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Uncertainties, Employment, and the Zero Lower Bound

Qing Nie[1]*, Xin L. Brown[2], Baohui Liu[3], Maruf Morshed[4]

[1]Department of Economics, Grinnell College, USA, [2]School of Business and Leadership, Our Lady of the Lake University, USA, [3]School of Economics, Shandong University of Finance and Economics, China, [4]Department of Economics, Illinois State University, USA. *Email: nieqing@grinnell.edu

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ABSTRACT

The purpose of this paper is to study the response of aggregate and sectoral employment in the United States to shocks and uncertainties in the oil and macro markets. To estimate the actual dataset, we employ a VAR model with 12 variables using U.S. data from 1986Q1 to 2021Q4. With alternative oil and macroeconomic uncertainties and different monetary authorities, we find that employment is significantly affected by both types of uncertainty when zero lower bound (ZLB) binds. Total employment and oil-related industries employment show a significant increase in the presence of the ZLB and the propagation of uncertainty shock from the oil market. These findings highlight the empirical relevance of oil prices and macroeconomic uncertainty on U.S. labor market dynamics.

Keywords: Employment, Oil Uncertainty, Aggregate Uncertainty, The Zero Lower Bound
JEL Classifications: J11, E2, E5

1. INTRODUCTION

The impact of volatilities is important in macroeconomics. A growing literature has focused on related issues. In general, it is hard to predict uncertainties, but they capture the conditional fluctuations of various types of disturbances in macro markets or specific markets as in Jurado et al. (2015). Bloom (2009) suggests that uncertainty shocks cause fluctuations in macroeconomic aggregates. The COVID-19 crisis has highlighted the relationship between uncertainty and economic fluctuations as in Altig et al. (2020).

Predictions of uncertainty can have multiple sources. Cascaldi-Garcia et al. (2020) mentioned that there are mainly three types of measures of risk, uncertainty, and volatility: (1) news-based, survey-based, and econometric; (2) asset market-based; and (3) Knightian uncertainty. Uncertainty has significant real and financial effects and spills over across countries, the size and persistence of these effects depend crucially on the source of uncertainty. A large literature examines aggregate uncertainty in macro markets. The uncertainty in Jurado et al. (2015) comes from superior econometric estimates. Based on the assumption that there is a common (usually countercyclical) uncertainty in uncertainty-based business cycle theory and the method of calculating conditional volatility after re-moving the predictable part of the data, they find an uncertainty factor with a general influence. This uncertainty is not influenced by a fixed model structure and a single (or few) economic indicator, is more persistent compared to stock market volatility, and establishes a greater degree of correlation with macroeconomic volatility dynamics. Basu (2017) argues that economic uncertainty drives business cycle movements and using the calibration of stock market volatility in a VAR model, they get an uncertainty shock that increases stock returns exogenously in implied volatility. More importantly, they suggest the importance of monetary policy in normal times to offset the negative impact of uncertainty shocks on macro markets, while the zero lower bound affects the stabilizing function of monetary policy. Ma and Samaniego (2019) measure aggregate and industry uncertainties based on the median absolute forecast error, EPS, extracted from a large firm-level dataset. It has a significant response to large events such as recessions and a significant and persistent negative impact on aggregate variables.

Given the importance of the oil market, there is a proliferation of literature focusing on uncertainty in the oil market. Elder and Serletis (2010) explored the impact of oil price uncertainty and estimated the impact of oil price volatility on U.S. real output using a GARCH model, where oil price uncertainty is defined as the unanticipated component of oil price volatility conditional on contemporaneous information sets in a VAR. Maghyereh et al. (2016), use the crude oil implied volatility index as a measure of uncertainty in the oil market. Yin and Feng (2019) use Carr and Wu's (2016) volatility risk premium to measure oil market uncertainty, calculated using oil futures prices. Ma and Samaniego (2020) derived oil return uncertainty using a methodology like their study of total uncertainty by collecting median forecast data for large companies in the oil industry. The advantage is that the indicator has a high oil market independence and a link to oil supply and demand shocks, establishing a dynamic link between the oil market and the macro market through its similar dynamic impact to macro market uncertainty. To show the relationship between oil uncertainty and macroeconomic variables, Kilian (2009), Elder and Serletis (2010), and Jurado et al. (2015) all use VAR models that include several important macroeconomic and oil industry indicators to analyze the dynamics.

Employment is directly affected by market uncertainty. Diamond says, "What is most critical now is not the functioning of the labor market, but the constraints on labor demand, as consumers and firms are very cautious because there is a great deal of uncertainty about what will happen next." Among the large literature that studies uncertainty, a small part explains the macro dynamics of employment in terms of uncertainty. Among them, Loungani (1986) provides evidence of the relationship between oil price volatility during the oil crisis of the 1970s and the reduction in employment across industries due to the massive reallocation of labor. Lee et al., (1995) compare the effects of different levels of oil price shocks and suggest that the effect of oil price shocks on unemployment is significant. Ferderer (1996) finds that oil price shocks and volatility help predict the growth rate of employment. Kocaaslan (2019) shows that oil price uncertainty increases unemployment in the U.S. economy. Koirala and Ma (2020) find that the impact of oil price shocks on employment is asymmetric by analyzing positive and negative oil price shocks, and this asymmetry is particularly pronounced in sectors that have a strong dependence on the oil industry.

The research in this paper includes the following main aspects. First, we structure a VAR model that includes 12 important economic variables to reflect the joint effect of monetary policy and uncertainty on the response of employment. Economic variables in the VAR model include macro variables such as interest rates and aggregate uncertainty reflecting U.S. monetary policy from 1986Q1-2021Q4 and oil market variables such as oil production and oil uncertainty. There are three main types of monetary policy, the policy rate of the U.S. federal funds rate, the desired rate of Bernanke's modified Taylor rule with the binding of the ZLB, and Bernanke's modified Taylor rule that is not constrained by the ZLB. By replacing oil uncertainty from Ma and total uncertainty from Jurado et al. the responses of employment to oil and macro uncertainty under the three monetary policies can be visualized. Then, we further analyze the response of sectoral employment to oil uncertainty under different monetary policy regimes. The sectors are derived from the U.S. Bureau of Labor Statistics classification of major private sectors, specifically, total private, construction, education, and health service, finance, government, information, leisure and hospitality, manufacturing, mining and logging, professional and business services, trade transportation, and utilities. The variation in the responses of employment in different sectors reflects the differential relationships between oil uncertainty and different sectors. The methodology used in this paper is very similar to Killian (2009) and Jurado et al. (2015). However, the difference is that this paper focuses on the impact of oil and macro uncertainty on total and sectoral employment in the United States under different monetary policies.

