Are Oil Price Shocks a Boon to the Korean Economy?[*]

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Abstract

In contrast to the common prior that oil shocks would deter the economic growth of Korea that imports most of its energy sources, we find that demand-driven global economic activity shocks can have sizable positive impacts on industrial production. Other structural oil shocks do not also decrease the aggregate-level economic activity. Further analyses at the industry level reveal that the mining and manufacturing sector shows a similar pattern, while the construction sector is negatively affected by only oil supply shocks. In addition, we find that accounting for the level of uncertainty materially changes economic responses, particularly to the supply shocks. Our findings highlight the importance of accounting for the structural sources of oil price changes, sectoral heterogeneity, and the level of uncertainty, to better understand the oil-macro relation for small open economies.

JEL classification: E31, Q41, Q43

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1 Introduction

An unexpected hike in oil price can generate economic recessions (Hamilton (1983)). This implies that South Korea, a country that heavily depends on the imported sources of energy including crude oil, would be particularly vulnerable to the oil price increases.[1] It is also a small open economy and thus widely exposed to global economic fluctuations. For this reason, oil price is one of the most crucial external risk factors that are closely monitored for Korea.[2] In contrast to this prior, several previous studies failed to find empirical support, to our surprise (see Baek and Kim (2020) and Cunado, Jo, and de Gracia (2015), for examples).

In the recent literature on the oil-macroeconomic relation, one factor that received much attention is to distinguish sources of oil shocks that drive unexpected changes in oil prices. Kilian (2009) and Baumeister and Hamilton (2019) showed that the effects of oil price shocks vary according to their sources. In particular, Baumeister and Hamilton (2019) found that a supply shock brings a persistent drag into the economy with some delay while a (oil) demand shock does not, indicating that ignoring the sources of shocks might lead researchers to imprecise estimates on the effects of oil price changes. This finding might be particularly important for Korea, as its economy is exposed to the global market in multiple dimensions. For instance, when the oil price increases because of global economic booms, it may result in the expansion in the Korean economy, if positive effects from greater export dominates negative effects from higher import prices on the energy.

Our paper, hence, attempts to reconcile the differences between the previous findings from the literature and the conventional prior on the effects of oil shocks, by incorporating the structural sources of oil price changes. In fact, Cunado, Jo, and de Gracia (2015) showed that the sources of oil price shocks do matter for five Asian countries. They used three types of structural oil shocks that are identified in a way similar to Baumeister, Peersman, and Van Robays (2010) and employed aggregate indicators such as GDP and exchange rates. We differ in that we focus on industrial production (IP hereafter) of Korea by utilizing four structural shocks identified by Baumeister and Hamilton (2019): oil supply shocks, economic activity shocks, oil consumption demand shocks, and inventory demand shocks. We examine if theses shocks incur differing effects on IP, while controlling for various macroeconomic variables of Korea, such as consumer price index and the Korean Won-US dollar exchange rate. We also extend our analysis to investigate the impacts of these shocks on relatively energy-intensive sectors such as the mining and manufacturing as well as construction sectors. Our empirical analysis employ the Local Projection method proposed by Jordà (2005)), which enables us to examine the effects of the four oil shocks at the aggregate- and sectoral-level IPs in one consistent framework.

We further assess if the level of economic uncertainty can have an impact on the propagation mechanism of

[1] In 2021, the share of imported energy sources in total energy use was 92.8% and the crude oil import share was about 40% in Korea.

[2] For example, see the newspaper article: https://en.yna.co.kr/view/AEN20220310003800320 at the time of the Russian invasion of Ukraine.

structural oil shocks. According to studies such as Van Robays (2016), macroeconomic uncertainty raises the sensitivity of oil price to structural oil shocks. If this finding also applies to the Korean economy, it would imply that a high-uncertainty (low-uncertainty) regime might result in greater (smaller) effects of oil price shocks.[3] In order to capture this idea, we consider the level of uncertainty in a state-dependent Local Projection model. We indeed find that the effects of oil price shocks on the Korean economy are non-linear with respect to the level of the uncertainty.

