Macroeconomic effects of the US quantitative easing during two zero lower bound periods

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Abstract

This study investigates the effects of the US quantitative easing (QE) at two zero lower bound (ZLB) periods on dual mandates by employing the structural VAR model with zero and sign restrictions imposed on impulse responses. The key findings are as follows. First, the QE shocks at ZLB have significant effects on unemployment rate the inflation rate. Second, the effects of the QE shocks at the ZLB on unemployment rate and inflation rate are stronger during the COVID 19 recession than during the Great recession. Third, strong wealth effects of QE and strong fiscal reactions are likely to contribute to the strong effects of QE during the COVID-19 recession.

Keywords: US unconventional monetary policy, Quantitative easing, Zero lower bound, Fed's total assets, Dual mandates, Zero and sign restrictions
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 (December 2007 – June 2009 based on NBER's business cycle dating) and the COVID-19 recession (February 2020 – April 2020). To recover from these recessions, the policymakers have depended on the unconventional monetary policies such as the zero lower bound (ZLB), because the conventional monetary policy, mainly the interest rate policy, could not be used anymore. Among these unconventional monetary policy tools, the Fed has conducted the quantitative easing (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, thus spurring aggregate demand and stimulating real activity even at the ZLB. To infer whether QE was effective as intended, a series of past empirical studies analyzed the effects of the QE.[1] These studies often reported significant effects on output, unemployment rate and inflation, by focusing on the early period of ZLB (during the Great Recession). However, no previous studies focused on the recent period of ZLB (during the COVID-19 Recession).[2] In this study, we empirically analyze the macroeconomic effects of the QE on dual mandates. Differently from past studies, this study compares the effects between two ZLB periods (during the Great recession vs. during the COVID-19 recession).

In order to compare the effects between two ZLB periods, we use weekly data to

[1] The empirical literature on the effects of the US unconventional monetary policy on the output and the inflation rate include: 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); and Bhattarai, Chatterjee and Park (2021).

[2] Feldkircher, Huber and Pfarrhofer (2021) investigated the period from the first week of 2011 to the 24th week of 2020, but they did not analyze effects on the period of COVID-19 separately. Feldkircher, Huber and Pfarrhofer (2021) reported that unconventional monetary policy expansion caused higher output growth and lower unemployment rate, but no significant upward effect in inflation.

complement the relatively short sample periods during COVID-19 recession. To measure the QE actions, this study uses he Fed's total assets as in Pounti(2019). In addition, two alternative indicators (the securities held outright and the spread between 10-year Treasury rate and federal funds rate) are used to check the robustness of the results. We identify QE shocks at ZLB by combining the zero and sign restrictions on impulse responses. To represent the basic properties of monetary policy shocks, sign restrictions on impulse responses of the Fed's total assets, the unemployment rate, and the inflation rate. To represent the ZLB, zero restrictions on impulse responses of the federal funds rate are imposed.

We find that the QE shocks have significant effects on the inflation rate and unemployment rate at both periods of the ZLB. More importantly, we found that the effects are larger in the COVID-19 recession period than in the Great recession period after normalizing the size of two shocks. We try to further explain the difference in the effects for two ZLB periods.

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

2. Methodology and Data

We investigate the effects of US QE at the ZLB by imposing zero and sign restrictions on impulse responses in the structural VAR model.

Consider a structural VAR as follows:

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

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

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

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.

Following Arias, Rubio-Ramirez and Waggoner (2018), the structural parameters (A_0, A_+) are observationally equivalent if and only if $A_0 = \tilde{A}_0 Q$ and $A_+ = \tilde{A}_+ Q$ for some $Q \in \mathcal{O}(n)$, which is the set of all $n \times n$ orthogonal matrices. The techniques apply to sign and zero restrictions on any function $F(A_0, A_+)$ from the structural parameters to the space of $r \times n$ matrices that satisfies the condition $F(A_0 Q, A_+ Q) = F(A_0, A_+)Q$, for every $Q \in \mathcal{O}(n)$, which is true for impulse response functions. For statistical inference, Arias, Rubio-Ramirez and Waggoner (2018) develop algorithms to independently draw from a family of conjugate uniform-normal-inverse-Wishart posterior distribution over the structural parameterization for the model with zero and sign restrictions

