Demand for and Supply of Government Bonds : Implications for the Bank of Japan's Bond Market Intervention

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Motivation

- Many researches try to quantify the effects of a large-scale purchase of government bonds (QE) on the yield curve.
- Few consider the government responses to the change in the yield curve caused by QE.
- The government may change the maturity mix of newly issued bonds responding to the yield curve to save debt costs.
- If we focus on the market responses to QE within a short window, it's OK to neglect the government responses.
- For a longer-window (e.g., monthly), which is likely to affect the real economy, it may be problematic.

Research Questions

- What are quantitative impacts of a central bank's purchase of government bonds with a specific tenor on the yield curve?
- Do they differ if we consider the government responses?

What we do

1. We build a model of a demand and supply system of government bonds for each tenor that is based on the preferred-habitat hypothesis and allows for the government to change the supply of bonds.

2. We estimate the system using a dataset from the primary market of Japanese government bonds from July 2001 to January 2016 allowing for a possible structural change

3. We quantify the effect of the BOJ's purchase of bonds with a specific tenor on the yields of the same and other tenors.

What we find

1. The estimated demand elasticities support the preferred-habitat hypothesis and inactive arbitrageurs.
2. The estimated supply elasticities suggest that the government actively engages in debt management policy to save debt costs in response to the changes in the yield curve.
3. The debt management policy substantially reduces the effects of QE on yields.

✓The interaction of QE and debt management policy is important in shaping the yield curve.

Literature Review

- Preferred habitat hypothesis: Culbertson (1957). Modigliani and Sutch (1966)

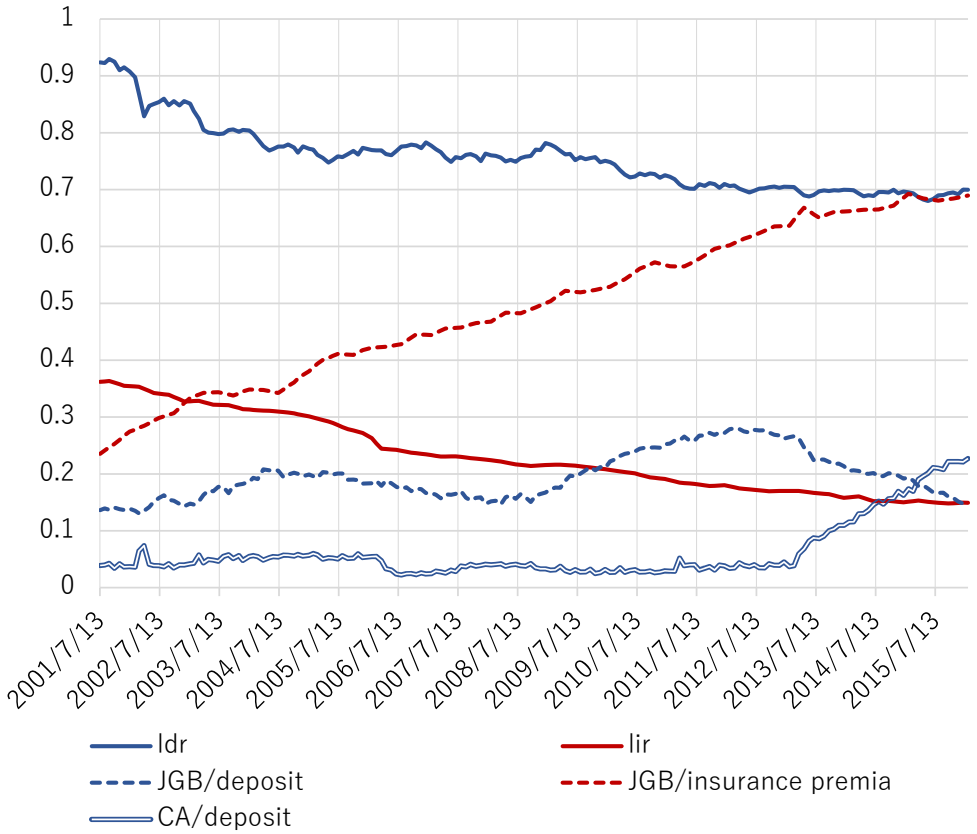
- Event study on QE: Gagnon et al. (2011), D'Amico and King (2013), Krishnamurthy and Vissing-Jørgensen (2011), Krishnamurthy et al. (2017), Fukunaga et al. (2015), Hattori (2018).

