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Short-run and Long-run Consequences of Unconventional Monetary Policy in Japan

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Abstract

Monetary policy is a powerful policy tool in stabilizing short-term economic fluctuations. However, no matter how effective it is, it could have unintended adverse impacts on the economy if the central bank continued extreme monetary easing over a long period of time. Japan is an exceptional country where such concern exists. This paper analyzes the effects of unconventional monetary policy in Japan since the end of the 1990s. We explore the effects not only on stabilizing short-term macroeconomic fluctuations such as the GDP gap, but also on medium- and long-term productivity such as total factor productivity (TFP). If the prolonged ultra-low interest rate environment distorts the price mechanism and causes misallocation of funds, the unconventional monetary policy could reduce the productivity of the economy. The estimation results show that the Bank of Japan (BOJ)'s unconventional monetary policy had a significant positive impact on the GDP gap even under a liquidity trap where the policy rate hit its effective lower bound (ELB). However, they also show that unconventional monetary policy had a significant negative impact on TFP growth. The results suggest that while unconventional monetary policy was effective in boosting the economy in the short term, the prolonged ultra-low interest rate environment may have had a negative impact on medium- and long-term productivity growth in the Japanese economy.

JEL Codes: E52, O33, E32, E43
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1. Introduction

Monetary policy is one of the most effective policy instruments in stabilizing short-term economic fluctuations. It has made a significant contribution to stabilizing short-term macroeconomic fluctuations in many countries. However, no matter how effective it is, it could have unintended adverse impacts on the economy if the central bank continued extreme monetary easing over a long period of time. Japan is an exceptional country where such concern exists.

This paper analyzes the effects of unconventional monetary easing in Japan since the late 1990s. We explore the effects not only on stabilizing short-term macroeconomic fluctuations but also on medium- and long-term productivity growth. Standard economic theories suppose that medium- to long-term productivity is determined by the supply side and is independent of monetary policy. However, prolonged ultra-low interest rates may distort the market mechanism and cause misallocation of funds. If this is the case, prolonged ultra-low interest rates could reduce the productivity growth of the economy. This paper empirically examines how the unprecedented monetary easing implemented by the Bank of Japan (BOJ) affected not only short-term economic fluctuations but also medium- to long-term productivity growth. Specifically, estimating structural Vector Autoregression (VAR) models, it explores what impacts the BOJ's monetary easing had on the GDP gap and the total factor productivity (TFP) during the period when the policy rate hit its effective lower bound (ELB).

In Japan, the BOJ substantially eased its monetary policy as a countercyclical policy measure after the bursting of the bubble in the early 1990s, and its policy rate fell to near zero around the mid-1990s. In particular, the BOJ introduced the zero-interest-rate policy (ZIRP) in February 1999, and since then, its policy rate remained almost zero for about a quarter of a century (**Figure 1**). Furthermore, the BOJ introduced the quantitative easing (QE) from March 2001 and the quantitative and qualitative monetary easing (QQE) from April 2013. The unconventional policy not only led to a tremendous increase in the monetary base but also to a dramatic decline in long-term interest rates. The BOJ introduced the negative interest rate policy (NIRP) in January 2016, and shortly thereafter, even the yield on 10-year Japanese Government Bond (JGB) often turned unusually negative under the Yield Curve Control (YCC).

Under a liquidity trap where the policy rate hits its ELB, conventional monetary policy is no longer effective. However, since the pioneering work of Krugman (1998) and Eggertsson and Woodford (2003), several studies have theoretically shown that unconventional policy measures can be effective even under a liquidity trap[1]. The BOJ has applied their ideas and attempted to prop up the sluggish Japanese economy by making use of various unconventional policy measures (Ueda (2012)). However, if extreme monetary easing continues over the long term, it will be important to evaluate its policy effects not only in terms of short-term macroeconomic stabilization but also in terms of medium- and long-term productivity growth. This is because if firms face an extremely low interest rate environment for a long period of time, the market discipline may be lost in the financial market and productivity growth may decline through misallocation of funds.

In recent studies, Asriyan et al. (2024) show that low interest rates can have a negative impact on productivity in the economy because a misallocation of funds allows less productive firms to increase their investment. Kiyotaki et al. (2021) construct a model where a permanent decline in the federal funds rate can reduce aggregate investment and growth, and even lead to a decline in the welfare of all individuals in the domestic economy. Liu, Mian, and Sufi (2022) demonstrate that when interest rates are near zero, lower long-term interest rates increase market concentration and reduce the rate of productivity growth. On the other hand, Acharya et al. (2019) empirically show that the European Central Bank's (ECB) Outright Monetary Transactions (OMT) program did not fully translate into economic growth. Monacelli, Sala, and Siena (2023), by estimating panel VARs, show that lower real interest rates tended to have a negative impact on productivity through cross-border misallocation of funds in advanced economies while having a positive impact on productivity in emerging economies. Except for Acharya et al., these existing studies did not explicitly analyze the impact of unconventional monetary policy on productivity growth. However, they suggest that, if extreme monetary easing were to continue for an extended period of time, the prolonged low interest rates could have a negative effect on medium- to long-term productivity growth.

In the following analysis, we estimate structural VARs for Japan since the late 1990s to analyze how the BOJ's unconventional monetary policy has affected not only the GDP gap, which reflects short-term macroeconomic fluctuations, but also TFP growth, which reflects medium- to long-term productivity growth. In literature, there has been extensive research using structural VARs to analyze the effects of the BOJ's unconventional monetary policy on the Japanese economy. Many previous studies, including Honda et al. (2007), Honda (2014), and Miyao and Okimoto (2017), show that an increase in the monetary base had a positive effect on output in the short-run; Michaelis and Watzka (2017), Hayashi and Koeda (2019), and Miyao and Okimoto (2020) also report that an increase in the

[1] See also Jung, Teranishi, and Watanabe (2005), and Oda and Ueda (2007).

monetary base had positive effects on output in the short-run even when taking endogenous regime switches into account. On the other hand, Fujiwara (2006) finds limited effects of unconventional monetary policy on output and prices for the early stage of unconventional monetary policy.

However, only a limited number of studies have explored the effects of the BOJ's monetary easing on TFP growth using structural VARs. This was because most studies considered that TFP, which reflects medium- to long-term productivity, is incompatible with a standard framework of short-run monetary policy analysis. In literature, a number of studies have estimated VARs including TFP as one of the variables[2]. However, most of them analyze the effects of real shocks on TFP. Even when they include the policy rate as one of the variables, they find no significant effect of the monetary policy shock on TFP (e.g., Mayer, Rüth, and Scharler (2016)), although Jorda et al. (2024) recently document that the real effects of monetary shocks last for over a decade. In Japan, Miyao (2006a) estimates structural VARs that include the policy rate and TFP growth. However, since the period covered by the analysis was from the second quarter of 1983 to the first quarter of 2004, before the full implementation of unconventional monetary policy, it finds no significant effect of the monetary policy shock on the TFP growth in Japan.

This paper thus examines the effect of unconventional monetary policy on TFP growth by estimating structural VARs using Japanese data since 1999, when the BOJ introduced the ZIRP. In our basic estimation, we use the "short-term shadow rate" as an indicator of the BOJ's unconventional monetary policy. The short-term shadow rate is a hypothetical policy rate which allows substantially negative values under a liquidity trap. We use the quarterly average of the "short-term shadow rate" calculated by the methodology of Krippner (2013).

Our structural VAR estimates show that a decline in the short-term shadow rate had a significant positive impact on the GDP gap. This confirms previous research findings that the BOJ's unconventional monetary policy was effective in boosting the economy even when the policy rate hit its ELB. However, they also show that a decline in the short-term shadow rate had a significant negative impact on the rate of TFP growth. This suggests that the prolonged BOJ's unconventional monetary policy, while effective in boosting the economy in the short term, may have had a negative impact on medium- to long-term productivity growth.

In the second half of this paper, we will show that these results are robust even when using a different estimation method and alternative data set. Regarding a different method, we calculate the impulse

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2 See, for example, Chen and Wemy (2015) and Kurmann and Sims (2021).

response functions using local projections proposed by Jordà (2005, 2009) to check the robustness of the results. Compared to structural VARs, Jordà's local projections is better suited to evaluate dynamic relationships when the data generation process may not be well approximated by the VAR. We confirm that our results of impulse response functions are still robust even when using local projections proposed by Jordà.

