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Determinants of Long-term Yields: A Panel Data Analysis of Major Countries and Decomposition of Yields of Japan and the US

Hibiki Ichiue*
hibiki.ichiue@boj.or.jp

Yuhei Shimizu**
yuuhei.shimizu@boj.or.jp

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Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* Monetary Affairs Department
** Monetary Affairs Department

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Hibiki Ichiue† and Yuhei Shimizu‡

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† Monetary Affairs Department, Bank of Japan (E-mail: hibiki.ichiue@boj.or.jp)

‡ Monetary Affairs Department (currently Financial System and Bank Examination Department), Bank of Japan (E-mail: yuuhei.shimizu@boj.or.jp)

Abstract

This paper examines the determinants of long-term bond yields through a panel data analysis of forward rates in 10 developed countries. We confirm that in addition to inflation expectations and the labor productivity growth rate, which influences the natural rate of interest, fiscal conditions, foreign borrowing, and demographics significantly influence long-term yields. The following are our main findings. First, for fiscal conditions, stock variables have greater explanatory power than a flow variable (primary balance). For stock variables, net government debt has greater explanatory power than gross government debt. Second, for foreign borrowing, net foreign debt, a stock variable, has greater explanatory power than current account balance, a flow variable. When an increase in government debt is financed entirely by borrowing from external sources, the increase in the forward rate is approximately twice that when financed domestically. Third, aging contributes to lowering yields. This appears to reflect elderly people's strong demand for financial assets, particularly for safety assets. Using the parameter values estimated by the panel data analysis, we decompose the forward rates of Japan and the US into the contributions of each independent variable. In Japan, while the increase in government debt has exerted upward pressure on yields, the outlook for rapid aging resulting from the retirement of baby boomers and the increase in net foreign assets have contributed to lowering yields. In the US, since 2000, aging resulting from the retirement of baby boomers has been reflected in bond prices, which has exerted downward pressure on yields.

Keywords: Long-term interest rates, Fiscal conditions, Foreign debt, Demographics

1. Introduction

Japan's fiscal balance has been in deficit for approximately 20 years following the bursting of the bubble economy. The gross government debt-to-GDP ratio is more than 200%, which is the highest among developed countries. Nevertheless, Japan's long-term government bond yields have been low and stable; this seems to be "an important puzzle" (Krugman, 2011). Certain cross-country studies that compare the relationship between fiscal conditions and long-term interest rates treat Japan as an outlier or exclude Japan's data from their analysis.[1]

On the other hand, some argue that low dependency on foreign borrowing has contributed to Japan's low interest rates. However, according to an increasing number of views, if the current account surplus shrinks or if the balance falls into the red because of a drop in savings accompanying progressive aging, it will be difficult to sell government bonds to domestic investors, which will push up interest rates.

Although various determinants of long-term interest rates are suggested as evident from the above discussion, to the best of our knowledge, no study comprehensively examines the determinants on the basis of international comparison. In this paper, we investigate the effects of variables related to fiscal conditions, foreign borrowing, labor productivity, demographics, and inflation by employing a panel data analysis for 10 developed countries. Following several earlier studies, including Laubach (2009), we use a long-term forward interest rate as the dependent variable for the panel data analysis. This can mitigate endogeneity bias, since business cycles barely influence forward rates, as will be discussed subsequently.[2] In order to be consistent

[1] For example, Alper and Forni (2011) consider Japan's gross government debt-to-GDP ratio to be an outlier and exclude Japan's data from their panel data analysis. OECD (2011) assumes that for every additional percentage point increase in the government debt-to-GDP ratio, the long-term interest rate increases by only 1 bps in Japan for no evident reason, while it increases by 4 bps in other countries drawing on the findings in the literature.

[2] Endogeneity bias arises when some independent variables are correlated with the error term in a regression model. Typically, when both the dependent variable and some independent variables are caused by another variable, or when the dependent variable causes some independent variables, a correlation between the independent variables and the error term is nonzero and an endogeneity bias arises. For example, when we use a naive regression that explains a long-term interest rate by fiscal conditions, appropriate estimates may not be obtained since business cycles may cause both the fiscal conditions and the long-term interest rate, or there may be reverse causality from the long-term

with the dependent variable, the long-term forward rate, we utilize forecasts such as those published by Consensus Forecasts and those of the OECD as the independent variables to the utmost extent. Further, we use the estimated parameters to decompose the past time variations of forward rates of Japan and the US into the contributions of each independent variable.

According to our analysis, Japan's long-term forward rate has faced upward pressure resulting from the increase in government debt since the 1990s. However, various factors have caused the forward rate to decrease: decreases in the expected inflation rate and the expected labor productivity growth rate, the outlook for rapid aging associated with the retirement of the "*dankai* generation"—Japan's post-war baby boomers, and the accumulation of net foreign assets. In the US, future population aging associated with the retirement of baby boomers has been reflected in bond prices since 2000. This, as well as the decrease in the expected inflation, has lowered the forward rate.

The remainder of this paper is organized in the following manner. Section 2 discusses the possible determinants of long-term interest rates and provides an overview of our panel data analysis. Section 3 presents the estimation results. Section 4 decomposes the forward rates of Japan and the US into the contributions from each independent variable. Section 5 presents the conclusion.

2. Determinants of Long-term Interest Rates and Overview of Panel Data Analysis

We study the long-term interest rates of 10 developed countries: Japan, the US, the UK, Germany, Canada, Norway, Sweden, Switzerland, Australia, and New Zealand.[3] Euro-zone countries other than Germany are omitted for the following reason. As shown in Figure 1, during the period from the introduction of the euro until the emergence of

interest rate to the fiscal conditions.

[3] We follow Wright (2011) in the choice of these 10 countries. Wright (2011) focuses on the effects of inflation uncertainty on long-term interest rates, but does not study the effects of fiscal conditions, foreign borrowing, productivity, and demographics.

the European debt problem, the long-term interest rates of peripheral countries converged on that of Germany, although in retrospect those were obviously mispriced. Thus, if we used the data for peripheral countries, the parameter estimates could be biased.

In our panel data analysis, we employ the 5-to-10-year forward rate as the dependent variable. In the literature on the determinants of long-term interest rates, employing a yield-to-maturity, such as the 10-year yield, used to be a general practice. However, this practice is likely to make the endogeneity problem serious. For example, since a decrease in interest rates—mainly in the short term—and the deterioration of fiscal conditions occur simultaneously in a recession, the upward effects of fiscal deterioration on interest rates are underestimated. Thus, we use long-term forward rates, which are not susceptible to business cycles.[4]

As independent variables, we employ five classes of variables: fiscal conditions, foreign borrowing, labor productivity, demographics, and inflation. In order to be consistent with the dependent variable, the long-term forward rate, we use forecasts by economists and international organizations as the independent variables to the utmost extent.[5]

Among the five classes of independent variables, labor productivity and demographics are employed mainly to detect changes in the natural rate of interest. According to the standard theory, the natural rate of interest is determined by the growth rate of real GDP per total population.[6] This can be decomposed into the growth rate of real GDP per working-age population and the growth rate of the working-age

[4] Following Laubach (2009), many studies use forward rates. While Laubach (2009) analyze time-series data for the US, we study panel data for developed countries.

