A Study of Budget Deficits and Interest Rates for Japan: Evidence from an Extended Loanable Funds Model

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Abstract This paper examines the behavior of the long-term interest rate in Japan based on a sample during 1972Q1-2010.Q3. Applying to the extended open economy loanable funds model, this paper finds that a higher government deficit as a percent of GDP leads to a lower long-term interest rate in Japan. In addition, the real money market rate, the GDP growth rate, the expected inflation rate, the world long-term interest rate, and the expected depreciation of the yen have positive effects on the Japan’s long-term interest rate. Finally, inclusion of the world interest rate and the exchange rate in the model may better capture the behavior of the long-term interest rate in Japan.

Keywords: government deficits, long-term interest rates, loanable funds model, expected inflation, world interest rates, exchange rates

JEL Classification: P43, E43, E62

1. Introduction

The widening fiscal deficits in response to the recent global slowdown have rekindled a growing amount of research on the effects of government deficit on interest rates. One view holds that higher government deficit leads to an increase in the long-term interest rate, crowding out the private investment and thus a lower economic growth. On the other hand, the proponents of the Ricardian equivalence contend that the effect of government deficit may be offset by private saving. Thus, government deficit does not affect the capital accumulation, and the interest rate remains intact. While most empirical studies indicate the positive association of the government deficit and the interest rate (to name a few, Feldstein, 1982; Hoelscher, 1986; Wachtel and Young, 1987; Cebula and Koch, 1989; Cebula, 1997, 2003), the others do not find any significant links
(for example, Aschauer, 1989; Barro, 1987; Evans, 1985; Gupta, 1989; Darrat, 1990, Findlay, 1990; Ostrosky, 1990). Overall, there is little empirical consensus about the magnitude of the effect.

Japan is a particular subject of interest. Japan’s ballooning budget deficit and ever-rising public debt have renewed anxieties about the country’s future solvency. As a result, Standard & Poor’s has downgraded the country’s credit ratings and a number of warnings from other rating agencies follow suit for lacking credible plans to resolve the debt problems. With the deficit widening sharply to over 7% of GDP in 2010 and the economy is still sluggish in the wake of the global financial crisis, Japan is facing more dire fiscal problems. The IMF is projecting that the debt will approach 225% of GDP by the end of 2010 (IMF, 2009). Japan’s growing debt pile is unsustainable in the long term although its bonds are likely to avoid speculative attacks in the market due to high domestic savings, “the suffocating legacies of massive public debt, sclerotic regulation and an aging and shrinking population will likely consign Japan's next decade to a painful process of managing long-term economic decline.” (Garrett, 2010, p. 31) The sheer scale of the debt and its likely trajectory—the IMF is also projecting that the debt will climb to 222% of GDP by 2014—are by far the largest among the major advanced economies.

This paper attempts to investigate the effects of the government deficit on the long-term interest rate in Japan. Our work focuses on several key aspects. First, based on the theoretical framework we use the exchange rate and the world interest rate as proxy for international capital flows. Second, we offer a comparative-static analysis of the equilibrium long-term interest rate, where the various partial derivatives are useful to determine the effects of the exogenous shocks. Third, using up-to-dated time series allows to address the timely issues that have now emerged as critical ones for researchers and policy-makers.

2. The Model

Following Devereux and Saito (2006) and De Santis and Luhrmann (2009), we use the relative interest rate and the exchange rate to measure net capital inflows. A lower US long-term interest rate than the Japan’s long-term interest rate, or an increase in the value of the Japanese yen (JPY) than the US dollar (USD), would lead to an increase in net capital inflow to Japan. In that sense that the supply of loanable funds shifts to the right and thus decreases the Japan’s long-term interest rate. Both the demand for loanable funds and the supply of loanable funds are assumed to be the function of the long-term interest rate, the real short-term interest rate, the expected inflation rate, the percent change in real GDP, and the government deficit. These variables affect the demand and the supply in opposite directions. For example, demand is inversely related to the long-term interest rate, whereas supply is positively associated with the long-term interest rate. The real short-term interest rate, the expected inflation rate, the world long-term interest rate, and the expected exchange rate have positive demand effects. This is contrary to the supply-side effects. Thus, following Hsing (2010a, 2010b), the extended open-economy loanable funds model, considering the demand for and the supply of loanable funds, can be expressed as:

\[ LF^d = D(R, R^s, \pi^e, Y, B) \]  \hspace{1cm} (1) \\
\[ LF^s = S(R, R^s, \pi^e, R^*, e^e) \]  \hspace{1cm} (2) \\

where

\[ LF^d = \text{the demand for loanable funds in Japan}, \]
\[ LF^s = \text{the supply of loanable funds in Japan}, \]
\[ R = \text{the long-term interest rate in Japan}, \]
\[ R^s = \text{the real short-term interest rate in Japan}, \]
\[ \pi^e = \text{the expected inflation rate in Japan}, \]
\[ Y = \text{percent change in real GDP in Japan}, \]
\[ B = \text{the government deficit in Japan}, \]
\[ R^* = \text{the world long-term interest rate}, \] and
\[ e^e = \text{the expected JPY/USD exchange rate. (An increase means depreciation of the Japanese yen.)} \]