Regarding alternative data set, we first replace the short-term shadow rate, a monetary policy indicator, by either the growth rate of the monetary base or the 10-year JGB yield. The BOJ started its QE with the current account balance as the policy target in 2001, and its QQE in 2013 with the monetary base as its primary operation target. The monetary base or its main component, the current account balance, has thus been widely used in previous studies as an indicator to examine the effects of the BOJ's unconventional monetary policy. On the other hand, the 10-year JGB yield is a representative long-term interest rate which fluctuates reflecting the expected future policy rates. Even after short-term interest rates hit their ELB, it took significantly positive values in most periods. We show that our conclusions are still robust even when using these alternative monetary policy indicators.

We next explore whether the results are robust even when using alternative data of TFP and GDP gap. The basic estimates in this paper rely on quarterly data of the TFP growth and the GDP gap estimated by the Cabinet Office (Japanese government). We will confirm that the results are robust even when using the "TFP growth rate" and "GDP gap" estimated by the BOJ. The BOJ's TFP growth rate has an undesirable feature in that it is semiannual data, which reduces the degree of freedom. However, we will confirm that the results are robust even when using the BOJ's estimates, suggesting that our conclusions are not attributable to a particular method of estimating the TFP growth or the GDP gap.

This paper is organized as follows. Section 2 describes the estimation methods of the TFP growth rate and the GDP gap used by the Cabinet Office. Section 3 describes the estimation method of our structural VAR and the data used for the estimation. Section 4 estimates a baseline structural VAR and shows the results of its impulse response functions. Section 5 presents the results of the impulse response functions using the Jordà's local projections. Section 6 estimates the VARs using the growth rate of the monetary base and the 10-year JGB yield. Section 7 estimates the VARs using alternative TFP growth rate and GDP gap. Section 8 provides an overall summary of this study.

2. Japan's TFP growth and GDP Gap

In the following analysis, we use quarterly data of TFP growth and GDP gap estimated by the Cabinet Office (Japanese Government) as key macroeconomic variables to explore the effects of unconventional monetary policy[3]. In the Cabinet Office's estimation, they suppose that Y is output (real GDP), K is capital stock (real, market value basis), S is capital utilization rate, L is the number of workers, and H is hours worked. They then consider the following Cobb-Douglas production function:

(1) $$Y = A(KS)^{a}(LH)^{1-a} \qquad (0 < a < 1),$$

where A is unobservable TFP.

Based on this production function, the Cabinet Office calculates TFP by the Solow residual, that is, the TFP growth rate ($\Delta A/A$) ≡ the real GDP growth rate ($\Delta Y/Y$) minus the contributions of capital (KS) and labor (LH). The capital share a is obtained as the average since 1980 of "1- compensation of employees /(consumption of fixed capital + operating surplus + compensation of employees - household operating surplus). The value of $\Delta A/A$ calculated as the Solow residual is smoothed by the Hodrick-Prescott filter (HP filter). The calculated TFP growth rate may not purely reflect the technological progress because equation (1) does not control the quality of labor. However, it reflects the productivity growth which are attributable either to the technological progress or to the improved quality of labor.

Potential output (potential real GDP ≡ Y^*) is, on the other hand, calculated by multiplying the potential capital and labor contributions by the TFP calculated above. The potential capital and labor contributions are calculated as the supply capacity that could be realized at average capital and labor utilization rates.[4] By using the potential output Y^*, the GDP gap is then obtained as

(2) The GDP gap ≡ $(Y - Y^*)/Y^*$.

[3] See appended note 2-4 in Cabinet Office (2001) for the detailed calculation method.

[4] In calculating potential capital input, we removed short-term fluctuations of the capacity utilization rate by utilizing the "production capacity DI (excessive capacity – insufficient capacity)" from the BOJ's Tankan survey. Potential labor hours are estimated by applying an HP filter to total actual labor hours. The number of potential workers is calculated as (population aged 15 and over) x (trend labor force participation rate) x (1 - structural unemployment rate), where the trend labor force participation rate is calculated by applying an HP filter to the labor force participation rate.

Figure 2 illustrates the GDP gap estimated by the Cabinet Office from 1980 to 2023. Japan's GDP gap exceeded 2% from the late 1980s to the early 1990s. However, since the early 1990s, when the bubble economy collapsed, it fell into negative territory for most of the period. In particular, the GDP gap was often less than -2%, and took extreme negative values in 2009 during the global financial crisis and in 2020 during the COVID-19 crisis. This implies that the persistently negative GDP gap was a major factor behind Japan's secular stagnation since the 1990s.

In the figure, we shadow the ZIRP period (February 1999-August 2000), the QE period (March 2001-March 2006), the comprehensive monetary easing (CME) period (October 2010-), the QQE period (April 2013-), and the yield curve control (YCC) period (September 2016- March 2024). With the exception of the year 2000 when the COVID-19 shock occurred, the GDP gap improved substantially during the shadowed periods when the unconventional monetary policy measures were in place. This suggests that the BOJ's unconventional monetary policy was effective in improving the GDP gap even under a liquidity trap where the policy rate hit its ELB.

Figure 3, on the other hand, illustrates the TFP growth rate over the same period. Japan's TFP growth rate was as high as about 1.8% in the 1980s. However, it began to decline from the end of the 1980s and dropped sharply to 0.6% in 1997. There were subsequent periods of reversal in 1999-2001, 2008-2010, and 2019-2023, but the declining trend continued in the 2000s and 2010s, falling temporarily to 0.2% in 2018. This suggests that the decline in the TFP growth rate was another major factor for the secular stagnation in the Japanese economy.

As in Figure 2, we shadow the periods during which the BOJ implemented several unconventional monetary policies. The TFP growth improved during the ZIRP period (February 1999-August 2000). Even under the YCC period (January 2016- March 2024), it improved during the recovery period from the COVID-19 crisis. However, it declined significantly during the QE policy period (March 2001-March 2006) and the QQE policy period (April 2013-). This suggests that the BOJ's unconventional monetary policy may have slowed down the Japanese productivity growth during these periods.

3. VAR Estimation

In the following sections, we estimate structural VARs with Cholesky decomposition and calculate their impulse response functions to analyze what dynamic relationship unconventional monetary policy had with the GDP gap and the TFP growth. The dynamic relationship shown by the impulse response functions implies "Granger causality" and does not necessarily mean true causal patterns. However, in literature, the impulse response functions have been widely used as one powerful method for analyzing the effects of monetary policy. It is thus important to explore whether the properties observed in the graphs in the previous section can be confirmed by the impulse response functions.

Since the BOJ's policy rate has been effectively zero since 1999 and has lost its value as a policy indicator, the following analysis uses the "short-term shadow rate" as an indicator of the BOJ's unconventional monetary policy in the baseline estimates. The short-term shadow rate is an artificial policy rate that captures the degree of unconventional monetary easing as a hypothetical fall in the policy rate. It measures the degree of monetary easing by allowing its value to take on negative territory. Various researchers such as Ichiue and Ueno (2015) and Wu and Xia (2016) have published their estimates. In the following, we use the quarterly average of the "short-term shadow rate" estimated by Leo Krippner which is based on the methodology of Krippner (2013). As noted by Krippner (2020) and Mavroeidis (2021), the short-term shadow rate includes various measurement errors, so that we need to be careful when interpreting the estimation results. However, the short-term shadow rate is a useful monetary policy indicator to examine the effects of monetary policy when the policy rate hit its ELB.

The sample period in the following estimations is from the first quarter of 1999 to the fourth quarter of 2023. The reason why the sample period starts from the first quarter of 1999 is that the BOJ started its ZIRP in February 1999. Our main purpose is to analyze the effect of monetary policy during the period when the Japanese economy fell into a liquidity trap. The sample period almost corresponds to the period of liquidity trap in Japan. In the analysis, we consider the following VAR using a vector Y_t consisting of three variables: the short-term shadow rate (SSR_t), the GDP gap ($GDPgap_t$), and the TFP growth rate (ΔTFP_t).

(3) $$B\, Y_t = b + \sum_{j=1}^{p} \beta_j \; Y_{t-j} + \varepsilon_t,$$

where B is the lower triangular matrix and b is the constant term vector. ε_t is a 3×1 vector of structural shocks whose mean is zero and whose variance-covariance matrix is the identity matrix.

Multiplying both sides of equation (3) by the inverse matrix B^{-1} leads to the following reduced-form equation :

(4) $$Y_t = c + \sum_{j=1}^{p} \gamma_j \; Y_{t\text{-}j} + u_t,$$

where $c \equiv B^{-1}b$, $\gamma_j \equiv B^{-1}\beta_j$, and $u_t \equiv B^{-1}\varepsilon_t$. The error term u_t in equation (4), whose variance-covariance matrix is $E[u_t\, u_t{}'] = B^{-1}B^{-1}$, is obtained multiplying the structural shock ε_t in equation (3) by the inverse matrix B^{-1}.

