

Macroeconomic effects of the US quantitative easing at the zero lower bound including Great Recession and COVID-19 recession

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Abstract

This study investigates the macroeconomic effects of the US quantitative easing at the zero lower bound including Great Recession and COVID-19 recession through imposing the zero and sign restrictions. This study focuses on the responses of the dual mandate to quantitative easing at zero lower bound. The key findings are as follows. First, the unemployment rate declines and the inflation rate rises in response to the US quantitative easing at two zero lower bound periods in line with the previous literatures. It suggests that the US quantitative easing has the policy effectiveness at the zero lower bound. Second, the macroeconomic effects of the US quantitative easing during COVID-19 recession are larger than those during Great Recession. Third, comparing the responses of the dual mandate between two zero lower bound periods, the results confirm that there exist the larger unconventional monetary transmission and the larger fiscal reaction to monetary expansion at the zero lower bound during COVID-19 recession; moreover, the US Phillips curve flattens with modest inflation rate despite large fluctuations in unemployment rate.

Keywords: US unconventional monetary policy, Quantitative easing, Zero lower bound, Dual mandate, Zero and sign restrictions, Great Recession, COVID-19 recession

JEL Classifications: E44, E52, E58, E61, E65

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1. Introduction

Over the last two decades, there have been two major economic recessions, the Great Recession (2008-2009) and the COVID-19 recession (2020-present). During these periods, the central banks have faced the unexpected circumstances, so that the policymakers tried to find the effective monetary policies on the path to recovery. As the economic effects of two recessions, the policymakers have depended on the unconventional monetary policies such as the zero lower bound (ZLB) and the quantitative easing (QE). Specially, onset of the Great Recession, the US economy has devastated, so that the Federal Reserve System (the Fed) had no choice but to adopt the unconventional monetary policies because the conventional monetary policy, mainly as the interest rate policy, was no more sufficient to overcome the recessions, because the effective zero lower bound on the short-term nominal interest rate was reached. Then, the policymakers relied on the unconventional monetary policy tools to provide further stimulus in light of the significant collapse of economic conditions. Among these unconventional monetary policy tools, the Fed has conducted the QE known as large-scale asset purchases as the major tool during the ZLB periods. The primary objective of QE was to put downward pressure on the long-term interest rate in order to support private borrowings, thus spurring aggregate demand and stimulating real activity even at the ZLB.

In this study, we focus on the macroeconomic effects, particularly the impacts of the QE on dual mandate at two ZLB periods. The empirical literatures related with the effects of the unconventional monetary policies on the macroeconomic variables have focused on the period of Great Recession, not much that of COVID-19 recession. Most of the previous literatures commonly find that the expansionary unconventional monetary policy impacts on increase in both output and inflation, but some literatures indicate the response of

inflation is less significant than that of output.¹ Recently, Kim, Laubach and Wei (2020) find that the significant expansionary effects on the macroeconomy, with real activity and inflation increasing and unemployment decreasing in response to unexpected expansions in the Fed's asset holdings during the ZLB period between 2008 and 2015. Feldkircher, Huber and Pfarrhofer (2021) show that the monetary expansion from the first week of 2011 to the 24th week of 2020, caused higher output growth and lower unemployment rate, but no significant upward effect in inflation. According to the previous empirical literatures, they do not compare between two ZLB periods until now, so that we comparatively analyze the macroeconomic effects of the QE between two ZLB periods.

In order to compare between two ZLB periods, we use the weekly data due to supplementing the relatively short sample periods during COVID-19 recession. We intend to identify the ZLB and the QE at the same time, so we combine the zero and sign restrictions, which are imposed on the impulse responses to the federal funds rate, the securities held outright, the unemployment rate, and the expected inflation rate. For measuring the QE, this study selects three indicators, the securities held outright, the Fed's total assets, and the spread between 10-year Treasury rate and federal funds rate; the securities held outright (SHO) is treated as main indicator of measuring the QE, which consists of the holdings of US Treasury securities, Federal agency debt securities, and mortgage-backed securities by the Federal Reserve as in Bhattarai, Chatterjee and Park (2022).

We find that the QE has significant expansionary effects on the macroeconomic

¹ The literatures are related with the effects of the US unconventional monetary policy on the output and the inflation rate: Baumeister and Benati (2013); Gambacorta, Hofmann and Peersman (2014); Meinusch and Tillmann (2016); Weale and Wieladek (2016); Wu and Xia (2016); Rogers, Scotti and Wright (2018); Puonti (2019); Bundick and Smith (2020); Kim, Laubach and Wei (2020); Bhattarai, Chatterjee and Park (2021).

conditions at the ZLB periods. The ZLB/QE shocks lead to decrease the unemployment rate and increase the expected inflation rate. After considering the size of the ZLB/QE shocks, both effects on the dual mandate are larger at second period of the ZLB.

Hence, these results confirm that first, the QE has the policy effectiveness at the ZLB, second, the macroeconomic effects of the QE at the ZLB are larger during COVID-19 recession than those at the ZLB during Great Recession through the macroeconomic fundamentals such as wealth effects and fiscal reactions in response to unconventional monetary policy, and third, the US Phillips curve gets flattening, which is revealed by the difference in responses of the unemployment rate and the inflation rate between two ZLB periods.