[5] Many empirical studies find that forecasts of fiscal conditions explain long-term interest rates better than their actual values (Gruber and Kamin, 2010). This result appears to be natural considering that financial market participants decide to hold government bonds while forecasting fiscal conditions.

[6] In the standard theory, the utility function of each household depends on the consumption per household member. This is why the natural rate of interest is determined by "the growth rate of real GDP per total population" rather than "the real GDP growth rate" or "the growth rate of real GDP per working-age population."

population ratio, which we use as the independent variables related to labor productivity and demographics, respectively. If the economy were as simple as it is in theory, this decomposition would be unnecessary. However, demographics may influence long-term interest rates not only through the natural rate of interest, but also through other channels, including the composition of the demand for financial assets, as we discuss subsequently. Therefore, we estimate the effects of these variables separately.

In the following account, we discuss each class of variables in terms of how they influence long-term interest rates and what specific variables we employ in the panel data analysis (see the appendix for the data sources).

Fiscal Conditions

Numerous studies in the literature empirically show that the deterioration of fiscal conditions raises long-term interest rates. The literature mainly suggests two channels through which fiscal conditions influence long-term interest rates: crowding out and default risk. Through the first channel, greater government funding leads to a smaller fund supply for private agents, which results in a higher long-term interest rate. Through the second channel, as fiscal conditions are more strained, the probability of government default is higher and investors require a larger premium to compensate for the risk, which leads to a higher interest rate.[7]

There are two issues with regard to the choice of fiscal variables. The first issue is whether stock variables (i.e., government debt) or flow variables (e.g., fiscal deficits) influence long-term interest rates. Theoretically, stock variables do, but flow variables do not (Engen and Hubbard, 2004). However, if flow variables are persistent, they may provide useful information for forecasting future stock variables. In fact, the fiscal deficit-to-GDP ratio, a typical flow variable, is persistent (Laubach, 2009).

The second issue is whether gross or net government debt is of significance for determining interest rate; theoretically, net debt is important. For default risk, if the

[7] Fiscal deterioration may cause long-term interest rates to increase through inflation expectations. However, the literature does not support this (Gruber and Kamin, 2010). This is possibly because fiscal deterioration also functions as disinflationary pressure through expectations for tax hikes.

financial assets held by the government can be used to repay debts, it is appropriate to consider that the effects of default risk are determined by net debt, which is calculated by offsetting those assets. On the other hand, some argue that since the financial assets held by the government are not necessarily highly liquid, using gross government debt leads to a more robust analysis.

In light of the above discussion, we use the ratios of three fiscal variables to GDP: net government debt, gross government debt minus net government debt, and primary balance.[8] We use primary balance as the flow variable because using fiscal balance, which includes interest payments and thus tends to be caused by interest rates, could cause an endogeneity bias.[9]

Figures 2 and 3 show the OECD forecasts for government debt and primary balance for 2013, respectively. According to these figures, in all fiscal variables—the gross and net debt and the primary balance—Japan is the worst among the 10 countries in our sample.

Foreign Borrowing

Some people claim that the effects of government debt on long-term interest rates are dependent on funding sources: domestic or foreign investors. According to this argument, when a country depends less on foreign borrowing, long-term interest rates are lower, since investors more firmly form the perception that the government has a strong incentive to avoid defaulting for the following reasons.[10]

[8] Both net and gross debt are highly correlated. Thus, if we include both these variables in the regression without any modifications, we are likely to obtain biased standard errors due to multicollinearity. Therefore, we employ net debt and gross debt minus net debt as independent variables. As will be shown, the coefficient of net debt is statistically significant, while that of gross debt minus net debt is not. This suggests that net debt significantly explains the forward rate, while gross debt does not provide additional information.

[9] A rise in interest rates accompanying an increase in the interest payment is likely to cause fiscal balance to deteriorate. Thus, if we used fiscal balance in the regression, the estimate would reflect not only the upward effects of the deterioration of fiscal balance on interest rates but also reverse causation. This would be a source of endogeneity bias and the estimate would overestimate the effects of fiscal balance on interest rates.

[10] The views expressed here are based on the discussion in Gros (2011).

When the government depends less on foreign borrowing and domestic investors hold a larger share of government bonds, the losses of its citizens are larger in the case of government default. In addition, if domestic banks hold large amounts of government bonds, the losses are even larger because of unease over the financial system. In such a situation, obtaining political support for a government default is considered more difficult, while that for a tax increase to avoid a default is considered easier. Thus, the government's incentive to choose a tax increase rather than a default becomes stronger.[11] In contrast, since only a small number of people stand against the losses of foreign investors due to a government default, the probability that the government will choose to default is considered higher when foreign investors have a larger share of government bonds.

With regard to foreign borrowing, some people consider current account balance, a flow variable, in addition to net foreign debt, a stock variable. This is because current account balance may provide useful information for forecasting net foreign debt. Therefore, we employ the ratios of both net foreign debt and current account balance-to-GDP as independent variables.[12]

Figure 4 shows the net foreign debt-to-GDP ratio of the countries in our sample. According to this figure, four countries, including Japan, Germany, and Switzerland, are net creditors, while the other six countries, including the US and the UK, are net debtors. Figure 5 compares the OECD forecasts for the current account balance-to-GDP ratio for 2013 and shows that six countries, including Japan, Germany, and Switzerland, are forecasted to register a current account surplus.

[11] Gennaioli, Martin, and Rossi (2011) use a theoretical model to show that default is less likely in countries where the ratio of banks' claims to the government to their total assets is higher. They also support this result using panel data analysis.

[12] The gross foreign debt-to-GDP ratio tends to be higher in countries that are more dependent on the financial sector, such as the UK and Switzerland. This is because these countries expand both their assets and debts as they play the role of financial intermediaries. Since the assets held can be used to repay debts, gross foreign debt is not necessarily an appropriate measure for assessing default risk. Therefore, we use net foreign debt.

Labor Productivity

According to the standard theory, an increase in the labor productivity growth rate has upward effects on interest rates. Therefore, we employ a forecast of the annualized growth rate of labor productivity 6–10 years ahead as an independent variable.

As shown in Figure 6, Japan's expected growth rate of labor productivity has exhibited a downward trend and has decreased from almost 4% to almost 2% since the bubble economy burst. On the other hand, in the US, the expected growth rate of labor productivity has increased from around 1% to slightly more than 2%. As of 2011, there is not much difference among the countries in our sample.

Demographics

Demographics can have various effects on long-term interest rates. For example, population aging lowers the marginal productivity of capital and reduces investment demand through a decrease in the labor supply. Thus, aging can put downward pressure on interest rates.

On the other hand, some adopt the view that aging contributes to increasing long-term interest rates. According to the life cycle hypothesis, individuals begin to spend their savings after retirement. Thus, a decrease in the savings rate due to population aging can lead to a rise in long-term interest rates.[13] However, the literature does not necessarily support the view that population aging leads to a decrease in the amount of assets held by households. In fact, as shown in Figure 7—which shows net financial assets by age group in Japan and the US—the average amount of financial assets held by the households whose heads are aged 70 and over appears to be larger than that held by other households. The literature presents several hypotheses for this, including strong bequest motives.[14] Given that the average amount of financial assets

[13] Population aging also has upward effects on long-term interest rates through expectations for fiscal deterioration caused by declining tax revenues and increasing social security benefits. We believe that those effects are controlled for since we also employ forecasts of government debt as independent variables in the regression.

