics for Japan has been explosive.

The result that the debt dynamics is not sustainable is consistent with what Doi and Ihori (2009) found using annual data from 1956 to 2000.[5] The result is not surprising if we look at the Figure 12, which plots the primary balance to GDP ratio against the debt to GDP ratio over the sample period. Overall we see the negative relation between primary balance and debt. But we also observe that the primary balance increased as the debt to GDP ratio increased during some sub-sample periods. This suggests the possibility that the debt dynamics was sustainable at least in some years.

To address this possibility, we estimate the dynamics with possible regime changes. Instead of (8), we consider the specification:

$$x_t = \alpha(S_t) + \beta(S_t) b_{t-1} + \rho(S_t) x_{t-1} + \gamma(S_t) z_t + \sigma(S_t) u_t \,. \tag{13}$$

Here S_t denotes the policy regime that follows a two-state Markov chain with transition probability matrix

$$\begin{pmatrix} p_{11} & 1-p_{22} \\ 1-p_{11} & p_{22} \end{pmatrix},$$

whose (i, j) element indicates the probability that the policy regime moves to Regime i from Regime j.

A natural interpretation of "regimes" would be different fiscal policy stances by different administrations. But, we cannot have the number of regimes as large as the number of distinct administration to get statistically reliable estimates. This is especially so for Japan in the recent years when the typical administration lasted only for four quarters (or less). Thus, this paper restricts the number of potential regimes to be two.

Table 3 reports the estimation result by the MLE assuming normality. We again consider two alternative specifications: with or without the quadratic term. The estimation result of

[5] Doi and Ihori (2009) follow Bohn (1998) and use the unemployment based measure to account for business cycle fluctuations. When we use the unemployment based measure instead of GDP gap, the result changes in a couple of ways. First, the point estimate of the coefficient on the linear term of debt to GDP ratio becomes positive but it is not statistically significant. Second, the model with the quadratic term shows a better fit. The qualitative result, however, remains the same. The debt dynamics is unsustainable at least for the level of debt to GDP ratio as high as that in recent years.

Model 1 suggests the existence of two regimes with somewhat different responses of the primary balance to increasing government debt. In Regime 1, the coefficient on the debt to GDP ratio is negative, suggesting an increase in the debt to GDP ratio leads to a reduction in the primary balance. The reduced primary balance (or the increase in the primary deficit) would increase the growth rate of debt. The situation is clearly unsustainable. In this regime, the coefficient estimate on GDP gap is positive and statistically significant, suggesting strong counter-cyclical fluctuations of primary deficit. The probability that the economy stays in this regime in the next period is estimated to be about 0.97. So the average duration of this regime is more than 8 years.[6]

In Regime 2, the coefficient estimate on the debt to GDP ratio is positive, suggesting that the dynamics could be sustainable. The coefficient estimate, however, is small and not statistically different from zero. In this regime, the coefficient on GDP gap is not significantly different from zero, suggesting little counter-cyclical fiscal policy. The probability that the economy stays in the regime is 0.96, or the regime continues for about six years and a quarter on average.

The likelihood for the model with Markov switching is larger than that for the model without regime changes. Indeed, the MSC clearly selects the model with regime changes over the model without regime changes.

Figure 13 shows the smoothed probability of state being Regime 1 for Model 1. We can see two occasions when the debt dynamics were clearly unsustainable (Regime 1). One is the period from the early 1990s to the early 2000s. This roughly corresponds to the period often referred to as the "lost decade." The primary deficit increased, while the debt to GDP ratio rose, making the debt dynamics clearly explosive. The other Regime 1 period is the late 2000s, when the budget deficit increased again as a response to the global economic crisis. In Regime 2, the point estimate of the coefficient on the debt to GDP ratio is positive but it is not significantly different from zero. Thus, the debt is not quite sustainable even in this regime, but the dynamics is less explosive than Regime 1. The figure shows Japan was in Regime 2 in the late 1980s. The period is often considered to have been a period of fiscal consolidation, although the model suggests that the debt dynamics was explosive even then. The other Regime 2 period emerged in the mid 2000s, which corresponds to the fiscal consolidation attempt under the Koizumi government.

Model 2 includes the quadratic term in the specification. Again Regime 1 is a clearly unsustainable regime: the budget balance falls as the debt to GDP ratio increases for all the possible values of the debt to GDP ratio. The probability that the economy stays in this regime is estimated to be 0.97. In Regime 2, the coefficient on the debt to GDP ratio is positive, so the dynamics can be sustainable. The positive coefficient estimate on the linear term, however, is again small and not statistically different from zero.

The MSC values suggest that Model 1 with Markov switching is the overall preferred model. The model suggests that the primary surplus did not respond positively to increasing debt

[6] The average duration of Regime i is given by $1/(1-p_{ii})$. See Kim and Nelson (1999, p. 72).

to GDP ratio in either regime. Thus, a fiscal policy change that is required to restore fiscal sustainability for the general government sector will have to be an unprecedented change (at least in the last 30 years).[7]

Tables 4 and 5 report the estimation results using the central/local governments as the definition of the government sector. Note that this analysis focuses only on the sustainability of the central/local governments, ignoring the social security system which probably has more serious sustainability issue. Thus, the question we ask here is whether the narrowly defined government is fiscally sustainable if the issue for the social security system is somehow solved separately. The results are similar to those for the general government sector. In the model without Markov switching (Table 4), the coefficient estimate on the lagged debt to GDP ratio is negative and significant. Thus, the primary surplus increases when the debt to GDP ratio increases, making the dynamics explosive.

Table 5 shows the estimation results for models with regime changes. Again the MSC selects the models with regime switching over those without regime switching. Among the models with regime switching, the MSC becomes the smallest for the model without the quadratic term of the debt to GDP ratio (Model 1). Similar to the result for the general government, the coefficient estimate on the debt to GDP ratio is positive but not statistically significant from zero. Thus, the situation is not sustainable even for the narrowly defined government sector.[8]

In summary, the analysis in this section points to serious problems for the Japan’s government debt. For both the general government sector and the central/local government only, the fiscal policy is found to be unsustainable, even when we allow for the possibility of regime changes.

6. Fiscal Sustainability and Monetary Policy

The analysis in Section 5 looked at the response of the primary surplus to the debt. Thus, it was not clear whether the tax revenue or the government expenditure changes responding to the changes in the level of government debt. This section focuses on the adjustment of the tax revenue side and investigates if the tax revenue has shown the tendency to increase as the debt increases given the government expenditure.

We examine how the tax revenue responds to the debt to GDP ratio by estimating a Markov switching model used by Davig and Leeper (2007). They specify the fiscal policy

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[7] When we use the unemployment rate based measure instead of GDP gap to proxy for the business cycle, the model with the quadratic term with Markov switching becomes the most preferred model by the MSC. In Regime 2, the policy becomes sustainable for low levels of debt to GDP ratio. Such sustainable situation, however, did not actually happened in the last 30 years because the debt to GDP ratio was already high when the economy was in Regime 2 with high probability.

[8] When we use the unemployment based measure of business cycle, the model with the quadratic term and Markov switching becomes the most preferred model for the central/local governments. In Regime 2, the process is found to be sustainable for relatively high level of debt to GDP ratio. Even then, the steady state level of debt to GDP ratio is very high, exceeding 140% even in the most favorable case (the interest rate is equal to the growth rate).

function in terms of the tax revenue to GDP ratio as a function of the debt to GDP ratio, output gap, and government purchases:

$$\tau_t = \alpha(S_t) + \beta(S_t)b_{t-1} + \gamma_y(S_t)gap_t + \gamma_g(S_t)g_t + \sigma(S_t)u_t \tag{14}$$

where gap_t stands for the output gap. We calculate the output gap as the deviation of GDP from its Hodrick-Prescott trend.

Table 6 shows the estimation results of the fiscal policy function (14) for the general government sector by the MLE assuming normality. Two regimes are identified. In Regime 1, the coefficient estimate on the debt to GDP ratio is negative, suggesting the tax revenue falls when the debt to GDP ratio increases. The smoothed probability of Regime 1 is shown in Figure 14. Since a counter-cyclical fiscal policy would generate such negative reaction of the tax revenue to the debt to GDP ratio, Davig and Leeper (2007) call this "active" fiscal policy regime. For the U.S. data, Davig and Leeper (2007) find the fiscal policy alternates between the "active" phase and the "passive" phase that is characterized by a positive coefficient on the debt to GDP ratio. For the general government sector of Japan, we find the coefficient on the debt to GDP ratio in Regime 2 to be zero.