The reminder of this study is structured as follows. Section 2 describes the data used in empirical analysis and the VAR model. Section 3 provides the empirical results. Section 4 concludes with a summary

2. Methodology and Data

We investigate the effects of US quantitative easing at the zero lower bound by using zero and sign restrictions to identify the quantitative easing and the zero lower bound at the same time.

Consider a structural VAR as in Rubio-Ramírez, Waggoner and Zha (2010):

$$A_0 Y_t = \sum_{l=1}^p A_l Y_{t-l} + \varepsilon_t$$

where $1 \leq t \leq T$, p is the lag length, T the sample size, Y_t an $n \times 1$ vector of

endogenous variables, ε_t an $n \times 1$ vector of exogenous structural shocks, and A_l an $n \times n$ matrix of parameters for $0 \leq l \leq p$ with A_0 invertible.

Let $A_+ = [A_1, \dots, A_p]$ and $\mathbf{x}_t = [Y_{t-1}, \dots, Y_{t-p}, 1]$ for $1 \leq t \leq T$. The reduced-form representation implied by the structural model is

$$Y_t = B\mathbf{x}_t + u_t$$

where $B = A_+ A_0^{-1}$, $u_t = A_0^{-1} \varepsilon_t$ and $E[u_t u_t'] = \Sigma = (A_0 A_0')^{-1}$. The matrices B and Σ are the reduced-form parameters, while A_0 and A_+ are the structural parameters.

The algorithm is based on Arias, Rubio-Ramírez and Waggoner (2018) as extended to allow for the zero restrictions as well as the sign restrictions. In detail, Arias, et al. (2018) develop algorithms to independently draw from a family of conjugate uniform-normal-inverse-Wishart posterior distribution over the structural parameterization.

Our VAR model includes four variables for examining the effects on the Fed's dual mandate as unemployment rate and inflation rate²: federal funds rate (FF) as policy rate, securities held outright (SHO) as indicator of QE, insured unemployment rate, and expected inflation rate.³ We identify the ZLB/QE shocks by imposing zero and sign restrictions on impulse responses to the FF, SHO and macroeconomic variables: FF sets zero on impact to represent the ZLB, SHO increase at 0- to 3-week horizons to represent

² The Fed's mandate for monetary policy is commonly known as the dual mandate, maximum employment and stable inflation. However, according to 'Statement on Longer-Run Goals and Monetary Policy Strategy', the Fed pursues to fulfill the statutory mandate of promoting maximum employment, stable prices, and moderate long-term interest rates. Then, we also examine 5-variable model including long-term interest rate whether the QE effectively impacts on three distinct goals of monetary policy or not. In response to ZLB/QE shocks, unemployment rate decreases, inflation rate increases, and the long-term interest rate decreases as Fed's wanted.

³ For high-frequency weekly analysis, this study chooses the insured unemployment rate, which is the number of people currently receiving unemployment insurance as a percentage of the labor force as useful measure of weekly unemployment rate. Besides, this study selects 5-year forward expected inflation rate as weekly inflation rate, which is a measure of expected inflation (on average) over the five-year period that begins five years from today. Moreover, the inflation expectations as key to the relationship that ties inflation to unemployment.

the QE⁴, unemployment rate decreases and inflation rate increases on impact. To overcome the relatively short sample periods at the second period of ZLB during COVID-19 recession, this study uses the weekly data from the 51st week of 2008 to the 49th week of 2015 for the first period of ZLB (ZLB1, 366 observations); from the 12th week of 2020 to the 8th week of 2022 for the second period of ZLB (ZLB2, 104 observations).⁵ A VAR with 4 lags (1 month) in levels (in terms of percentage) except for the SHO with the logarithm. Time trends and a constant term are not included. The 68% probability bands are calculated on 5,000 draws estimated by a Bayesian procedure.

3. Empirical results

This study analyzes the effects of the QE on the dual mandate at two ZLB periods. Figure 1 plots the impulse responses on the dual mandate to ZLB/QE shocks with 68% probability bands over 20 weeks. First of all, according to the median impulse responses of the dual mandate, the unemployment rate decreases and inflation rate increases statistically significant to the ZLB/QE shocks at two ZLB periods.⁶ These responses of the dual mandate are in line with the results from previous literatures, which find that the expansionary unconventional monetary policy impacts on the increase in inflation and the

⁴ To set the 0- to 3-week as the benchmark horizons, the (median) impulse responses between varying the horizons – for example, 0- to 1-week, 0- to 11-week or only on impact – are almost similar with each other. Then, the benchmark horizons as used are reasonable, which supports that the responses of dual mandate are not sensitive to sign horizons on securities held outright.

⁵ The specific sample time for each period is as follows (as of Wednesday). The first period of ZLB is from December 17, 2008 to December 16, 2015; the second period of ZLB is from March 15, 2020 to March 16, 2022.