[14] See Hassan, Salim, and Bloch (2011), who survey these hypotheses in detail. De Nardi, French,

held by the elderly is larger than that held by other age groups in both Japan and the US, the demand of households for financial assets may increase as the population continues to age. Moreover, even if the demand for assets decreases, as suggested by the life cycle hypothesis, it is possible that the demand will decrease mainly in risk assets, including stocks, and that the demand for safety assets, including government bonds, will not decrease.[15]

We employ a 6-to-10-year-ahead forecast of the annualized growth rate of the working-age population ratio as the proxy of population aging. The left upper panel of Figure 8 plots the evolution of this variable for Japan and shows that the forecasted declining rate widened from the 1990s to around 2005, which reflected that the *dankai* generation would reach 65 years of age in 6–10 years. Since then, the expected pace of aging has slowed, given that the elderly are defined as the population aged 65 years and over. As of 2011, the 6-to-10-year-ahead forecasts of the growth rate of working-age population ratio are similar among many countries, including Japan.

Inflation

Inflation may influence nominal interest rates through two channels: the level of the inflation rate itself and inflation uncertainty, which influences nominal interest rates through risk premiums.

Figure 9 depicts the 6-to-10-year-ahead survey forecast of the annualized inflation rate published by Consensus Forecasts and shows that the forecast for Japan is the lowest. Figure 10 shows the standard deviation of individual forecasts of next-year inflation as a measure of inflation uncertainty. According to this figure, there is not

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and Jones (2009, 2010) use theoretical models to show that a considerable part of elderly people's saving behavior can be explained by uncertainty in lifespan and preparation for medical expenses.

[15] In general, prices of risk assets, including stocks, tend to fluctuate greatly in the short run. In the long run, it is expected that acceptable returns will be earned by holding these assets. However, since the life expectancy of elderly people appears to be too short to benefit from risky assets, they may prefer safety assets. In this regard, Poterba (2001) examines US household data and finds that corporate stock as a share of net financial assets declines after heads of households attain retirement age.

much difference in inflation uncertainty among Japan, the US, the UK, and Germany.[16] We use these two variables—the 6-to-10-year-ahead forecast of the inflation rate and the standard deviation of individual forecasts of next-year inflation—as independent variables in the panel data analysis.

3. Estimation Results

The following are the specifications of our panel data analysis:

$$
\begin{aligned}
&Forward\ rate_{i,t} \\
&= a \times Net\ government\ debt_{i,t}/GDP_{i,t} \\
&+b \times \left(Gross\ government\ debt_{i,t} - Net\ government\ debt_{i,t}\right)/GDP_{i,t} \\
&+c \times Primary\ balance_{i,t}/GDP_{i,t} \\
&+d \times Net\ foreingn\ debt_{i,t}/GDP_{i,t} \\
&+e \times Current\ account\ balance_{i,t}/GDP_{i,t} \\
&+f \times Labor\ productivity\ growth\ rate_{i,t} \\
&+g \times Working\text{-}age\ population\ ratio\ growth\ rate_{i,t} \\
&+h \times Inflation\ expectation_{i,t} \\
&+k \times Standard\ deviation\ of\ inflation\ expectation_{i,t} \\
&+Constant + Fixed\ effect_i + Residual_{i,t}.
\end{aligned}
$$

Following numerous studies in the literature, country fixed effects are included to control unobserved country-specific factors. The data are annual over the period 1990–2010, given the availability of independent variables.

According to the Fischer equation, an increase of one percentage point in expected inflation rates leads to an increase of one percentage point in the corresponding long-term interest rates. However, some argue that an increase in long-term expected inflation rates also leads to an increase in term premiums, mainly due to increasing long-run inflation uncertainty (Laubach, 2009).[17] Therefore, we

[16] Wight (2011) uses an essentially identical standard deviation of inflation forecasts.

[17] Many empirical studies, including Ball, Cecchetti, and Gordon (1990), support the existence of a

conduct two regressions: the first one does not impose a restriction on h, the parameter related to the expected inflation rate, while the second imposes the restriction $h = 1$.

The following results are evident from the estimation results presented in Table 1. First, for fiscal variables, only the coefficient of net government debt is statistically significant, while that of gross government debt minus net government debt is not. This suggests that net government debt is superior to gross government debt in explaining the forward rate. The coefficient of primary balance is insignificant as well.

Second, for foreign borrowing, the coefficient of net foreign debt is significant, while that of current account balance is not.[18] The coefficient of net foreign debt is estimated to be similar to that of net government debt. This suggests that when an increase in government debt is financed entirely by borrowing from external sources, which leads to identical increases in government and foreign debt, the increase in the forward rate is approximately twice that when financed domestically.

Third, the labor productivity growth rate has a statistically significant effect. The estimated coefficient is close to one. Thus, an increase in the expected productivity growth rate leads to an increase in the long-term forward rate to a similar extent.

Fourth, the coefficient of the expected growth rate of the working-age population ratio, which is employed as the proxy for demographics, is significantly positive. Thus, when a decline in the working-age population ratio associated with population aging is expected, long-term interest rates face downward pressure. This can be interpreted to reflect various consequences of population aging, including a decline in the marginal productivity of capital (a decrease in investment demand), an increase in households' demand for financial assets, and a shift in asset allocation to safety assets.

Fifth, for expected inflation, only its level has significant effects, while the standard deviation of inflation expectations—the proxy for uncertainty—does not.

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positive correlation between the level and uncertainty of inflation.

[18] We also estimate a regression model that allows asymmetry in the effects of net foreign debt on the long-term forward rate depending on the sign of net foreign debt. However, we find no significant asymmetric effects.

However, it is possible that we find such a low explanatory power because we employ the standard deviation of next-year inflation forecasts published by Consensus Forecasts, whose forecast horizon does not match the horizon reflected in the 5-to-10-year forward rate, the dependent variable. When we do not impose a restriction regarding the coefficient of the inflation rate, $h = 1$, we obtain $h = 1.9$, which is much greater than 1. This can be understood to mean that an increase in the level of inflation rate heightens inflation uncertainty in the long run and that the standard deviation of next-year inflation forecasts cannot fully capture the uncertainty. When we impose the restriction $h = 1$, the estimated coefficient on the standard deviation of inflation forecasts is still insignificant, but is greater than when we do not impose the restriction. This suggests that the inflation rate can provide some information regarding inflation uncertainty.

Finally, Figure 11 shows that the estimated fixed effect for Japan is not a large negative value. In particular, when we do not impose the restriction $h = 1$, the fixed effect is estimated to be very close to zero. This shows that Japan's low interest rates in the past can largely be explained by the independent variables employed in this paper. On the other hand, the fixed effect for the US is the largest negative value. This suggests the possibility that US interest rates are influenced by factors other than the independent variables we employ, such as the high liquidity of the US government bond market or the strong demand for the dollar as the key currency.