Thus, regardless the state, the tax revenue fails to increase when the debt to GDP ratio rises. In both regimes, the tax revenue increases when the government expenditure increases but by much less than one-to-one. The fiscal dynamics for Japan does not show the tax adjustment to make the fiscal policy sustainable.

Table 7 shows the estimation result for the central/local governments. The result is qualitatively the same as that in Table 6. In Regime 1, the fiscal policy is active, with tax revenues responding negatively to increases in the debt to GDP ratio. In Regime 2, the coefficient estimate on the debt to GDP ratio is zero.

An active fiscal policy is not necessarily unsustainable. As Davig and Leeper (2010) and others show, an active fiscal policy can be sustainable if the monetary authority acts "passively" and allows the price level to adjust eventually to make the value of the government bonds outstanding equal to the present discount value of future expected primary surpluses. Because the Japanese fiscal policy has looked active in the last 30 years both at the level of the general government sector and at the level of the central/local governments, it is important to check how the monetary policy has been conducted.

To check this, we estimate the following monetary policy function, which is potentially state dependent.

$$r_t = \alpha_M(S_t^M) + \beta_M(S_t^M)\pi_t + \delta_y(S_t^M)gap_t + \delta_e(S_t^M)ex_t + \sigma(S_t^M)v_t\,, \tag{15}$$

where r_t is the nominal interest rate, π_t is the inflation rate, gap_t is the GDP gap and ex_t is the deviation of the real exchange rate from its trend. The trend GDP and the trend real exchange rate are the HP trend of each series. S_t^M is the monetary policy regime that evolves according to a Markov chain.

Table 8 reports the estimation results. Column 1 reports the estimated coefficients from the model without regime switches. The estimated coefficient on the inflation rate is much greater than one, suggesting an active monetary policy to maintain a targeted inflation rate. When the actual inflation rate goes up above the target rate, the central bank raises the interest rate by more than one to one, raising the real interest rate. Such monetary policy eventually brings the inflation rate back to the target level. Thus, the model that ignores the possibility of regime changes for the monetary policy suggest that the monetary policy in Japan has been "active" in the sense that the central bank reacted strongly to deviations of the inflation rate from its target level. The combination of active fiscal policy and active monetary policy is unsustainable. This combination cannot continue forever. Eventually, either the fiscal authority or the monetary authority is forced to be inactive and accommodate the other.

The coefficients on the variables other than the inflation rate are not precisely estimated in the model without regimes changes, although the point estimates have the expected signs. When the output falls below the trend (*gap* variable is negative), the monetary policy becomes more expansionary (lower interest rate). When the real exchange rate appreciate above the trend (*ex* variable is positive), the monetary policy becomes expansionary.

The result for active monetary policy disappears when we estimate a model with regime switches. The last two columns of Table 8 report the result for the Markov switching model. The MSC suggests that the model with regime switches is much more preferred to the one without. The coefficient on the inflation rate is less than one in both regimes, suggesting the monetary policy is inactive. Regime 1 is relatively more active but the coefficient estimate is still less than one. The response to the output gap in Regime 1 is large but not precisely estimated. The response to the exchange rate is significantly different from zero.

Regime 2 shows the smaller response of the interest rate to all the variables, but each coefficient estimate is statistically significantly different from zero. Regime 2 also shows low volatility of the interest rate.

Figure 15 shows the smoothed probability of Regime 1. Regime 1 lasted for the first 15 years of the sample. From the third quarter of 1995 (note this is when the Bank of Japan lowered the target rate to 0.5%) to the fourth quarter of 1995, the monetary policy quickly moved to Regime 2, which has been continuing for the next 15 years.

Given this result, we suspect that the result for active monetary policy in the model without regime switches came mostly from the comparison between the period before 1995 (high inflation rate and high interest rate) and the period after 1995 (low inflation rate and low interest rate). Within each regime, the interest rate never responded to the inflation rate by more than one for one.

The analysis of this section finds fluctuations of regimes of fiscal policy and monetary policy. Unlike the results for the U.S. found by Davig and Leeper (2007), we do not find the policies fluctuate between active and inactive regimes. For the fiscal policy, both regimes are active. The result does not change when we examine only the central/local governments ignoring the solvency of the social security system. For the monetary policy, both regimes are inactive. Thus, this section's analysis suggests that the active fiscal policy has been supported by inactive monetary policy in Japan for the last 30 years. If this pattern persists, the most likely scenario for the future reconciliation of the mounting government debt may be the reduction of the value of government debt through inflation under accommodative monetary policy, however unlikely it seems in the current deflationary environment.

7. Conclusions

In this paper, we have examined the fiscal sustainability of Japan using three alternative but complementary approaches and for two alternative definitions of the government sector. All the results point to the same conclusion: the Japanese government debt poses serious challenges. To stabilize the debt to GDP ratio, Japan needs to implement a tax rate hike with an extraordinary magnitude. Such tax increase to make the fiscal policy sustainable would represent a drastic departure from the Japanese fiscal policy in the last 30 years. The fiscal policy in Japan is found to be unsustainable even when we allow the possibility of regime changes. If the government fails to reduce the primary deficit by increasing the taxes and reducing the expenditures and transfer payments, Japan would be forced to reduce the value of government debt through either inflation or outright default.

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Table 1. Simulation Results of Government Revenue-GDP Ratio Required for Fiscal Sustainability

Panel A. 95 years horizon, η (nominal growth rate) = 2%

Rate Gap (interest rate)	Case 1	Case 2	Case 3	Broda and Weinstein (2005)		Doi (2009)
				Case 2	Case 3	
0% (2%)	39.9%	38.8%	38.9%	32.3%	44.9%	37.2%
1% (3%)	41.8%	40.9%	41.0%	33.7%	44.4%	38.8%
2% (4%)	44.1%	43.4%	43.5%	34.9%	43.9%	40.8%
3% (5%)	45.2%	44.6%	44.7%	36.0%	43.3%	41.7%
4% (6%)	46.7%	46.4%	46.5%	36.9%	42.9%	43.1%
n	95	95	95	98	98	90

Panel B: 38 years horizon, η (nominal growth rate) = 2%

Rate Gap (interest rate)	Case 1	Case 2	Case 3	Broda and Weinstein (2005)	
				Case 2	Case 3
0% (2%)	41.1%	40.9%	41.0%	35.3%	40.2%
1% (3%)	42.5%	42.4%	42.5%	35.9%	40.4%
2% (4%)	44.7%	44.6%	44.7%	36.5%	40.6%
3% (5%)	45.4%	45.3%	45.4%	37.0%	40.8%
4% (6%)	46.8%	46.8%	46.9%	37.6%	41.0%
n	38	38	38	38	38

Table 2. Estimation Results of the Debt Dynamics for General Government Sector

Explanatory variable	Model 1	Model 2
constant	0.0020 (0.0009)	0.0014 (0.0008)
b_{t-1}	-0.0037 (0.0013)	-0.0016 (0.0015)
$(b_{t-1} - \bar{b})^2$		-0.0063 (0.0033)
$GVAR_t$	-0.3169 (0.0869)	-0.2708 (0.0863)
GDP gap	0.0009 (0.0002)	0.0009 (0.0002)
ρ	0.8614 (0.0502)	0.8954 (0.0469)
σ	0.0028 (0.0002)	0.0027 (0.0002)
Log-likelihood	523.10	524.85
MSC	-916.4	-917.7

Notes: Estimated by the MLE assuming the error term are normally distributed with mean 0 and variance σ^2. The dependent variable is the primary balance divided by GDP. Numbers in the parentheses are standard errors. GVAR is the deviation of the government expenditure from its trend divided by GDP. GDP gap is measured as the deviation from the Hodrick-Prescott trend. ρ is the coefficient on the lagged dependent variable. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 3. Models with Markov Switching for General Government Sector

	Model 1		Model 2	
	Regime 1	Regime 2	Regime 1	Regime 2
Transition probability	0.9722 (0.0193)	0.9638 (0.0193)	0.9710 (0.0233)	0.9703 (0.0227)
Constant	0.0015 (0.0008)	0.0012 (0.0006)	0.0012 (0.0010)	0.0017 (0.0008)
b_{t-1}	-0.0057 (0.0012)	0.0007 (0.0010)	-0.0057 (0.0020)	0.0007 (0.0015)
$(b_{t-1}-\bar{b})^2$			-0.0027 (0.0034)	-0.0046 (0.0068)
$GVAR_t$	-0.2803 (0.0875)	-0.2226 (0.0842)	-0.2423 (0.0811)	-0.2156 (0.1000)
GDP gap	0.0013 (0.0002)	0.0001 (0.0002)	0.0011 (0.0002)	0.0000 (0.0003)
ρ	0.7057 (0.0542)	0.9378 (0.0338)	0.6347 (0.0710)	0.9094 (0.0466)
σ	0.0023 (0.0002)	0.0013 (0.0001)	0.0019 (0.0002)	0.0016 (0.0002)
Log-likelihood	563.9		564.1	
MSC	-955.1		-942.8	
Without switching	-916.4		-917.7	