⁶ Furthermore, the response of unemployment rate at ZLB2 is larger than at ZLB1 over all horizons; however, the that of inflation rate at ZLB1 is larger than at ZLB2.

decrease in unemployment.⁷

To compare the sizes of effects between two ZLB periods, we calculate the ratio of the unemployment rate and inflation rate responses (to ZLB/QE shocks) the securities held outright (to the shocks) followed by Kim(2015). That is,

$$R_IRF(U) \equiv \frac{\sum_{k=1}^K IRF(U)_k}{\sum_{k=1}^K IRF(SHO)_k}, R_IRF(P) \equiv \frac{\sum_{k=1}^K IRF(P)_k}{\sum_{k=1}^K IRF(SHO)_k}$$

where $IRF(U)_k$, $IRF(P)_k$ and $IRF(SHO)_k$ are the impulse responses of unemployment rate, inflation rate and securities held outright, respectively, in the k -th period after a ZLB/QE shocks. These ratios represent the 1% changes in SHO lead to how much changes in the dual mandate. We use the cumulative responses to calculate the ratio because cumulative effects may better summarize the effects over a given horizon.⁸

Figure 2 plots the shock-adjusted responses of dual mandate ($R_IRF(U)$ and $R_IRF(P)$) over 20-week horizons with 90% probability bands. The dash lines represent the ratio and the probability bands for the ZLB1, while the solid lines represent those for ZLB2. The shock-adjusted responses of dual mandate also indicate the same directions from the impulse responses, which is the decrease in unemployment rate and the increase in inflation rate. With regard to 1% changes in QE (represented by SHO), R_IRF for the dual mandate at ZLB2 are much larger than those at ZLB1. Moreover, Table 1 and Figure

⁷ This study also examines a 5-variable model including long-term interest rate as explained above as Figure A1 in Appendix. The results from 5-variable analysis suggest the decrease in unemployment rate, the increase in inflation rate, and the decrease in long-term interest rate, which means the QE is effective tool to achieve the Fed's statutory mandate for monetary policy at the ZLB.

⁸ Furthermore, we attempt to compare the 1 dollar change in SHO leads to how much changes in dual mandate with multiplying $R_IRF(U)$ and $R_IRF(P)$ by the average of SHO during each ZLB period, which indicated by $R_IRF1(U)$ and $R_IRF1(P)$ in Figure A2 and Table A2 in Appendix. The results show the unemployment rate at ZLB2 is still much larger than that at ZLB1, but inflation rate shows not much different between two ZLB periods, rather the responses at ZLB1 slightly larger than that at ZLB2, which are also reported in Table A2.

2 are complementary. Table 1 shows the probability that the effects are larger at ZLB2 compared to those at ZLB1. Table 1 confirms the results from Figure 2, that is, the dual mandate at ZLB2 responses much larger to 1% changes in SHO than that at ZLB1 does.

In essence, these results indicate that, first, the effects of the QE on the dual mandate at the ZLB are consistent with previous empirical literatures after Great Recession, which still maintains after COVID-19 recession; second, the responses of dual mandate to the ZLB/QE shocks indicate the QE is effective monetary policy tool at the ZLB periods to stimulate the economy; third, the shock-adjusted responses of dual-mandate are much larger at ZLB2 during COVID-19 recession than those at ZLB1 during Great Recession; fourth, both impulse and shock-adjusted responses of the unemployment rate show much larger difference between two ZLB periods than those of the inflation rate.

These results suggest that there exists not only the larger unconventional monetary transmission but also the larger fiscal reaction to monetary expansion at ZLB2 than those at ZLB1⁹; moreover, the US Phillips curve flattens after Great Recession. First, the large responses on the dual mandate are induced by the large unconventional monetary policy transmission and the large fiscal reaction. Jannsen, Potjagailo and Wolters (2019) find that unconventional monetary policy works mainly via the wealth channel to spur aggregate demand. To compare the size of the wealth channel, this study roughly measures the wealth effect through personal consumption expenditures (PCE) followed by Ludvigson, Steindel and Lettau (2002). The changes in PCE at ZLB1 indicate 0.3% on average; however, those at ZLB2 indicates 0.6%, which is about 2 times larger than before. Furthermore, Kaplan,

⁹ In addition to two reasons describe above, since the market participants have improvement to the predictive power after the Great Recession, the responses to ZLB/QE shocks become larger than before. However, this study tries to present the objective values to explain why the responses are larger during the COVID-19 recession than during the Great Recession.

Moll and Violante (2018) find in Heterogenous Agent New Keynesian model, the fiscal reaction to the monetary expansion is a key determinant of the size of the macroeconomic responses. To measure the fiscal reaction, this study uses the personal current transfer receipts (PCTR). The change in PCTR at ZLB1 indicates 0.4% on average; however, that at ZLB2 indicates 4.7%, which is 10 times more than before.¹⁰ Based on the unconventional monetary policy transmission and the fiscal reaction, the responses of the dual mandate are much larger at ZLB2 than those at ZLB1.

Second, flattening US Phillips curve derives that the difference in the responses of unemployment rate between two ZLB periods are much larger than that of the inflation rate. Occhino (2019) states that the Phillips curve relationship has weakened, with the curve becoming flatter with modest inflation. That is, the inflation in the US economy has been remarkably stable over the past two decades including two ZLB periods, in spite of the large fluctuations in economic activity such as unemployment rate. The estimated slope of US Phillips curve between unemployment rate and the median CPI inflation rate at ZLB1 is -0.24 and that at ZLB2 is -0.11, which indicates the Phillips curve has flattened.¹¹ This observation confirms that both the impulse responses and the shock-adjusted responses of unemployment rate show much larger difference between two ZLB periods than those of inflation rate.