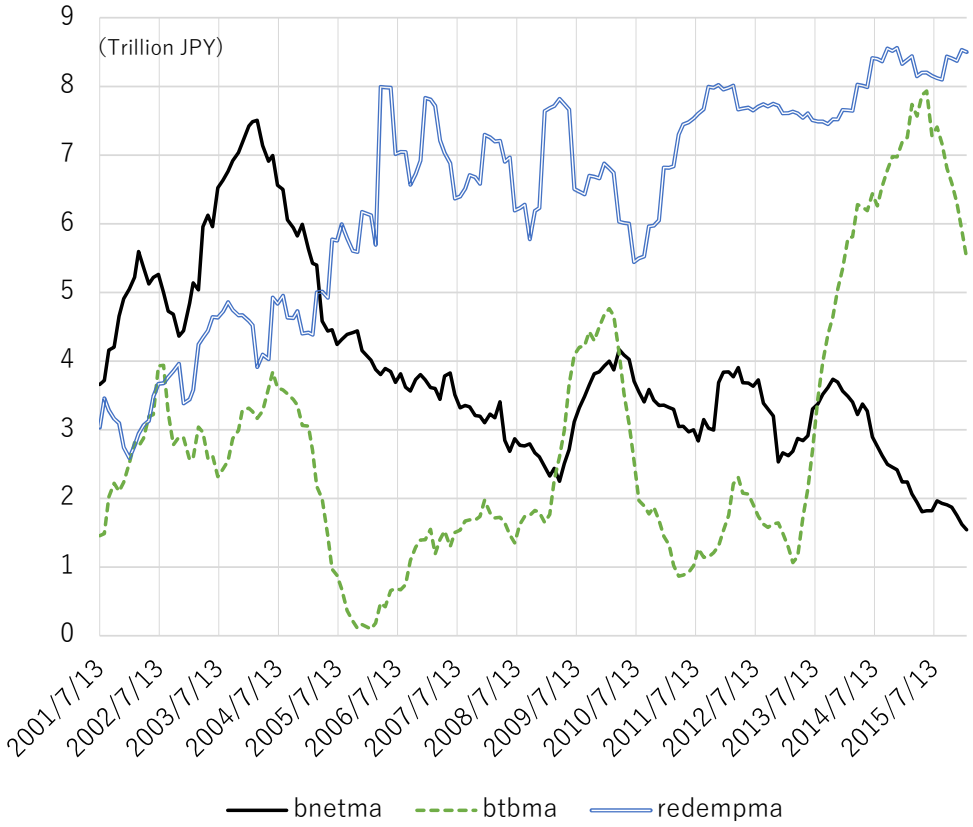
- Extension of multiple-factor term structure model by introducing preferred-habitat investors and risk averse arbitrageurs: Vayanos and Vila (2021), Hamilton and Wu (2012), Koeda (2017)

✓None studies the interaction of QE and debt management policy.