Notes: Estimated by the MLE assuming normality. The dependent variable is the primary balance divided by GDP. Numbers in the parentheses are standard errors. b_{t-1} is the average of the debt to GDP ratios for the last four quarters, and $\bar{b}$ is its average over the sample period. GVAR is the deviation of the government expenditure from its trend divided by GDP. GDP gap is measured as the deviation from the Hodrick-Prescott trend. ρ is the coefficient on the lagged dependent variable. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 4. Estimation Results of the Debt Dynamics for Central/Local Governments

Explanatory variable	Model 1	Model 2
constant	0.0012 (0.0006)	0.0012 (0.0006)
b_{t-1}	-0.0021 (0.0007)	-0.0021 (0.0009)
$(b_{t-1} - \bar{b})^2$		-0.0003 (0.0021)
$GVAR_t$	-0.4165 (0.0885)	-0.4136 (0.0859)
GDP gap	0.0007 (0.0002)	0.0007 (0.0002)
ρ	0.8298 (0.0490)	0.8314 (0.0455)
σ	0.0025 (0.0002)	0.0025 (0.0002)
Log-likelihood	533.40	520.59
MSC	-937.0	-934.8

Notes: Estimated by the MLE assuming the error term are normally distributed with mean 0 and variance σ^2. The dependent variable is the primary balance divided by GDP. Numbers in the parentheses are standard errors. GVAR is the deviation of the government expenditure from its trend divided by GDP. GDP gap is measured as the deviation from the Hodrick-Prescott trend. ρ is the coefficient on the lagged dependent variable. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 5. Models with Markov Switching for Central/Local Governments

	Model 1		Model 2	
	Regime 1	Regime 2	Regime 1	Regime 2
Transition probability	0.9656 (0.0298)	0.9652 (0.0291)	0.9654 (0.0316)	0.9652 (0.0320)
Constant	-0.0010 (0.0008)	0.0008 (0.0006)	-0.0012 (0.0010)	0.0009 (0.0006)
b_{t-1}	-0.0029 (0.0009)	0.0003 (0.0007)	-0.0026 (0.0016)	0.0005 (0.0009)
$(b_{t-1} - \bar{b})^2$			-0.0007 (0.0028)	-0.0013 (0.0044)
$GVAR_t$	-0.3339 (0.0669)	-0.3613 (0.1231)	-0.3285 (0.0764)	-0.3582 (0.1175)
GDP gap	0.0009 (0.0002)	-0.0002 (0.0002)	0.0009 (0.0002)	-0.0002 (0.0003)
ρ	0.5870 (0.0587)	0.8981 (0.0463)	0.5999 (0.0706)	0.8864 (0.0589)
σ	0.0017 (0.0002)	0.0016 (0.0002)	0.0017 (0.0002)	0.0016 (0.0002)
Log-likelihood	569.2		566.9	
MSC	-966.0		-953.1	
Without switching	-937.0		-934.8	

Notes: Estimated by the MLE assuming normality. The dependent variable is the primary balance divided by GDP. Numbers in the parentheses are standard errors. b_{t-1} is the average of the debt to GDP ratios for the last four quarters, and $\bar{b}$ is its average over the sample period. GVAR is the deviation of the government expenditure from its trend divided by GDP. GDP gap is measured as the deviation from the Hodrick-Prescott trend. ρ is the coefficient on the lagged dependent variable. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 6. Estimation Results of the Fiscal Policy Function for General Government Sector

	Regime 1	Regime 2
Transition probability	0.9374 (0.0404)	0.9771 (0.0165)
Constant	0.0623 (0.0070)	0.0812 (0.0040)
Lagged (debt / GDP)	-0.0268 (0.0035)	-0.0003 (0.0009)
GDP gap	-0.0004 (0.0003)	0.0001 (0.0002)
Government expenditure / GDP	0.6425 (0.0762)	0.3196 (0.0353)
σ	0.0020 (0.0003)	0.0020 (0.0002)
Log-likelihood	549.4	
MSC	-948.3	
Without switching	-915.6	

Notes: Estimated by the MLE assuming normality. The dependent variable is the tax revenue divided by GDP. Numbers in the parentheses are standard errors. The lagged debt to GDP ratio is the average of the debt to GDP ratios for the previous four quarters. GDP gap is measured as the deviation from the Hodrick-Prescott trend. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 7. Estimation Results of the Fiscal Policy Function for Central/Local Governments

	Regime 1	Regime 2
Transition probability	0.9607 (0.0243)	0.9238 (0.0389)
Constant	0.0842 (0.0040)	0.0398 (0.0038)
Lagged (debt / GDP)	-0.0095 (0.0008)	0.0008 (0.0007)
GDP gap	0.0001 (0.0002)	0.0002 (0.0001)
Government expenditure / GDP	0.1179 (0.0446)	0.4742 (0.0369)
σ	0.0022 (0.0002)	0.0011 (0.0001)
Log-likelihood	562.3	
MSC	-974.9	
Without switching	-928.9	

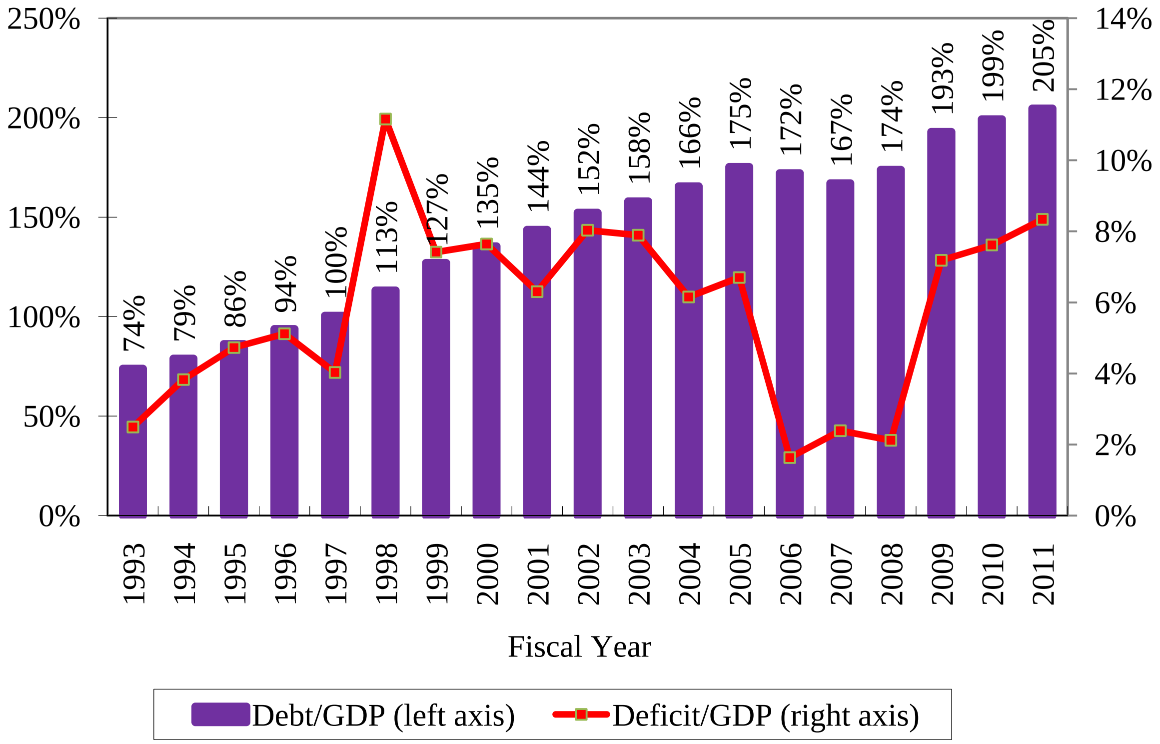
Notes: Estimated by the MLE assuming normality. The dependent variable is the tax revenue divided by GDP. Numbers in the parentheses are standard errors. The lagged debt to GDP ratio is the average of the debt to GDP ratios for the previous four quarters. GDP gap is measured as the deviation from the Hodrick-Prescott trend. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Table 8. Estimation Results for Monetary Policy Function

	Model without switching	Model with switching	
		Regime 1	Regime 2
Transition probability		0.991 (0.011)	0.991 (0.012)
constant	2.500 (0.120)	4.140 (0.234)	0.333 (0.035)
π_t	1.681 (0.079)	0.875 (0.139)	0.137 (0.030)
gap_t	0.033 (0.095)	0.192 (0.134)	0.056 (0.013)
ex_t	-0.017 (0.018)	-0.090 (0.020)	-0.008 (0.003)
σ	1.272 (0.084)	0.975 (0.084)	0.123 (0.011)
Log-likelihood	-194.16	-49.58	
MSC	515.861	259.585	

Notes: Estimated by the MLE assuming the error term are normally distributed with mean 0 and variance σ^2. The dependent variable is the average overnight call rate. Numbers in the parentheses are standard errors. *gap* is the GDP gap, which is measured as the deviation from the Hodrick-Prescott trend. *ex* is the deviation of the real effective exchange rate from its Hodrick-Prescott trend. MSC reports the value of Markov switching criteria proposed by Smith, Naik, and Tsai (2006).