We have the following main conclusions. The results of the VAR model suggest that subject to the ZLB, oil and aggregate uncertainties have a significant and persistent negative effect on employment. In the absence of ZLB, the negative effect of employment is attenuated by the change in monetary policy and the fluctuations of responses are signification. The responses of employment to oil uncertainty vary significantly across sectors. Away from the zero lower bound, the employment in sectors with production and financial relationship to the oil industry declines significantly due to the increase of oil uncertainty, while the absence of the ZLB causes changes in sectoral employment to exhibit similar volatility to changes in total employment.

The main contributions of this paper are as follows. First, most of the literature studying the relationship between labor and shocks focuses on shocks to levels or changes in volatility. In contrast, this paper considers the impact of monetary policy on the relationship between employment and different uncertainties. Second, to consider the role of uncertainty on labor force dynamics comprehensively, we cite various types of uncertainty indices. The oil earning uncertainty of Ma and Samaniego (2020) is one of the few uncertainty indices that are based on the independence of the oil market. The aggregate uncertainty of Jurado et al. (2015) is an index that explicitly reflects the pre-21st century economic recessions estimated from a large amount of data. Basu's (2017) uncertainty is an index that significantly reflects economic recessions, and he even analyzes the calibrations to different monetary policies. The survey-based aggregate uncertainty of Scotti (2016) mainly screens economic fluctuations during the economic recessions since the 21st century. By analyzing uncertainty indices with different emphases, we can get a more complete understanding of the dynamics of employment and uncertainties. Finally, we innovatively combine sectoral employment, uncertainty, and different monetary regimes for further analysis. Our paper adds to the literature focusing on sectoral employment and uncertainty.

The paper is structured as follows. Section 2 constructs the VAR model including macroeconomic variables. Section 3 shows mainly the impact of oil and aggregate uncertainty measures on aggregate and sectoral employment. Section 4 summarizes the robustness check under alternative scenarios. Section 5 concludes with a discussion of the main findings and possible future work.

2. EMPIRICAL MODEL

2.1. Methodology

To characterize the dynamic impacts of uncertainties on employment with the binding of the ZLB and the actual data, in line with Basu and Bundick (2017) and Ma and Samaniego (2020), we employ the vector-autoregression (VAR) method to estimate the response of macro variables involved in the model.

Since our study focuses on the impact of oil price uncertainty and the monetary policy regime with the ZLB, the variables included in the model come from oil markets and macroeconomics. The variables of the oil market are referred to Killian (2009) and Ma and Samaniego (2020), while the variables of the macro market are employed following Bloom (2009) and Jurado et al. (2015). We estimate our baseline VAR using 12 variables on oil uncertainty, the policy interest rate, consumer price index, total employment (in thousands), real wage, working hours, real oil price(in dollars per barrel), S&P500 index, U.S. industrial production, U.S. crude oil production (in thousand barrels of oil), world crude oil production (in thousand barrels of oil) and world real economic activity from Kilian Index in Kilian (2009). The model is estimated on quarterly data from 1986Q1 to 2021Q4 with 4 lags since more lags are useful for analyzing higher order systems and generating consistent estimates according to Keating and John (1990) and Toda and Yamamoto (1995):

Here, oil uncertainty is the oil earning uncertainty derived by Ma and Samaniego (2020). To further understand the role of macroeconomic uncertainty, the VAR model also cites macroeconomic uncertainty indexes of Jurado et al. The variable of interest rate, which is the effective federal funds rate, reflects different monetary policy regimes. The total employment is from the FRED dataset, which is the time series of "All Employees: Total Nonfarm Payrolls (PAYEMS)". Following Jurado et al. (2015), to detail the fluctuations in employment by sector, we substitute the total employment in the VAR model with sectoral employment available on the Bureau of Labor Statistics. The real wage is the deflated average weekly earnings of production and nonsupervisory employees: total private, obtained via FRED. Working hours are from FRED reflected by average weekly hours of production and nonsupervisory employees: total private.

$$\text{VAR}-12=\begin{bmatrix}\text{Uncertainty shock}\\ \text{Policy interest rate}\\ \text{Log}\left(\text{CPI}\right)\\ \text{Log}\left(\text{employment}\right)\\ \text{Log}\left(\text{real wage}\right)\\ \text{Working hours}\\ \text{Log}\left(\text{oil price}\right)\\ \text{Log}\left(\text{S\&P 500}\right)\\ \text{Log}\left(\text{U.S. industrial production}\right)\\ \text{Kilianworld economic activity index}\\ \text{Log}\left(\text{U.S. crude oil production}\right)\\ \text{Log}\left(\text{world crude oil production}\right)\end{bmatrix}$$

The variables of the VAR model are mainly data in level or logarithm, except for Kilian's world economic activity index derived by percentage deviation from trend estimation. The impulse responses of variables in level can visualize the dynamic relationship between variables as in Jurado et al. (2015). ADF and ZA tests indicate that all variables included in the model are at least first-order smooth. Following Sims et al. (1990), the stationarity of the variables at the level is not necessary given that we focus only on the impulse responses of the variables. To test robustness, we also estimate the VAR with the monthly dataset to show the impulse responses of employment to the oil uncertainty of Ma and Samaniego (2020) and the aggregate uncertainty of Jurado et al. (2015).

2.2. Monetary Policy Regime

The literature of Basu suggests that the response of macroeconomic variables to aggregate demand shock is influenced by the ZLB. Following the papers of Bloom (2009) and Jurado et al. (2015), we introduce the endogenous variables of interest rate, employment, and oil price uncertainty in a VAR model to obtain the response of employment to oil price uncertainty under different monetary regimes.

To capture how the response of employment to oil price uncertainty varies under different monetary policy regimes. We employ the dataset during 1986Q1-2021Q4 and then reflect the impact of oil price uncertainties on employment in two subsamples, away from the ZLB (1986Q1-2008Q4 & 2016Q1-2020Q1), and at the ZLB (2009Q1-2015Q4 & 2020Q2- 2021Q4).

By comparing the two subsamples, we aim to measure the response of employment to oil price uncertainty and macroeconomic uncertainty under the following three scenarios.

1. The response of total employment in the full sample(1986Q1-2021Q4) when the interest rate is the effective federal funds rate, i.e. the policy rate.
2. The effect of oil price uncertainty on employment when the interest rate is the policy rate but in different monetary policy regimes, i.e. at and away from the ZLB.
3. The response of sectoral employment under different monetary policy regimes.

We still retain the original VAR model, but by changing the interest rate in the VAR model among the three scenarios, we obtain the response of employment to oil price uncertainty in the presence and absence of ZLB binding.