Background Information : JGB Market

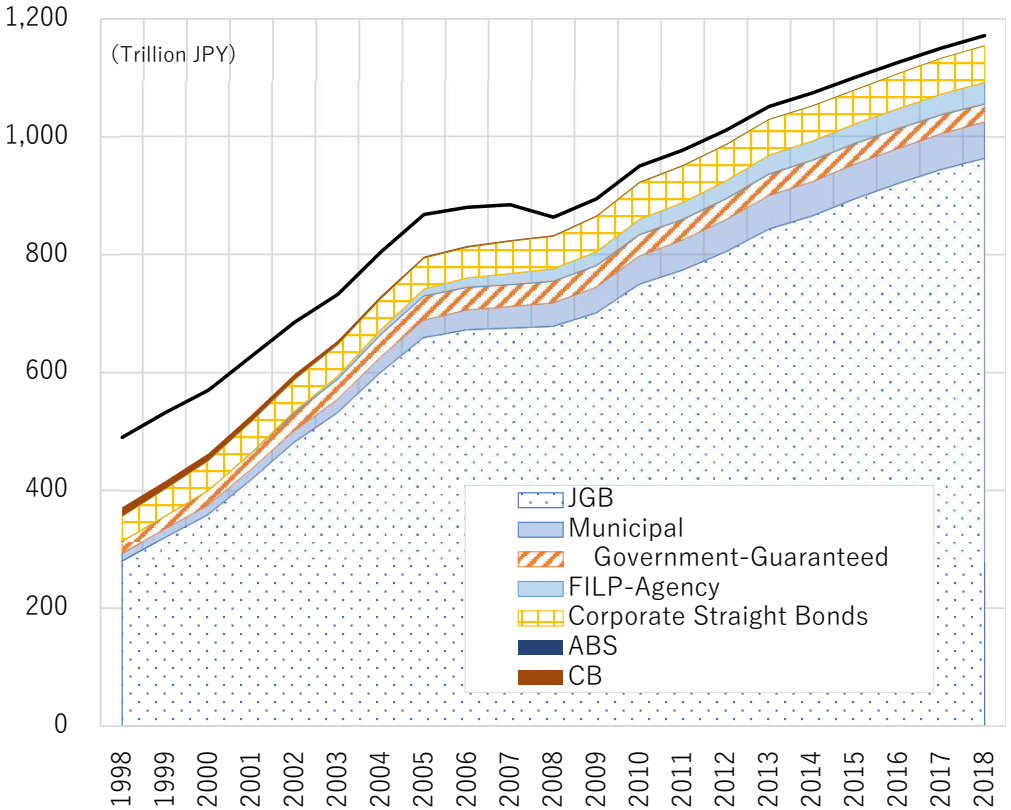
- Banks and life insurance companies faced weaker demand for loans
- MOF needed to actively engage in the debt management policy

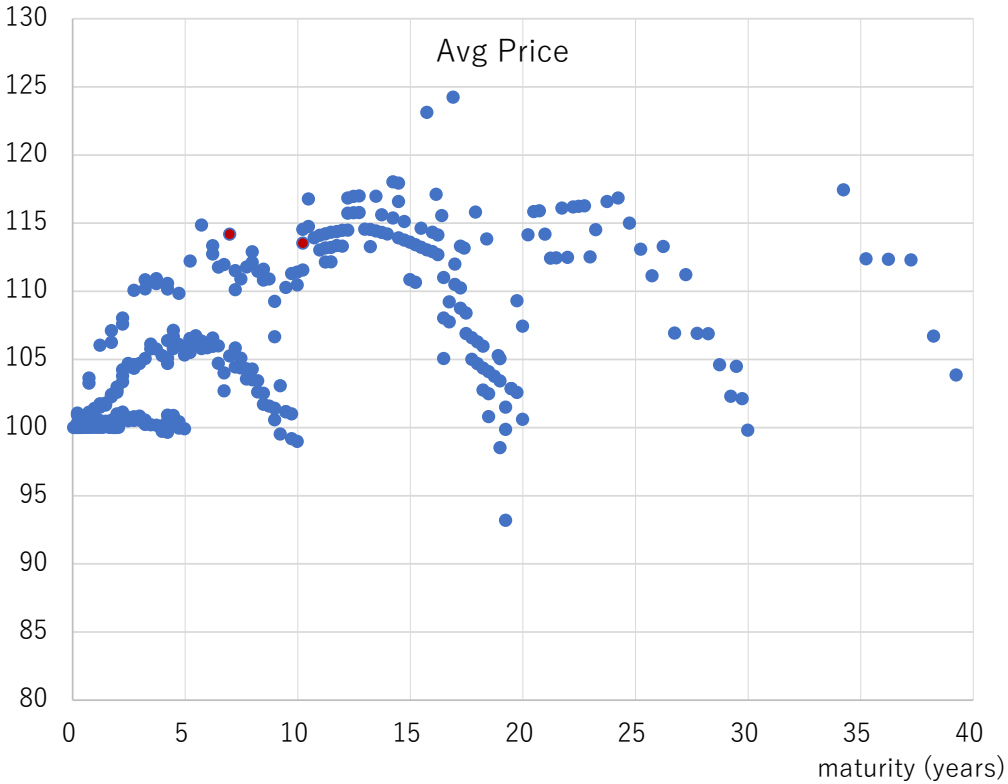




Background Information : JGB Market

- JGBs dominate the fixed-income securities market. Corporate bonds and other bonds have not been well developed
- Most JGB investors for aiming at income gains rather than for aiming at capital gains through active trading