Based on the estimation results in equation (4), we implement a Cholesky decomposition of the structural shocks, assuming that the components of the vector Y_t are in the order of ΔTFP_t, SSR_t, and $GDPgap_t$. We ordered ΔTFP_t as the first variable because productivity shocks are medium- and long-term shocks and are less likely to respond instantaneously to other macro shocks. However, for the other two variables (SSR_t and $GDPgap_t$), their order in the Cholesky decomposition cannot be determined a priori. In Appendix 1, we will thus show that the following results are generally robust even when the Cholesky decomposition is ordered differently. In Appendix 2, we will also show that the following results do not change even when the vector Y_t consists of four variables including the consumer price inflation rate as an extra variable.

In the analysis, the quarterly data for the GDP gap (%) and the TFP growth rate (%) were obtained from the data published by the Cabinet Office as described in the previous section. **Table 1** summarizes the basic statistics of these data from the first quarter of 1999 to the fourth quarter of 2023. Among the three variables, the GDP gap is the most volatile variable, fluctuating widely between -9.1% and 2.0%. Its skewness indicates that the distribution is skewed to the right (i.e., flat tailed on the negative side). This reflects the fact that the GDP gap took a large negative value during the global financial crisis and the COVID-19 crisis. The short-term shadow rate is the second most volatile variable. Its mean, median, and standard error are -1.76%, -1.62%, and 1.44, respectively, reflecting the unprecedented monetary easing. Its skewness is negative (i.e., flat-tailed on the negative side), implying that the large negative short-term shadow rate is relatively rare over the sample period. On the other hand, the TFP growth rate is the least volatile variable, with a range of only between 0.2% and 1.2%. This can be attributed to the fact that it is a variable smoothed by the HP filter. However, like the GDP gap and the short-term shadow rate, its skewness is negative and its distribution is skewed to the right.

4. Impulse Response Functions

We estimated equation (4) setting the lag length p = 6 based on the Akaike Information Criterion

(AIC). **Figure 4** shows its impulse response functions. To save the space, the impulse response functions to their own shock. It depicts the region of 90% confidence intervals by shadows in each impulse response function.

The top panel shows the impulse response functions of the TFP growth rate to each experimental structural shock. The most noteworthy result is that the responses of the TFP growth rate to a shock in the short-term shadow rate were positive. They were small for the first 6th quarters. However, its positive impact become large from the 10th quarter and remained significantly positive at the 90% confidence intervals until the 25th quarter. In a normal period, the short-term interest rate is less likely to affect productivity growth. However, in Japan, extreme monetary easing (i.e., an unprecedented increase in the monetary base) and ultra-low interest rates have continued for about a quarter of a century, which may have preserved low-productivity firms and lead to significant decline in productivity in the economy. The impulse response function supports this possibility. The responses of the TFP growth rate to the GDP gap were, on the other hand, insignificant. This suggests that short-term economic fluctuations did not have a significant effect on productivity growth in the Japanese economy, which remained stagnant for a long period of time.

The third panel shows the impulse responses of the GDP gap to a shock in each variable. The responses to a TFP growth shock were significantly negative from the 3rd to the 8th quarters. This reflects the fact that an increase in productivity decreases the GDP gap through increasing potential output. The responses to its own shock GDP gap were also significantly positive for the first 4 quarters. This suggests the persistence of the business cycles. The more interesting result is that the GDP gap showed negative responses to a shock in the short-term shadow rate. The GDP gap had a significantly negative response to a shock in the short-term shadow rate from the 9th to 21st quarters at the 90% confidence intervals. During the estimation period, Japan's policy rate hit its ELB and the Japanese economy was in a liquidity trap. Thus, conventional monetary policy became ineffective. However, even in such a situation, the BOJ has contributed to boosting the economy by using a variety of unconventional policy measures including unprecedented increases of the monetary base. The negative responses reflect the effectiveness of such policy measures.

However, as we have already seen, a decline in the short-term shadow rate had a significant negative impact on the TFP growth rate. This suggests that while the BOJ's unconventional policies were effective for boosting short-term economic activities, the extreme monetary easing over a quarter of a century may have reduced the productivity growth of the Japanese economy. Even under a liquidity trap, monetary policy was an effective policy tool to stabilize short-term macroeconomic fluctuations in Japan. However, no matter how effective it is in the short run, unintended adverse effects may occur in the economy if it is continued in an extreme form over a long period of time. Our results of the impulse response functions suggest that Japan was an exceptional country that suffered from such unintended adverse effects.

The second panel shows the impulse responses of the short-term shadow rate to a shock in each variable, respectively. The short-term shadow rate showed a negative but insignificant responses to a shock in the GDP gap. In normal times, monetary policy should move counter-cyclically, so that the short-term shadow rate should have shown significantly negative responses to a shock in the GDP gap. However, in Japan, where extreme monetary easing policies were implemented for a quarter of a century, the short-term shadow rate tended to decrease regardless of economic conditions. The weak insignificant responses to a shock in the GDP gap may capture the feature of Japan's monetary policy.

5. Jordà's local projections

In the previous section, we estimated a structural VAR with Cholesky decomposition and derived the impulse response functions to analyze the dynamic relationship of unconventional monetary policy with the TFP growth and the GDP gap. However, if the data generating process is not well approximated by the VAR, its impulse response functions could be biased and may lead to inaccurate results. If this is the case, the local projections proposed by Jordà would derive more appropriate impulse response functions for evaluating the dynamic relationship than the VAR. This is because local projections can derive impulse response functions by estimating simple equations without relying on any restrictive assumptions on the model.

In this section, we explore how robust the results in the previous section are by calculating the impulse response functions using Jordà's local projections. We implement Jordà's local projections through estimating the following forecast equation for each s (= 0, 1, 2, ... , h) from the first quarter of 1999 to the fourth quarter of 2023.

$$(5) \qquad Y_{t+s} = d^{s} + \sum_{j=0}^{p} \delta_{j,s} Y_{t-j} + v_{t+s,s},$$

where a vector Y_t consists of the same three variables as before. By using the estimated parameters in equation (5), the impulse response in the sth quarter is obtained as

$$(6) \qquad \widehat{IR}(t, s. \xi_t) = \widehat{\delta_{0,s}}\xi_{t,}$$

where $\widehat{\delta_{0,s}}$ is the estimate of $\delta_{0,s}$ and ξ_t is the relevant experimental shock of vector Y_t.

Figure 5 shows the impulse response functions derived by equation (6) for each s (= 0, 1, 2, ... , h). When estimating equation (5), we set the lag length of p =6, as in the previous section. In the figure, we draw the impulse response functions derived by the Jordà's local projections by a solid blue line and depict the region of its 90% confidence intervals by the red dotted lines. To compare the results with those in the previous section, we also draw the corresponding impulse response functions of the VAR by a green line with circle points.

In the figure, the solid blue and green lines with circle points move show almost similar movements in the other impulse response functions. This indicates that the results in the previous section are generally robust, at least for the impulse response functions of the TFP growth rate and the GDP gap. In particular, the impulse response functions of the TFP growth rate to a shock in the short-term shadow rate are similar to those in the previous section. Using Jordà's local projections, the results are significantly negative at the 90% confidence intervals from the 14th to 24th quarters. This supports our previous result that a decline in the short-term shadow rate reduces the TFP growth rate.

In case of the impulse response function of the GDP gap to a shock in the short-term shadow rate, the impulse response function was relatively smooth in the VAR estimate, whereas it showed significant upward and downward movements in the Jordà's local projections. In addition, the number of non-significant periods was somewhat longer in the Jordà's local projections. However, the impulse response functions were not so different on average between the two estimates. Even in the Jordà's local projection, it was significantly negative at the 90% confidence intervals from the 11th to 15th quarters. This support out previous findings that a decrease in the short-term shadow rate raises the GDP gap. In other words, the unconventional policy implemented by the BOJ under the liquidity trap were effective in stabilizing short-term macroeconomic fluctuations. However, no matter how effective it is in the short run, its unintentional perverse effect may have slowed down the growth of productivity because it was continued in an extreme form over a long period of time.

6. Alternative monetary policy indicators

In previous sections, we have analyzed the effects of unconventional monetary policy using the "short-term shadow rate" as an indicator of the BOJ's monetary policy. Under a liquidity trap where the policy rate has hit its ELB, the short-term shadow rate could be a reasonable proxy of the monetary policy that the policy rate cannot capture. In previous studies, it has thus been widely used to explore the effectiveness of the BOJ's unconventional policy. However, since the BOJ has implemented a variety of unconventional policy measures, the short-term shadow rate may not proxy all of them well. In this section, we therefore analyze whether our previous results are still robust even when using alternative indicators of monetary policy. In the analysis, we consider two alternative indicators: (i) the "growth rate of the monetary base (ΔMB_t)" and (ii) the "10-year JGB yield (JGB_t)".