¹⁰ Considering the aggregate demand shocks including the fiscal expansion such as government spending as well as the expansionary unconventional monetary policy shocks, the unemployment rate decreases and the inflation rate increases as found. To identify the aggregate demand shocks, we impose the zero and sign restrictions followed by Weale and Wieladek (2016); that is, the securities held outright set zero, the unemployment rate declines, and the inflation rate rises on impact. Moreover, the shapes and magnitudes of impulse responses are similar whether demand shocks are considered or not, which suggests that the main results still hold after considering the expansionary fiscal policy.

¹¹ We replace the median CPI inflation rate with the core CPI inflation rate to estimate the slope of US Phillips curve. Then, the slopes of Phillips curve are -0.20 at ZLB1 and -0.16 at ZLB2, in line with results from median CPI inflation rate.

To check the robustness of these results, this study extends the model by (1) replacing the securities held outright with the Fed's total assets and the spread between 10-year rate and federal funds rate as Figure 3 and Figure 4, (2) varying the horizon of sign restriction such as 0- to 1-week as Figure 5, (3) varying the lag lengths to 4 weeks as Figure 6, and (4) including a constant term in the benchmark VAR model as Figure 7. Overall, the results (based on median impulse responses) from the benchmark model remain unchanged with these variations. That is, the unemployment rate declines, but the inflation rate rises in response to the ZLB/QE shocks.

We also conduct the robustness check under the recursive identification scheme with the Cholesky decomposition as Figure 8. We find that with the recursive identification scheme, the results are not reliable. These responses of the dual mandate are weaker statistical significance than those from main results; even at ZLB2, the unemployment rate increases and the inflation rate decreases, which indicates the price puzzle.

4. Conclusion

This study provides the new evidence on the macroeconomic effects of the US quantitative easing at the zero lower bound periods, particularly responses of the dual mandate, through the zero and sign restrictions. The quantitative easing impacts on the decrease in the unemployment rate and the increase in the inflation rate at two zero lower bound periods in line with the previous empirical literatures. Adjusting the size of the ZLB/QE shocks, the shock-adjusted median responses suggest that first, the responses of the dual mandate at the zero lower bound during COVID-19 recession is much larger than those at the zero lower bound during Great Recession (particularly in terms of 1 %

increases in the measure of quantitative easing) due to the larger unconventional monetary transmission and the larger fiscal reaction to monetary expansion; second, the responses of the unemployment rate show the larger difference between two zero lower bound periods than those of the inflation rate, which reflects the US Phillips curve gets flattening with modest inflation rate in spite of large fluctuation in unemployment rate. Therefore, the quantitative easing can make the Fed's statutory mandate to achieve at the zero lower bound, which indicates that the quantitative easing at the zero lower bound acts as the effective monetary policy tool to stimulate the economic activity.

Figure and Table

Figure 1 Impulse responses of the dual mandate (Main results)