The baseline VAR model includes four variables: the federal funds rate as the policy rate, the Fed's total assets as an indicator of QE, unemployment rate, and PCE inflation rate. The first two variables are included to represent monetary policy actions, while the last two variables are included to analyze the effects on these two variables representing

the dual mandates. We identify the QE shocks at the ZLB by imposing zero and sign restrictions on impulse responses. The positive responses of total assets is assumed to represent the (expansionary) QE actions. The response of the federal funds rate sets zero to represent the ZLB. In addition, we also assumed the negative impact responses of unemployment rate and the positive impact response of inflation rate to represent (expansionary) QE shocks (that are a kind of monetary policy shocks), as in past studies such as Uhlig (2005), Canova and Nicolo (2002), Kapetanios, Mumtaz, Stevens and Theodoridis (2012) and Baumeister and Benati (2013).[6]

To overcome the relatively short sample periods of the period of ZLB during the COVID-19 recession, this study used weekly data.[7] The 1st period of ZLB covers from the 51st week of 2008 to the 49th week of 2015 (366 observations) while the 2nd period of ZLB covers from the 12th week of 2020 to the 8th week of 2022 (104 observations). 4 lags (1 month) are assumed. The logarithm is taken for total assets. Time trends and a constant term are not included. The 68% probability bands are calculated, based on 5,000 draws estimated by the Bayesian procedure.

3. Empirical results

This study analyzes the effects of the QE on the dual mandates at two ZLB periods. Figure 1 plots the impulse responses of unemployment rate and inflation rate to QE shocks with 68% probability bands over 20 weeks. First, the unemployment rate decreases and the

[6] In the baseline model, we impose the restrictions only on the impact responses, but the results are qualitatively similar when the restrictions are imposed on impact responses of longer horizons as reported in Sections 3.

[7] This study adopts the cubic spline interpolation to convert the monthly data into weekly data in case of the unemployment rate and the inflation rate.

inflation rate increases significantly and persistently in both ZLB periods. These responses are in line with the results from previous literature.[9] Feldkircher, Huber and Pfarrhofer (2021) investigated the period from the first week of 2011 to the 24th week of 2020, but they did not analyze effects on the period of COVID-19 separately. Feldkircher, Huber and Pfarrhofer (2021) reported that unconventional monetary policy expansion caused higher output growth and lower unemployment rate, but no significant upward effect in inflation.

To compare the sizes of effects between two ZLB periods, we normalize the unemployment rate and the inflation rate responses, by dividing by total asset responses at each horizon. By doing so, the responses of unemployment rate and inflation rate to 1% changes in total assets are obtained. We use the cumulative responses of each variable to calculate the ratio because cumulative effects may better summarize the effects over a given horizon.

Figure 2 plots the shock-adjusted responses of dual mandates over 20-week horizons with 68% probability bands.[11] The shock-adjusted responses of dual mandate also show a decrease in unemployment rate and an increase in inflation rate. With regard to 1% changes in total assets, the responses of unemployment rate and the inflation rate are much larger in the second period of ZLB than those in the first period of ZLB at any horizons. Unemployment rate responses are more than 6 times larger on impact and more than 4 times larger at 20 week horizon. Inflation rate responses are more than 3 time larger on impact and more than 5 times larger at 20 week horizon.

[9] Interestingly, Feldkircher, Huber and Pfarrhofer (2021) investigated the period that covers both periods of the ZLB, and found an insignificant effect on inflation. The result of current study may suggest that estimating the effects of the two periods is needed to accurately measure the effects of QE at ZLB on inflation rate.

[11] The median responses of total assets are used.

Table 1 shows the probability that the effects are larger in the second period of ZLB than the first period of ZLB. The probability is at least 90% for unemployment rate responses at the horizons up to 20 weeks. The probability is 90% for inflation rate responses at the 20th week horizon. These results confirm the results of Figure 2. The effects of QE on inflation rate and unemployment rate are larger in the second period of ZLB than in the first period of ZLB.

We further explore two potential explanations. First, Jannsen, Potjagailo and Wolters (2019) find that unconventional monetary policy works mainly via the wealth channel to spur aggregate demand. The wealth channel may work better during the COVID-19 recession than during the Great recession. To compare the size of the wealth channel worked during two recessions, we measure the size of wealth effect with personal consumption expenditures (PCE), following Ludvigson, Steindel and Lettau (2002). PCE changes by 0.3% on average during the ZLB period of the Great recession but by 0.6% during the ZLB period of the COVID 19 recession.[13]

Second, Kaplan, 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. Following Kaplan, Moll and Violante (2018), this study uses the personal current transfer receipts (PCTR) to measure the size of fiscal reactions. PCTR changes by 0.4% on average during the ZLB period of the Great recession but by 4.7%

[13] To compare the wealth components of PCE, there is clear difference between two ZLB periods. The changes in wealth components of PCE at ZLB1 indicate 0.2%, but those at ZLB2 indicate 0.9%, which is 4.5 times larger than before.