The growth rate of the monetary base has been used as an indicator of the BOJ's monetary policy in many previous studies. In 2001, the BOJ started the "QE" with the current account balance, the main component of the monetary base, as its policy target, and in 2013, it launched the "QQE" with the monetary base as its main operating variable. Therefore, at least since the early 2000s, when the unprecedented quantitative easing policy started, it is reasonable to consider the growth rate of the monetary base as a key indicator of the BOJ's monetary policy. The quarterly data for the growth rate of the monetary base was calculated by taking the growth rate (yearly change, %) of the quarterly averaged monetary base (reserve requirement rate change adjusted, average amounts outstanding) published by the BOJ.

The 10-year JGB yield is, on the other hand, a representative long-term interest rate that took positive values for most of the time even after the policy rate hit its ELB. In the analysis, we use the quarterly average of the "10-year JGB yield" for our analysis. Since it reflects expectations of future policy rates, Swanson and Williams (2014) noted that it is a proxy variable for unconventional monetary policy as long as its dynamics has remained unaffected by a binding ELB on shorter-term rates. In previous studies, Debortoli, Gali, and Gambetti (2019) and Rogers, Scotti, and Wright (2018) have analyzed the effects of unconventional monetary policy using similar long-term interest rates. In Japan where unconventional policy was expanded at unprecedented levels, the yield even the 10-year JGB yield fell below 1% in 2012 and often took negative values after 2016, when negative interest rate policy was launched. Thus, the 10-year JGB yield may not be a desirable proxy for unconventional monetary policy after 2016. However, under the environment where the policy rate hit its ELB, it is one useful indicator of monetary policy to check whether our results in previous sections are robust.

Figure 6 and **Figure 7** show the impulse response functions with Cholesky in the order of ΔTFP_t, ΔMB_t, and $GDPgap_t$ and of ΔTFP_t, JGB_t, and $GDPgap_t$, respectively. As before, the sample period is from the first quarter of 1999 to the fourth quarter of 2023. Except that we use ΔMB_t or JGB_t instead of SSR_t for the monetary policy indicator, the data used in the analysis are the same as in the previous section. The lag length p in estimating the VAR was chosen based on the AIC, resulting in p =6 in both cases. In the figures, the region of the 90% confidence intervals is shadowed in each impulse response function. However, since our main interest is to see what effect unconventional monetary policy had on the TFP growth rate and the GDP gap, we only depict the impulse response functions that show the responses of the TFP growth rate and the GDP gap to an experimental shock in ΔMB_t or JGB_t respectively. Contrary to the short-term shadow rate, monetary easing is achieved when the monetary base increases. Thus, the responses of the TFP growth rate and the GDP gap in Figures 6 are expected to be opposite in sign to those in the previous sections.

The top panel of Figure 6 shows the responses of the TFP growth to a shock in the ΔMB_t. The responses of the TFP growth rate to a shock in the growth rate of the monetary base were negative. They were initially small. However, they became significantly negative at the 90% confidence intervals from the 9th quarter to the 24th quarter. In a normal period, the growth rate of the monetary base is less likely to affect productivity growth. However, in Japan, extreme monetary easing (i.e., an unprecedented increase in the monetary base) and ultra-low interest rates have continued for about a quarter of a century, which may have preserved low-productivity firms and lead to significant decline in productivity in the economy. The impulse response function supports this possibility.

The second panel, on the other hand, shows the responses of the GDP gap to the ΔMB_t shock. The GDP gap showed positive responses to a shock in the growth rate of the monetary base. The responses were significant in the 90% confidence intervals from the 13th to 19th quarters. During the estimation period, Japan's policy rate hit its ELB and the Japanese economy was in a liquidity trap. Thus, conventional monetary policy became ineffective. However, even in such a situation, the BOJ has contributed to boosting the economy by using a variety of unconventional policy measures including unprecedented increases of the monetary base. The positive responses reflect the effectiveness of such policy measures.

The top panel of Figure 7 shows the responses of the TFP growth to a shock in the JGB_t. As in the case of the short-term shadow rate, the responses were positive. They were small for the first approximately four quarters. However, it became significantly positive at the 90% confidence intervals from the 11th quarter and remained significantly positive until the 25th quarter. The second panel, on the other hand, shows the responses of the GDP gap to the JGB_t shock. The GDP gap had a significantly negative responses at the 90% confidence intervals to a shock to the 10-year JGB yield from the 11th to 14th quarters.

The above results suggest that the results in the previous sections are robust even when using alternative monetary policy indicators. In other words, while unconventional monetary policy has been effective in stabilizing short-run economic fluctuations even under a liquidity trap, nearly a quarter century of extreme low interest rates has resulted in a significant decline in productivity in the Japanese economy. Monetary policy is an effective policy tool for macroeconomic stabilization even when the policy rate hit its ELB. However, even though it is effective in the short-run, unintended adverse effects may occur in the economy when it is continued in an extreme form over a long period of time. The above impulse response functions suggest that we can confirm the feature using alternative monetary policy indicators.

7. Alternative TFP Growth and GDP Gap

In the previous sections, we have analyzed the effects of unconventional monetary policy using the "TFP growth rate" and "GDP gap" estimated by the Cabinet Office. However, the estimated "TFP growth rate" and "GDP gap" may contain measurement errors and do not necessarily fully capture true productivity growth and business cycle fluctuations. Therefore, in this section, we explore whether our results are still robust when using alternative "TFP growth rate" and "GDP gap" data. Specifically, we will analyze the effects of unconventional monetary policy using the "TFP growth rate" and "GDP gap" estimated by the BOJ.

The data estimated by the BOJ, as well as those estimated by the Cabinet Office, have been used extensively in previous studies on the Japanese economy. The BOJ's estimation method of the GDP gap is essentially different from the Cabinet Office's in that it derives the GDP gap by using labor input gap and capital input gap rather than by using potential GDP. The BOJ's estimation method of the TFP growth rate is relatively similar to the Cabinet Office's method. However, because they are different in details, the TFP growth rate estimated by the BOJ sometimes deviates significantly from that by the Cabinet Office. Unfortunately, the TFP growth rate published by the BOJ is semiannual data, which reduces the degree of freedom in estimating the structural VAR. But it is worthwhile to explore whether our results are still robust when using the "TFP growth rate" and "GDP gap" data estimated by the BOJ.

In the following, we estimate a structural VAR by using the TFP growth rate and the GDP gap estimated by the BOJ. As in the baseline estimates, we use the short-term shadow rate as an indicator of monetary policy. The data is semi-annual from 1999 to 2003. To ensure a degree of freedom, we set the lag length to p =4. We also performed a Cholesky decomposition in the order of ΔTFP_t, SSR_t, and $GDPgap_t$. **Figure 8** shows the impulse response functions, shadowing the region of the 90% confidence intervals. Since our primary interest is to examine the effects of unconventional monetary policy on the TFP growth and the GDP gap, it only shows the impulse responses of the TFP growth and the GDP gap to an experimental SSR_t shock. Since the data are semi-annual, the period of the impulse responses is limited for 15 periods (7.5 years).

The top panel of Figure 8 depicts the response of the TFP growth to an experimental SSR_t shock. It shows that the response of the TFP growth to the shock was positive. The impact was initially small. However, it became significantly negative after the 5th period (2.5 years) and remained significant until the 14th period (7 years). On the other hand, the second panel depicts the response of the GDP gap to a SSR_t shock. The GDP gap showed a negative response to the short-term shadow rate. The negative response was significant from around the 10th to 12th periods.

The results suggest that our results are still supported even when using the BOJ's "TFP growth rate" and "GDP gap". That is, even under a liquidity trap, the BOJ’s quantitative easing, which increased the monetary base and lowered the short-term shadow rate dramatically, contributed to the recovery of the GDP gap. However, the continuation of the extreme monetary easing for about a quarter of a century may have resulted in a decline in productivity growth. Japan was an exceptional country where the unconventional monetary policy was accompanied by such an adverse effect on medium- and long-term productivity growth. This was confirmed by using alternative data of TFP growth rate and "GDP gap.

8. Concluding remarks

This paper analyzed the effects of unconventional monetary policy in Japan since the late 1990s. It explored not only the effects on stabilizing short-term fluctuations of the GDP gap, but also on medium- and long-term changes of TFP growth. The results of our analysis revealed that the BOJ's unconventional monetary policy had a significant effect in restoring the GDP gap even under the liquidity trap. However, they also revealed that unconventional monetary policy had a significant negative impact on the TFP growth.