Key findings can be summarized as follows. First, a non-structural oil price shock measured by an exogenous shock to the real refiner acquisition cost (RAC hereafter), increases IP, consistent with the findings in the previous literature (Baek and Kim (2020) and Cunado, Jo, and de Gracia (2015)). Further analyses with structural oil shocks unveil the fact that such increases in IP are mainly driven by economic activity shocks, that captures global business cycle fluctuations. The IP does not, however, significantly respond when both supply shocks and inventory demand shocks are considered.[4] Together, these findings imply that demand from the outside of Korea dominates potential negative impacts which may arise from higher energy costs. Second, there is substantial heterogeneity across different sectors. For example, the findings from aggregate variables are preserved and intensified for the mining and manufacturing sector, which takes a significant portion of Korean GDP. On the contrary, the construction sector exhibits a decline or modest increase in the IP index; a shock to RAC does not have significant impacts on the production of the construction sector, while the supply shock lowers it. Third, the state of the economic uncertainty affects the findings, but without a clear pattern. Such state-dependence in responses is more notable at the sector level, either by showing diverging patterns in responses across regimes (the mining and manufacturing sector) or yielding higher statistical significance in them (the construction sector). Hence, it would be important to account for the level of uncertainty when examining the impacts of structural oil shocks.

The rest of the paper is organized as follows. We introduce data and our empirical method in Section 2 and then present empirical findings in Section 3. Section 4 concludes.

2 Data and Methodology

2.1 Data To examine the effects of structural oil shocks on the Korean economy, we use the structural oil market shocks identified in Baumeister and Hamilton (2019). The authors impose informative sign restrictions on

[3] While this paper divides the regime based on the level of uncertainty, following Van Robays (2016), it would be interesting if one considers the regimes depending on the state of the economy (recession vs. expansion). In order to focus on the relationship between the level of uncertainty and effectiveness of oil price shocks, we leave this as future works.

[4] One possible explanation for this non-negative response can be active policy responses by the government. For instance, the government lowers fuel taxes and/or import duties on oils when there is a significant jump in the oil price so that it can mitigate the negative effect of the oil price shocks on the Korean economy. We thank our referee for pointing out this possibility.

a vector autoregressive model of the global oil market consisting of four variables: oil prices using RAC, industrial production of OECD+6 countries, world oil production, and OECD oil inventory changes as a proxy for global oil inventories. Four types of structural shocks are estimated in this framework, i.e., oil supply shocks, economic activity shocks, oil consumption demand shocks, and inventory demand shocks. An oil supply shock occurs when there is an unexpected disruption in oil supply; an economic activity shock is associated with changes in the global business cycle; an oil consumption demand shock comes from changes in demand specifically for oil, not particularly due to the fluctuations in the global business cycle; and finally, an inventory demand shock incurs an unanticipated change in above-ground crude oil inventories.[5] We normalize all of the structural shocks to elicit a 10-percent increase in the real RAC of oil.[6] We sometimes replace the structural oil shocks series with the real RAC to investigate and compare the magnitude of pass-through when the sources of oil price changes are not distinguished.

We focus on the responses of the aggregate Korean IP index to the above-mentioned structural shocks for the sample period spanning from January 1990 to February 2022. In the model detailed below, we also use other aggregate indicators of Korea, such as Korean consumer price index (CPI), Korean Won-US Dollar exchange rates, and the Korean government bond rate, as control variables in our empirical models. All of the aggregate-level indicators except the structural oil market shocks series and the disaggregated IP indices are retrieved from the FRED database. The FRED data codes are as follows: aggregate Korean IP index (KORPROINDMISMEI, index 2015=100), Korean CPI (KORCPIALLMINMEI, index 2015=100), Korean Won-US Dollar exchange rate (DEXKOUS), Korean government bond rate (INTGSBKRM193N).

We also extend our analysis to the sectoral level: For the sectoral analysis, We use disaggregated Korean IP index for the sample period from February 2000 to February 2022.[7] To be more specific, we use the industry-level IP indexes of the following two sectors, mining and manufacturing (AB00) and construction (AD00), to analyze how oil price shocks propagate to such relatively energy-intensive industries. According to the Input-Output Tables by the Bank of Korea (2019), most of petroleum and coal products (C04) and chemical products (C05) are used in the above two sectors while other sectors including service sectors do not directly use such products at all. These disaggregated IP series are obtained from Statistics Korea.

With regards to the selection of the benchmark sample period, we acknowledge that due to the abnormality of the Covid-19 pandemic shock, including the Covid-19 period (i.e., after December 2019) may not be suitable, especially for analyses using a linear model (Diebold (2020) and Carriero, Clark, Marcellino, and Mertens (2022)). However, since we also employ a non-linear, state-dependent model where states are identified by the level of

[5]As noted in Baumeister and Hamilton (2019), the inventory demand shock has often been referred as a "speculative demand shock" in the literature.

[6]The historical realization of the four structural shocks before the normalization is available in Christiane Baumeister's website: https://sites.google.com/site/cjsbaumeister/datasets?authuser=0.