4. Decomposition of Interest Rates

This section decomposes the long-term forward rates of Japan and the US into the contributions from each independent variable on the basis of the coefficients estimated without the restriction $h = 1$.[19]

As suggested in Figure 12, Japan's forward rate has faced upward pressure

[19] Even though we use the coefficients estimated with the restriction $h = 1$, the main results do not change; however, there are minor changes, such as some declines in the contributions from inflation-related variables and a change in the contribution from the fixed effect.

because of the increase in government debt since the 1990s. On the other hand, the accumulation of net foreign assets and decreases in the expected inflation rate and expected labor productivity growth rate have contributed to lowering the forward rate. In addition, around 2005, it was expected that the *dankai* generation would be 65 years old in 6–10 years, which would lead to rapid population aging. This demographic factor also contributed to lowering the forward rate.

In the US, as in Japan, the decrease in the expected inflation rate has greatly contributed to the declining trend in the forward rate since the 1990s. In addition, since 2000, the expected future decline in the working-age population ratio resulting from the retirement of baby boomers has been reflected in bond prices. This has also contributed to pushing down interest rates.[20]

Figure 13 decomposes the difference between the forward rates of the US and Japan as of 2011—around 1.5%—into the contributions from each factor or class of variables. The figure shows that the inflation factor and the foreign borrowing factor push up the interest rate of the US compared to Japan. On the other hand, the upward pressure is partially offset by the fiscal factor—the deterioration of the fiscal conditions in Japan relative to those in the US.

5. Conclusion

This paper examines the determinants of long-term forward rates using a cross-country panel data analysis. In addition, based on the parameter estimation results, we decompose the forward rates of Japan and the US into the contributions of each factor.

The following are the main results of the panel data analysis. First, for fiscal indicators, stock variables have greater explanatory power than a flow variable (primary balance). Second, for foreign borrowing, net foreign debt, a stock variable, has greater explanatory power than current account balance, a flow variable. When an increase in

[20] As of 2011, in both Japan and the US, the actual forward rate was lower than predicted by the regression model; the residual is negative. This may reflect the downward pressure on the interest rates resulting from the fund flows into the government bond markets of Japan and the US in reaction to the European debt problem.

government debt is financed entirely by borrowing from external sources, the increase in the forward rate is approximately twice that when financed domestically. Third, population aging contributes to lowering interest rates. This appears to reflect elderly people's strong demand for financial assets, particularly for safety assets. However, it is necessary to bear in mind that our method of uniformly regarding the population aged 65 and over as elderly may not fully capture the saving behavior predicted by the life cycle hypothesis since longevity has increased. Fourth, the fixed effect for Japan is not estimated to be a large negative value. This shows that Japan's low interest rates in the past can largely be explained by the independent variables employed in this paper.

According to the decomposition, Japan's long-term forward rate has faced upward pressure resulting from the increase in government debt since the 1990s. On the other hand, the decreases in the expected inflation rate and the expected labor productivity growth rate, the outlook for rapid aging associated with the retirement of the *dankai* generation, and the accumulation of net foreign assets have contributed to lowering the forward rate. In the US, future population aging associated with the retirement of baby boomers has been reflected in bond prices since 2000. This, as well as the decrease in the expected inflation, has lowered the forward rate.

Although this paper examines various determinants of long-term interest rates comprehensively, some issues are not fully investigated. For example, we do not take into account the possibility of a nonlinear relationship between government debt and long-term interest rates; that is, as government debt continues to increase, the credibility of fiscal sustainability decreases, which leads to a rapid increase in long-term interest rates. Therefore, it is necessary to bear in mind the limitation of our results and address this in future studies.

Data Appendix

Long-term forward rate: The 5-to-10-year forward rate calculated using the year-end 5- and 10-year zero-coupon rates taken from Bloomberg.

Net government debt-to-GDP ratio: The two-year-ahead projection of general government net financial liabilities (percentage of nominal GDP) taken from OECD Economic Outlook.

Gross government debt-to-GDP ratio: The two-year-ahead projection of general government gross financial liabilities (percentage of nominal GDP) taken from OECD Economic Outlook.

Primary balance-to-GDP ratio: The two-year-ahead projection of general government primary balances (percentage of nominal GDP) taken from OECD Economic Outlook up to 2007. It is the sum of the two-year-ahead projections of general government financial balances and general government net debt interest payments from 2008 onward.

Net foreign debt-to-GDP ratio: The year-end net international investment positions taken from IMF International Investment Position divided by the nominal GDP taken from IMF World Economic Outlook with a reversed sign.

Current account balance-to-GDP ratio: The two-year-ahead projection of current account (percent of nominal GDP) taken from OECD Economic Outlook.

Labor productivity growth rate: The 6-to-10-year-ahead forecast of the GDP growth rate taken from Consensus Forecasts minus the 6-to-10-year-ahead expected growth rate of the working-age population (aged 20–64). The expected growth rate of the working-age population is calculated using the actual population up to 2010 and the projection obtained from the United Nations World Population Prospects (the 2010 Revision).[21]

[21] We implicitly assume perfect foresight when we use the actual population. The problem arising from this assumption appears to be small, since the working-age population 6–10 years ahead is highly predictable, unlike the fertility rate. It is the same for the expected growth rate of the total population, which is used to calculate the expected growth rate of the working-age population ratio.

Working-age population ratio growth rate: The 6-to-10-year-ahead expected growth rate of the working-age population ratio minus that of total population. These expected growth rates are calculated using the actual population up to 2010 and the projections obtained from the United Nations World Population Prospects (the 2010 Revision).

Inflation expectation: The 6-to-10-year-ahead projection of the consumer price inflation rate taken from Consensus Forecasts, with an exception: for the UK, prior to 2004, the 6-to-10-year-ahead projection of the retail price inflation rate is linked to that of the consumer price inflation rate by subtracting the difference between them in 2004.

Standard Deviation of Inflation Expectation: The standard deviation of the individual forecasts of year-ahead consumer price inflation taken from Consensus Forecasts, with an exception: for the UK, prior to 2004, the standard deviation of individual forecasts of the year-ahead retail price inflation rate taken from Consensus Forecasts is linked to that of the consumer price inflation rate by subtracting the difference between them in 2004.

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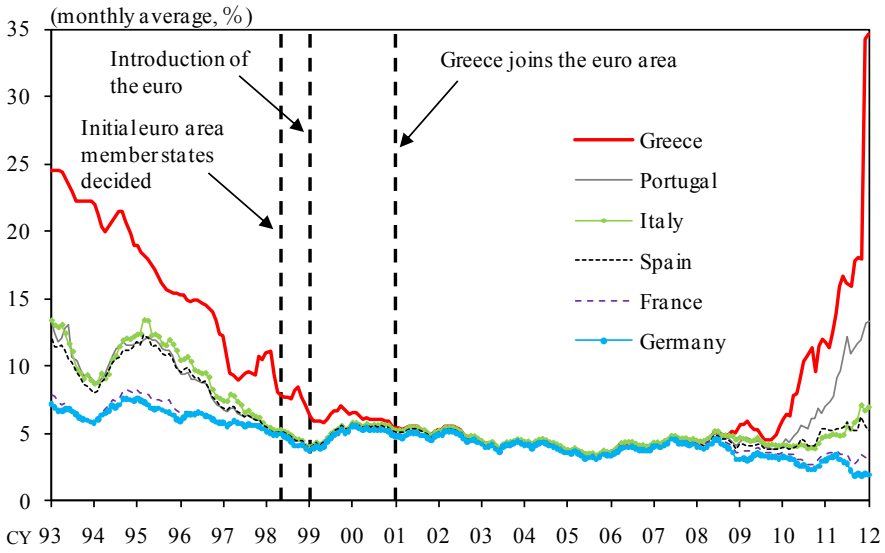
Table 1: Estimation Results