Figure 1. Budget Deficit and Government Debt: Fiscal 1993 to 2011



Source: OECD Economic Outlook 87 database. Annex Table 27.

Figure 2. Budget Surplus for Selected OCED Countries (% of GDP)

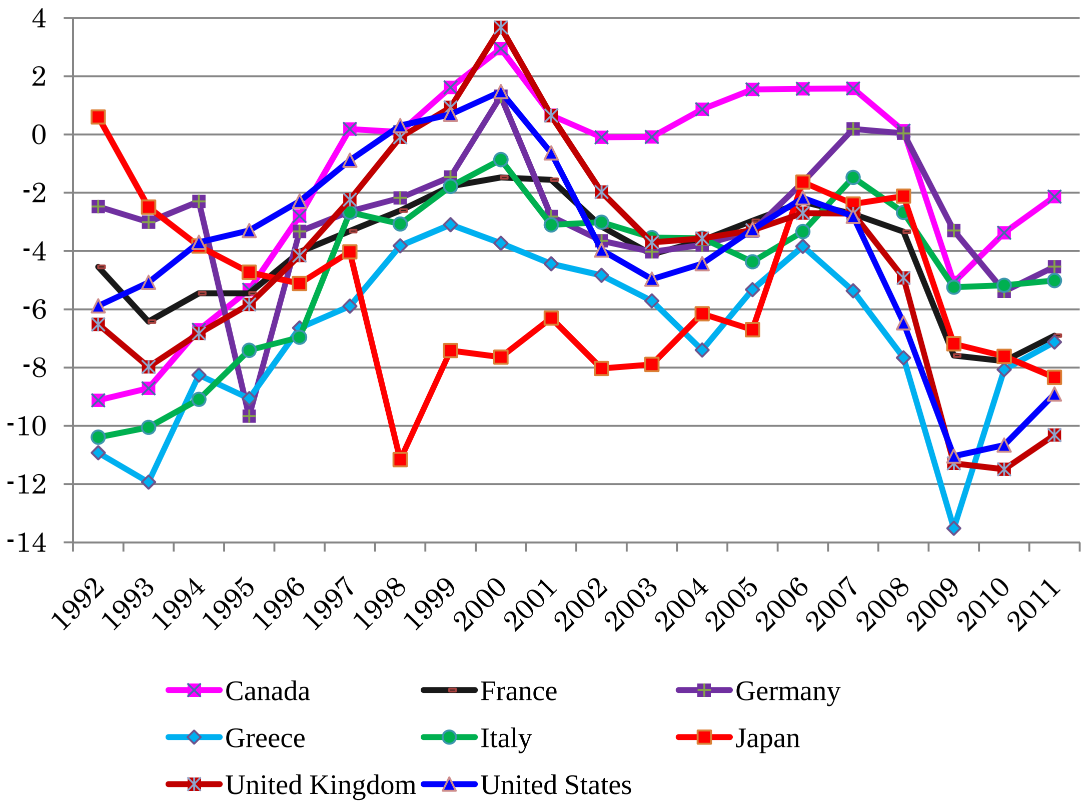


Figure 3. Gross Government Debt of Selected OECD Countries (% of GDP)

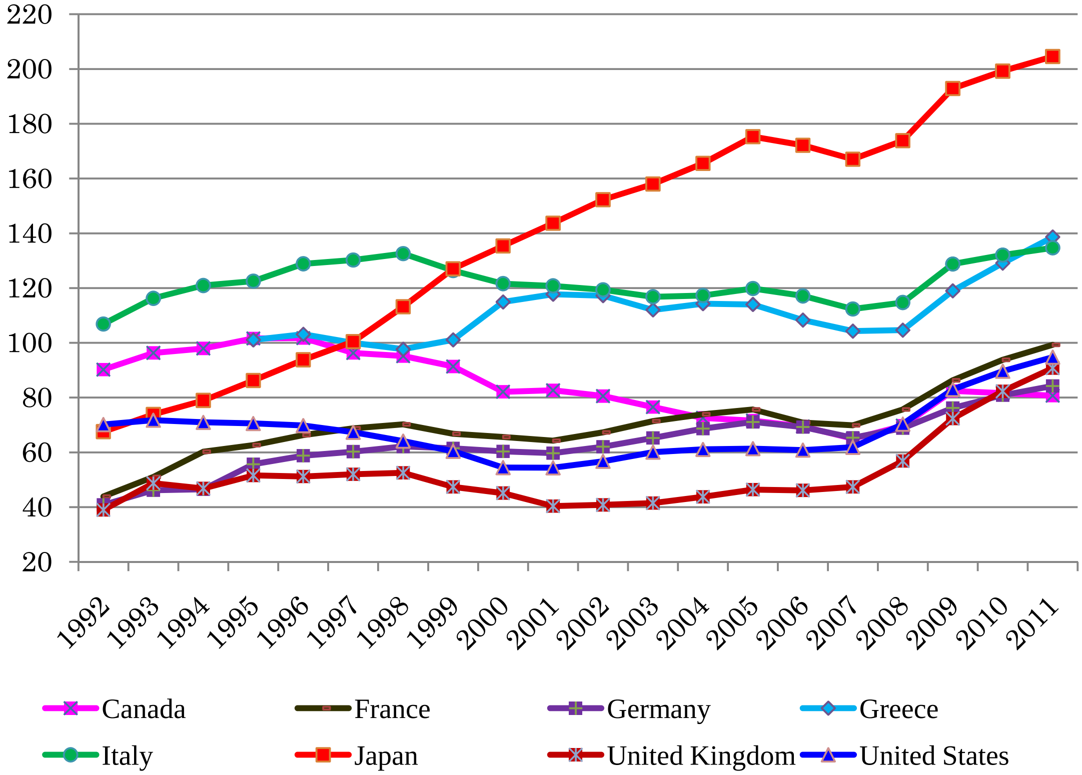


Figure 4. Net Debt for Selected OECD Countries (% of GDP)