2.3. Uncertainty Indices

Uncertainty shocks have an important impact on the volatility of macroeconomic variables as in Bloom (2009), and Bachmann and Bayer (2013). Based on how the data are constructed, who is studied, and the impact, Cascaldi-Garci et al. (2020) summarize the measures of uncertainty and volatility into three categories. In this section, to reflect the impact of oil price uncertainty on employment, the VAR model introduces the oil earning uncertainty of Ma and Samaniego (2020) to get the baseline estimation. The macroeconomic uncertainty obtained by Ma and Samaniego (2019) behaves very similarly to other measures of aggregate uncertainty, such as uncertainties in Jurado et al. (2015) and Basu and Brent (2017), which helps us with further comparison of differences in employment responses to oil uncertainty and aggregate macroeconomic uncertainty. Following Cascaldi-Garci et al. (2020), the aggregate uncertainties of Jurado et al. (2015) and Basu (2017) are important representations of econometric-based uncertainty and the aggregate uncertainty derived by Scotti (2016) showing a survey-based un- certainty index. Among them, Basu's analysis also guides our study of the impact of ZLB in the Great Recession and the COVID outbreak.

1. The oil uncertainty employed in the VAR model is estimated by Ma and Samaniego from a large set of firm-level forecasts and forecast error data, which differs from traditional oil uncertainty that includes macroeconomic market information such as oil output and prices. They calculate the forecast error from a monthly sample of firm forecasts and observations covering 1982-2018, and the median absolute forecast error across all firms within the month is the oil earning uncertainty (OEU). There are several benefits to citing this uncertainty in this paper to analyze oil market uncertainty. First, the data on oil earning uncertainty are monthly data from 1982-2018, which has a wide time and high availability. Second, Ma's OEU is derived from corporate data of the oil market, which is relatively less influenced by the overall macro market, facilitating our analysis based on the independence of the oil market and thus amplifying the comparison between the impact of oil market uncertainty and macroeconomic market uncertainty. Finally, by later comparing the impact of oil uncertainty and aggregate uncertainty on employment, we can establish the relationship between the oil market and the macroeconomic market, thus verifying the interaction between oil uncertainty and aggregate uncertainty in the long run.
2. Jurado used a data-rich approach with three key ingredients to measure macroeconomic uncertainties. They considered the forecast from large predictors for a data-rich environment, time-varying volatility in the errors of the predictor variables for more contributions on uncertainty, and the equally weighted average of individual uncertainties for the estimates of the macroeconomic uncertainties. They included the information in hundreds of macroeconomic and financial indicators, covering the months surrounding the 1973–1974 and 1981–1982 recessions and the Great Recession of 2007–2009. The defensible measure of time-varying macro uncertainty that can be tracked over time and related to fluctuations in real activity. The macroeconomic uncertainty is the average of the uncertainty measures across all macro variables, which differentiates uncertainty from traditionally used measures of volatility, such as conditional volatility since conditional volatility does not necessarily remove the forecastable component of a time series, while the JLN index does so by incorporating a large number of indicators into the forecasting model for each individual time series according to Cascaldi-Garci et al. (2020).
3. Basu and Bundick consider the co-movement of macroeconomic variables as a key empirical feature of the economy's response to a deterministic uncertainty shock, thus they employ a standard DSGE model that takes demand-determined output as the key mechanism for generating such a co-movement. The VAR model covering data from 1986 to 2014 and the observable ex-ante stock market volatility index are used to calibrate the resulting uncertainty shocks. The DSGE model contains both sticky and flexible price mechanisms capturing the impulse responses of macroeconomic activity to demand uncertainty shocks. Notably, they examine the role played by the ZLB in magnifying the real effects of uncertainty shocks, which helps to quantify the likely impact of uncertainty shocks during the Great Recession.
4. Scotti's macroeconomic uncertainty is survey-based aggregate uncertainty obtained from weighted average of economic data surprises. Scotti defines this uncertainty as an uncertainty index that measures the attitudes and uncertainty of agents in the macroeconomy about current economic conditions. This index is the result of an unexpected combination of dynamic models and economic data. In this case, the dynamic model is used to estimate the index of business conditions and the associated weighting of each economic indicator, and the economic data surprises are estimated by the deviation of the economic data from the consensus expectations projected by Bloomberg. Thus, Scotti's uncertainty index is closely related to macroeconomic activity and has a high correlation with the VIX. But since the analysis of Scotti for the surprise and uncertainty indexes covers the period from May 2003 through March 2016, we can obtain an uncertainty index covering 2003Q2-2021Q1, which helps us to understand more about the impact of macroeconomic uncertainty on employment during recessions since the 21st century.

The impulse response of employment to oil price uncertainty reflects the relationship between employment and volatility in the oil market, while the response of employment to macroeconomic uncertainty suggests the relationship between employment and the macro environment. These results establish the link between oil price uncertainty and aggregate uncertainty. If the two responses are similar, the conclusion can explain the importance of the oil market in the macroeconomic environment; otherwise, the conclusion suggests that the trend of fluctuations in oil market uncertainty is significantly different from the total uncertainty.

3. EMPIRICAL RESULTS

3.1. The Effects of the ZLB on Employment

In this section, we show the impulse response of employment to uncertainty under different monetary policy regimes, the policy rate at and away from the ZLB. The four main types of uncertainty are the oil uncertainty of Ma and Samaniego (2020), which mainly reflects information about the oil market itself, the macroeconomics aggregate uncertainty of Jurado et al. (2015), which is measured by the dynamic DSGE model, and the uncertainty derived by Basu, which is measured by the standard DSGE model and emphasizes the role of the ZLB, and aggregate uncertainty from Scotti (2016), which is predicted based on survey market information and focuses on the economic recessions periods.

Since our main topic is the impact of uncertainty on employment, given the comparison of different monetary regimes and uncertainty outcomes, we can reflect on the impact of the ZLB on the relationship between employment and oil/aggregate market uncertainty. Figure 1 plots the estimated responses of employment to different uncertainties along with the 95% confidence intervals. Oil price uncertainty based on forecast errors in oil market returns causes employment to significant and persistent fluctuations. The positive impact of this uncertainty persists for 5-6 years, and in the long run, employment slowly increases, which connects the oil market and macro market uncertainties. On the one hand, oil is an important basis for other products, the volatility of oil products' returns affects uncertainty and employment in other markets, and such effect is unstable and persistent (Elder and Serletis, 2010). On the other hand, this response also indicates a rigid demand for petroleum products in macro markets. Oil uncertainty usually hurts the economy, but the rigid market demand for oil stimulates production and employment growth in the long run (Maghyereh et al., 2016). Similarly, the increase in aggregate uncertainty of Jurado leads to a significant decline in employment over 3 years, with its peak occurring about a year after the onset of uncertainty, which is with more magnitude than that of oil uncertainty, demonstrating the significant relationship between total employment and aggregate uncertainty. Employment is more sensitive to changes in Jurado's aggregate uncertainty and adjusts in time to return to a steady state after about 8 years, like Jurado's et al. (2015) findings. Aggregate market power as well as government intervention are conducive to shortening the negative effects of uncertainty, thus ensuring regular production activities and relatively stable income levels for workers. The result of the response of employment to Scotti's uncertainty also reflects it. The stark difference is that Basu's uncertainty does not have a significant impact on employment within a year after its occurrence, after which it leads to a sharp short-term decline and a further slight increase in employment. It is worth noting that Basu's uncertainty index is calibrated by an ex-ante stock market volatility index and tends to reflect uncertainty shocks to aggregate demand so that the result of Basu is consistent with Ma's conclusion based on the Volatility Index Overview (VXO) in the short run, that there is no clear evidence of a volatility overshoot in response to any of the uncertainty measures, including VXO. Intervention policies, such as the ZLB, preserve the relative stability of the market in the short run (Loungani, 1986) and reduce the impact on employment of macro uncertainty inferred from market information.