	Without restriction	With restriction
Net government debt/GDP (2 years ahead)	0.016***	0.013**
	(0.005)	(0.005)
(Gross government debt	0.008	0.007
－Net government debt)/GDP (2 years ahead)	(0.006)	(0.006)
Primary balance/GDP (2 years ahead)	-0.012	-0.020
	(0.027)	(0.030)
Net foreign debt/GDP	0.017**	0.016**
	(0.007)	(0.007)
Current account balance/GDP (2 years ahead)	0.005	0.005
	(0.051)	(0.053)
Labor productivity	0.972**	0.915*
growth rate (6-10 years ahead)	(0.398)	(0.473)
Working age population ratio	3.373***	3.822***
growth rate (6-10 years ahead)	(0.545)	(0.720)
Inflation expectation (6-10 years ahead)	1.914***	1.000
	(0.298)	
Standard deviation of inflation expectations	0.029	0.682
	(0.645)	(0.801)
Adjusted R-squared	0.772	0.736
Durbin-Watson statistic	1.573	1.268

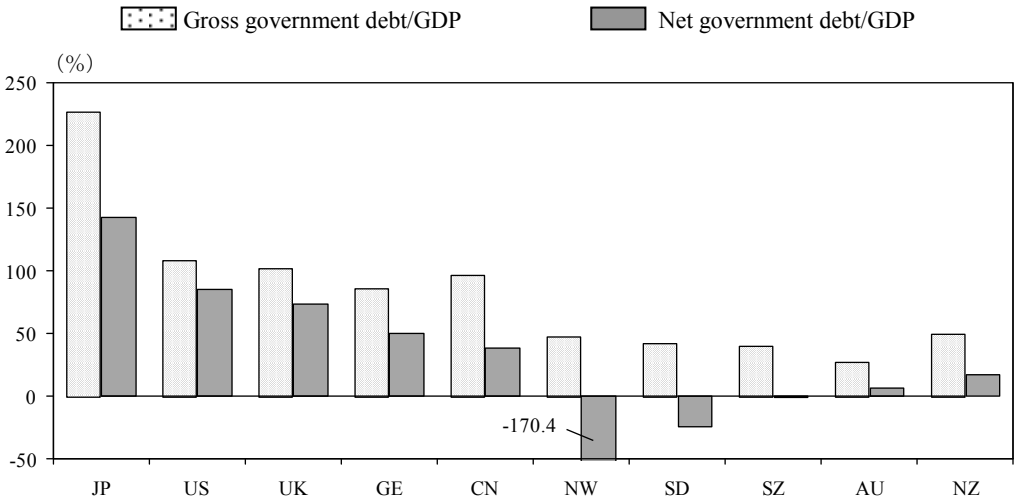
Notes: Standard errors are given in parentheses. In order to correct for bias introduced by heteroscedasticity and contemporaneous correlation, we use panel-corrected standard errors developed by Beck and Katz (1995). * denotes significance at 10%; ** at 5%; *** at 1%.

Figure 1: 10-year Government Bond Yields in Europe



Sources: IMF; Bloomberg.

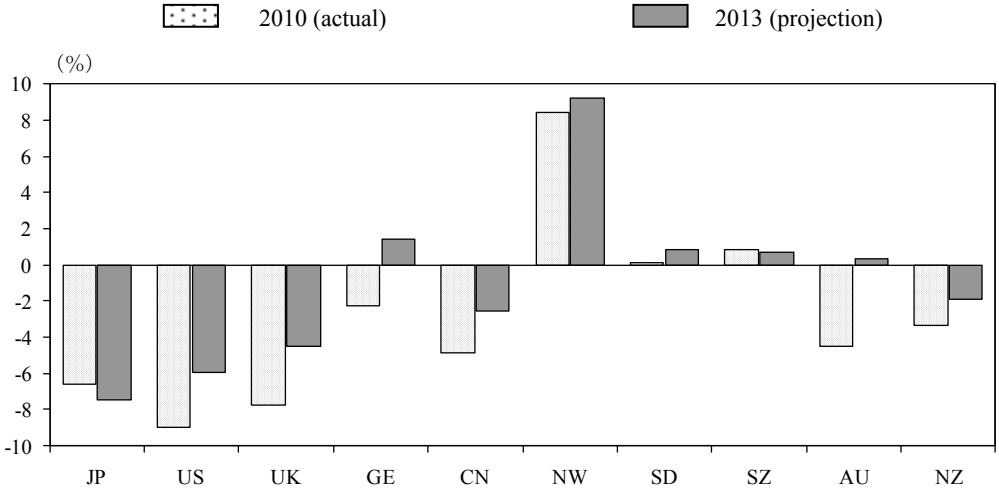
Figure 2: Government Debt-to-GDP Ratio



Notes: This figure reports the two-year-ahead projections taken from OECD Economic Outlook, December 2011. The following are the full forms of the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

Sources: OECD, "Economic Outlook."

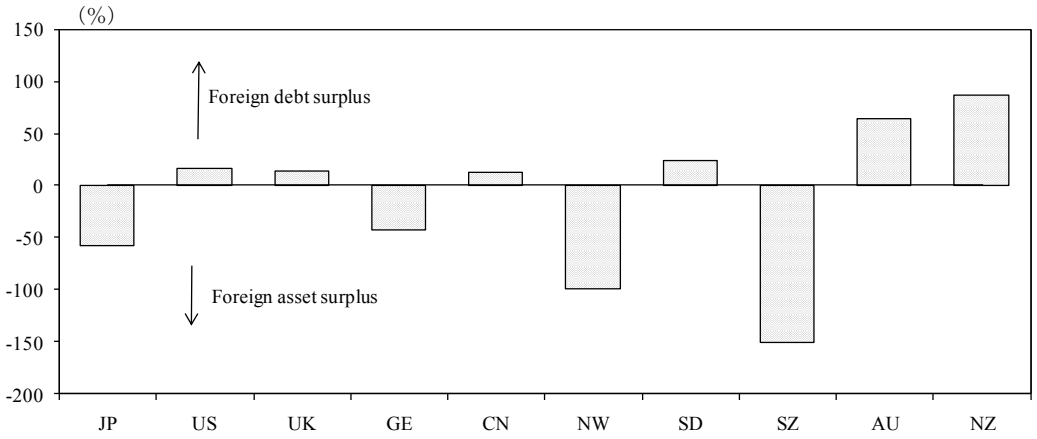
Figure 3: Primary Balance-to-GDP Ratio



Notes: The figures for 2013 are the two-year-ahead projections taken from OECD Economic Outlook, December 2011. The following are the full forms of the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

Sources: OECD, "Economic Outlook."