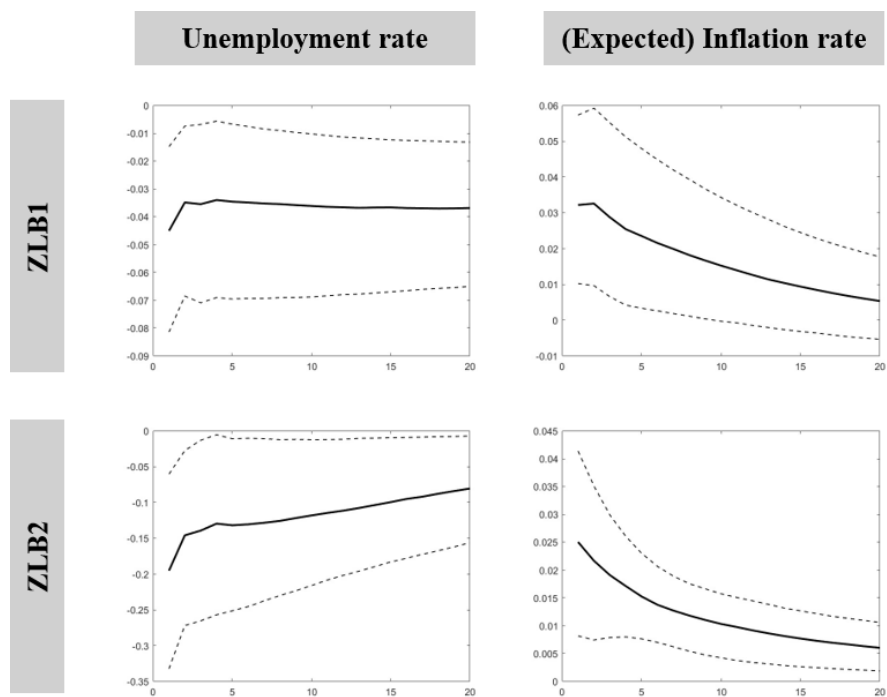


Figure 2 Cumulated shock-adjusted responses of the dual mandate

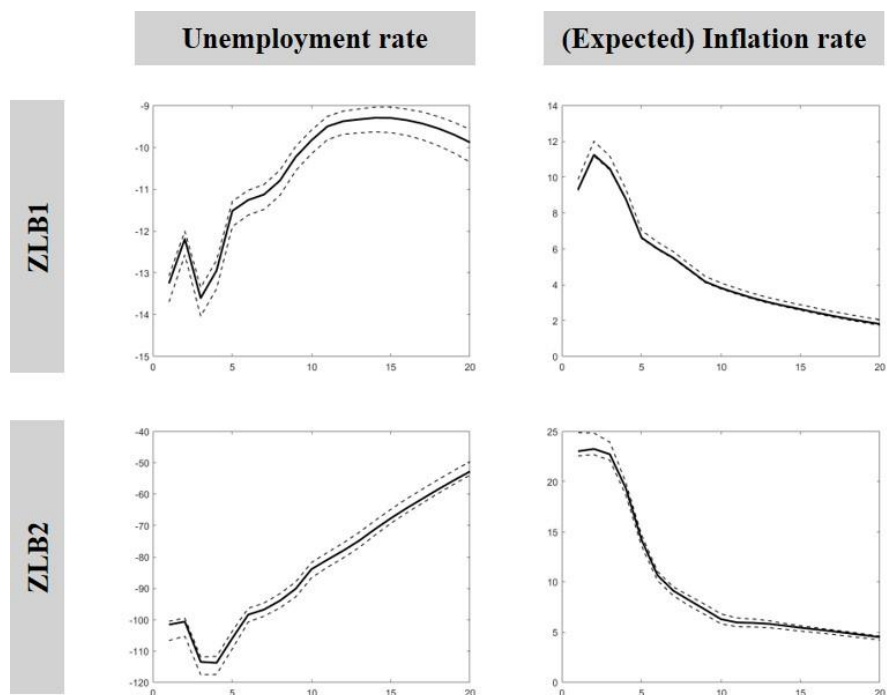


Figure 3 Impulse responses of the dual mandate
(Alternative indicators of QE: Total assets)

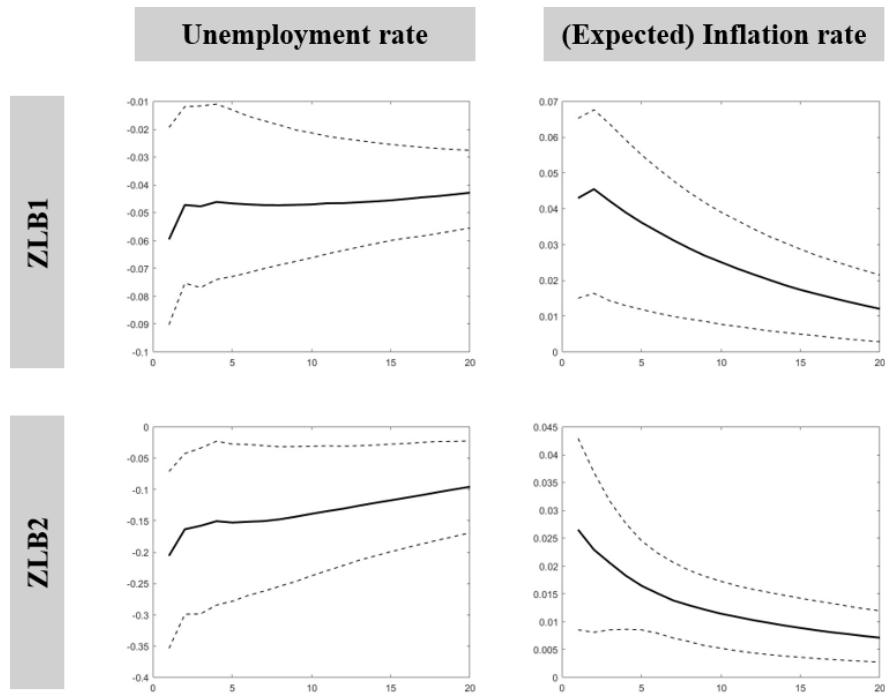


Figure 4 Impulse responses of the dual mandate
(Alternative indicators of QE: Spread)