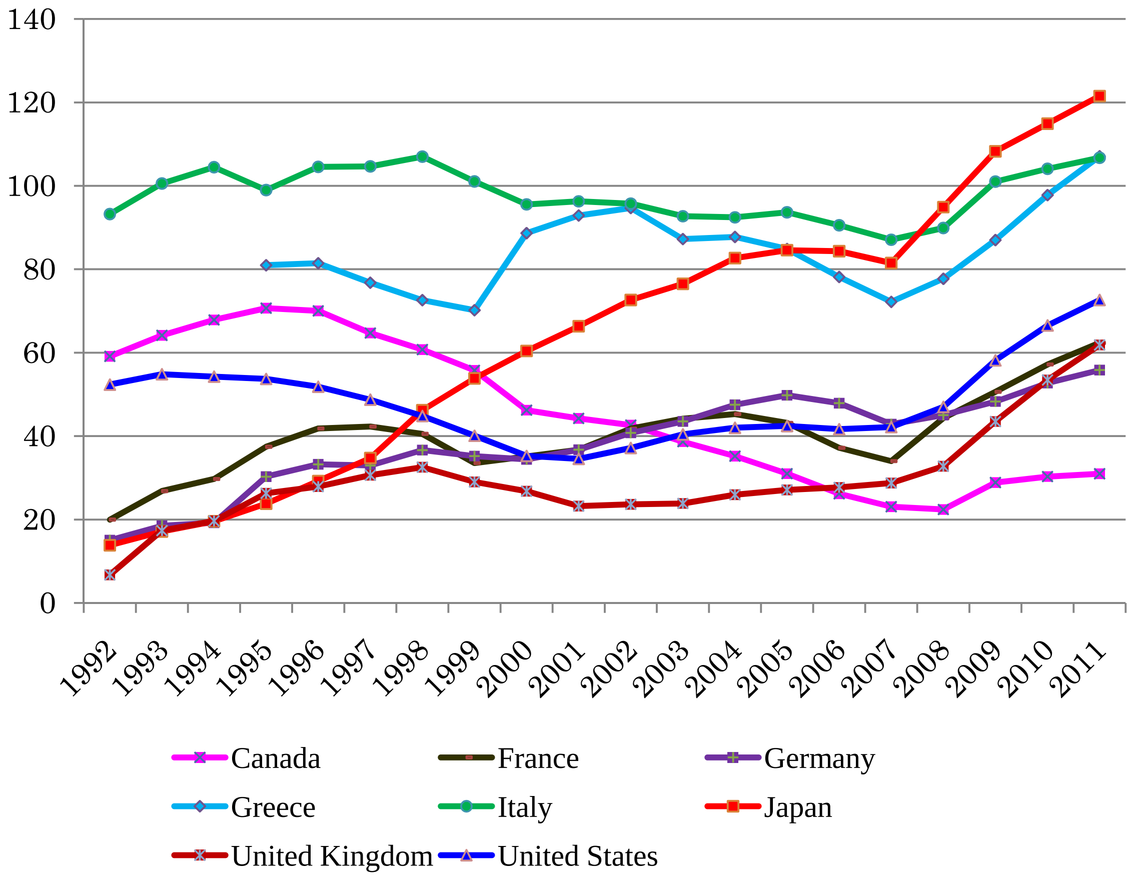


Figure 5. Gross Debt, Net Debt, and Adjusted Net Debt for General Government sector (4 quarters moving average, % of GDP)

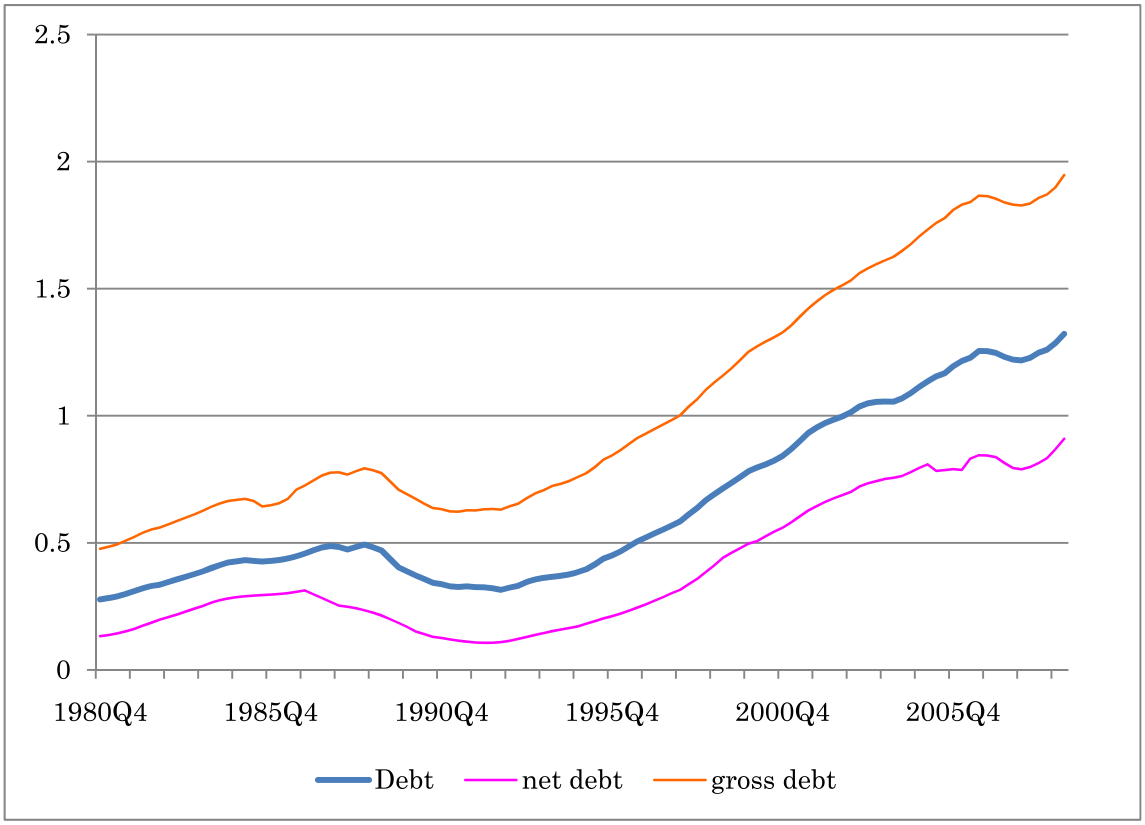


Figure 6. Gross Debt, Net Debt, and Adjusted Net Debt for Central/Local Governments (4 quarters moving average , % of GDP)

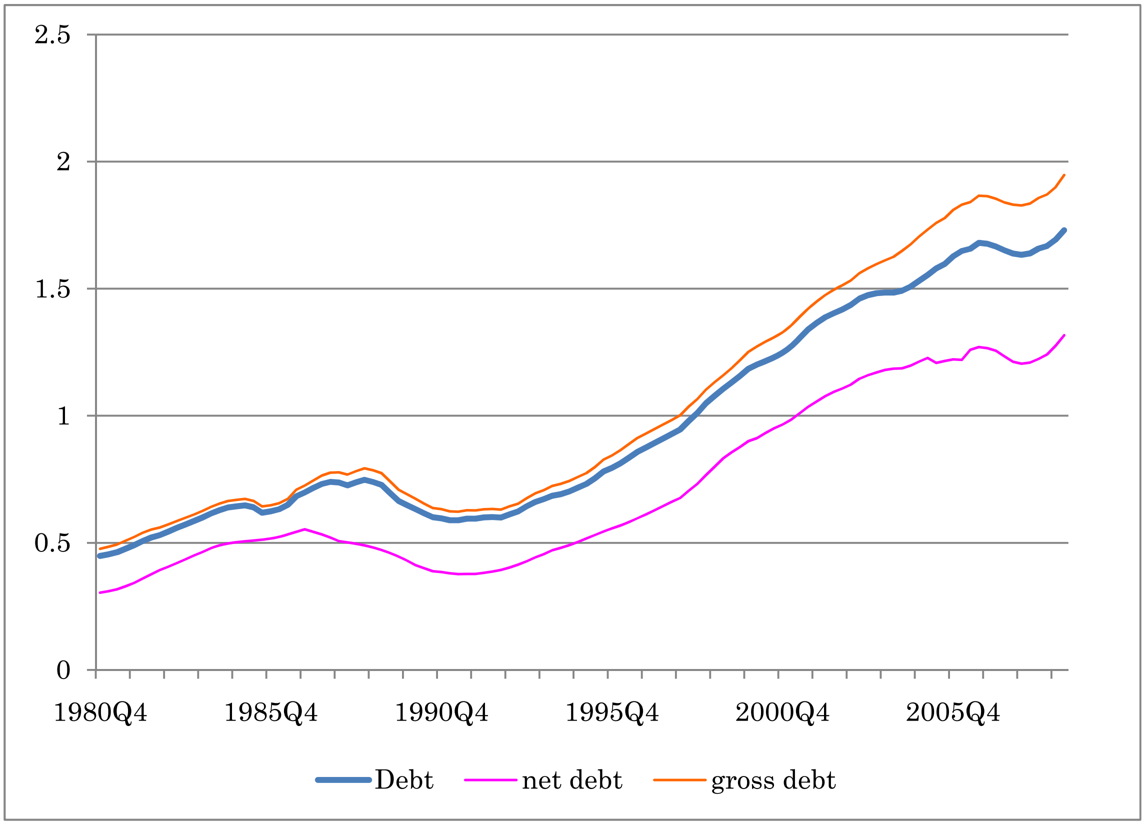


Figure 7. Government Revenue and Expenditure for General Government Sector (% of GDP)

Figure 8. Government Revenue and Expenditure for Central/Local Governments (% of GDP)