Figure 1 reflects impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado and Basu in 40 forecast horizons, where all variables are series data in level. The periods of all estimated data in the three figures are as follows: 1986Q1- 2018Q4(quarterly), 1986Q1-2021Q4(quarterly), 1987Q1-2014Q4(quarterly).

The responses of employment away from the ZLB as in Figure 2, which explains the consistency of the impulse response of employment to uncertainty in normal times, have an extremely high fit to the full sample. According to the findings, we get significant fluctuations in employment due to various uncertainties in normal times. However, in normal times, under the regime away from the zero lower bound, the response of employment under the same uncertainty shock remains consistent with the trend in the total sample.

Figure 2 shows impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado and Basu in 40 forecast horizons, where all variables are series data in level. To further figure out the functions of the ZLB on the impulse response of employment to uncertainty shocks from the oil market and macro market, we retain the policy rate under the regime of the ZLB. It is clear in Figure 3 that with the binding of the ZLB, employment responds more volatile than at normal times. The

Figure 1: Employments to uncertainties in quarterly data at the ZLB

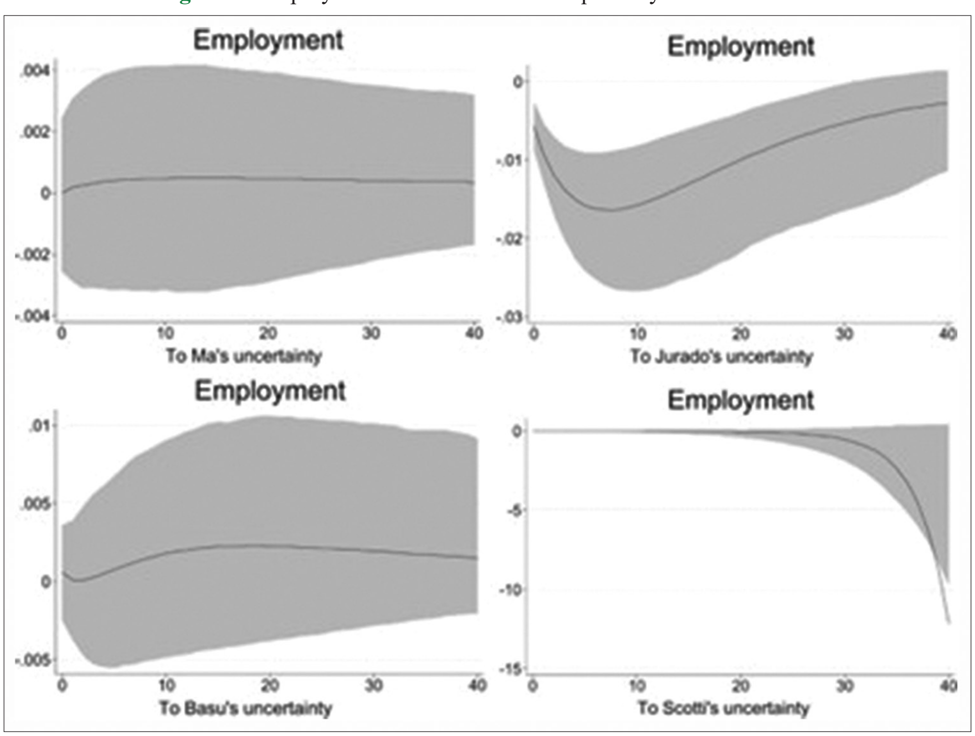


Figure 2: Employment responses to uncertainties in quarterly data away from the ZLB

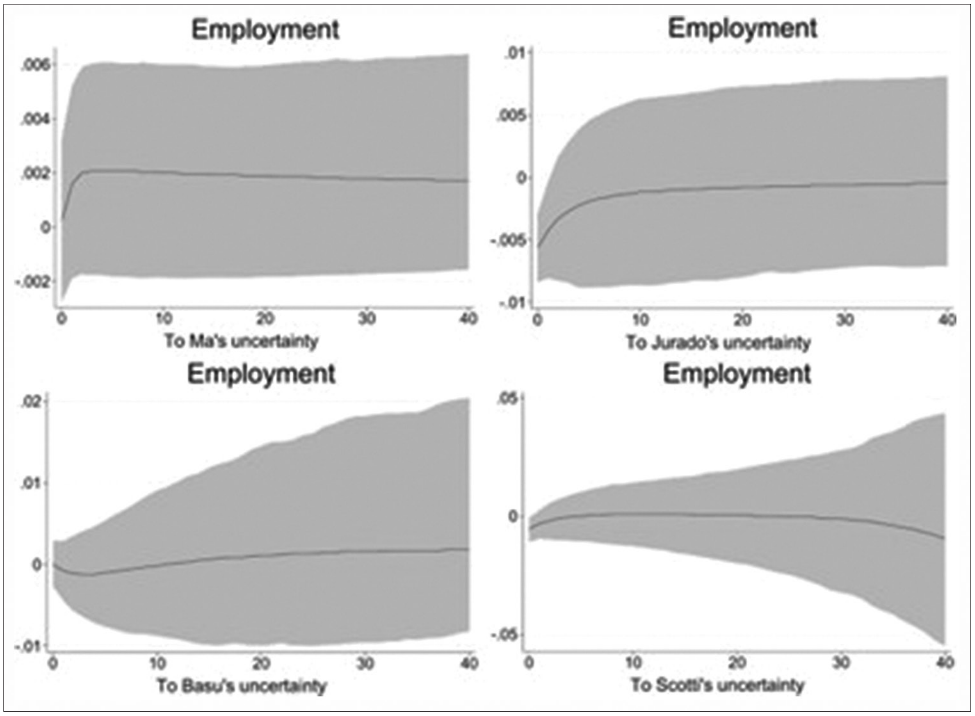
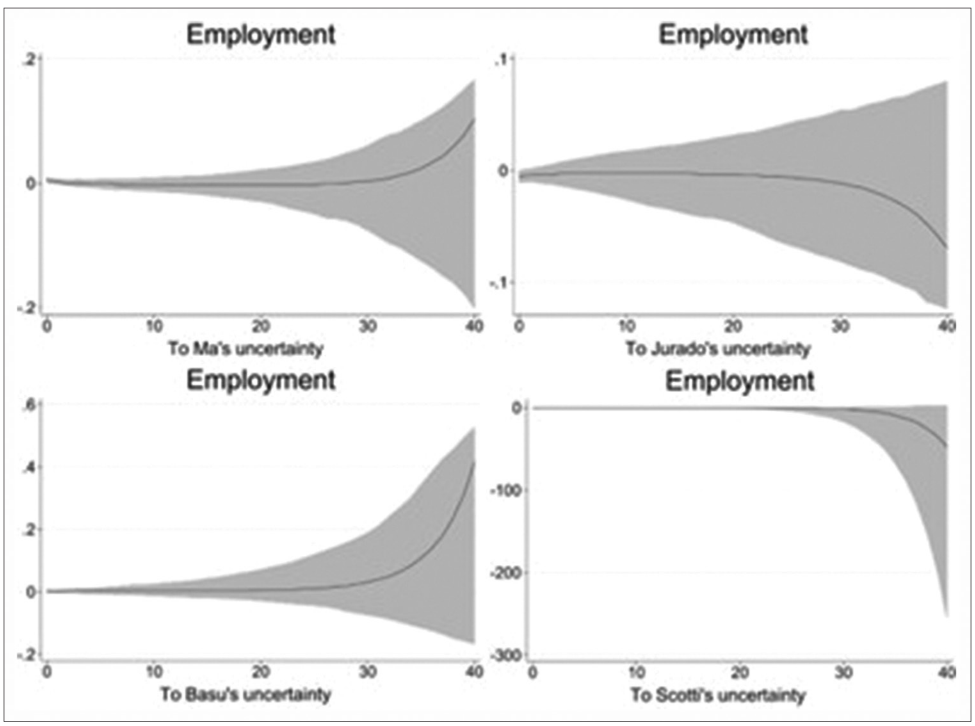