Furthermore, to compare the responses of wealth effect to ZLB/QE shock, this study adds PCE into 4-variable VAR model, and then draws the cumulative shock-adjusted responses of monetary transmission (in first column of Figure A1). This result confirms the 2nd period of ZLB has larger wealth effect than the 1st period.

during the ZLB period of the COVID-19 recession.[14]

To check the robustness of the main results, this study extends the model by (1) replacing the Fed's assets with the securities held outright or the spread between 10-year rate and the Federal Funds rate (in Figures 3 and 4), (2) varying the horizon of the sign restriction (for example, 0- to 3-week, in Figure 5), (3) varying the lag lengths to 12 weeks (in Figure 6), (4) including a constant term in the benchmark VAR model (in Figure 7).

We further constructed extended models. First, we include an additional variable of the long term interest rate, as the long term interest rate may be regarded as another goal of monetary policy (in Figure 8).[15] Second, we drop the sign restrictions on unemployment rate as some studies such as Uhlig (2005) did not impose any restrictions on impulse responses of real sector variables in identifying monetary policy shocks (in Figure 9). Third, we further exclude the aggregate demand shocks other than QE shocks in the model. To identify the demand shocks, we impose the zero and sign restrictions by following Weale and Wieladek (2016). The responses of the total assets set zero. The responses of unemployment are restricted to be negative and those of the inflation rate are restricted to

[14] 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 total assets 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.

Furthermore, to compare the fiscal reactions to ZLB/QE shock, this study adds transfer into 4-variable VAR model, and then draws the cumulative shock-adjusted responses of monetary transmission (in second column of Figure A1). This result confirms the 2nd period of ZLB has larger fiscal reactions than the 1st period.

[15] 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.

be positive (in Figure 10).

Overall, the main results of the benchmark model remain unchanged qualitatively. That is, QE shocks at ZLB have significant effects on unemployment rate and inflation rate, and the effects are larger during the COVID-19 recession than during the Great recession.

4. Conclusion

This study provides the new evidence on the macroeconomic effects of the US QE at the ZLB periods, particularly on the dual mandates, by employing the structural VAR model. The QE shocks at the ZLB are identified by imposing zero and sign restrictions on impulse responses. The main results are as follows. First, the QE shocks at the ZLB have significant effects on unemployment rate and inflation rate. This suggests that the QE can be an effective tool for the Fed to achieve the dual mandates by stimulating the economy at the ZLB. Second, the effects of QE shocks at the ZLB on unemployment rate and inflation rate are stronger during the COVID 19 recession than the Great recession. A strong wealth effects of the QE shocks and a strong fiscal reaction to the QE shocks are likely to contribute to the strong effects of QE during the COVID 19 recession.