Model

All the quantity and yields are measured in natural logarithm

Investors' Demand : $d_t^{inv,m} = \sum_{l=2,5,10,20} b_{m,l}^{inv} y_t^l + b_{m,ca}^{inv} carate_t + \sum_{k=1}^{nd} b_{m,k}^{inv} z_t^{D_k} + v_t^m$

$$\begin{bmatrix} d_t^{inv,2} \\ \vdots \\ d_t^{inv,20} \end{bmatrix} = \begin{bmatrix} b_{2,2}^{Dinv} & \cdots & b_{2,20}^{Dinv} \\ \vdots & \ddots & \vdots \\ b_{20,2}^{Dinv} & \cdots & b_{20,20}^{Dinv} \end{bmatrix} \begin{bmatrix} y_t^2 \\ \vdots \\ y_t^{20} \end{bmatrix} + \begin{bmatrix} b_{2,1}^{Zinv} & \cdots & b_{2,nd}^{Zinv} \\ \vdots & \ddots & \vdots \\ b_{20,1}^{Zinv} & \cdots & b_{20,nd}^{Zinv} \end{bmatrix} \begin{bmatrix} z_t^{D_1} \\ \vdots \\ z_t^{D_{nd}} \end{bmatrix} + \begin{bmatrix} v_t^2 \\ \vdots \\ v_t^{20} \end{bmatrix}$$

$\{b_{m,l}^{Dinv}\}$: own- and cross-yield elasticities of JGB demand

SHORTRATE : CALLON (overnight call rate),
CARATE (interest rate on current account at the BOJ)

BS : LDR (banks' loan-to-deposit ratio),
LIR (life insurance companies' loan-to-insurance reserve ratio)

MARKET : JUSSPREAD (10-year US TB-JGB), JCD5Y(CDS spread for 5-yearJGB),
Y2FSP (futures interest rate – spot rate for 2-year JGB),
JYBS20 (20-year basis swap of JPY and USD)

VARSHOCK : Dummy for VaR shock (from Nov. 2002 to June 2003)

Model

all the quantity and yields are measured in natural logarithm

BOJ's demand : $d_t^{BOJ} = C^X x_t$ (exogenous)

$\boldsymbol{x_t}$: monetary policy dummy such as the introduction of QE and QQE

Government Supply :$s_t^m = \sum_{l=2,5,10,20} a_{m,l}^S y_t^l + \sum_{k=1}^{ns} a_{m,k}^z z_t^{S_k} + \varepsilon_t^m$

$$\begin{bmatrix} s_t^2 \\ \vdots \\ s_t^{20} \end{bmatrix} = \begin{bmatrix} a_{2,2}^S & \cdots & a_{2,20}^S \\ \vdots & \ddots & \vdots \\ a_{20,2}^S & \cdots & a_{20,20}^S \end{bmatrix} \begin{bmatrix} y_t^2 \\ \vdots \\ y_t^{20} \end{bmatrix} + \begin{bmatrix} a_{2,1}^Z & \cdots & a_{2,ns}^Z \\ \vdots & \ddots & \vdots \\ a_{20,1}^Z & \cdots & a_{20,ns}^Z \end{bmatrix} \begin{bmatrix} z_t^{S_1} \\ \vdots \\ z_t^{S_{ns}} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^2 \\ \vdots \\ \varepsilon_t^{20} \end{bmatrix}$$

$\{a_{m,l}^S\}$: own- and cross-yield elasticities of JGB supply

FISCAL : BNETMA (government expenditure – revenue),
BTBMA (amount of issuance of short-term JGBs)
REDEMPMA (amount of long-term JGBs issued to redeem already issued JGB)
D_CRISIS (dummy for the global financial crisis: from Sept. 2009 to Mar. 2013)

Model

Equilibrium

$$D_t^{inv,m} + D_t^{BOJ} = S_t$$

Implication

$$\Delta \boldsymbol{y}_t^* = (\boldsymbol{\varphi} - \boldsymbol{\phi})^{-1} \Delta \boldsymbol{d}_t^{\boldsymbol{boj}}$$

, where $\phi_{ij} \equiv \frac{\partial D^{inv,i}}{\partial Y_j} = b_{ij}^{Dinv} \frac{D^{inv,i}}{Y_j}$ and $\varphi_{ij} \equiv \frac{\partial S^i}{\partial Y_j} = a_{ij}^S \frac{S^i}{Y_j}$.