In the equilibrium loanable funds (\( LF \)), both \( LF^d \) and \( LF^s \) determines the equilibrium long-term interest rate

\[ \bar{R} = \bar{R}(B, R^s, Y, \pi^e, R^*, e^e) \]  \hspace{1cm} (3) \\

By taking the partial derivative of the reduced-form in equation (3) with respect to a given
exogenous variable, an expression is obtained that relates the response of $\bar{R}$

$$\frac{\partial \bar{R}}{\partial B} = \frac{D_B}{|J|} > 0$$  \hfill (4)

$$\frac{\partial \bar{R}}{\partial R^*} = \frac{(D_{R^*} - S_{R^*})}{|J|} > 0$$  \hfill (5)

$$\frac{\partial \bar{R}}{\partial Y} = \frac{D_Y}{|J|} > 0$$  \hfill (6)

$$\frac{\partial \bar{R}}{\partial \pi^e} = \frac{(D_{\pi^e} - S_{\pi^e})}{|J|} > 0$$  \hfill (7)

$$\frac{\partial \bar{R}}{\partial R^s} = -\frac{S_{R^s}}{|J|} > 0$$  \hfill (8)

$$\frac{\partial \bar{R}}{\partial \varepsilon^e} = -\frac{S_{\varepsilon^e}}{|J|} > 0$$  \hfill (9)

where $|J|$ is the Jacobian and is expected to be a positive. As shown in equations (4)–(9), the equilibrium long-term interest rate depends positively on the government deficit, the real short-term interest rate, the percent change in real GDP, the expected inflation rate, the world interest rate, or the expected exchange rate.

3. Empirical Results

The data were obtained from Datastream, covering from 1972Q1 to 2010Q3 at a quarterly frequency. The dependent variable is Japanese 10-year government bond (JGB) yield. To allow for possible substitution effects, the Japan’s real money market rate is used as the short-term interest rate. The expected inflation rate is measured by the average inflation rate of the past ten quarters,\(^3\) where the inflation rate is based on the consumer price index (CPI). \(Y\) denotes the growth rate of real GDP in percent. \(B\) is the government budget deficit normalized by GDP in percent form. To facilitate the interpretation of the results, the deficit was multiplied by -1. Thus, a rise in \(B\) is interpreted as a rising deficit-to-GDP ratio. We also use the debt-to-GDP ratio as alternative proxy for fiscal policy in Japan.\(^4\) The US long-term government bond yield is chosen to be the world interest rate. The expected exchange rate is given by the average exchange rate of the past four quarters, and the exchange rate is quoted as JPY per USD. The variables, \(R, R^*\) and \(\varepsilon^e\), are entered the model in log form.

Figures 1a and 1b show the scatter diagrams between the JGB yield in log form and the fiscal
variables of interest, with a line of best fit superimposed on the data points. The diagrams clearly suggest that the long-term interest rate is inversely related to both the fiscal deficit and the public debt as a share of GDP. Although the preliminary examination of the data may seem counter-intuitive, more analysis of the regression will be conducted. Figure 2 illustrates the relationship between the JGB yield and the expected inflation rate. As predicted, there exists a clear positive correlation.

The Phillips-Perron (PP) unit root tests were conducted for the series of interest. The test results show that, except for the government deficit and the real GDP growth, the variables contain a unit root in the level form and are stationary in first difference. In order to test whether a stationary linear combination exists among the variables, we use the Johansen cointegration test. The cointegration results are given in Table 1 and show that the significant number of cointegrating vectors is 2. Thus, the variables share a long-run equilibrium relationship.