Figure and Table

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

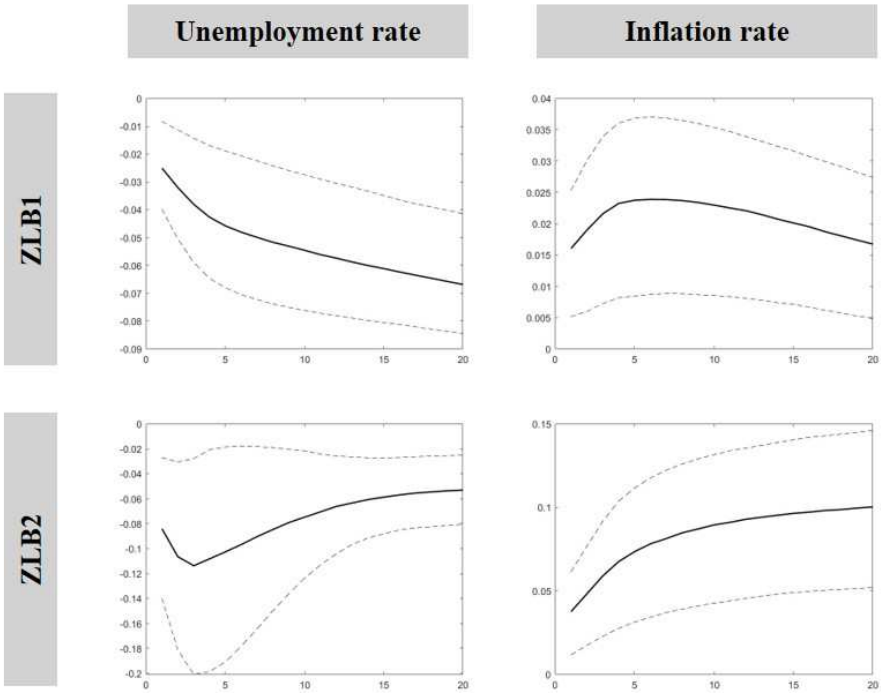


Figure 2 Cumulated shock-adjusted responses of the dual mandates

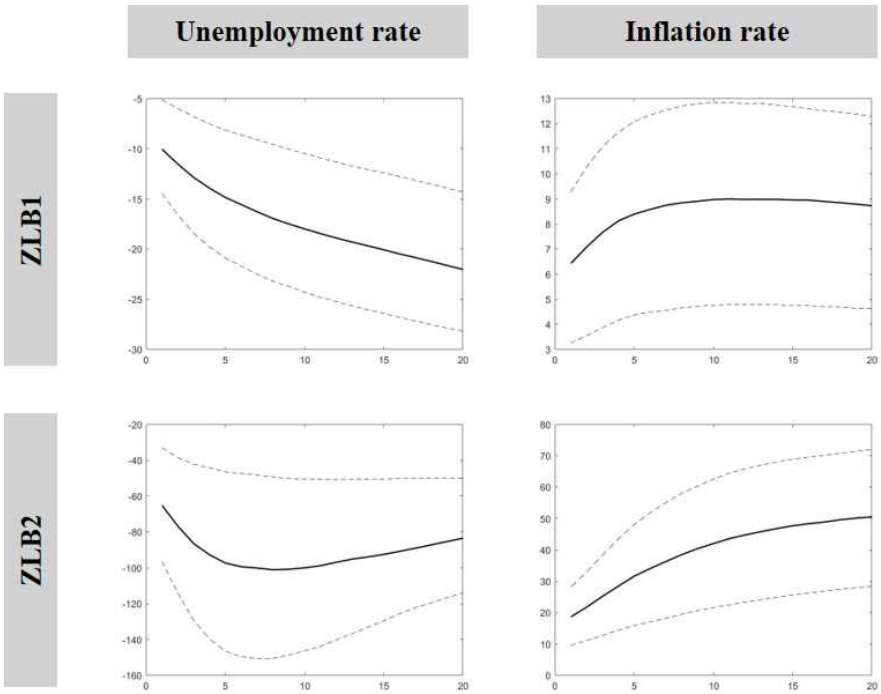


Figure 3 Impulse responses of the dual mandates

(Alternative indicators of QE: Securities held outright)

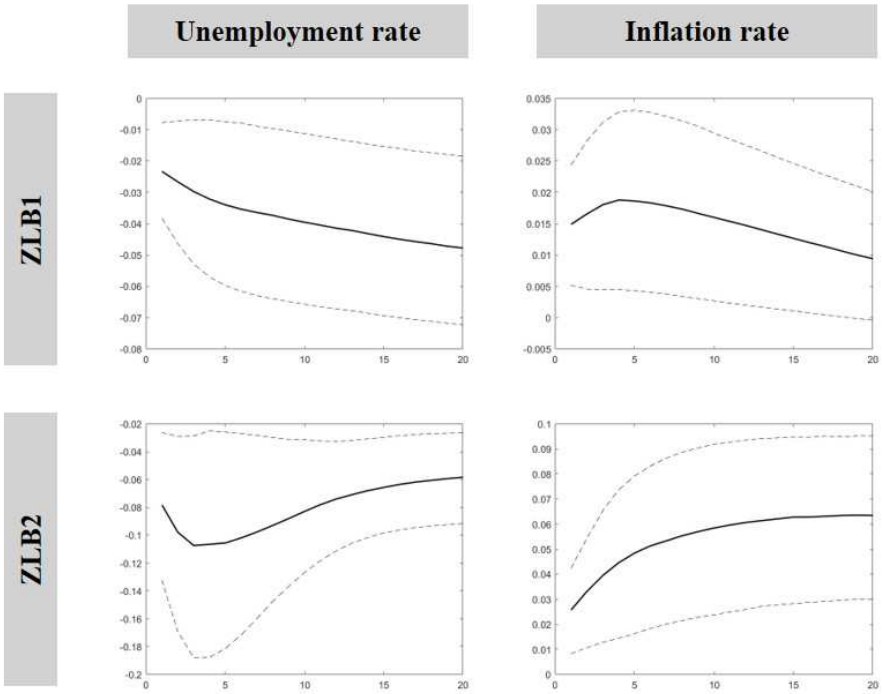


Figure 4 Impulse responses of the dual mandates

(Alternative indicators of QE: Spread)