Figure 3: Employment responses to uncertainties in quarterly data at the ZLB



sensitivity of the market to uncertainty increases and the stability of employment and the market is greatly threatened under economic recessions (Altig et al., 2020). With the intervention of the ZLB constraint, both model-based and survey-based uncertainties cause similar significant fluctuations in employment. Thus, monetary policy is one of the important pre-requisites for distinguishing the effects of uncertainties from different resources. While the findings of Scotti's uncertainty with sample data mainly from economic recessions are more meaningful. Comparing the findings here with those of the figure without the binding of the ZLB, the existence of the constraint causes more dramatic fluctuations in the response of employment to various uncertainty shocks (Kocaaslan, 2019). In other words, employment is significantly affected by the growth of economic uncertainty during the recessions, which is clearly consistent with economic development so we can further show the importance of the ZLB. Nie (2023) mentioned with the binding of the ZLB, the contractionary effect of oil shocks is enhanced based on the theoretical calibration and borrowing of the dataset of the U.S. under two economic recessions. However, she also proposed an exception that with the interaction of price tool and constraint of the ZLB, the contractionary effect of oil demand shock may be suffered.

The above images are impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado et al. in 40 forecast horizons, where all variables are series data in level. The more dramatic volatility in employment under the zero lower bound constraint reflects both the prompt response of the market to expansionary policy and the limited control of the Fed and the government over the market in times of recession. Under the zero lower bound constraint, the central bank lacks the capability to endogenously offset the volatility generated by shocks.

The response to uncertainty shocks in the oil market can be discussed further in connection with Chapter 1 of this thesis (Nie, 2023). The response to oil market uncertainty shocks in the regime of the zero lower bound can be discussed further in the context of Chapter 1 of this thesis. Under the zero lower bound regime, the buffered contractionary effect of oil demand shocks, as well as the rising oil prices, may stimulate employment, especially in oil-related sectors. It is worth noting that under the same uncertainty shocks, changes in the monetary policy regime do not significantly alter the consistent response of aggregate employment.

3.2. The Effects of the ZLB and Uncertainties on Sectoral Employment

This section focuses on the differences in the impact of oil uncertainty on sectoral employment under different monetary policies. The 11 sectors analyzed are drawn from the Bureau of Labor Statistics classification of the private and government sectors, including total private, construction, education, and health service, finance, government, information, leisure and hospitality, manufacturing, mining and logging, professional and business services, trade transportation, and utilities. This analysis not only provides a concrete picture of the response pattern of employment in the major economic sectors under oil uncertainty but also allows us to compare the symmetry of the impact on employment. Further, by analyzing the difference in impacts under the ZLB and non-ZLB, we can further understand the superiority of government monetary policy.

According to Figure 4, without the binding of the ZLB, oil uncertainty has a negative impact on employment in most sectors, especially oil-related sectors, although the significance and persistence of the impact varies. The negative impact on employment in the totally private, construction, finance, and mining and logging sectors is more pronounced, and the decline in employment in the totally private, manufacturing, professional, and business services, trade transportation, and utility sectors is more persistent. Bjørnland et al. (2018) argue that oil price shocks are a recurring source of economic volatility, a finding that both explains and is further justified by our results.

Importantly, the response of employment in the major economic sectors to oil uncertainty is also asymmetric. As mentioned above, different sectors of the economy are subject to different degrees of negative shocks. For example, sectors such as total private, construction, and mining and logging are directly or closely linked to the oil industry in production, while sectors such as manufacturing, professional and business services, finance, and trade transportation and utilities are directly or closely linked to the oil industry in production. sectors such as manufacturing, professional and business services, finance, trade transportation, and utilities have financial links to the oil industry, which explains the significant impact of sectoral employment on economic cycle fluctuations due to oil uncertainty. The response of employment in the above sectors to oil uncertainty is more significant and persistent, while in contrast, the impulse response to oil uncertainty in the education, health, and government sectors is relatively short and smooth.

Further, we try to discuss the effect of the ZLB on the transmission mechanism of oil uncertainty. Figure 5 shows the response of employment in different sectors to the policy rate at the ZLB intervention. According to the figure, the dynamic impact of high economic uncertainty on employment in the above sectors is quite different from that under the effective policy rate during economic recessions. In contrast to the clear directionality of the employment response in the major sectors, the responses of the sectoral employment fluctuate significantly at the ZLB. To clarify the results, we shorten the time period of the horizontal axis to 15 quarters. As a result, the ZLB enhances the magnitude of the employment response and even changes the trend of the employment response in many sectors, such as the growth of employment in oil-related industries during the recessions. It is noteworthy that most of the oil product-related industries and capital-related sectors mentioned above are not only taking more pressure under the propagation of increasing uncertainty shocks but also getting benefits for laborers to some extent due to the interaction of monetary policy and change in contractionary effect. Thus, in the presence of the ZLB, oil price uncertainty, although leading to an increase in employment in the main sectors and an asymmetric response, is generally conducive to increasing long-term employment volatility and promoting macroeconomic sectoral development in the long run. We can also conclude that by changing the response mechanism of the central bank and the forecast of different characters in the market, the systematical change of the monetary policy regime alters the economic environment and also changes the responses of employment in various sectors.