The impact of the BOJ's purchase of on the yield is smaller if

i) the own-elasticity of demand is larger,

ii) the cross-elasticities of demand is larger, and

iii) the own-elasticity of supply is larger.

Data

- The data periods are 175 months from 2001/7 to 2016/1.
- The amount of JGBs that the BOJ owns is available from 2001/7.
- To avoid the effect of the direct control of the yield of JGBs under the yield curve-control policy that began in 2016/9, our data ends in 2016/1 because the BOJ adopted the negative interest rate policy in 2016/1/29.

Estimation Method

- Two-stage least squares (2SLS)
- We allow the structural parameters to vary over the sample period (Bai and Perron, 1998, 2003).

Estimation results for demand functions

- Structural breaks occurred from 2010/8 to 2011/10. These timings are almost coincident with the timing when the BOJ began to purchase two-year newly issued JGBs for the first time in 2011/11.

- Own-yield elasticities are all positive, and most of them are significant especially after the structural breaks.

- Few cross-yield elasticities are negative and significant, supporting the preferred-habit hypothesis and suggesting inactive arbitragers in the JGB markets.

- Cross-yield elasticities with respect to $CARATE$ are negative and significant for 2- 5- and 10-year JGBs after the structural breaks. Current accounts at the BOJ were a substitute for such JGBs under the low-interest rate environment.

Estimation results for demand functions

Sum of the estimated coefficients

ca	Coef.	t/F	**$d^{inv,2}$**	Coef.	t/F	**$d^{inv,5}$**	Coef.	t/F	**$d^{inv,10}$**	Coef.	t/F	**$d^{inv,20}$**	Coef.	t/F
carate	0.094	0.39	carate	0.014	1.88	carate	0.001	0.10	carate	-0.009	-1.13	carate	0.059	6.07
			carsb1008	-0.096	7.05	carsb1110	-0.126	20.00	carsb1011	-0.156	19.23			
y2h	-1.663	-1.40	y2h	0.053	1.30	u2_5	0.041	0.88	u2_10	0.088	1.31	u2_20	0.002	0.15
y2hsb1008	-0.821	14.05	y2hsb1008	0.026	5.27	u2_5_sb1110	-0.024	6.75	u2_10_sb1011	-0.001	0.01			
u5_2	-3.240	-0.50	u5_2	-0.057	-0.27	y5h	0.110	1.27	u5_10	-0.612	-2.97	u5_20	-0.085	-1.07
u5_2_sb1008	-3.106	5.07	u5_2_sb1008	-0.049	0.45	y5hsb1110	0.104	18.59	u5_10_sb1011	0.048	1.03			
u10_2	-12.159	-0.71	u10_2	1.239	2.21	u10_5	1.451	3.67	y10h	0.587	2.11	u10_20	0.292	0.72
u10_2_sb1008	-8.883	5.88	u10_2_sb1008	-0.052	0.20	u10_5_sb1110	0.124	2.40	y10hsb1011	0.186	9.08			
			u20_2	2.246	1.45							y20h	0.584	2.60
			u20_2_sb1008	1.981	6.84									

Estimation results for supply functions

- Structural breaks occurred from 2006 to 2010. During this period, yields on JGBs tended to decline, which likely to have affected the debt management policy by MOF.

- Own-yield elasticities of JGB supply are all negative and significant after the structural breaks. MOF tended to save interest payments by decreasing the amount of issuance of JGB with a tenor that pays a high interest rate.

- Cross-yield elasticities of 10- or 20-year JGBs with respect to yields on shorter maturity JGBs are negative and significant. MOF issues longer-maturity bonds to lengthen the overall debt maturity and stabilize their funding in the long run.