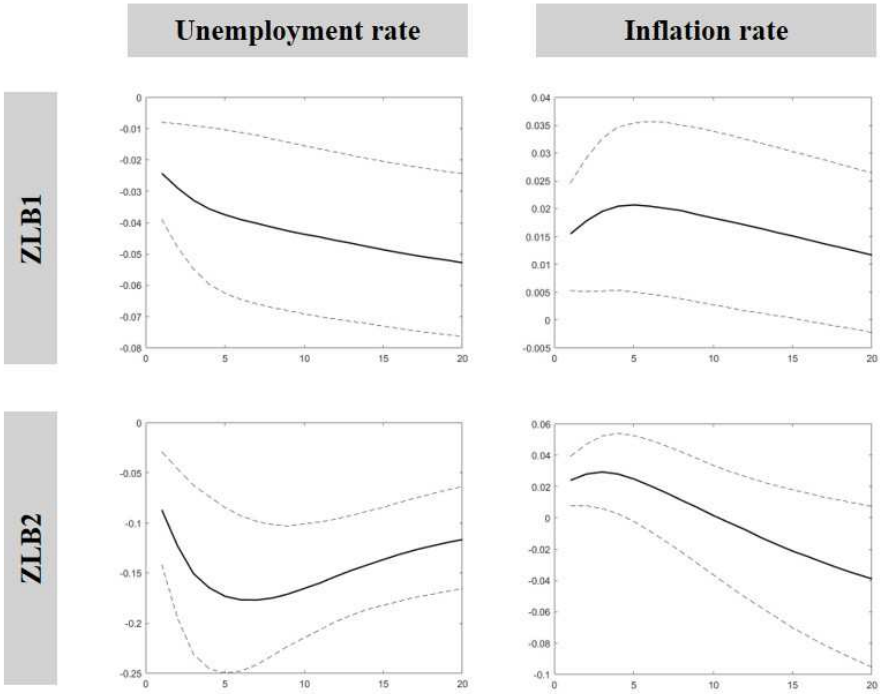


Figure 5 Impulse responses of the dual mandates

(Sign horizons imposed on QE)

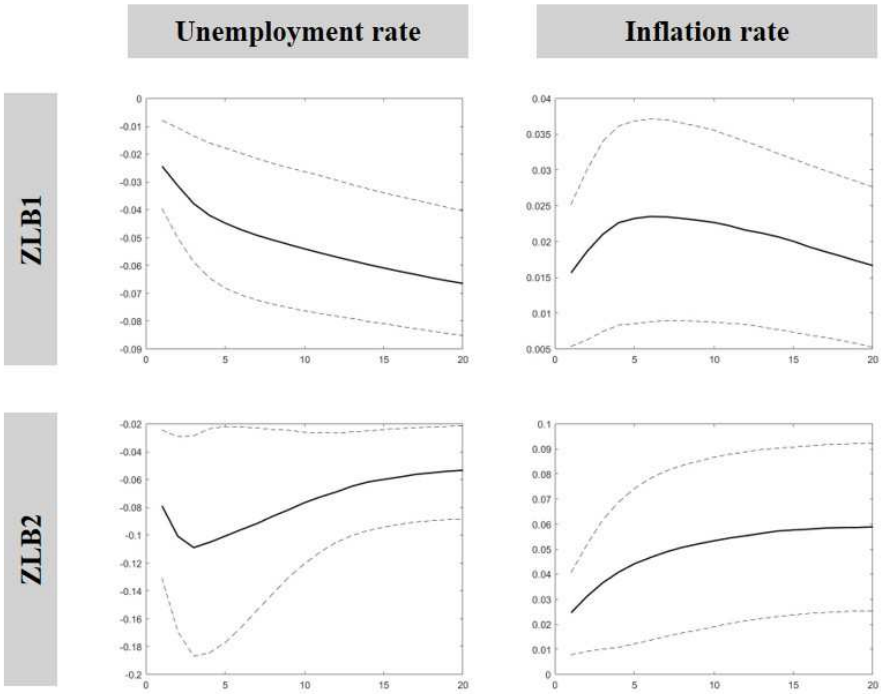


Figure 6 Impulse responses of the dual mandates

(12-week lags)