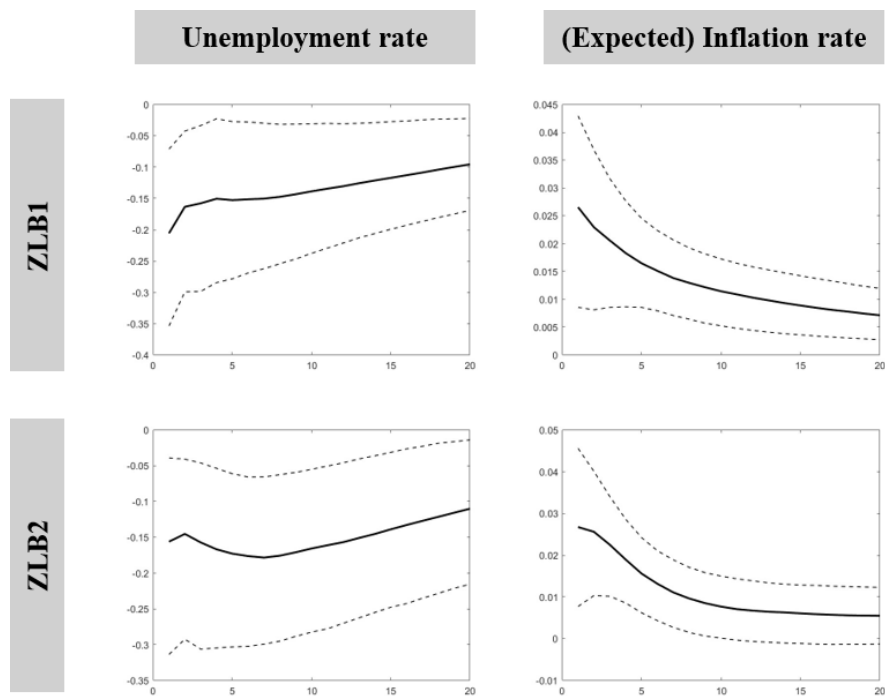


Figure 5 Impulse responses of the dual mandate
(Robustness check: Sign horizons imposed on QE)

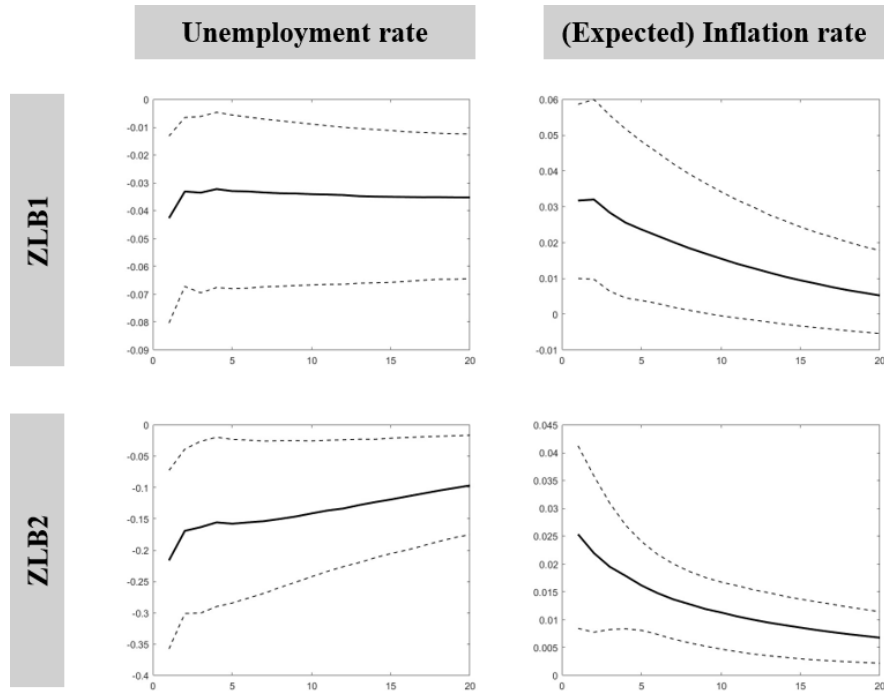


Figure 6 Impulse responses of the dual mandate
(Robustness check: 12-week lags)

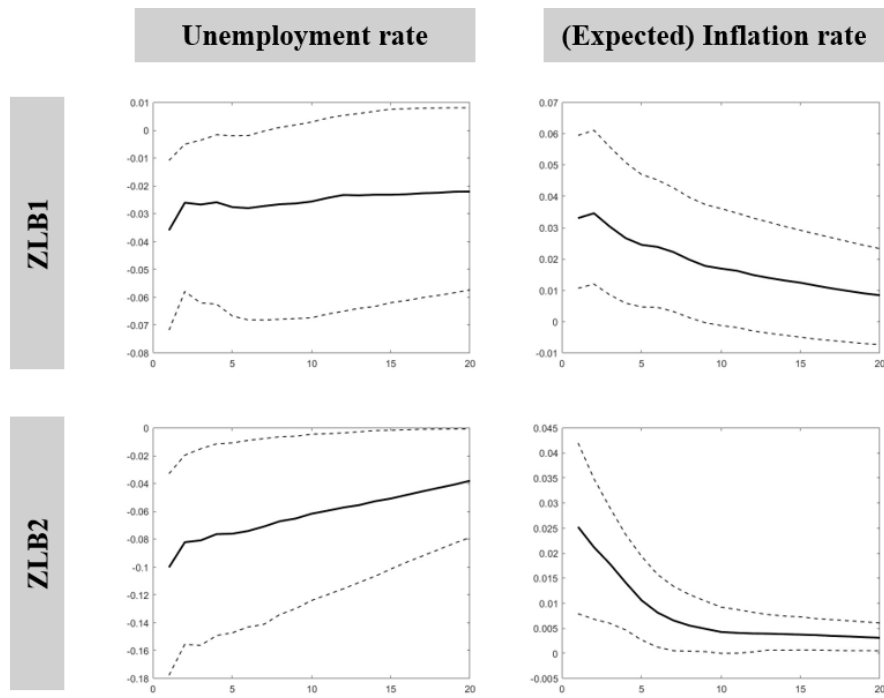


Figure 7 Impulse responses of the dual mandate
(Robustness check: Constant term)