Estimation results for supply functions

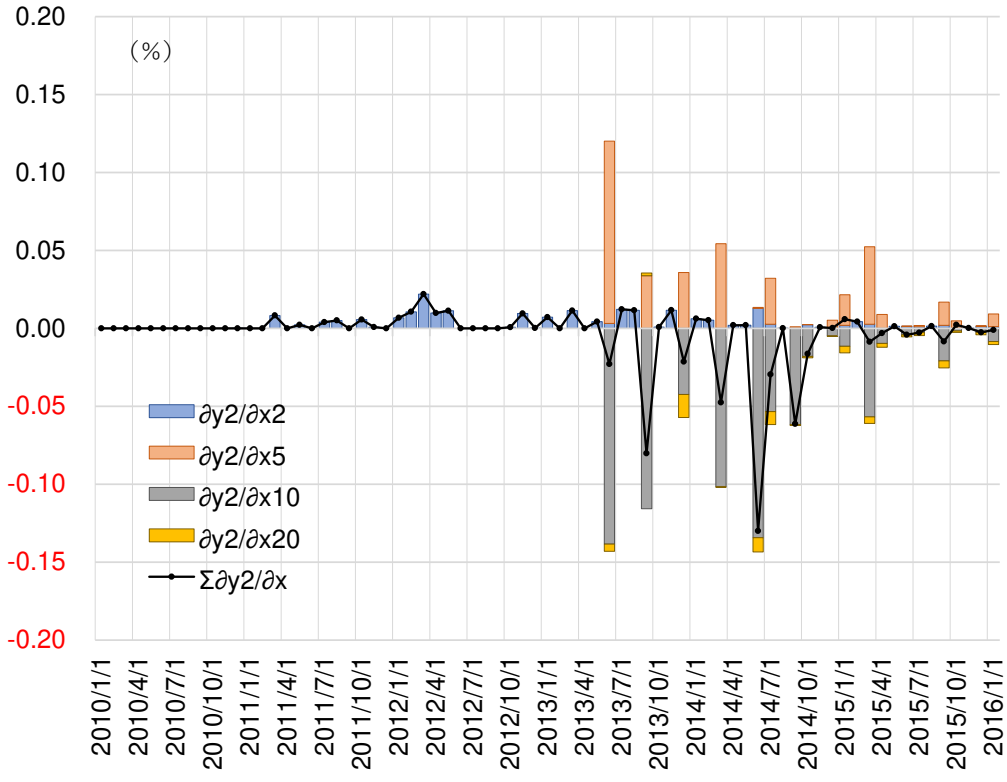
s^2	Coef.	t/F	s^5	Coef.	t/F	s^{10}	Coef.	t/F	s^{20}	Coef.	t/F
y2h	-0.027	-3.43	u2_5	0.001	0.20	u2_10	0.010	1.77	u2_20	-0.073	-3.40
y2_sb1006	-0.158	-74.25	u2_5_sb0905	0.067	1.96	u2_10_sb0705	-0.196	-21.44	u2_20_sb0602	-0.299	-4.45
u5_2	-0.098	-2.27	y5h	0.038	1.65	u5_10	-0.017	-0.26	u5_20	2.589	7.34
u5_2_sb1006	0.213	12.49	y5_sb0905	-0.145	-161.94	u5_10_sb0705	-0.462	-15.59	u5_20_sb0602	-0.927	-4.95
u10_2	0.064	0.52	u10_5	0.244	2.75	y10h	0.030	0.61	u10_20	-1.484	-5.59
u10_2_sb1006	-0.845	-11.11	u10_5_sb0905	-0.489	-13.61	y10_sb0705	-0.146	-28.38	u10_20_sb0602	-0.863	-4.27
u20_2	0.023	0.10	u20_5	-0.285	-1.96	u20_10	0.120	0.64	y20h	-0.636	-3.36
u20_2_sb1006	-2.265	-5.50	u20_5_sb0905	-0.022	0.00	u20_10_sb0705	-0.241	-0.41	y20_sb0602	-0.435	-5.86