The regression model was first estimated by least squares methods. However, the results are not robust to several diagnostic tests. Although the Jarque-Bera normality test indicates that the regression residuals tend to follow a normal distribution, the Breusch-Godfrey serial LM test suggests that there exists autocorrelation. In addition, the Engle ARCH (Autoregressive Conditional Heteroscedasticity) test was conducted for possible heteroskedastic errors. The LM statistics could not reject a null hypothesis of no ARCH effects up to order 4 in the residuals. To account for the possible volatility clustering (i.e., time-varying variance), we consider a GARCH(1,1) model for the long-term bond yield. ARCH models were first introduced by Engle (1982) and then generalized as GARCH (Generalized ARCH) by Bollerslev (1986) and Taylor (1986). To allow for fat-tailed residuals, we will assume that the errors follow a Student's t-distribution. In Table 2 parameters estimation of GARCH(1,1) model, using the Berdnt, Hall, Hall and Hausman (1974) algorithm, are presented.

As shown in Model 1 of Table 2, 84.7% of the variation in the JGB yield can be explained by explanatory variables under consideration with significant coefficients at the 1% level. For most coefficients, the effects on the yield are as predicted. The JGB yield is positively associated with the real money market rate, the real GDP growth, the expected inflation rate, the US government bond yield, and the expected depreciation of the JPY vis à vis the USD. The effect from the government deficit is, however, negative and statistically significant, suggesting that a one percentage point increase in government deficit as a share of GDP is associated with a decrease of 0.5 basis point of the 10-year JGB interest rate. In comparing to the previous studies which test fiscal deficits across countries, the estimate found in this study is relatively small. The low
sensitivity of the government bond yield to changes in fiscal deficits is attributable to Japan’s large pool of household savings, stable institutional investors, and a strong home bias (Tokuoka, 2009). To determine whether the estimated regression is robust, the Jarque-Bera normality and the Engle ARCH tests are applied. The test results suggest that, at the 5% level of significance, the standardized residuals are white noises and no additional ARCH left in the standardized residuals. Thus, the GARCH(1,1) specification correctly describes the variability of the JGB yield.

We also test whether the estimates are sensitive to alternative measures of the variables under consideration. First of all, we use different proxies for the expected inflation rate and summarize the regression results in Model 2-4 of Table 2. \( \pi_{t-4} \) is calculated from the last four quarters, whereas \( \pi_{t-8} \) from the last eight quarters. It is interesting to note that the latter produces a positive coefficient on the expected inflation rate and is significant at the 5% level (Model 3) although the GDP growth is not statistically significant. In contrast, averaging over the past four quarters does not produce significant coefficients on the GDP growth and the expected inflation (Model 2).\(^7\) It seems that a longer-term moving average of the inflation rates has a greater impact on the long-term interest rate than a short-term moving average. If the last four quarters of the GDP deflator (\( \pi_{\text{DEF}} \)) replaces the CPI-based measure for inflationary expectations, its coefficient and the GDP growth become significant at the 1% and 5% level, respectively (Model 4). Second, if the ratio of the government debt to GDP is used to reflect the fiscal imbalance, the negative effect of the public debt on the JGB yield remains significant at the 1% (Model 5). However, the coefficient on the output growth is not significant and the expected exchange rate turns into an opposite sign. Finally, we attempt to use the trade-weighted nominal effective exchange rate (NEER) instead of the nominal exchange rate.\(^8\) The Japan’s NEER is a weighted average of the yen against a basket of currencies of its major trading partners. A fall in the NEER means Japan is trading internationally on worsening terms and thus costing more to buy goods and services from abroad. Inclusion of the expected NEER (\( \varepsilon_{\text{NEER}} \)) as shown in Model 6 of Table 2, the expected inflation becomes negative although it is not statistically significant. Other results are similar, the real GDP growth, however, is not significant. In general, the negative relationship between fiscal imbalances and the long-term interest rate is robust to a number of alternative specifications. The estimated impact of fiscal policy is remarkably stable across these regressions, with a point estimate average of 0.006, and statistically significant at the 1% level.
4. Conclusion

This paper attempts to empirically examine the relationships between the Japan’s long-term interest rate and macroeconomic performance. In so doing, we first use the comparative-static analysis for extended open-economy loanable funds model to determine the possible direction of the exogenous shocks to the long-term interest rate, and then adopt a GARCH(1,1) model to characterize the time-varying variance of the JGB yield. The results show that the fiscal deficit or debt as a share of GDP is negatively associated with the JGB yield. A higher real money market rate, a growing economy, higher inflationary expectations, a higher US government bond yield, and expected depreciation of the JPY would cause the long-term interest rates to rise.