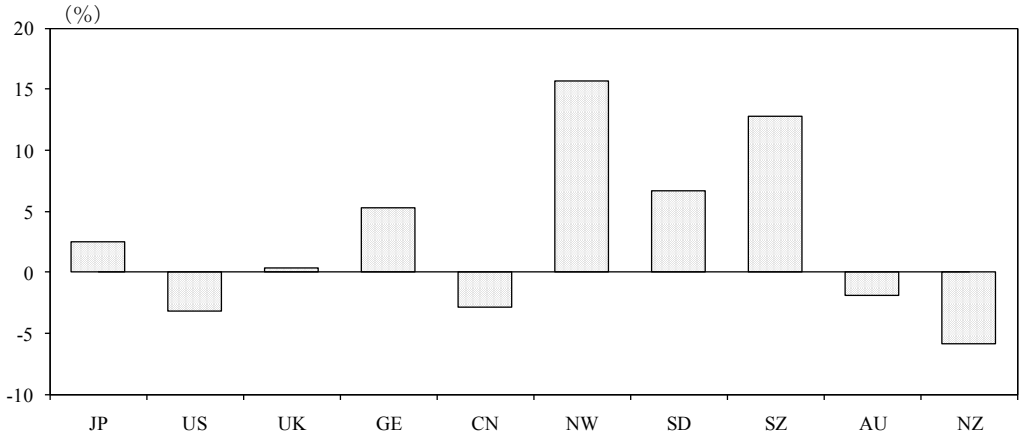
Figure 4: Net Foreign Debt-to-GDP Ratio



Notes: The figures are as of the end of 2010. The following are the full forms of the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

Sources: CEIC; IMF, "World Economic Outlook."

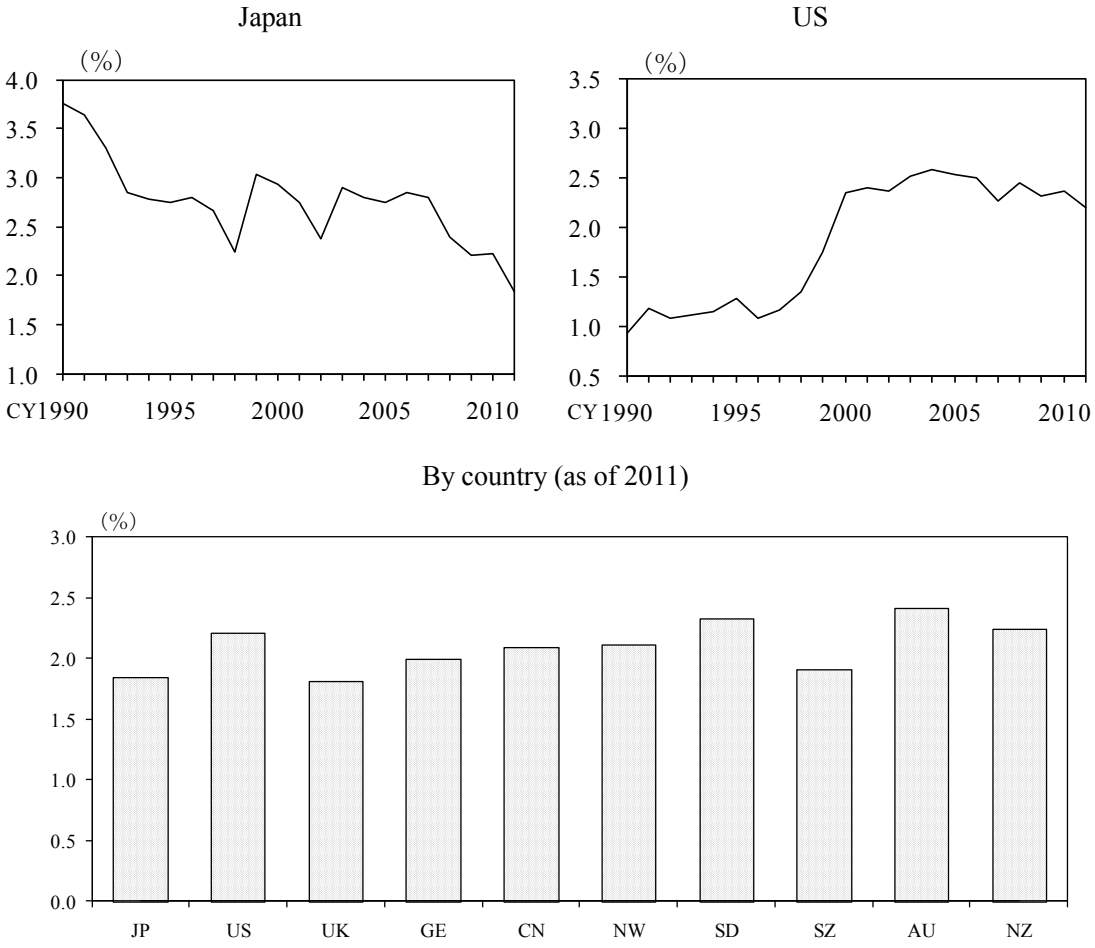
Figure 5: Current Account Balance-to-GDP Ratio



Notes: This figure depicts the two-year-ahead projections taken from OECD Economic Outlook, December 2011. The following are the full forms of the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

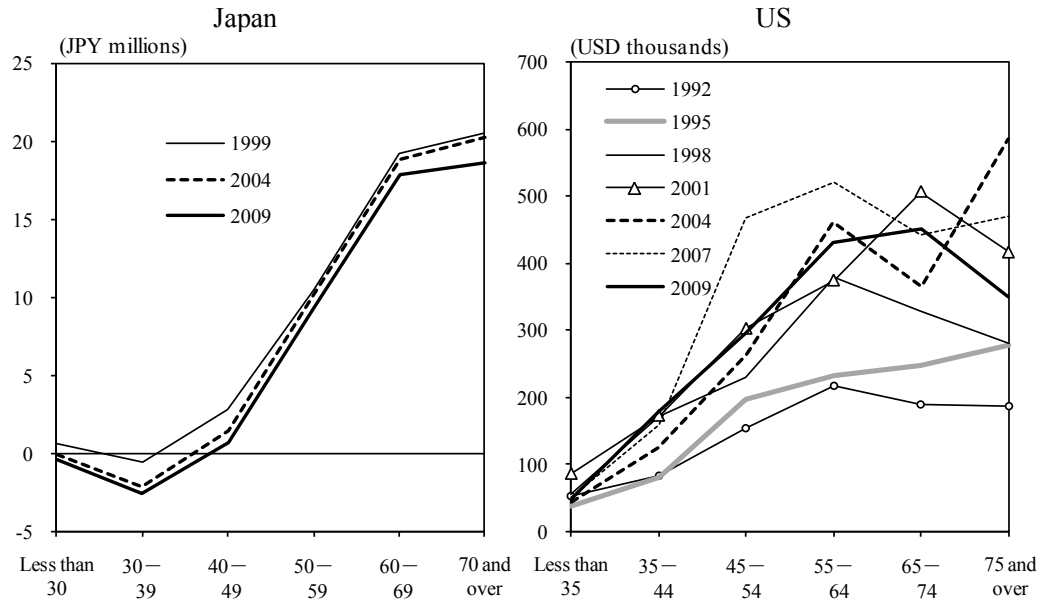
Sources: OECD, "Economic Outlook."