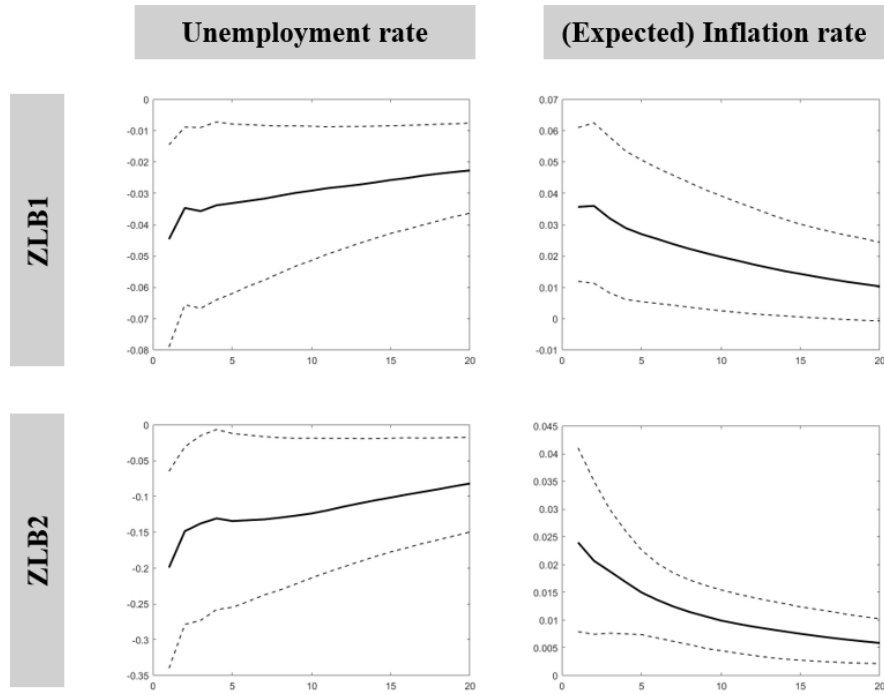


Figure 8 Impulse responses of the dual mandate
(Robustness check: Recursive identification scheme)

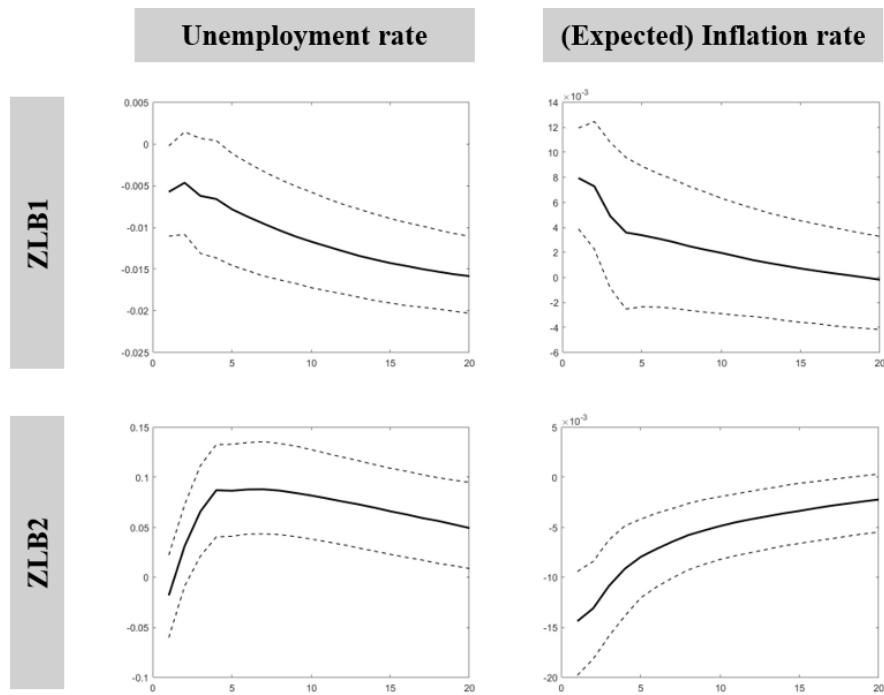


Table 1 Comparison between two ZLB periods in terms of shock-adjusted responses

Horizon	Unemployment rate	(Expected) Inflation rate
After 1 week	100.00	100.00
After 1 month	100.00	99.97
After 5 months	99.97	99.97

Note: The probability represents that the measure of the effect is larger for the second ZLB period than the first ZLB period over 20-week horizons. Numbers in bolds indicate that the probability is larger than 95%.

Appendix

Table A1 Data descriptions

Description	Source
Federal Funds Rate	FRED from Federal Reserve Bank of St. Louis Available at:
Assets: Securities Held Outright: Securities Held Outright: Wednesday Level, Millions of U.S. Dollars	https://fred.stlouisfed.org/ (Accessed: December 20, 2022.).
Insured Unemployment Rate	
5-Year, 5-Year Forward Inflation Expectation Rate	
Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity	
Assets: Total Assets (Less Eliminations from Consolidation): Wednesday Level, Millions of U.S. Dollars	
10-Year Treasury Constant Maturity Minus Federal Funds Rate	

Table A2 Comparison between two ZLB periods in terms of shock-adjusted responses

Horizon	Unemployment rate	(Expected) Inflation rate
After 1 week	100.00	27.73
After 1 month	100.00	1.70
After 5 months	99.97	49.80

Note: The probability represents that the measure of the effect is larger for the second ZLB period than the first ZLB period over 20-week horizons. Numbers in bolds indicate that the probability is larger than 95%.