3.3. Robustness Check

To check the robustness of the responses on employment to different types of uncertainties in the U.S., we use alternative frequency and variable measures. In the first alternative, we use monthly data to check the impulse response of employment to the oil uncertainty of Ma and aggregate uncertainty of Jurado under the Federal Fund policy rate. In the second alternative, we use the first log difference of all variables except uncertainties indices in quarterly data to testify the responses of employment to all uncertainties under different interest rate rules. In the last alternative, we use the first log difference on all variables except uncertainties in monthly data to check the responses of total employment under different monetary policy regimes. Further tests conclude that oil uncertainty and aggregate uncertainty still lead to more significant volatility in employment when the ZLB binds.

Figure 4: Impulse responses of employment to oil uncertainty away from the zero lower bound

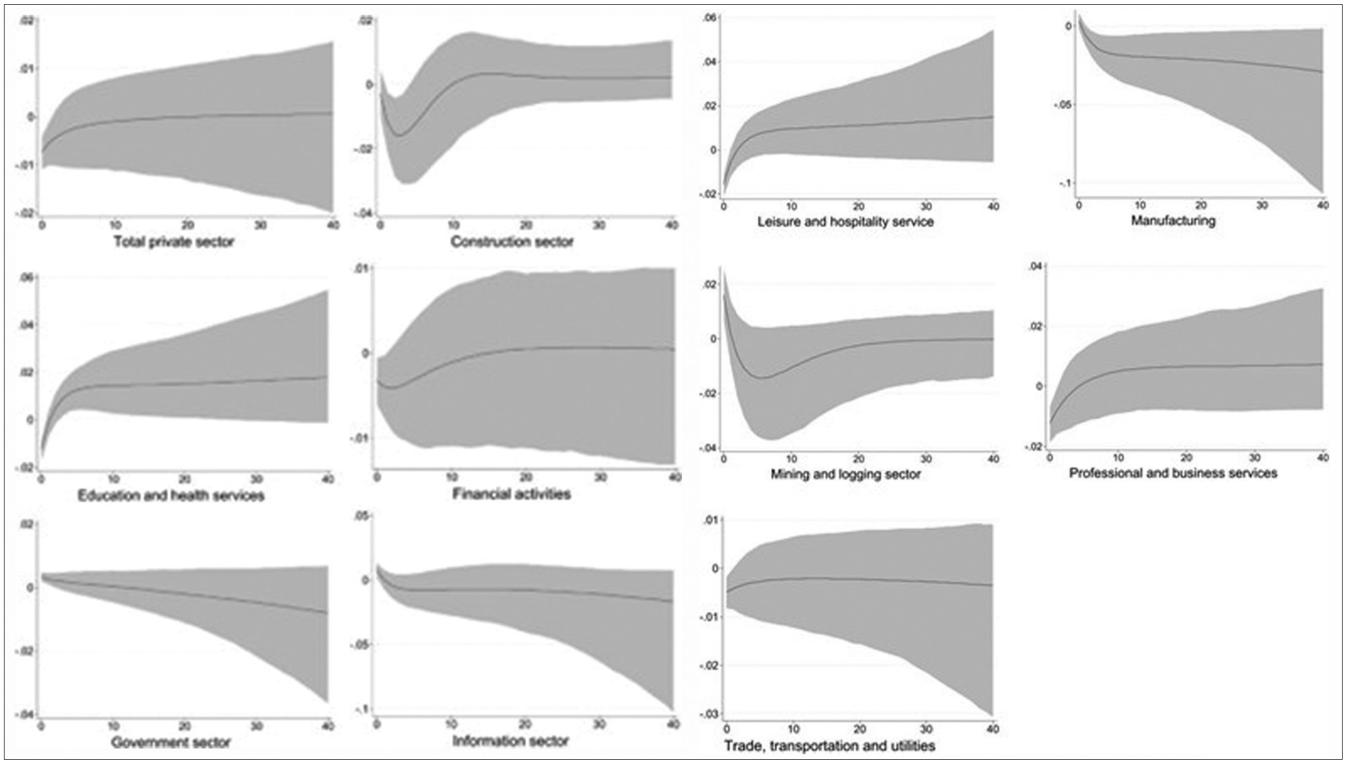
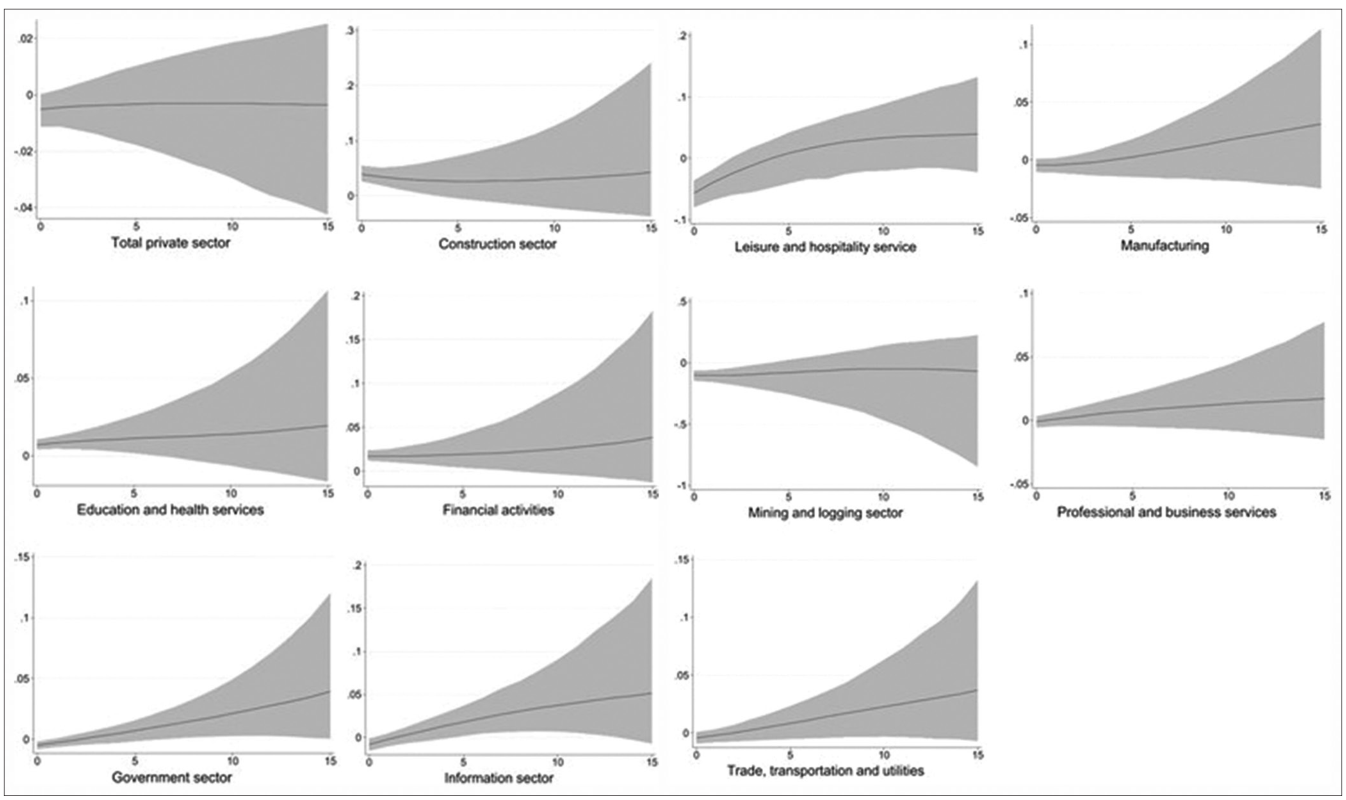