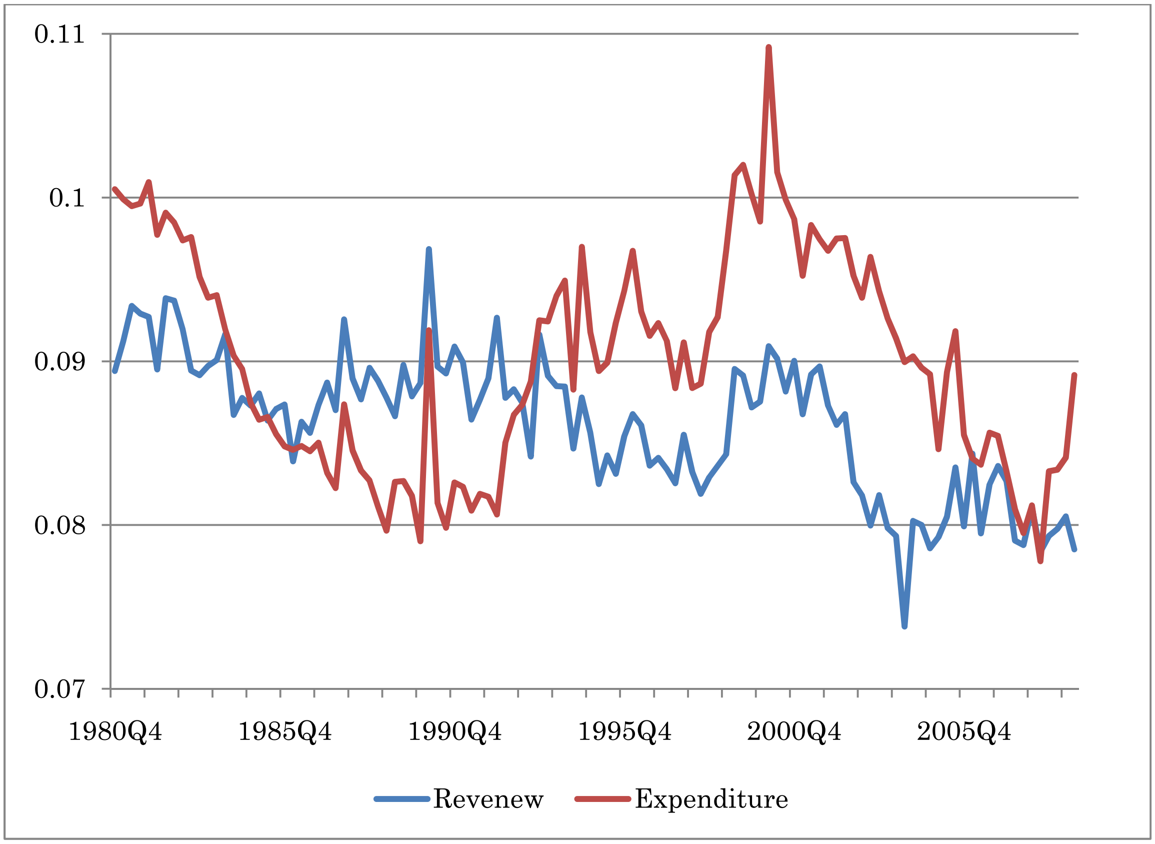
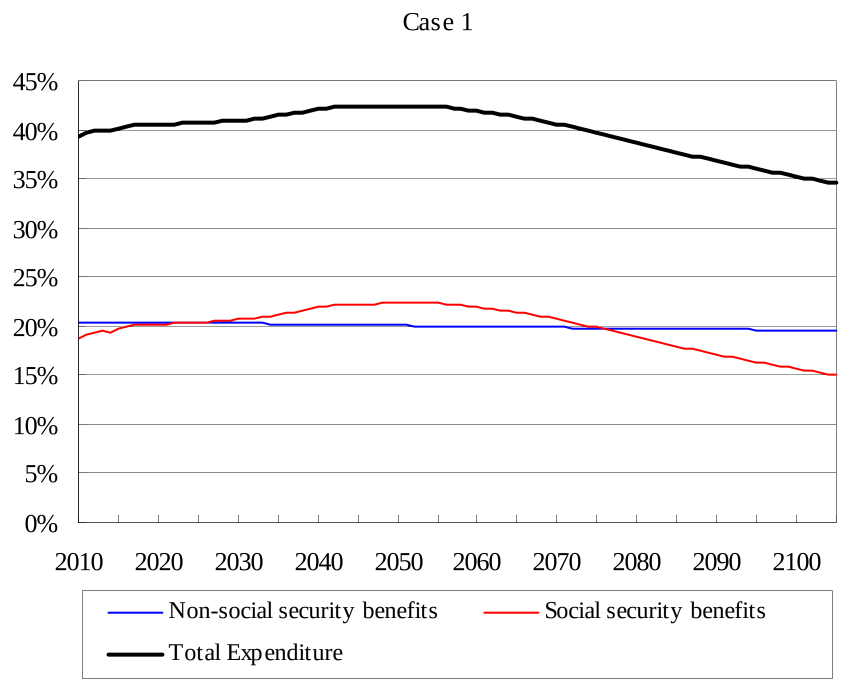
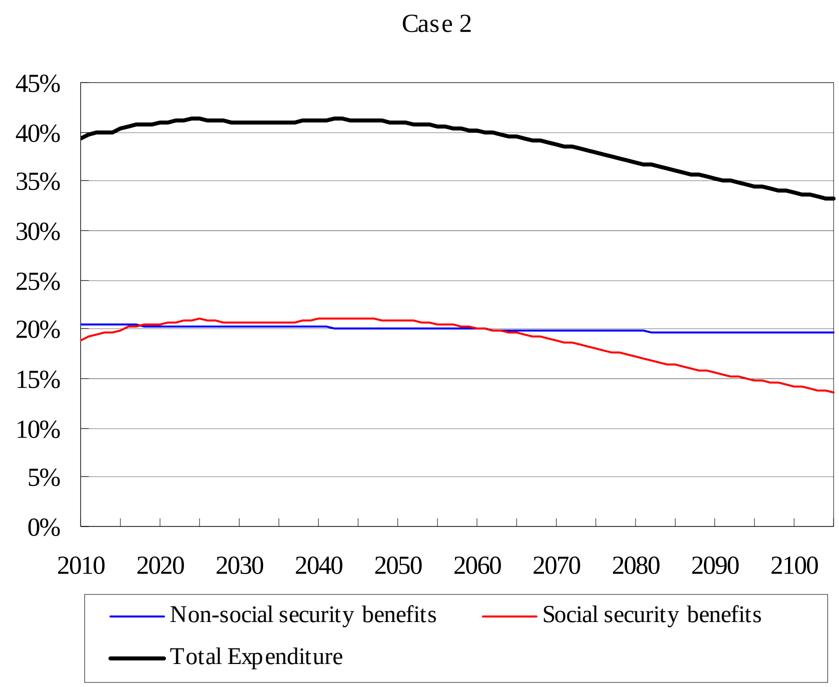


Figure 9. Future Government Expenditures





Case 3

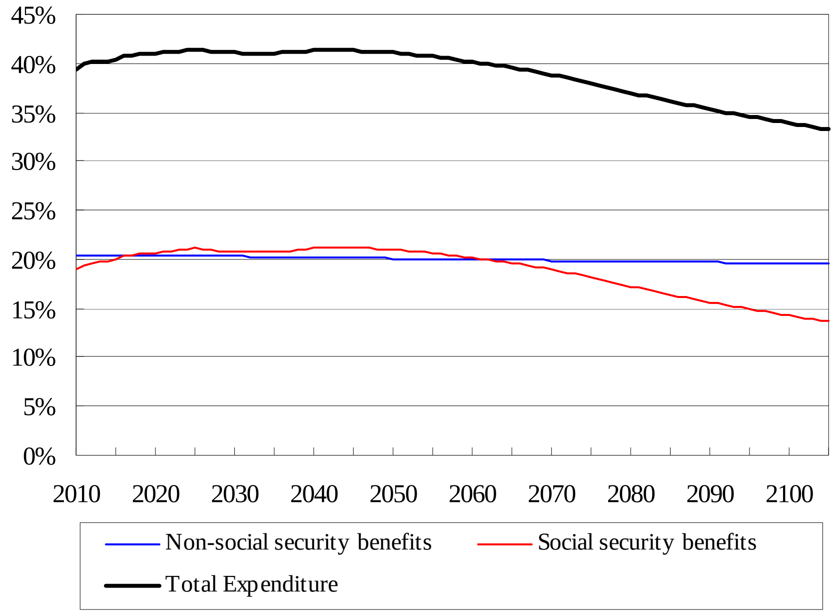

45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Non-social security benefits
Social security benefits
Total Expenditure

Figure 10. Primary Surplus under Each Scenario (with tax increases to τ*)