Medium- and long-term productivity is usually considered to be determined independently of monetary policy. However, if an ultra-low interest rate policy is continued for a long period of time, inefficient firms are less likely to exit from the markets, and the economy's overall productivity growth may decline. In Japan, the unprecedented monetary easing has continued for about a quarter of a century. This may have resulted in misallocation of funds and reduced the productivity growth in the Japanese economy. Even if unconventional monetary policy is an effective policy tool, its perverse effects would become apparent when it has been continued in its extreme form over a long period of time. Japan is such a country where the effective unconventional monetary policy had an unintended adverse effect on the economy.

Appendix 1. Robustness of Alternative Cholesky Decompositions

In the main text, we analyzed the impact of the short-term shadow rate on the TFP growth and the GDP gap by calculating the impulse response functions by a Cholesky decomposition in order of ΔTFP_t, SSR_t, $GDPgap_t$. However, for the three variables, the order cannot be determined a priori. Therefore, in this Appendix, we investigate how the impulse response functions in section 4 may change when we make alternative ordering of the three variables in the Cholesky decomposition over the sample period.

In addition to the ordering in the main text, we can consider five different orderings for the three variables. In general, impulse response functions can be different for different orderings. However, in the case of our analysis, the differences were almost negligible, and the results in section 4 were essentially the same for all orderings. **Figure A1** depicts the impulse response functions of ΔTFP_t and $GDPgap_t$ to an experimental shock of SSR_t for each ordering. In the experiment, the impulse response functions were calculated with lag length p =6 as in section 4, and the regions of the 90% confidence intervals are shown in shadows.

The impulse response function of ΔTFP_t showed a negative response to a shock in SSR_t for any ordering. The statistical significance tends to be slightly higher when we ordered ΔTFP_t later. However, regardless of the orderings, the shape of the impulse response functions was essentially similar and did not change our conclusion that an increase in the monetary base had a negative impact on TFP growth. The impulse response function of $GDPgap_t$ tended to show a positive response to an experimental shock in SSR_t for any ordering. The statistical significance was somewhat lower when we ordered SSR_t first. However, the shape of the impulse response functions was essentially similar for any ordering, and did not change our conclusion that an increase in the monetary base had a positive impact on the GDP gap.

These results suggest that our results in the main text are generally robust even when the Cholesky decomposition is ordered differently. In other words, regardless of the ordering of the Cholesky decomposition, the impulse response functions derived from the structural VAR estimation indicate that the BOJ's unconventional monetary policy had a positive effect in boosting the GDP gap, while having a significant negative impact on the TFP growth rate.

Appendix 2. VAR including the Inflation Rate

In the main text, we examined the impacts of an increase in the short-term shadow rate on the GDP gap and TFP growth rate by estimating the structural VAR and its impulse response functions using three variables, SSR_t, $GDPgap_t$, ΔTFP_t. We limited our analysis to these three variables because the degree of freedom becomes smaller in our quarterly data when we include extra variables. However, previous studies have extensively discussed the impact of unconventional monetary policy on inflation rates of consumer price index (CPI) in Japan. In this Appendix, we thus examine the effects of an increase in the monetary base by estimating a structural VAR consisting of four variables: SSR_t, $GDPgap_t$, ΔTFP_t. and the CPI inflation rate (ΔCPI_t). In the analysis, we estimate equation (4) assuming that the vector Y_t is in the order of ΔTFP_t. SSR_t, $GDPgap_t$, and ΔCPI_t, and calculate their impulse response functions over the sample period. The quarterly CPI data was obtained by taking the quarterly average of the monthly consumption tax-adjusted core CPI (excluding fresh food prices) published by the Ministry of Internal Affairs and Communications. Its growth rate was calculated to obtain ΔCPI_t by using its year-on-year rate of increase (%).

Figure A2 depicts the impulse response functions when we estimate a structural VAR setting the lag length $p = 6$. As in the main text, the figure shadows the region of the 90% confidence intervals in each impulse response function. Since the main interest of our study is to explore how unconventional policies (i.e., an increase in the monetary base) have affected the TFP growth rate, the GDP gap, and the inflation rate, we only depict the impulse response functions of ΔTFP_t, $GDPgap_t$, and ΔCPI_t to a shock in SSR_t in the figure.

Even when ΔCPI_t is included as an extra variable, the shape of the impulse response function of ΔTFP_t to a shock in SSR_t remains the same. The positive impact was initially small. However, after the 9th quarter, it took on a positive value with the 90% confidence intervals, which continued until the 22nd quarter. The significant range was almost the same as that in section 4 (the 9th through 24th quarters). The inclusion ofΔCPI_t as an extra variable did not change our conclusion that a decline in the short-term shadow rate had a negative impact on the TFP growth in Japan.

The impulse response function of the GDP gap to a shock in SSR_t was negative even when ΔCPI_t is included as an extra variable, with the exception of first few quarters. Its statistical significance was somewhat reduced; The response was significant at the 90% confidence intervals from the 9th to 21st quarters when we did not include ΔCPI_t, while it was significant at the 90% confidence intervals at the 8th and 9th quarters and from the 14th to 18th quarters when we included ΔCPI_t. The less significant results may have happened because the GDP gap shows similar movements with the newly added ΔCPI_t. However, except for a slight decrease in statistical significance, the shape of the impulse response function is similar to that in section 4. The inclusion ofΔCPI_t as an extra variable did not change our conclusion that an increase in the monetary base has a positive impact on the GDP gap in Japan.

On the other hand, the impulse response function of ΔCPI_t to a shock in SSR_t was negative except for the first few quarters but only at low statistical significance levels; the impulse response function was not significant even at the 90% confidence intervals. During our sample period, the rate of price increases was very low in Japan. We cannot deny that the extreme monetary expansion may have played some role for avoiding deflation spirals. However, our impulse response function suggests that the effect, if any, was limited.

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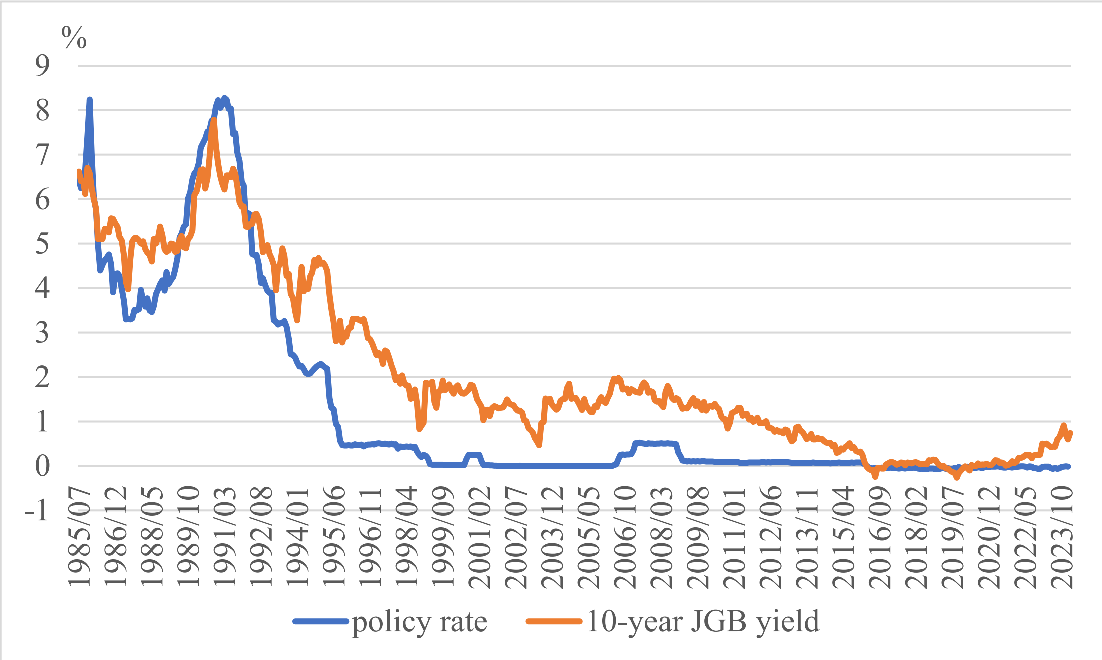
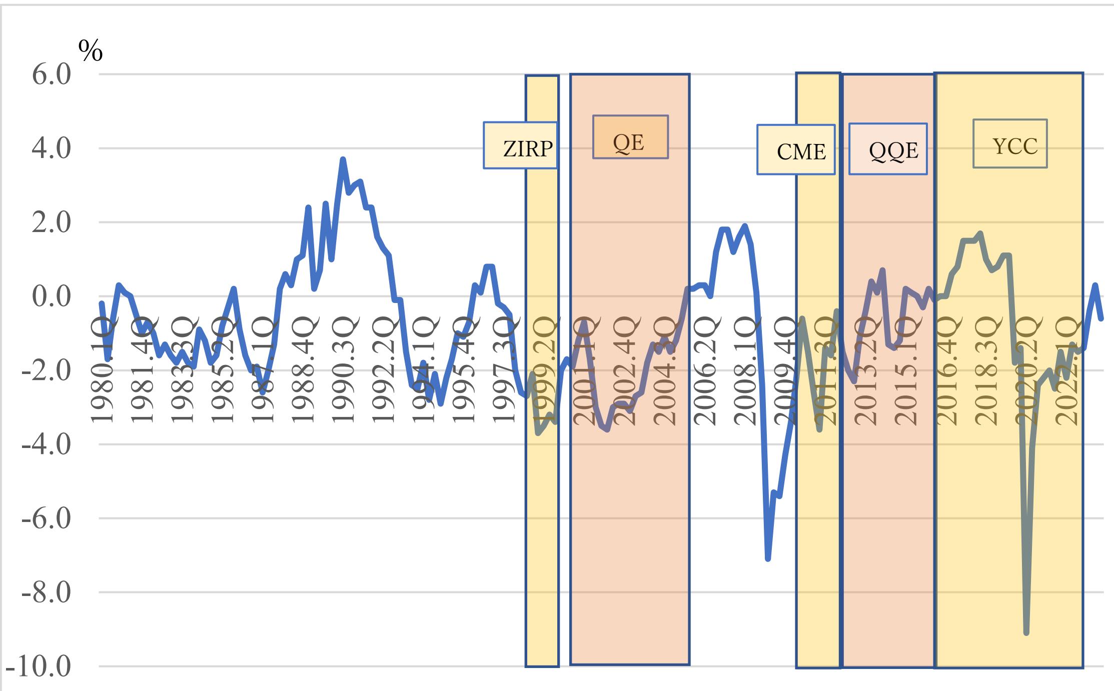
Figure 1. The Policy Rate and the 10-year Government Bond (JGB) Yield in Japan