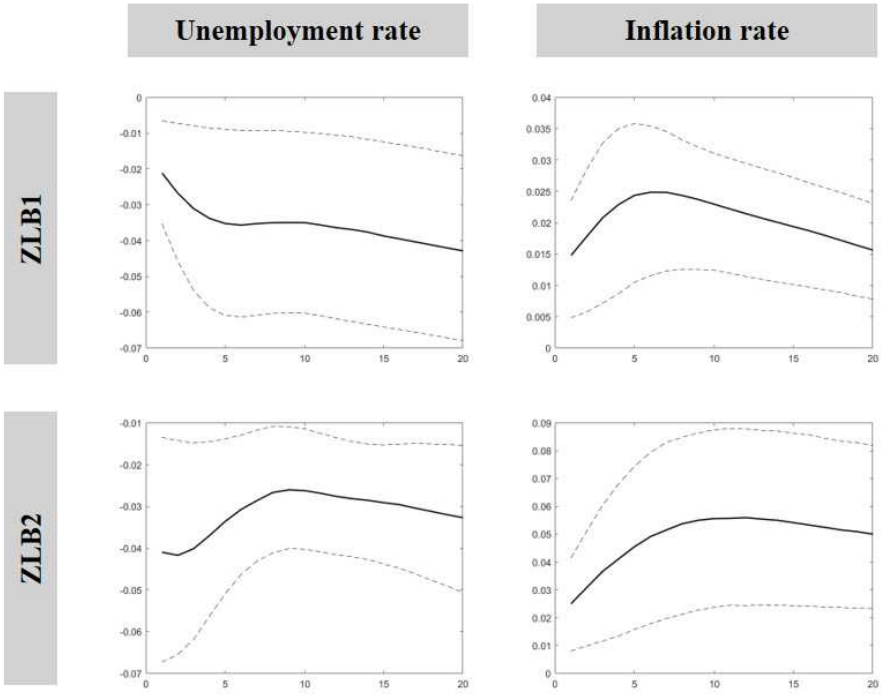


Figure 7 Impulse responses of the dual mandates

(Constant term)