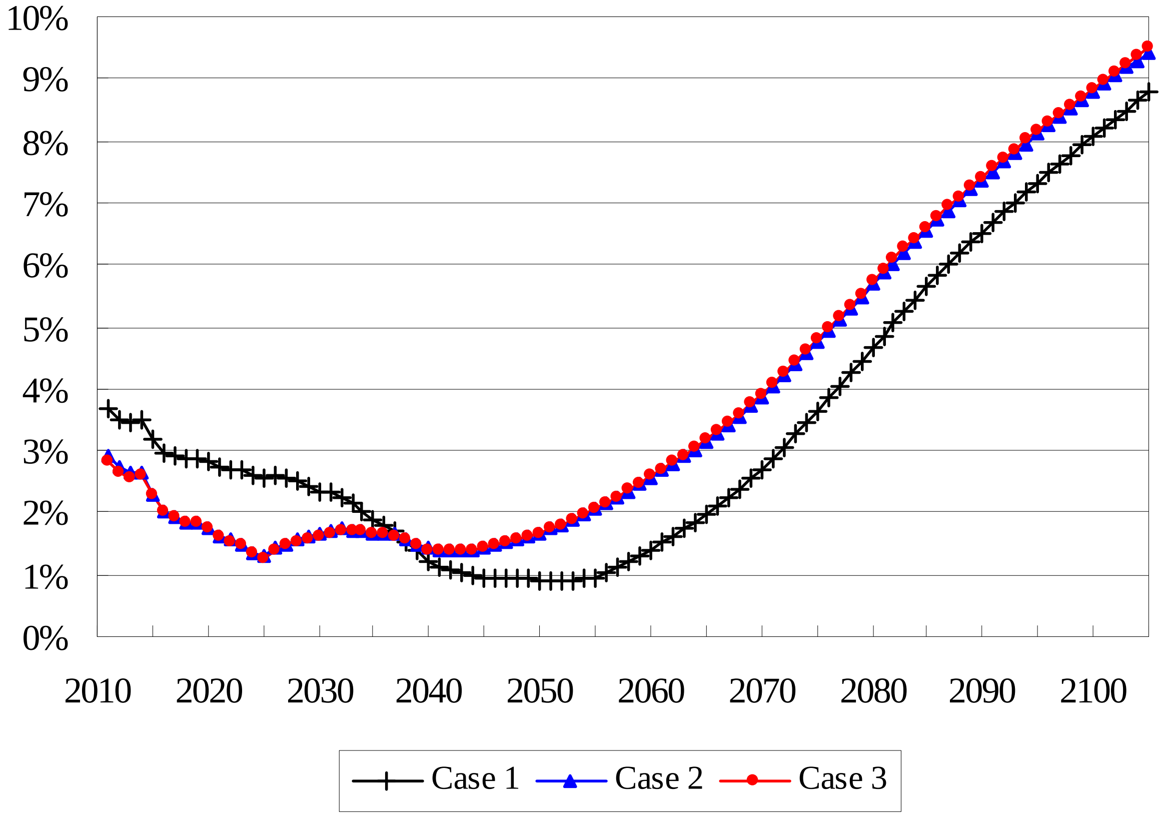


Figure 11. Adjusted Net Debt to GDP Ratio under Each Scenario

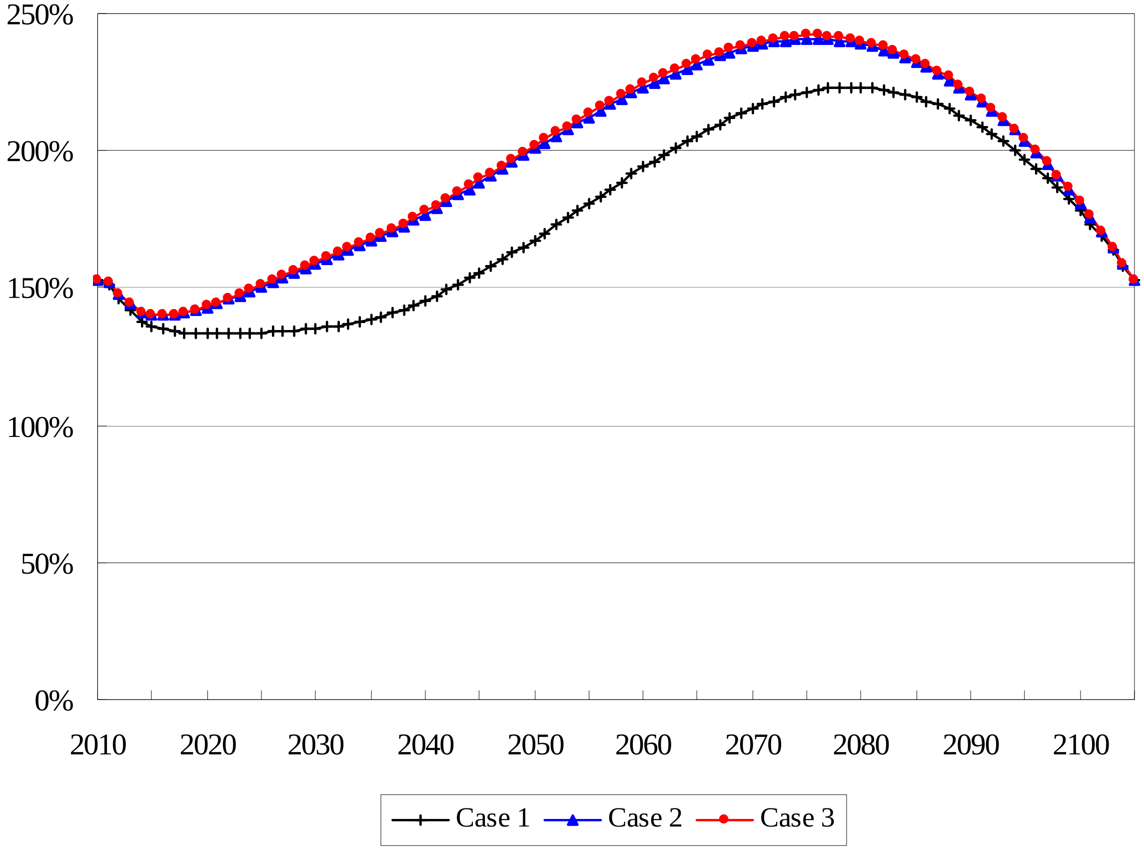


Figure 12. Primary Balance and Adjusted Net Debt as a Percentage of GDP: 1980-2009