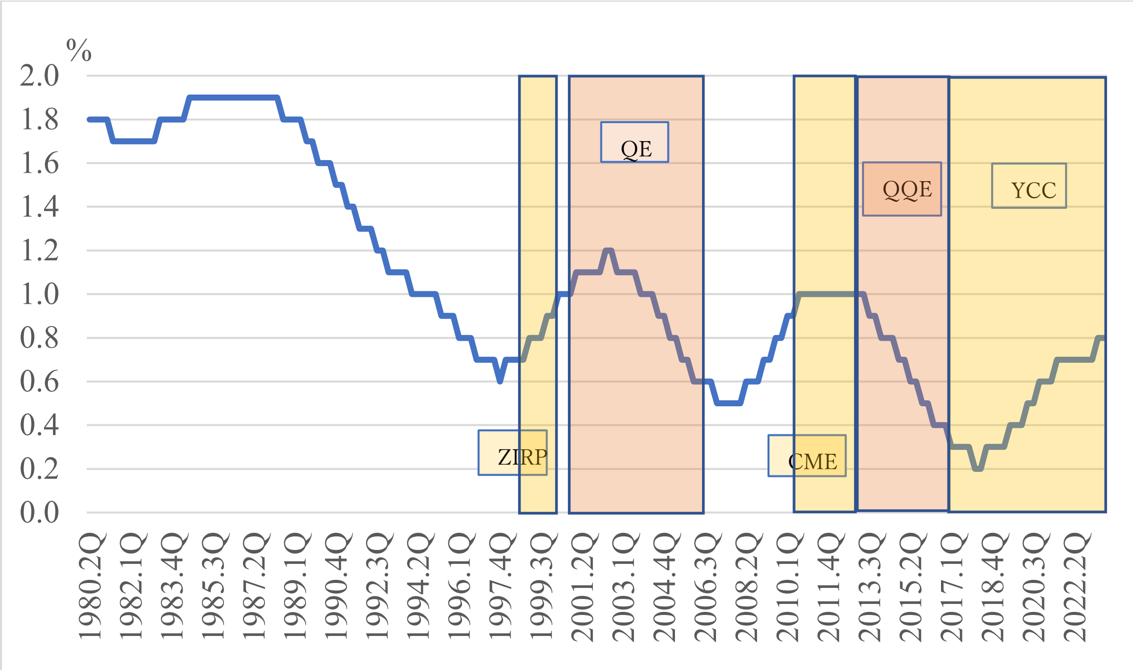
Note) The policy is the overnight uncollateralized call rate.

Figure 2. The GDP Gap Estimated by the Cabinet Office



Note) ZIRP = zero interest rate policy, QE =quantitative easing, CME =comprehensive monetary easing, QQE = quantitative and qualitative easing, and YCC =yield curve control.

Figure 3. The TFP Growth Rate Estimated by the Cabinet Office



Note) ZIRP = zero interest rate policy, QE =quantitative easing, CME =comprehensive monetary easing, QQE = quantitative and qualitative easing, and YCC =yield curve control.