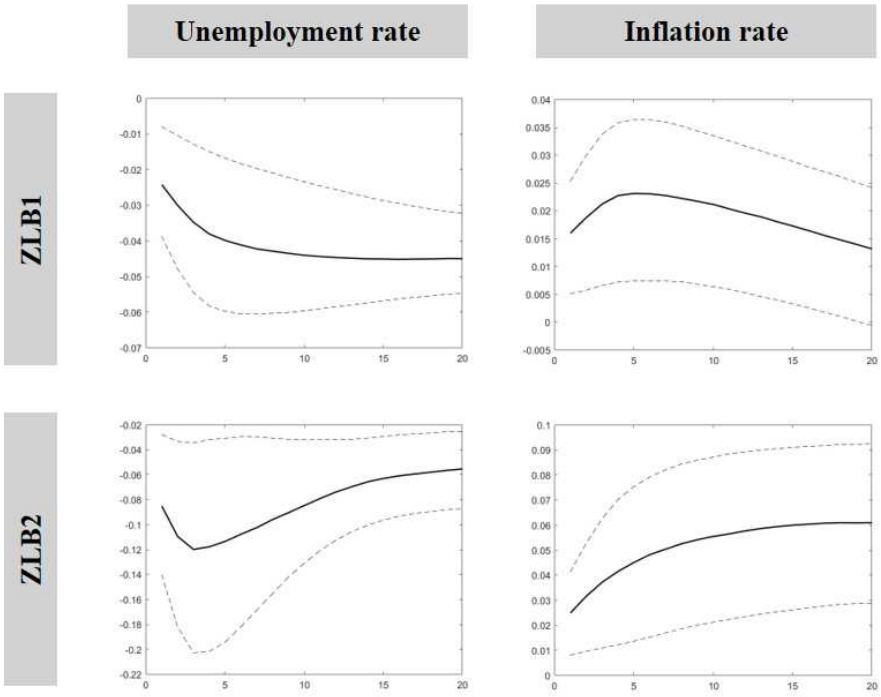


Figure 8 Impulse responses of Fed's statutory mandates

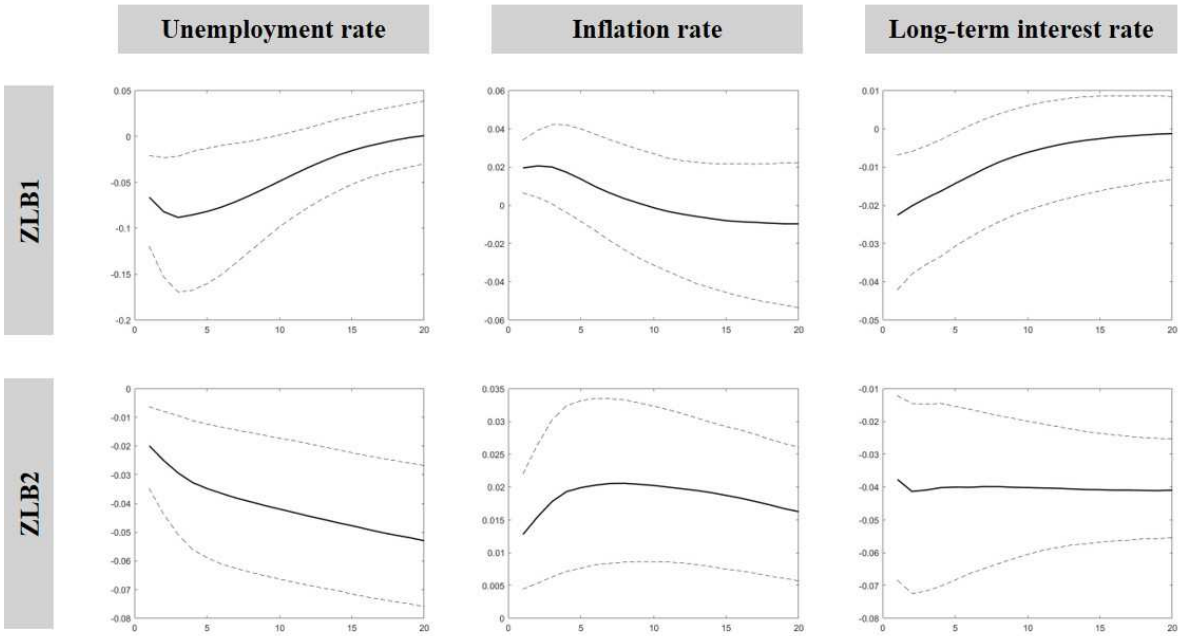


Figure 9 Impulse responses of the dual mandates

(Unrestricted unemployment rate)

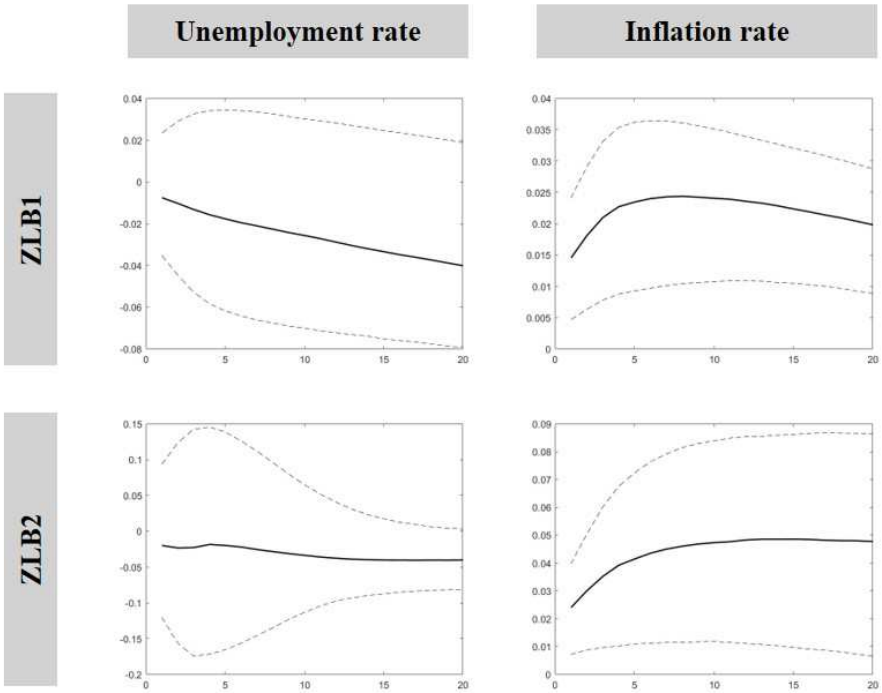


Figure 10 Impulse responses of the dual mandates

(Excluding demand shock)