Figure 6: Labor Productivity Growth Rate (6 to 10 Years Ahead)



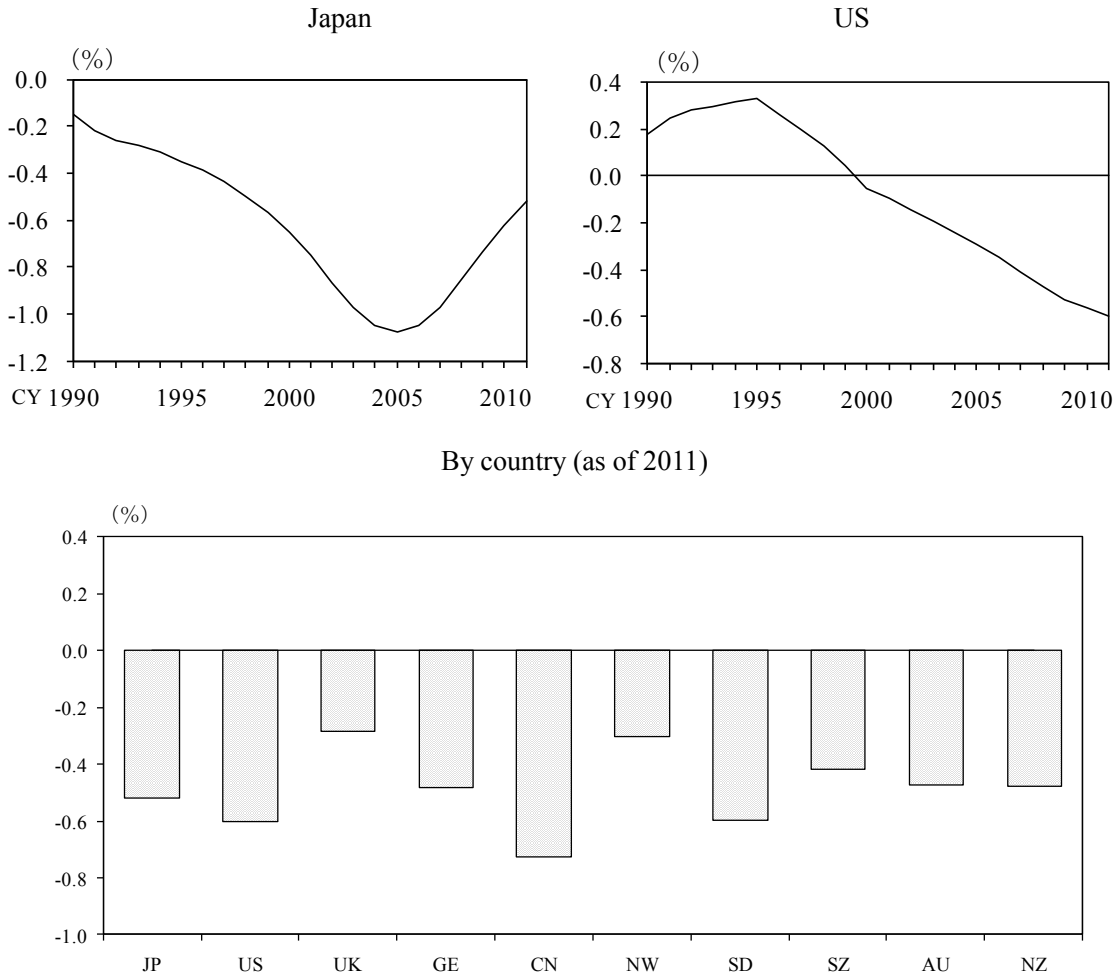
Notes: The following are the full forms of the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.
Sources: Consensus Forecasts; United Nations, "World Population Prospects: The 2010 Revision."

Figure 7: Net Financial Assets by Age Group in Japan and the US



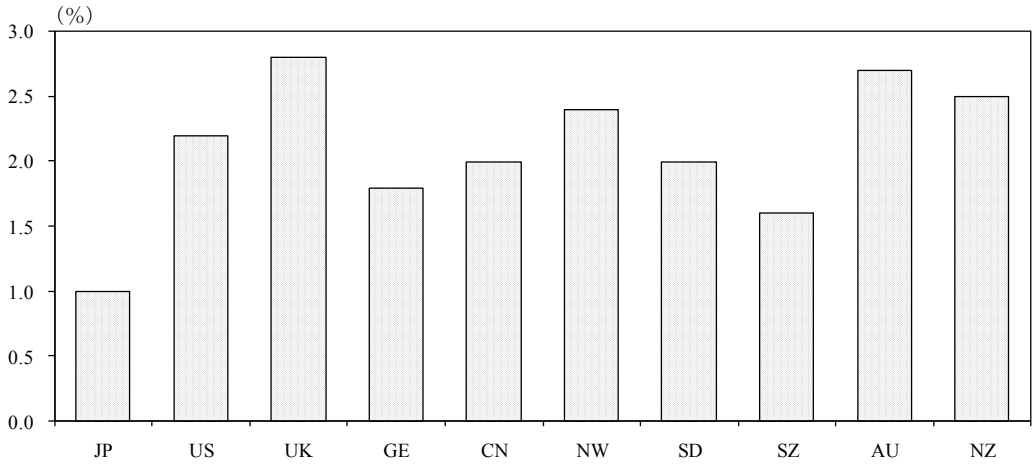
Sources: Ministry of Internal Affairs and Communications, "National Survey of Family Income and Expenditure"; FRB, "Survey of Consumer Finances."

Figure 8: Working-Age Population Ratio Growth Rate (6 to 10 Years Ahead)



Notes: The following are the full forms for the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.
Sources: Consensus Forecasts; United Nations, "World Population Prospects: The 2010 Revision."

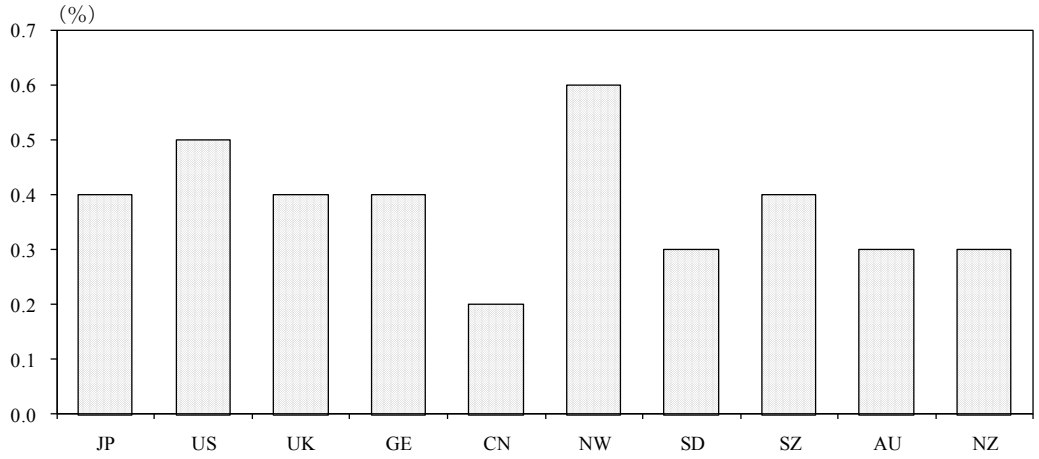
Figure 9: Inflation Expectations (6 to 10 Years Ahead)



Notes: The figures are taken from the October 2011 issue of Consensus Forecasts. The following are the full forms for the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

Sources: Consensus Forecasts.