[7]The beginning of the sample period is determined by the availability of the industry-level IP series.

uncertainty, we retain the Covid-19 period in our benchmark analysis.[8] As noted in the previous section, we use the VIX series as our main measure of uncertainty, that captures uncertainty of the U.S. financial market participants.

2.2 Methodology

We employ the Local Projection framework proposed by Jordà (2005) to examine the responses of IP to oil market structural shocks as well as oil price changes. By using this method, we are able to investigate the pass-through of different oil shocks in one step as follows:

$$y_{t+h} - y_{t-1} = \alpha_h + \Sigma_{i=1}^{4} \beta_{i,h} \tilde{u}_{i,t} + \Phi_h(L) z_{t-1} + \epsilon_{t+h}, \quad \text{where} \quad h = 0, \cdots, 18. \tag{1}$$

Here, y_t denotes a dependent variable of interest in month t. In our benchmark model, y is the logarithm of IP index in month t. The shock variables $\tilde{u}_{i,t}$ are four types of structural shocks: oil supply shocks, economic activity shocks, oil consumption demand shocks, and inventory demand shocks. A set of control variables, z_t, is also included in our baseline model. First, this contains 12 lags of a dependent variable. Second, we include the same number of lags of first-differenced logs of the CPI and Korean Won-US Dollar exchange rates as well as the government bond rate, to reflect the state of the economy and the financial conditions.

Furthermore, we examine how IP responds differently depending on the level of uncertainty in the economy. For this analysis, we employ a model similar in spirit to the state-dependent Local Projection framework in Ramey and Zubairy (2018). The extended version of the Local Projection model can be written as follows:

$$y_{t+h} - y_{t-1} = I_{t-1}[\alpha_h + \Sigma_{i=1}^{4} \beta_{i,h} \tilde{u}_{i,t} + \Phi_h(L) z_{t-1}] + (1 - I_{t-1})[\alpha_h + \Sigma_{i=1}^{4} \beta_{i,h} \tilde{u}_{i,t} + \Phi_h(L) z_{t-1}] + \epsilon_{t+h}, \quad \text{where} \quad h = 0, \cdots, 18. \tag{2}$$

Here, the dependent variable of interest, y_t, again is the logarithm of aggregate IP index or sector-level IP index in equation (2). The rest of the variables are the same as the variables in equation (1). The notable difference compared to equation (1) is the indicator variable I_{t-1}. This is a dummy variable indicating the state of the economy in the previous period, i.e. high and low uncertainty states. In particular, we use the median of the uncertainty index during the sample period as the threshold to divide each period into the high or low uncertainty state. For our benchmark analysis, we use the VIX as our main uncertainty index. All in all, Equation (2) examines whether structural oil shocks would affect the Korean economy differently, if those happen during the times of high uncertainty, compared to the times of low uncertainty.

[8] Results obtained from the pre-Covid-19 sample (i.e., January 1990 to December 2019) remain largely similar to our benchmark case, which are available upon request.

Figure 1 shows which periods are classified as highly uncertain. Uncertainty peaked along with the Great Recession in 2007-2008 as well as the beginning of the Covid-19 pandemic. As such, periods around these two episodes are those of high uncertainty. In addition, about a decade surrounding 2000 was noted as periods of persistently high uncertainty.

3 Empirical Findings

3.1 Effects of Oil Shocks from a Linear Model We first investigate the extent to which oil price shocks affect the Korean economy at the aggregate level. We estimate Equation (1) with the aggregate IP index as a dependent variable. The impulse responses of the aggregate IP to various types of oil price shocks are presented in Figure 2. Shaded regions refer to 90-percent error bands. To facilitate the comparison, all of the oil shocks are normalized to elicit a 10-percent increase in real RAC of oil.

The first panel exhibits the effect of non-structural oil shocks (shock to real RAC) to the aggregate IP index. The responses are obtained by plugging in the real RAC directly into equation (1) in the place of structural oil shocks. Different from conventional belief that higher oil price generates the recession, the unexpected increase in oil price by 10 perent boost the IP for about six months after the impact in Korea. This finding is in line with the results from previous literature, i.e., Baek and Kim (2020) and Cunado, Jo, and de Gracia (2015). Although Korea depends entirely on imported crude oil, the unexpected oil price shocks do not render negative spillover to the aggregate-level industrial production since 1990s.