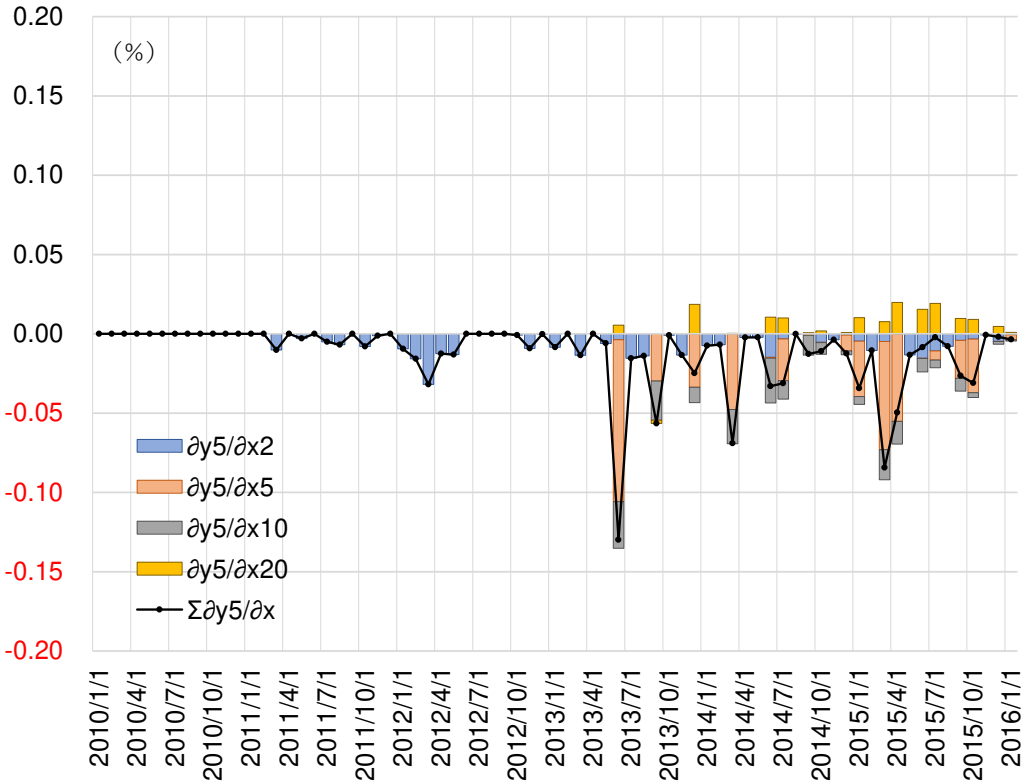
The estimated effects of QE on yields

- After the introduction of QQE, the quantitative impacts became larger than before, but still up to almost 0.1 percentage point on 2- and 5-year JGBs and 0.2 percentage points on 10- and 20-year JGBs.
- The effects of BOJ's purchase of bonds with a specific tenor on the yield of that tenor depends on the tenors: for the 2- and 5-year tenors, they were negative while for the other tenors, they were positive.
- We hypothetically assume that supply curves were vertical to analyze the demand effects. → The elastic supply of JGBs accounts for the actual small impacts of the BOJ's purchase on yields.
- We hypothetically assume that demand curves were vertical. → The elastic demand for JGBs plays a small roll in accounting for the actual small impacts of the BOJ's purchases.

The change in equilibrium level of yields due to external shock

$$\Delta y_t^* = (\varphi - \phi)^{-1} \Delta D_t^{boj} \quad \text{where} \quad \phi_{ij} \equiv \frac{\partial D^{inv,i}}{\partial Y_j} \quad \varphi_{ij} \equiv \frac{\partial S^i}{\partial Y_j}$$





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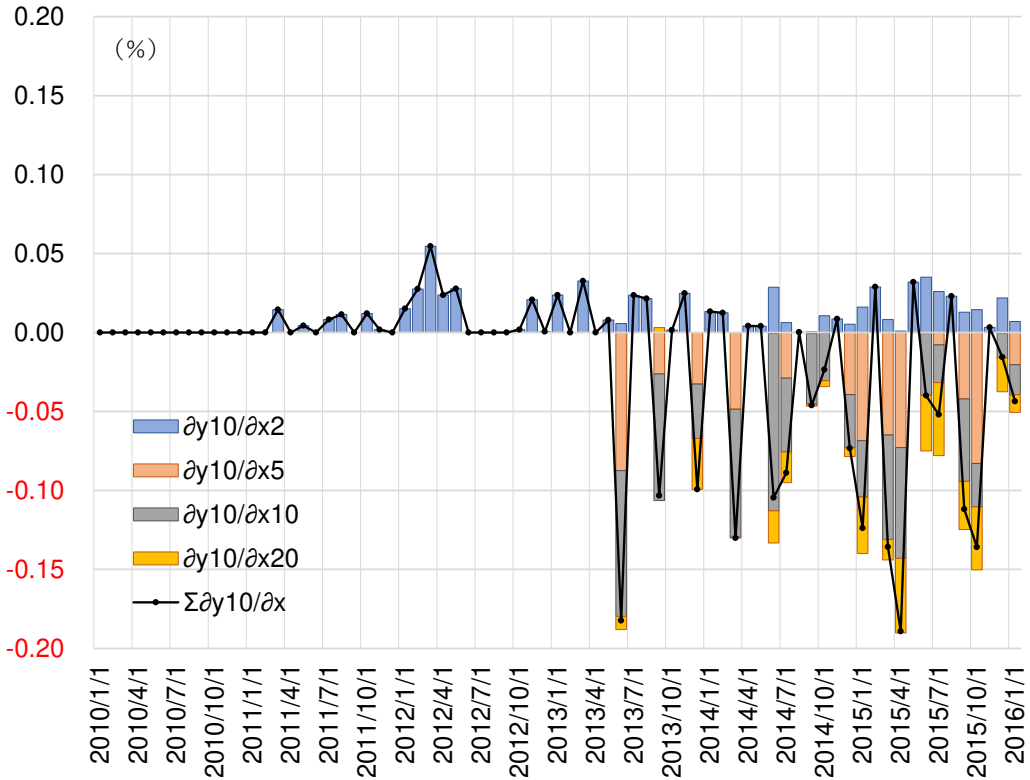