Figure 4. Impulse Response Functions of the Baseline Estimation

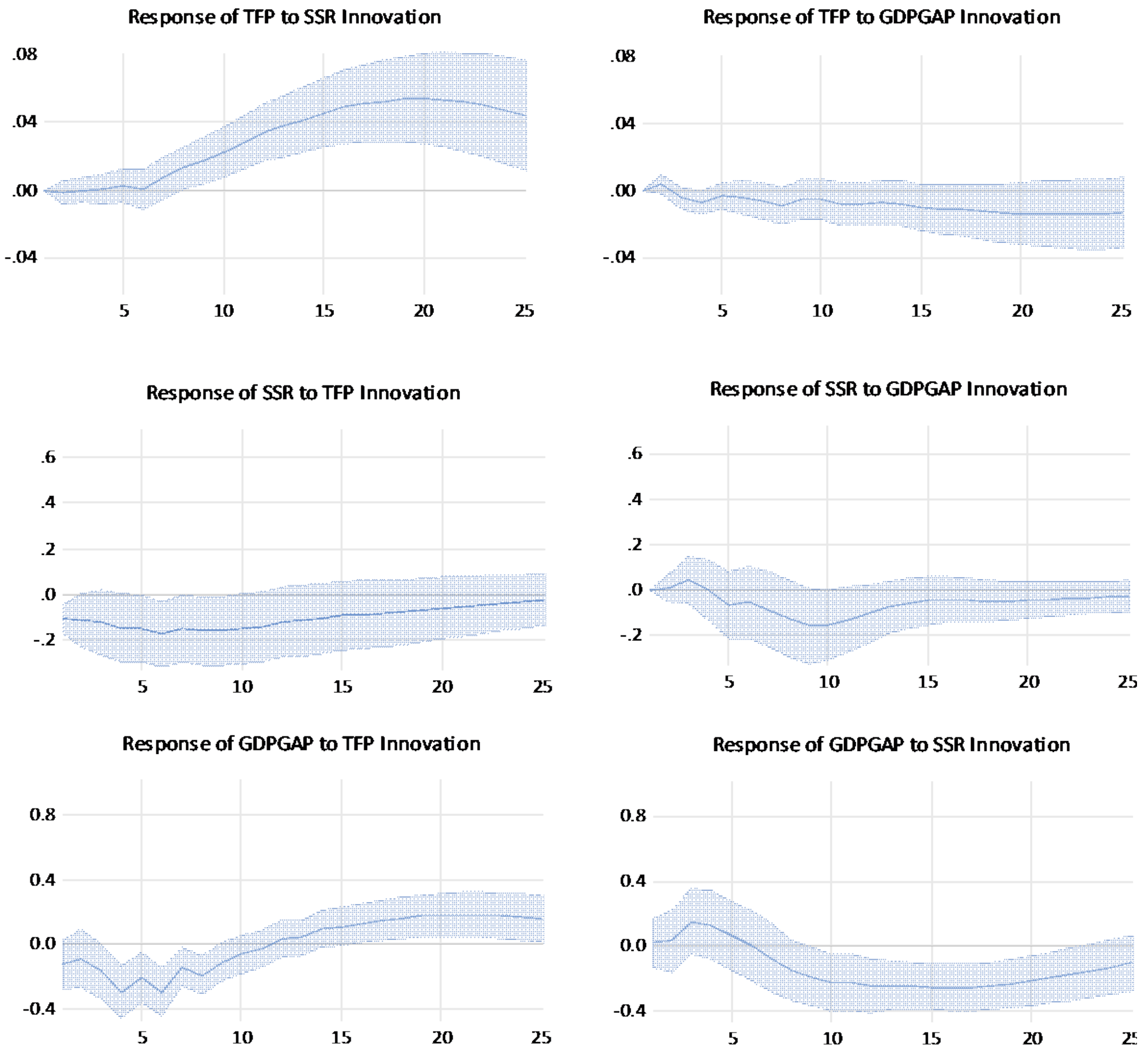


Figure 5. Impulse Response Functions derived by Local Projections

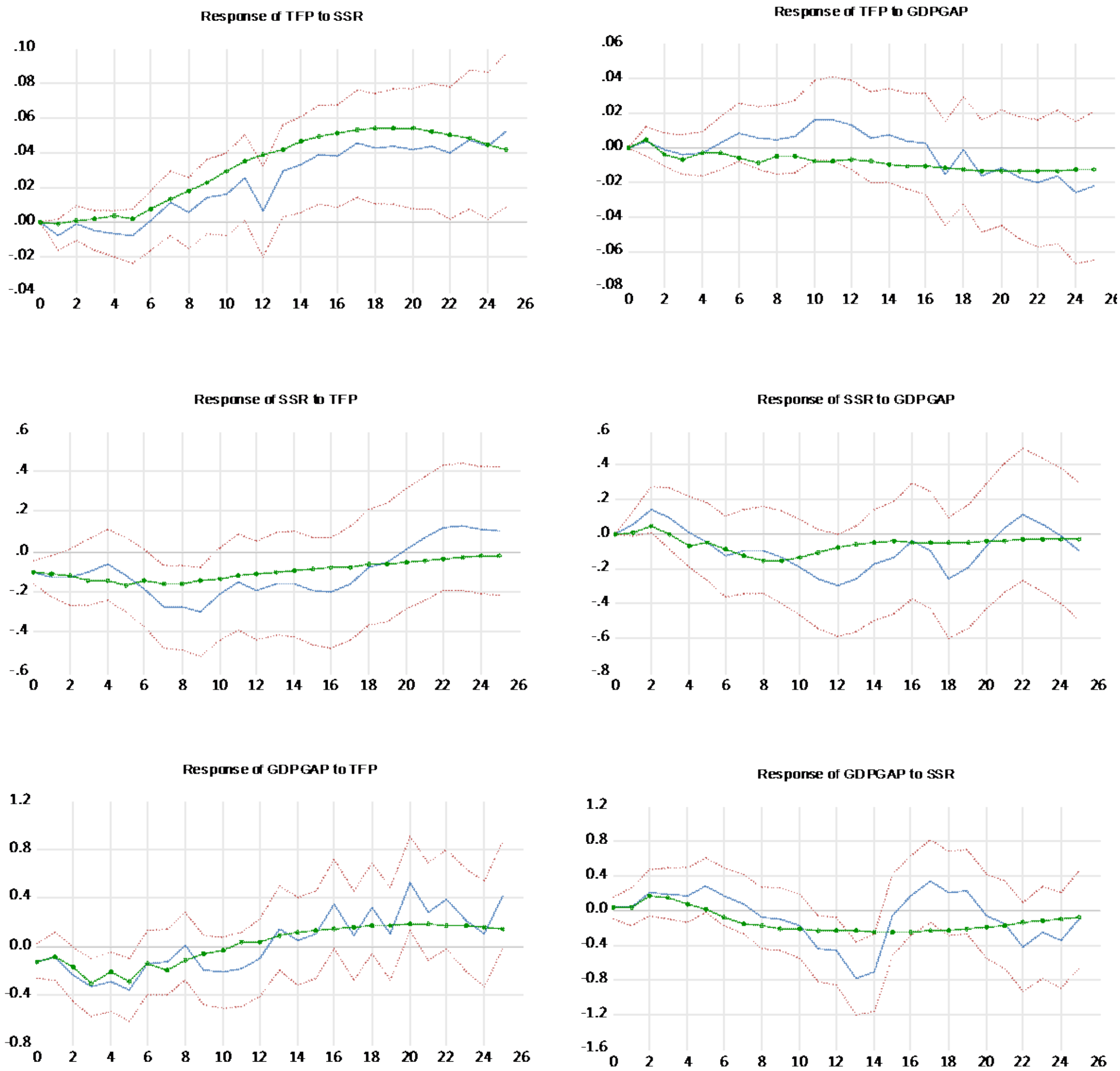


Figure 6. Impulse Response Functions using the Monetary Base

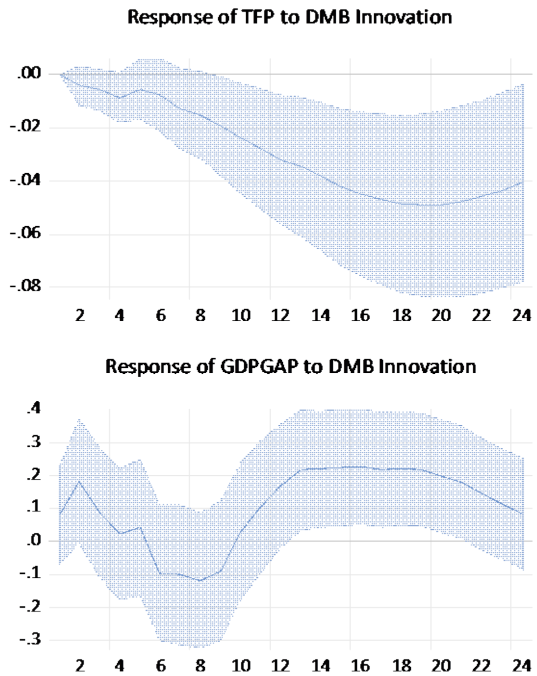


Figure 7. Impulse Response Functions using the 10-year Yield

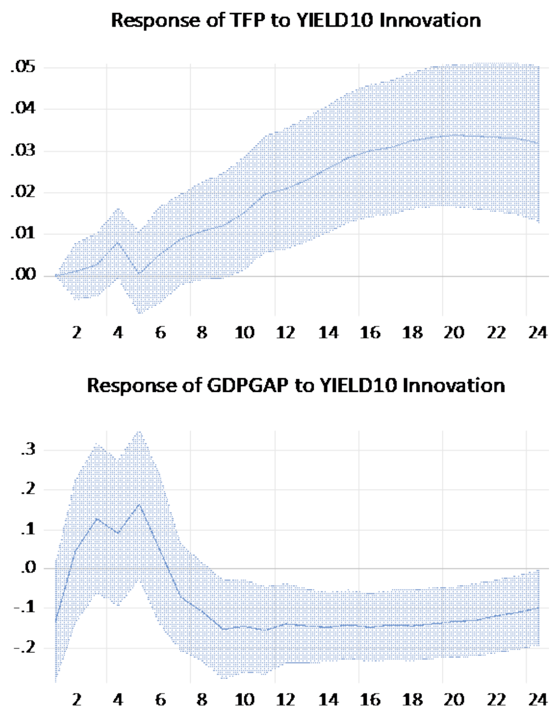


Figure 8. Impulse Response Functions using Alternative TFP growth rate and GDP gap