Our results have important policy implications. The negative effect of the government borrowing implies that pursuing expansionary fiscal policy by raising government debts reduces the long-term interest rate since agents switch from lower quality issues. Strong home bias in Japan may also play a role. JGBs have been financed largely by domestic investors who are traditionally inclined to make safe and low-risk investments (Tokuoka, 2010), which in turn may add to domestic demand raising the price of the issue and so reducing the yield. Nevertheless, this result does not serve as an excuse for laxity in Japan’s fiscal policy. Inexorable rise in government debt would lead to financial tipping points that could put severe downward pressure on ratings. It could sharply raise the risk premium for JGBs and entail repercussions such as domestic investors’ reluctance to buy JGBs due to the heightened risks of default. This finding echoes the recent warnings made by ratings agencies that the Japan government needs to pursue effective fiscal reform in order to bring the ever-rising public debt under control (Reuters, 2011). In addition, the Bank of Japan needs to carefully contain expectations of price rise and the yen devaluation to avoid undesirable effects on the long-term interest rate. In the open-economy loanable funds model, the world interest rate and the exchange rate need to be considered as international investors search for better returns in determining supplying loanable funds to Japan or other countries. The results for the output growth and the expected inflation are sensitive to different measures of the variables. Thus, further study may be necessary to determine their links to the long-term interest rate in loanable funds.

The results presented in this paper should be interpreted with caution. As argued by Eugen and Hubbard (2004) and Laubach (2009), the change of the bond yield today may be confounded by the current business cycle conditions, which are not captured completely by the output growth or the interest rates. Ideally, considering future yields and official forecasts for deficits in longer term should mitigate the problems (Tokuoka, 2010). Unfortunately, the Japanese Cabinet Office
has only started 5-year forecasts for the deficit in recent years. It will be years from now to produce sufficiently long series to compare with the outcomes in this paper.

Endnotes

* Department of Economics, National Cheng Kung University, Tainan, Taiwan 701. Email: yichi@ncku.edu.tw. The author is grateful to Professor Yu Hsing for his invaluable comments and inspiration during the work. The author is also thankful to the anonymous referee for insightful comments. Any errors are the author’s sole responsibility.

1 See Engen and Hubbard (2004) and Quayes and Jamal (2007) for a review.

2 The notations and derivation draw heavily on the work of Hsing (2010a, 2010b).

3 We adopt several alternative measures for the expected inflation, including the weighted inflation rate (Cebula, 1997), the lagged inflation rate, and the average inflation rate over the last \( n \) quarters, where \( n = 4, 6, 8, 10, 12 \). We also use the measure based on the GDP deflator. In this study we draw our conclusion based on the 10-quarter average as it produces significant regression result.

4 Due to the data availability, the government debt begins from 1982Q2.

5 We are not the first study to produce a negative coefficient on fiscal variables. Similar results are also found in Caporale and Williams (2002), Ardagna et al. (2007), Ardagna (2009) and Tokuoka (2010). One explanation for the opposite sign is due to a portfolio effect. That is, when the sovereign debt is high quality and low risk, investors may switch from low quality to sovereign debt. This leads to high demand for new issues of sovereign debt and therefore lowering the yield (Caporale and Williams, 2002).

6 The recent estimates of the impact of fiscal deficits are in the range of 10 to 60 basis points. See Brooks (2003), Hauner and Kumar (2006), and Ardagna et al. (2007).

7 Using the weighted inflation rate leads to similar result as Model 2. If the lagged inflation rate replaces the average inflation rate of past periods as the expected measure, its coefficient is positive, but is not significant at any sensible levels. The results are available upon request.

8 The nominal effective exchange rates (2005 = 100) were downloaded from the Bank of Japan website, http://www.boj.or.jp/en/statistics/index.htm/.
References


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Figure 1a. Scatter diagram between government bond yield and deficit-to-GDP ratio for Japan during 1972Q1—2010Q3
Figure 1b. Scatter diagram between government bond yield and debt-to-GDP ratio for Japan during 1982Q2—2010Q3