We break down change in RAC further by the sources of oil price increases, using the structural oil market shocks from Baumeister and Hamilton (2019) in equation (1). The next four panels of Figure 2 present impulse responses of the aggregate IP to the structural oil shocks. While the negative effect of oil price shocks on the Korean economy does not still appear, the results show a substantial degree of heterogeneity in the responses. The IP expands greatly in response to oil price hikes, when they are driven by economic activity shocks. That is, if oil price unexpectedly increases due to higher global economic activity, such increases will have a strong positive impact on the Korean IP; a 10-percent increase in real RAC driven only by the economic activity shocks would result in 6-percentage point (p.p) higher IP, and the impacts would last about 10 months after the impact. We postulate this positive response is likely due to changes in export. Since the Korean war, the country has focused strategically on boosting its export as a small open economy. As a result, export and import take a large share of Korean GDP. For example, the share of export and import in GDP amounted to 83.8 percent, according to the data from the Korean national account.[9] This implies that potential hikes in production costs for overall industries could be more than offset by higher global economic growth, which, in turn, likely leads to higher demand for products from Korea. The oil consumption demand shocks also results in increases in IP,

[9] https://www.index.go.kr/unify/idx-info.do?idxCd=4207&clasCd=7

but this response is much weaker in magnitude and also transitory, dissipating less than four months from the impact. In contrast, when the shock is supply-driven, i.e., global oil supply shocks, there is no significant impact on the aggregate IP. If there is any, a slightly negative response is observed on impact while it is not statistically significant at the 90-percent confidence interval. Similarly, only muted responses are observed in the case of inventory demand shocks.[10]

Our findings highlight substantial heterogeneity in the responses of IP to oil price increases depending on their sources. The positive responses of aggregate IP to real RAC increases appear to be the result of economic activity shocks. Other shocks may lead to rather muted, but not at all negative, responses. In turn, this implies the importance of distinguishing the sources of oil price shocks to precisely assess their impacts. More importantly, our findings suggest that unexpected increases in oil prices may not necessarily result in a negative impact for Korea, especially when one focuses on the aggregate level IP dynamics.

Why, then, do supply-driven shocks bring about muted responses in Korea, in contrast to common prior beliefs? In order to answer this question, we further analyze the effects of oil price shocks on two sectors: the mining and manufacturing as well as construction sectors. While both sectors are relatively energy intensive, they differ in terms of the degree of dependence on trade. Specifically, the mining and manufacturing sector depends heavily on trade, while the construction sector does not. For instance, manufacturing sector takes almost 99 percent of total exports in Korea.[11] We estimate Equation (1) using the two sectoral IP indexes as a dependent variable. As sectoral IP indices are available since February 2000, the sample for this exercise covers the period after 2000.

The estimated impulse responses of the two sectors are presented in Figures 3 and 4. Three points stand out. First, we find substantial heterogeneity of these industries in the responses to real RAC of oil shocks. That is, the responses of the mining and manufacturing sector largely mimic those of the aggregate-level IP and are positive for about seven months since the impact (Fig 3-(a)). However, the construction sector does not appear to be significantly responding to the RAC changes (Fig 4-(a)). Second, distinguishing the sources of the oil price shocks highlights such sectoral heterogeneity even further. For instance, the finding that demand-driven oil market shocks are expansionary in Korea is observed only for the mining and manufacturing sector. In the case of the construction sector, all of the oil market shocks price do not yield any positive responses. Finally, we start to see negative impacts of oil price increases. The construction sector' IP declines greatly in response to the oil supply shocks. This seems to be the consequence of the export structure in the construction sector: exports to the Middle East take about 30% of total exports in the construction sector.[12] Given that oil supply shock usually arises from disruptions in such a region, it will also affect the (new) contracts and hence potentially lower the IP

[10]These results are similar to the estimated impulse responses of global IP from the baseline model of Baumeister and Hamilton (2019) provided in Figure 8; the economic activity shocks have most notable and persistent responses.

[11]https://www.istans.or.kr/su/newSuTab.do?scode=S105.

[12]https://www.korea.kr/news/policyNewsView.do?newsId=148910355

index in the construction sector. In other words, the negative impacts of oil price shocks that are in line with the common priors are observed for the construction sector. Theses findings indicate the importance of accounting for the sectoral heterogeneity in addition to the sources of the oil price shocks in order to better understand their economic impacts.

All in all, for a small open economy like Korea, oil price increases can be a boon if it is driven by higher global economic activity that generates greater demand for trade as well as oil. The manufacturing sector seems to benefit as well in this case, where a large share of its output is exported. This is surprising, considering the fact that Korea imports almost all of its energy to consume. The common perception of the negative impacts of oil price shocks can only be observed once we account for heterogeneity across sectors as well as sources of oil shocks.