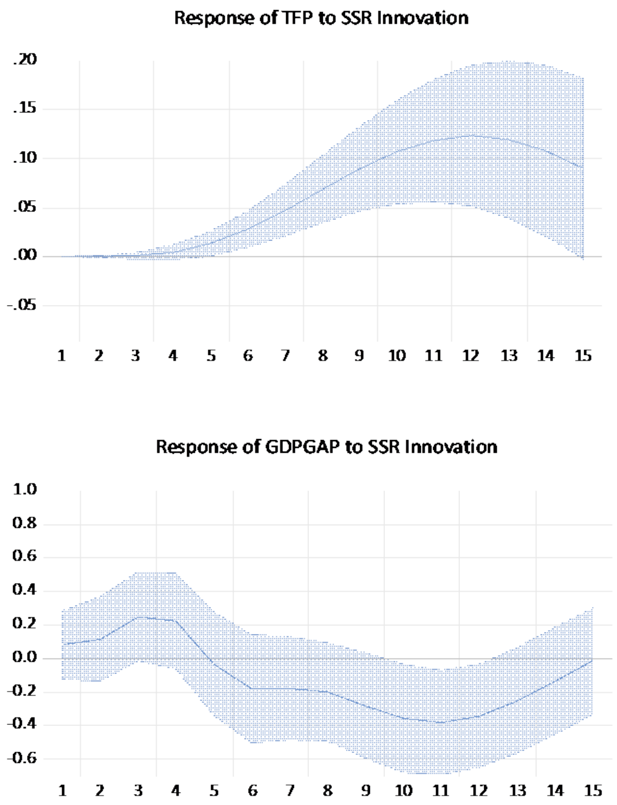
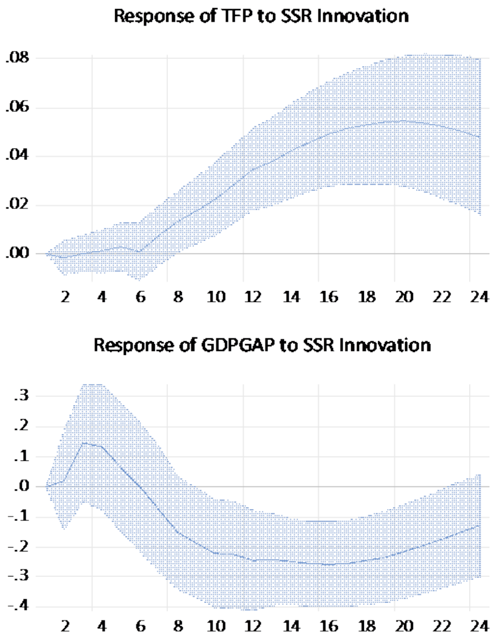
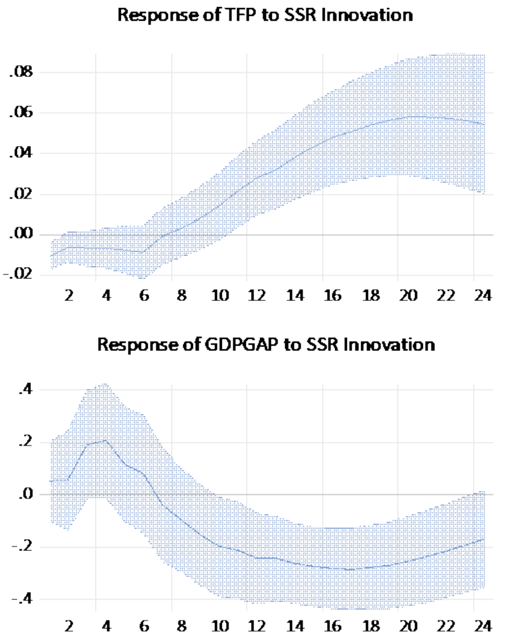


Figure A1. Impulse Response Functions for Alternative Orderings

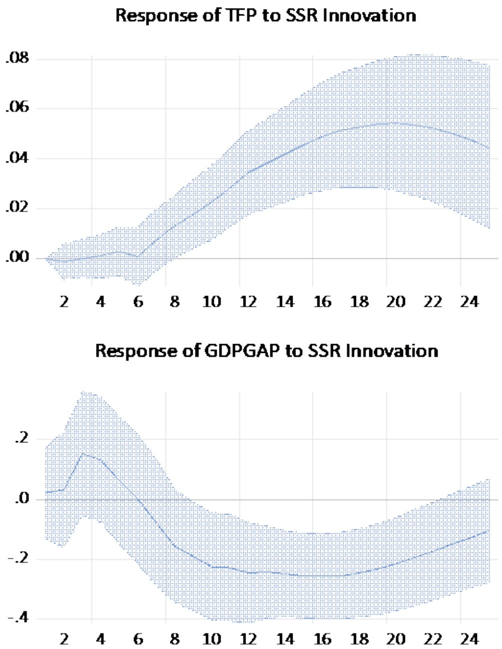
(1) Order of *ΔTFP*$_t$, *GDPgap*$_t$. and *SSR*$_t$



(2) Order of *SSR*$_t$. *ΔTFP*$_t$, and *GDPgap*$_t$



(3) Order of *SSR*$_t$, *GDPgap*$_t$, and *ΔTFP*$_t$



(4) Order of *GDPgap*$_t$. *ΔTFP*$_t$, and *SSR*$_t$

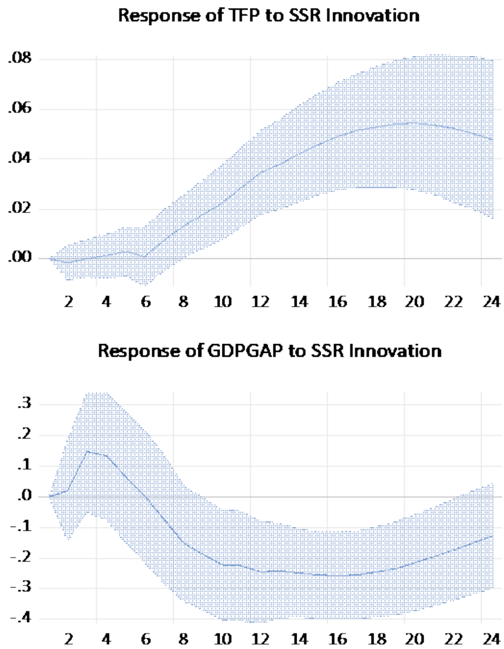
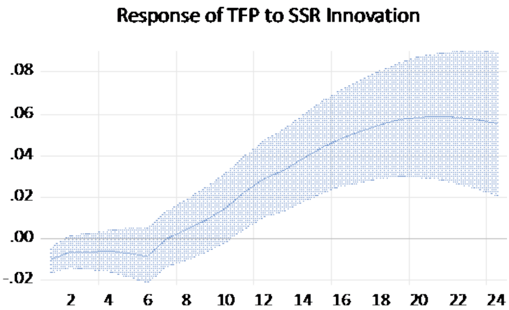


Figure A1. Impulse Response Functions for Alternative Orderings (continued)

(5) Order of $GDPgap_t$, SSR_t, and ΔTFP_t



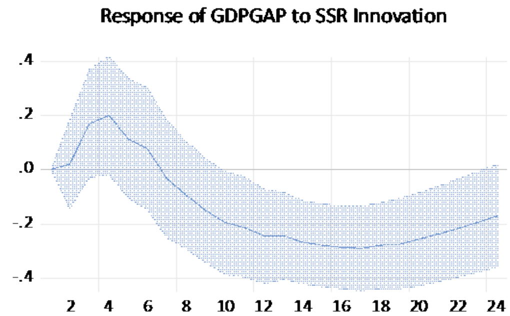


Figure A2. Impulse Response Functions including CPI Inflation Rate

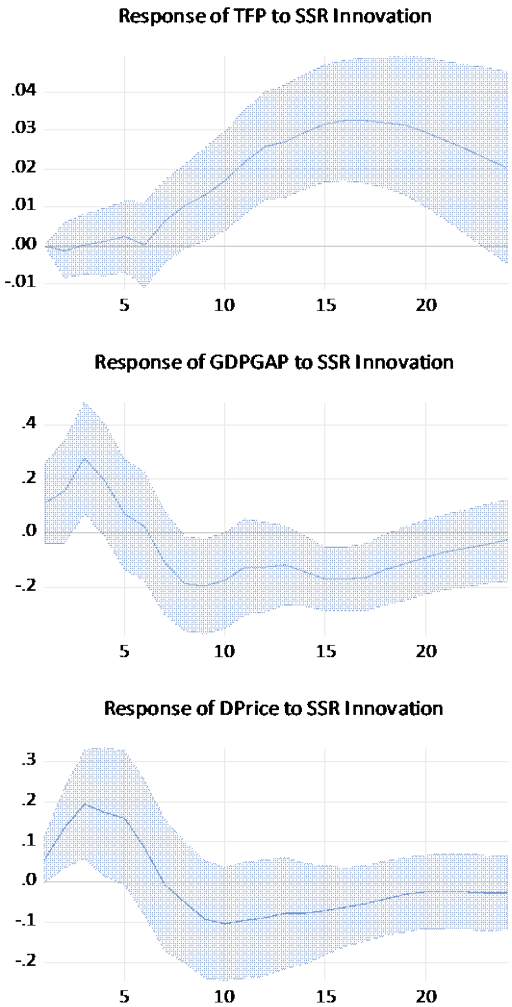


Table 1. The Basic Statistics of the Data

	DTFP	*GDP gap*	*SSR*
Mean	0.74	-1.20	-1.76
Median	0.70	-1.20	-1.62
Maximum	1.20	2.00	0.51
Minimum	0.20	-9.10	-5.69
Std. Dev.	0.26	1.95	1.44
Skewness	-0.20	-0.93	-0.46
Obs.	100	100	100