Government bond yield (%) vs Debt-to-GDP ratio (%)
Figure 2. Scatter diagram between government bond yield and expected inflation rate for Japan during 1972Q1—2010Q3.
Table 1. Unrestricted Conintegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Hypothesized Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
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<tr>
<td>None *</td>
<td>0.417950</td>
<td>81.17983</td>
<td>50.59985</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.288149</td>
<td>50.98304</td>
<td>44.49720</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.185091</td>
<td>30.70181</td>
<td>38.33101</td>
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<tr>
<td>At most 3</td>
<td>0.159898</td>
<td>26.13484</td>
<td>32.11832</td>
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<td>At most 4</td>
<td>0.096160</td>
<td>15.16546</td>
<td>25.82321</td>
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<td>At most 5</td>
<td>0.055158</td>
<td>8.510614</td>
<td>19.38704</td>
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<tr>
<td>At most 6</td>
<td>0.047064</td>
<td>7.231085</td>
<td>12.51798</td>
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Notes:
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Table 2. GARCH(1,1)-t Distribution Result of the Long-Term Bond Yield  
(Quarterly, 1972Q1~2010Q3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
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<tr>
<td></td>
<td>0.005*** 0.003*</td>
<td>0.006*** 0.001</td>
<td>0.006*** 0.001</td>
<td>0.007*** 0.001</td>
<td>0.003*       0.002</td>
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<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
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</tr>
<tr>
<td>$D$</td>
<td>0.043*** 0.035</td>
<td>0.070*** 0.035</td>
<td>0.063*** 0.035</td>
<td>0.011** 0.035</td>
<td>0.142*** 0.032***</td>
<td></td>
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<tr>
<td></td>
<td>(0.007)</td>
<td>(0.013)</td>
<td>(0.012)</td>
<td>(0.004)</td>
<td>(0.014)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>$R^*$</td>
<td>0.033*** 0.092**</td>
<td>0.027 0.092**</td>
<td>0.031 0.092**</td>
<td>0.033** 0.092**</td>
<td>0.004 0.092**</td>
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<tr>
<td></td>
<td>(0.009)</td>
<td>(0.021)</td>
<td>(0.020)</td>
<td>(0.016)</td>
<td>(0.017)</td>
<td>(0.002)</td>
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<tr>
<td>$\pi_{t-10}^e$</td>
<td>0.125***</td>
<td>0.035 (0.034)</td>
<td>0.342*** -0.047</td>
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<td></td>
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<tr>
<td></td>
<td>(0.027)</td>
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<td>(0.113)</td>
<td>(0.033)</td>
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<td>$\pi_{t-4}^e$</td>
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<td>$\pi_{t-8}^e$</td>
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<tr>
<td>log($R^*$)</td>
<td>0.866*** 0.105***</td>
<td>0.799*** 0.027</td>
<td>0.850*** 0.027</td>
<td>1.050*** 0.027</td>
<td>0.676*** 0.027</td>
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<tr>
<td></td>
<td>(0.066)</td>
<td>(0.106)</td>
<td>(0.101)</td>
<td>(0.085)</td>
<td>(0.130)</td>
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<tr>
<td>log($\epsilon_{t-4}^e$)</td>
<td>0.467*** 0.092**</td>
<td>0.520*** 0.092**</td>
<td>0.417*** 0.092**</td>
<td>0.617*** 0.092**</td>
<td>-0.544*** 0.092**</td>
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<td>(0.113)</td>
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<td>(0.121)</td>
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<tr>
<td>log($\epsilon_{NEER}^e$)</td>
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<tr>
<td>Variance equation</td>
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<tr>
<td>ARCH(-1)</td>
<td>0.352*** 0.357**</td>
<td>0.157        0.172</td>
<td>0.144 0.172</td>
<td>0.357** 0.158</td>
<td>0.605*** 0.165</td>
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<tr>
<td></td>
<td>(0.119)</td>
<td>(0.120)</td>
<td>(0.115)</td>
<td>(0.141)</td>
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<td>(0.165)</td>
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<td>GARCH(-1)</td>
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<td>0.661** 0.347</td>
<td>0.670** 0.347</td>
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<td>0.111 0.347</td>
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<tr>
<td></td>
<td>(0.156)</td>
<td>(0.300)</td>
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<td>$R^2$</td>
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<td>$N$</td>
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<td>114</td>
<td>155</td>
</tr>
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</table>

Notes: The dependent variable is log($R$) where $R$ denotes the Japan’s 10-year government bond yield. $B$ is the Japan’s government deficit (or surplus) as a share of GDP in percent, whereas $D$ is the debt-to-GDP ratio and is available from 1982Q2. $R^*$ is the Japan’s real money market rate. $Y$ is the percentage change of Japan’s real GDP. $\pi_{t-10}^e$, $\pi_{t-4}^e$, and $\pi_{t-8}^e$ are the expected inflation rates for Japan based on the average inflation rate of the past ten, four and eight quarters, respectively. $\pi_{DEF}^e$ is calculated from the GDP deflator of the past four quarters. $R^*$ is the US 10-year government bond yield. $\epsilon_{t-4}^e$ is the expected JPY/USD exchange rate based on the average exchange rate of the past four quarters, whereas $\epsilon_{NEER}^e$ is measured by the Japan’s nominal effective exchange rate. The regression constant is ignored for brevity. The numbers in parentheses are standard errors. *, ** and *** denote the 10%, 5% and 1% significance level, respectively.