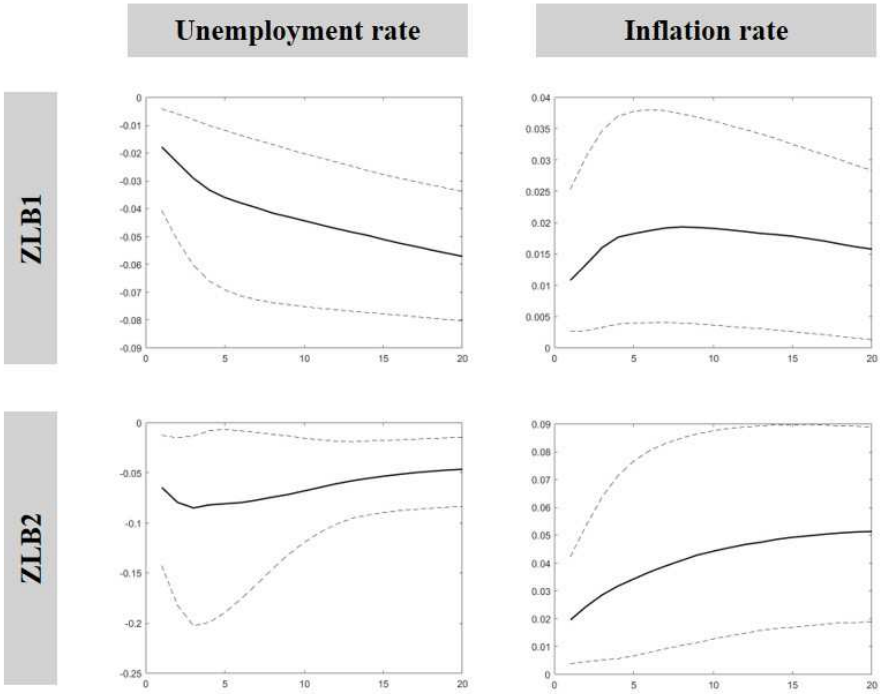


Table 1 Comparison between two ZLB periods in terms of shock-adjusted responses

Horizon	Unemployment rate	Inflation rate
After 1 week	**92**	84
After 4 weeks	**92**	85
After 5 months	**90**	**90**

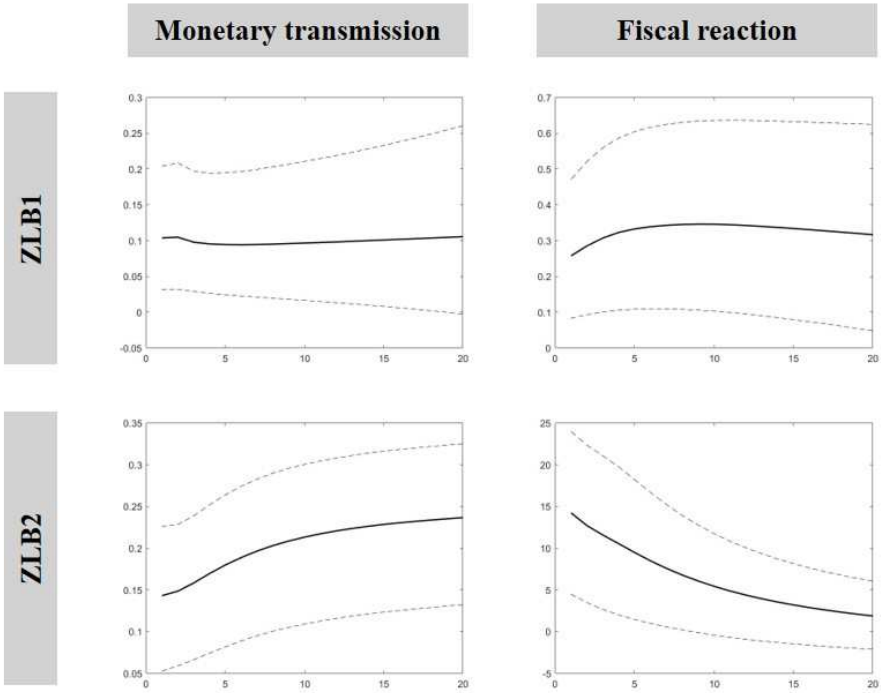
Note: Each number shows the probability that the effect of QE on each variable is larger for the second ZLB period than the first ZLB period at each horizon. Numbers in bolds indicate that the probability is larger than 90%.

Appendix

Table A1 Data descriptions

Description	Source
Federal Funds Effective Rate Assets: Total Assets (Less Eliminations from Consolidation): Wednesday Level, Millions of U.S. Dollars Unemployment Rate Personal Consumption Expenditures: Chain-type Price Index, Percent Change from Year Ago Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity Assets: Securities Held Outright: Securities Held Outright: Wednesday Level, Millions of U.S. Dollars 10-Year Treasury Constant Maturity Minus Federal Funds Rate	FRED from Federal Reserve Bank of St. Louis Available at: https://fred.stlouisfed.org/ (Accessed: April 10, 2023.).

Figure A1 Cumulative shock-adjusted responses of monetary transmission and fiscal reaction



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