Figure 5: Impulse responses of employment to oil uncertainty away from the zero lower bound



4. CONCLUSION AND POLICY IMPLICATIONS

The analysis of monetary policy and uncertainty by the VAR model leads us to the following main conclusions. First, the results of the VAR model suggest that subject to the ZLB, oil and aggregate uncertainties have a significant and persistent negative effect on employment. With the binding of the ZLB, the negative effect of employment is attenuated by the change in monetary policy regime and the fluctuations of responses are significant. Second, the responses of employment to oil uncertainty vary significantly across sectors. Under normal times, employments in sectors with production and financial relationship to the oil industry decline significantly due to the increase in oil uncertainty, while the presence of the ZLB causes changes in sectoral employment to exhibit more volatility. With the interaction of uncertainty shocks and monetary policy, oil-related industries' employments grow during economic recessions.

However, there are still many questions worth exploring concerning this topic. We hope to construct the new Keynesian model to provide more theoretical support. For example, employing a segmented model with higher-order perturbations to deal with the oil uncertainty, and assuming wages with stickiness or rigidity, as important factors, also have significant impacts on the response of employment.

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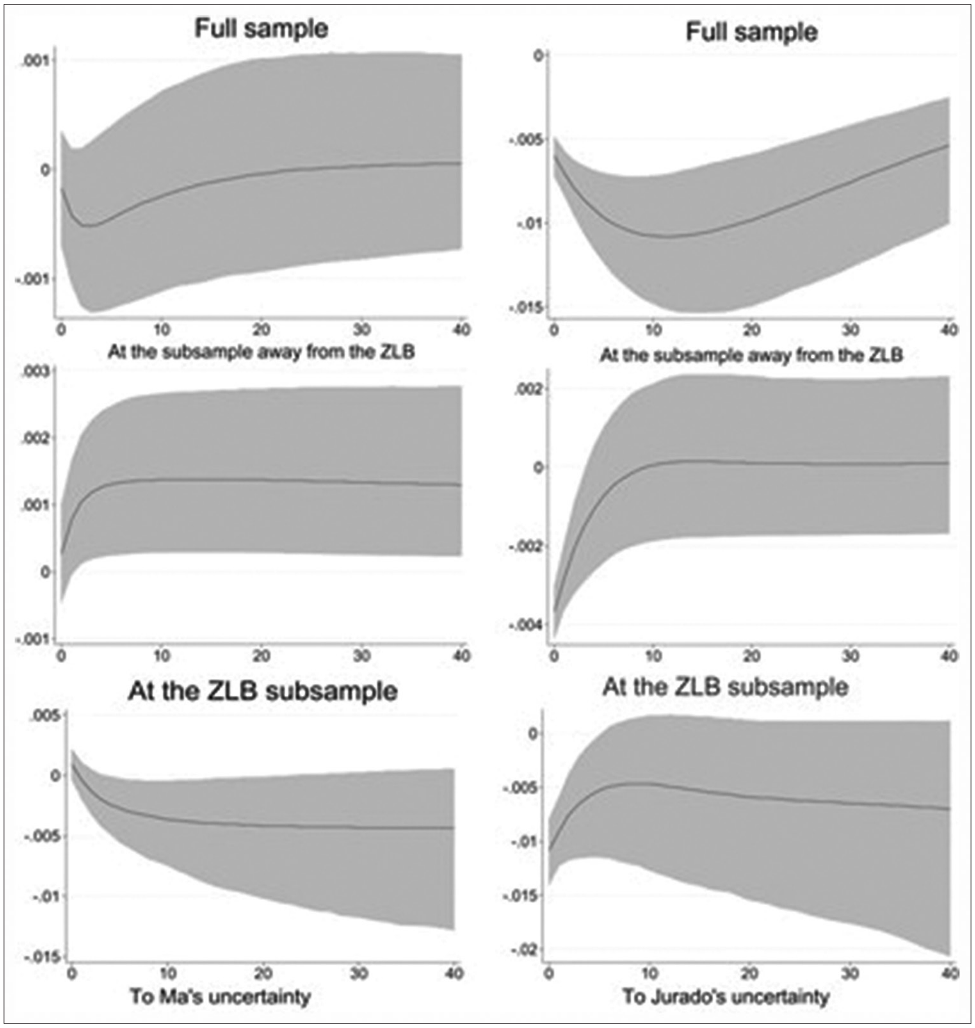
APPENDIX

Robustness check

1. Impulse responses of employment from monthly dataset

Appendix Figure 1: Impulse responses of employment to oil uncertainties in the full sample, in the subsamples at and away from the zero lower bound