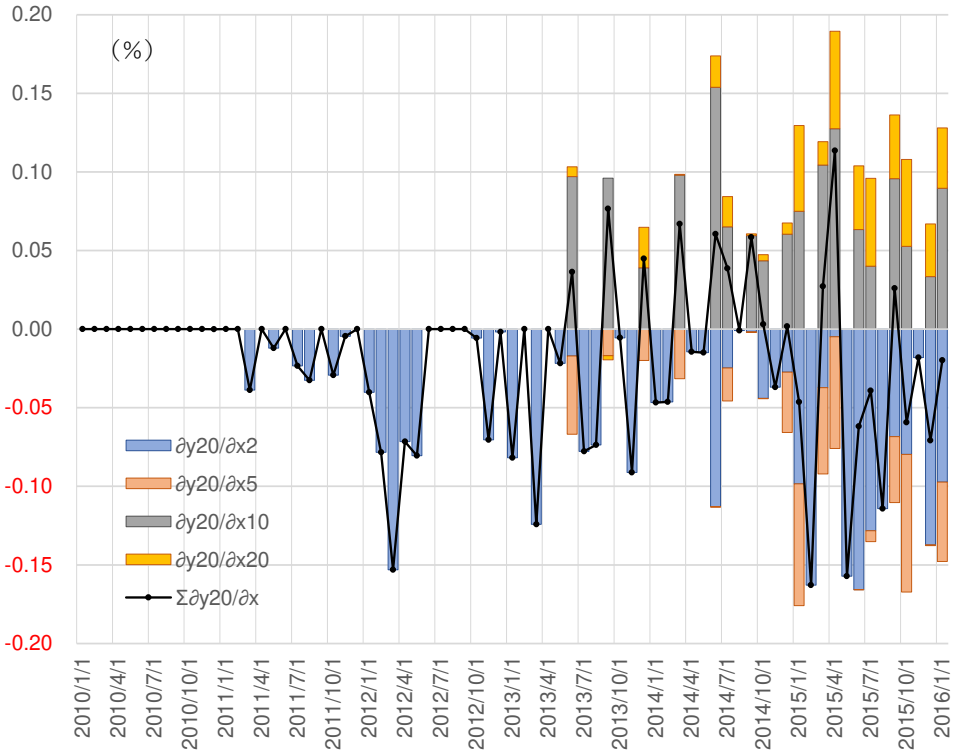

Summary

- Due to the fiscal authorities' debt management policy, the effects of the BOJ's large-scale intervention on JGB yields were substantially mitigated.

Appendix: Endogenous intervention by the BOJ?

- To allow for endogenous intervention by the BOJ, $d_t^{BOJ} = C^X x_t$ should be replaced with the following:

$$d_t^{boj} = B^{DY} y_t + B^F Fiscal_t + C^X x_t$$

- None of the variables in $\boldsymbol{y_t}$ and $\boldsymbol{Fiscal_t}$ takes a significant coefficient except for the yield on 5-year JGB ($u_{5,2}$) in the regression of two-year JGB purchases by the BOJ $\left(d_{2t}^{boj}\right)$.
- We can almost safely regard the BOJ's intervention as being driven only by exogenous policy shocks.