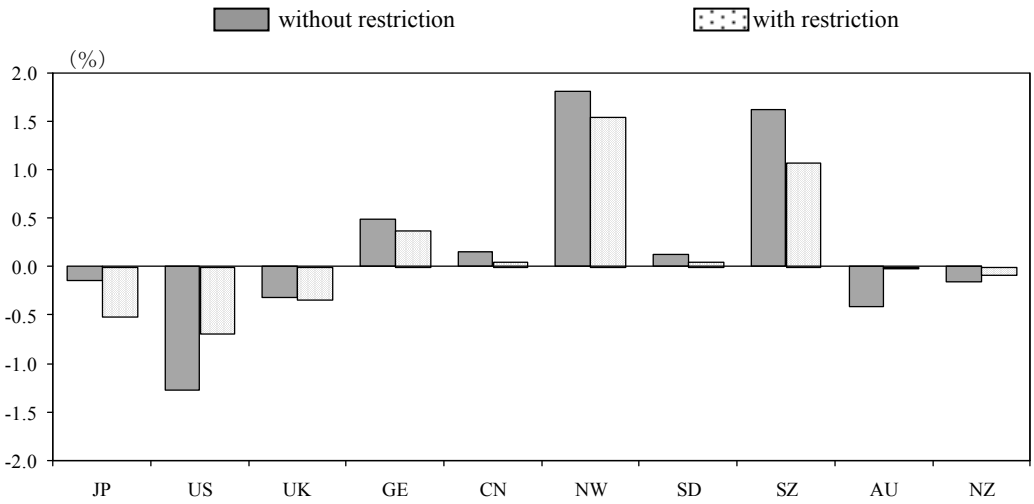
Figure 10: Standard Deviation of Inflation Expectations



Notes: The figure reports the standard deviation of individual forecasts of year-ahead consumer price inflation taken from the October 2011 issue of Consensus Forecasts. The following are the full forms for the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

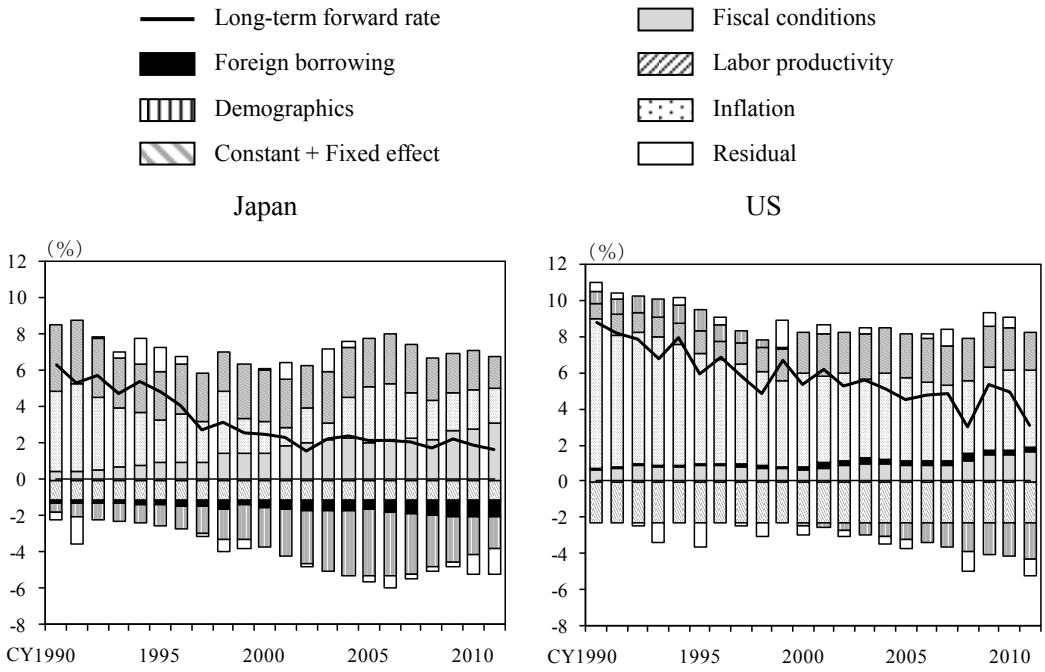
Sources: Consensus Forecasts.

Figure 11: Fixed Effect



Notes: The following are the full forms for the country abbreviations: JP, Japan; US, the United States; UK, the United Kingdom; GE, Germany; CN, Canada; NW, Norway; SD, Sweden; SZ, Switzerland; AU, Australia; NZ, New Zealand.

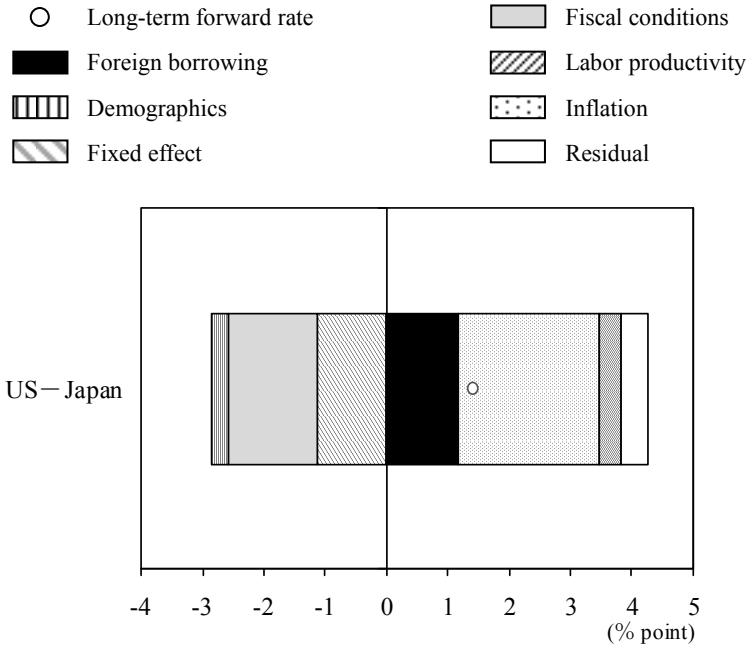
Figure 12: Decomposition of Forward Rates of Japan and the US



Notes: 1. The net foreign debt-to-GDP ratio in 2011 is assumed to remain at the same level as in 2010.

2. Fiscal conditions are the effects on the long-term forward rate of net government debt/GDP, (gross government debt - net government debt)/GDP, and primary balance/GDP. Foreign borrowing is the result of net foreign debt/GDP and current account balance/GDP. Labor productivity is the labor productivity growth rate. Demographics are represented by the working-age population ratio growth rate. Inflation is the effect of inflation expectations and the standard deviation of inflation expectations.

Figure 13: Decomposition of the Difference between the Forward Rates of the US and Japan as of 2011



Notes: 1. The net foreign debt-to-GDP ratio in 2011 is assumed to remain at the same level as in 2010.

2. Fiscal conditions are the effects on the long-term forward rate of net government debt/GDP, (gross government debt – net government debt)/GDP, and primary balance/GDP. Foreign borrowing is the effects of net foreign debt/GDP and current account balance/GDP. Labor productivity is the effects of the labor productivity growth rate. Demographics are the effects of the working-age population ratio growth rate. Inflation is the effects of inflation expectations and the standard deviation of inflation expectations.