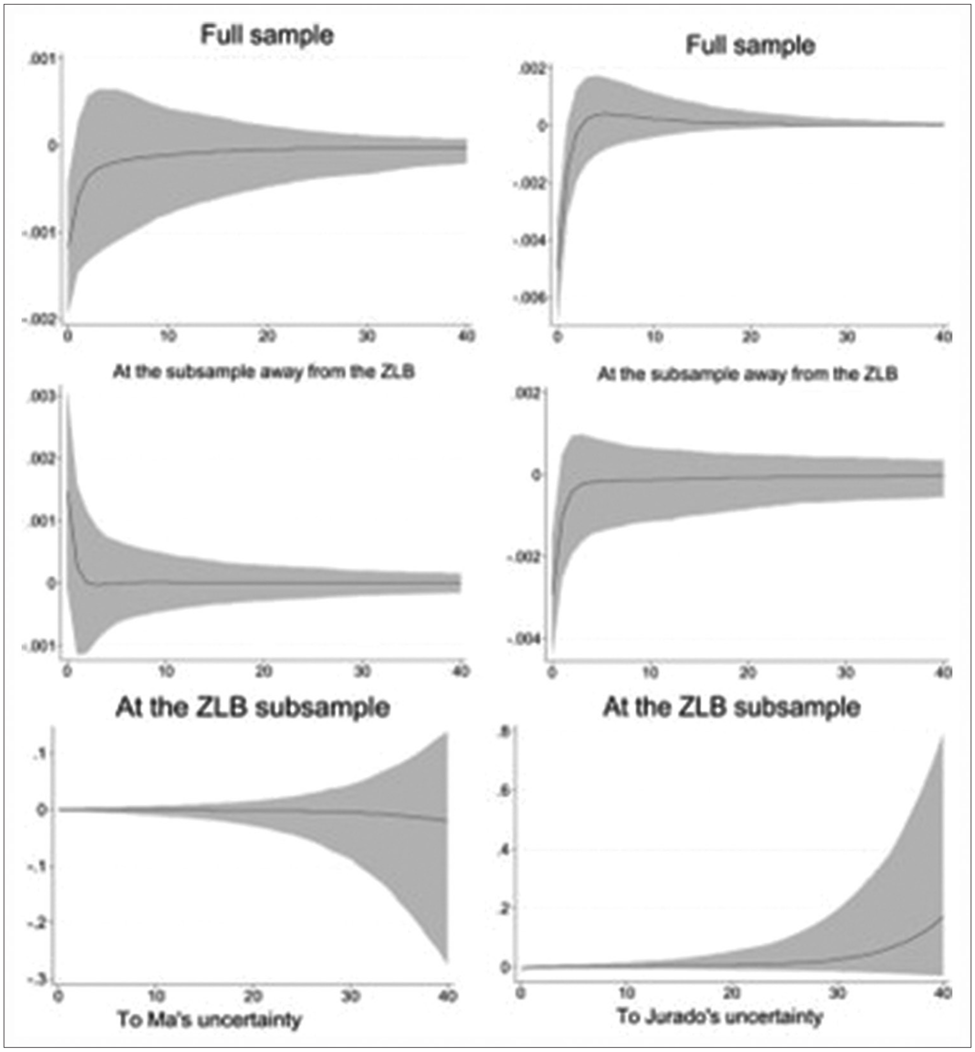


The above Appendix Figure 1 are impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado in 40 forecast horizons, where all variables are series data in level.

The time period of all estimated data in the full sample is 1986M1-2021M12, in the ZLB subsample is 2008M12-2015M12 & 2020M4-2021M12, and in the sub-sample away from the ZLB is 1986M1-2008M11 & 2016M1-2020M3.

2. Impulse responses of first log difference of employment from the quarterly dataset

Appendix Figure 2: Impulse responses of employment to oil uncertainties in the full sample, in the subsamples at and away from the zero lower bound

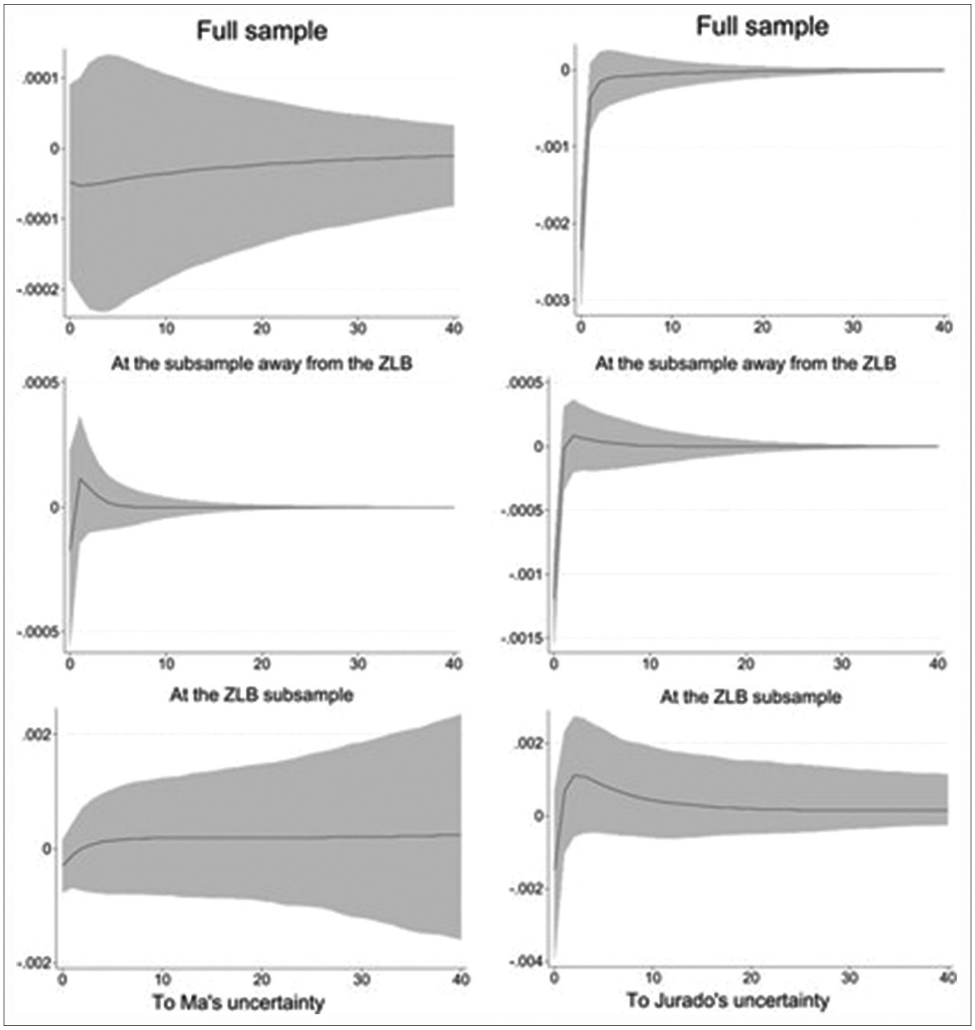


The above Appendix Figure 2 are impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado in 40 forecast horizons, where all variables are series data in first log difference except for uncertainties.

The time period of all estimated data in the full sample is 1986Q1-2021Q4, in the ZLB subsample is 2009Q1-2015Q4 & 2020Q2-2021Q4, and in the subsample away from the ZLB is 1986Q1-2008Q4 & 2016Q1-2020Q1.

3. Impulse responses of first log difference of employment from the monthly dataset

Appendix Figure 3: Impulse responses of employment to oil uncertainties in the full sample, in the subsamples at and away from the zero lower bound



The above Appendix Figure 3 are impulse responses of total employment to oil uncertainty of Ma, and aggregate uncertainties of Jurado in 40 forecast horizons, where all variables are series data in first log difference except for uncertainties.

The time of all estimated data in the full sample is 1986M1-2021M12, in the ZLB subsample is 2008M12-2015M12 & 2020M4-2021M12, and in the sub-sample away from the ZLB is 1986M1-2008M11 & 2016M1-2020M3.