Figure A1 Impulse responses of Fed's statutory mandate

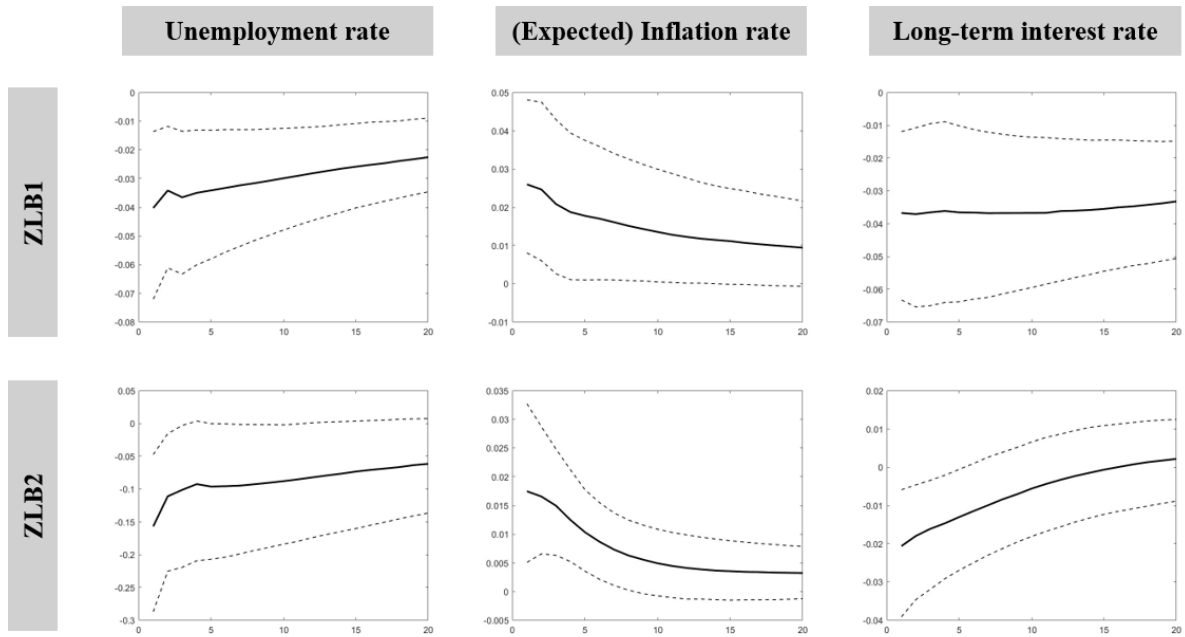
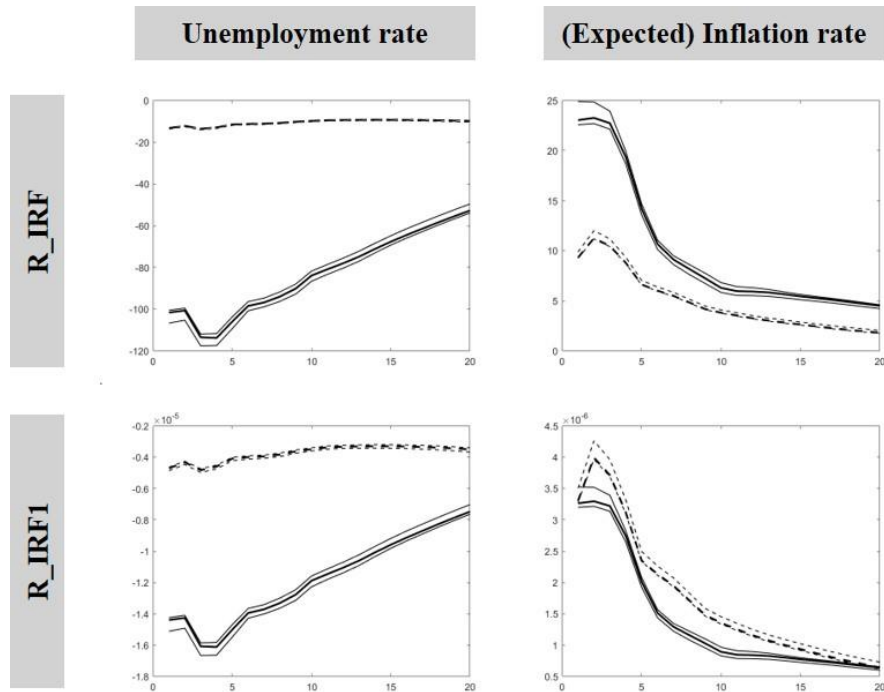


Figure A2 Comparison shock-adjusted responses of dual mandate



Note: The dash line (--) indicates the responses of dual-mandate at ZLB1; the solid line (-) indicates the responses at ZLB2 over 20-month horizons with 90% probability bands.

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