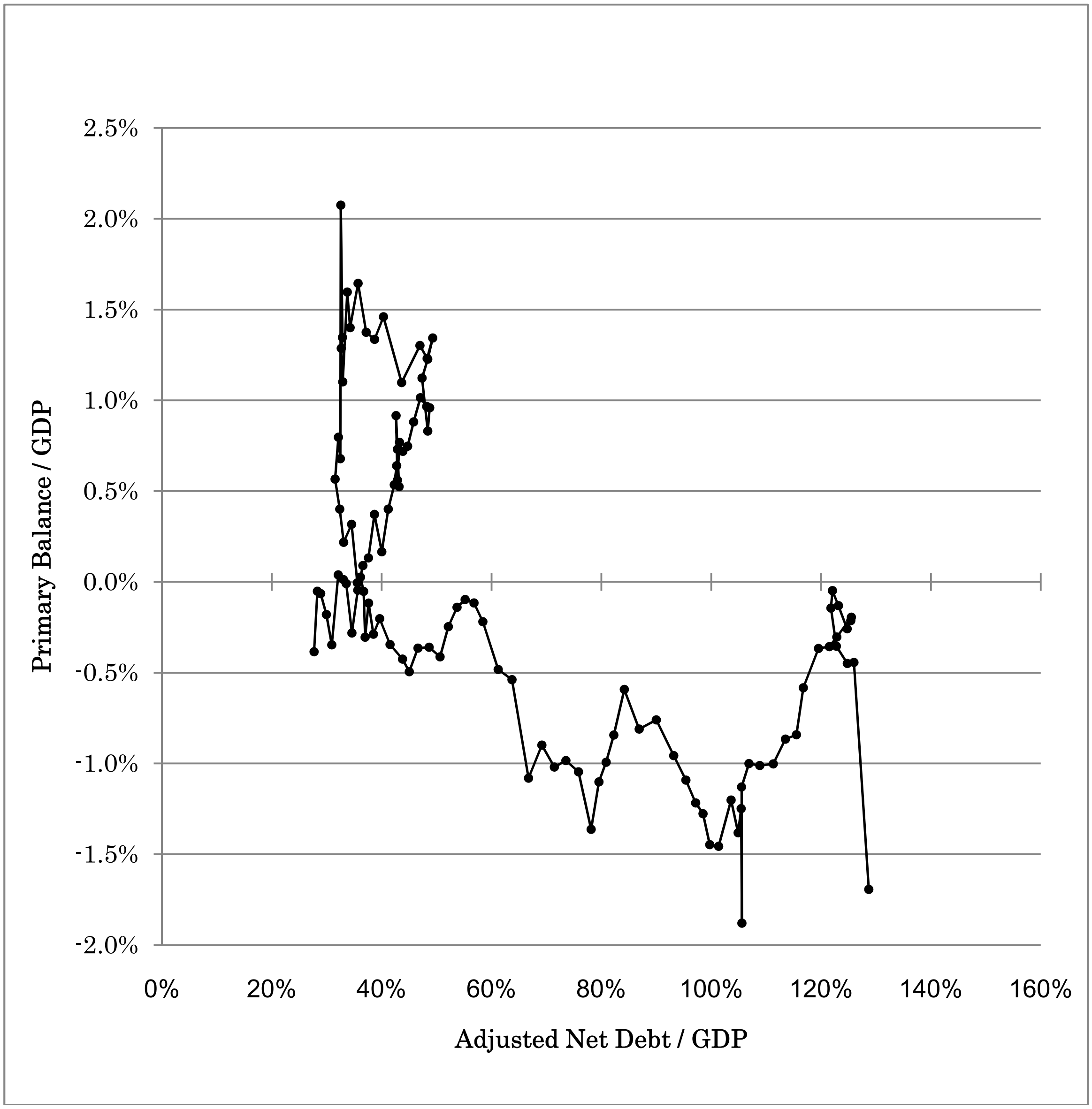


Figure 13. Smoothed Probability of Regime 1 for the Model 1

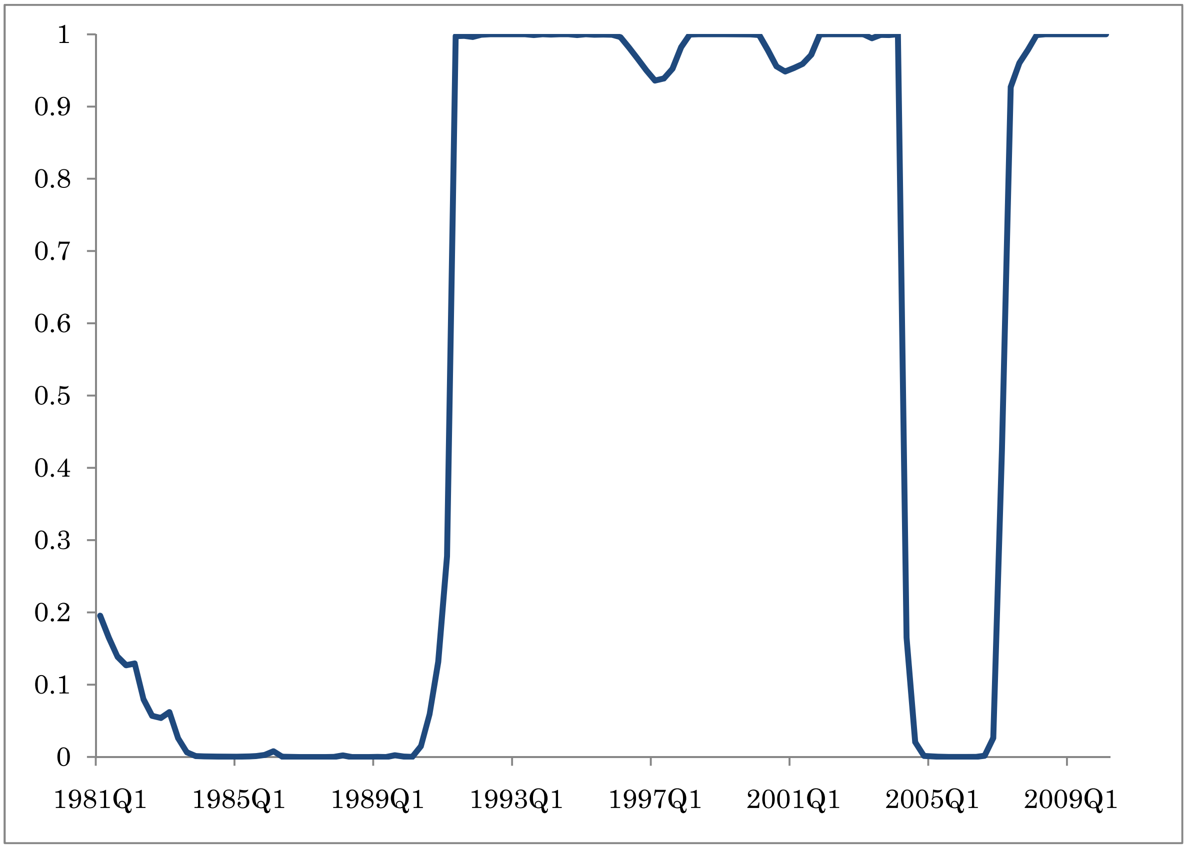


Figure 14. Smoothed Probability of Regime 1 for the Fiscal Policy Function of General Government Sector

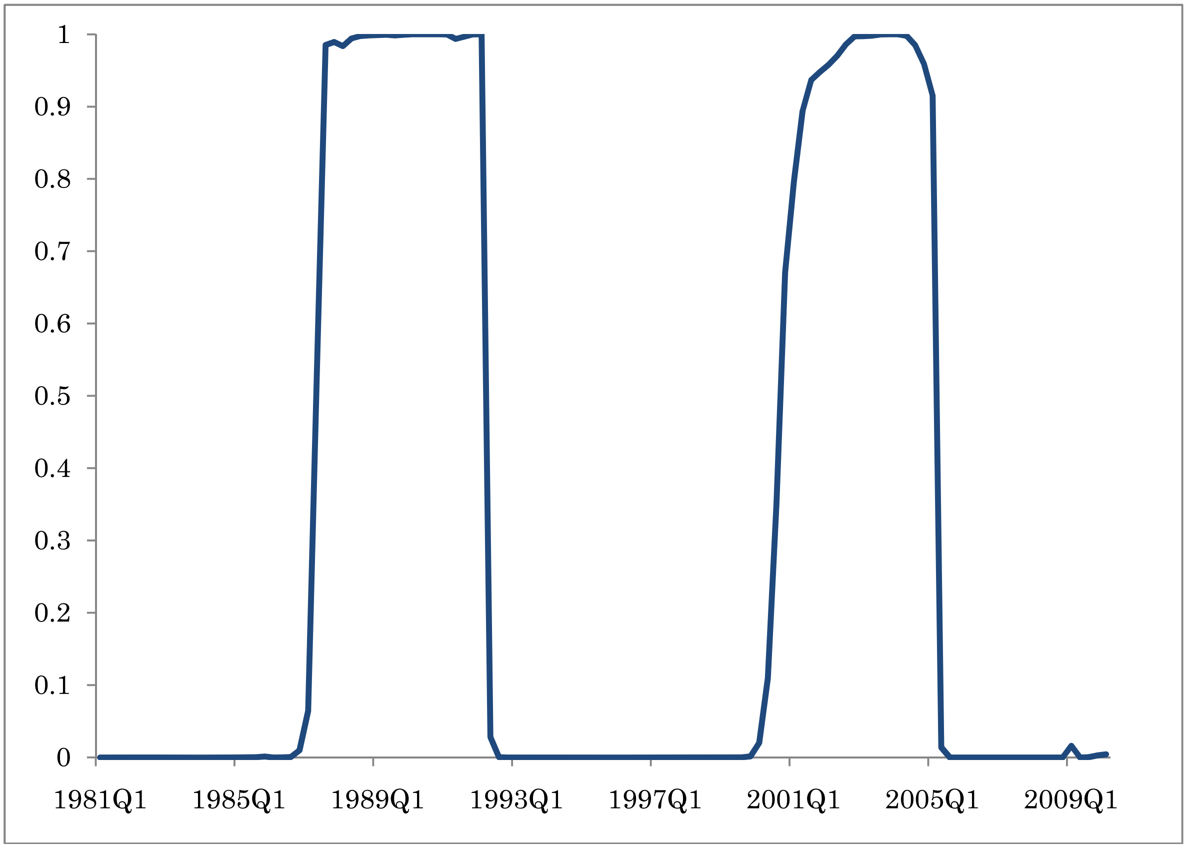


Figure 15. Smoothed Probability for Regime 1 for the Monetary Policy Equation