3.2 Uncertainty and Oil Shock Propagation

In the previous section, we study the effects of oil price shocks on the Korean economy in a linear model. An implicit assumption here is that the propagation of the oil shocks would be the same regardless of the state of the economy at the time the shocks hit. However, several studies have found empirical evidence supporting the state-dependent effects of the oil shocks on the aggregate economy. For instance, Equiza-Goñi and de Gracia (2019) showed that the oil price shocks affect the U.S. stock returns depending on the level of oil prices. Hwang and Kim (2021) estimated a Smooth-Transition Vector Autoregressive (STVAR) model to study the state-dependent effects of oil price shock on the U.S. stock returns where the state is determined by whether the economy is in the recession or not. Van Robays (2016) examined the extent to which the level of macro uncertainty affects the sensitivity of the responses to structural oil shocks, using a Threshold VAR model. If IP indeed responds to the oil shocks differently depending on the state of the economy, our estimates from the previous section would be capturing the average impacts across the different regimes.

We hence investigate further potential state dependence in the oil shock propagation mechanism in Korea. Among many other variables that may possibly define relevant states for the Korean economy, we examine two regimes determined by the level of economic uncertainty, i.e., high-uncertainty and low-uncertainty regimes. Our consideration of the level of uncertainty as a factor that can switch regimes is in line with Van Robays (2016). To be more specific, she found that macroeconomic uncertainty can have impacts on oil price volatility. This implies that high uncertainty would lower the price elasticity of oil demand and supply. As such, if an economy is hit by oil shocks in uncertain times, oil price changes by the same magnitude can have much more sizable impacts on the oil market and production. Our paper further examines that such differential impacts on the oil market may lead to distinct responses of the economic activity in Korea, either by amplifying or mitigating its responses. Our analysis is also motivated by a line of literature that highlights the negative impacts of economic uncertainty, particularly the ones with high adjustment costs such as investment (see Bernanke (1983) and Bloom (2009), for instance). Putting these lines of literature together, this paper considers the high- and low-uncertainty regimes for the examination of the state-dependent effects of uncertainty.

In particular, we define the high uncertainty regime as the periods with the level of uncertainty being greater than the sample median and the low uncertainty regime as those below the median.[13] Our benchmark measure for economic uncertainty is the VIX index, a variable capturing the stock market volatility. Our selection of the VIX as our benchmark is based on the findings by Choi and Shim (2019) that financial uncertainty have much larger and more notable impacts than economic policy uncertainty on the economic activity of six emerging economies including Korea. Additional analyses using other types of uncertainty proxies constructed for both the U.S. and Korea are provided in Section A.1.[14]

We estimate the state-dependent responses for the aggregate and sector-level IP indices, similar to the previous section. Results are presented in Figures 5 to 7. In each plot, the solid red (blue) line denotes the responses to the oil price shocks in the high (low) uncertainty regime. Responses with solid circles denote that the estimated response of the associated horizon is statistically significant at 90 percent. To facilitate our discussions, we present the results for the four structural oil market shocks, excluding the responses to real RAC of oil.

It is worthwhile to note some important features of impulse responses. First, as shown in Figure 5, uncertainty regimes elicit differential impacts only for some structural oil shocks, including oil supply and consumption demand shocks. When economic uncertainty is high, the supply shock decreases aggregate IP temporarily (Figure 5-(a)), whereas the oil consumption demand shock hitting the economy during the low uncertainty regime generates negative impacts with some lags (Figure 5-(c)). However, the negative responses of the supply and inventory demand shocks are statistically significant only for a few horizons, suggesting the reason that the previous linear model (Equation (1)) yielded rather muted responses of the aggregate IP to these shocks. In the case of the economic activity shocks, accounting for the uncertainty regimes does not result in much distinct dynamic responses, except some differences in statistical significance (Figure 5-(b)).

Second, state dependence in responses is most notable in the mining and manufacturing sector, as shown in Figure 6. For example,the supply and oil consumption demand shocks yield very distinct responses. The responses to the supply shock (Figure 6-(a)) explain the insensitivity of the sector's IP observed in a linear model (Figure

[13]We also consider the sample mean as an alternative threshold, but the findings are both qualitatively and quantitatively very similar to our baseline results. These results are available upon request.

[14]While the VIX index is a widely-used proxy of economic uncertainty in economic literature (e.g., Bloom (2009) and Caggiano, Castelnuovo, and Groshenny (2014)), a number of alternative uncertainty indicators are available.[15] These measures aim to capture different features of economic uncertainty and also are constructed in distinct ways. While we focus on the results with the VIX index, we further investigate how alternative measures affect our benchmark conclusion in the Appendix A.1. We first replace VIX with the macro uncertainty index constructed in Ludvigson, Ma, and Ng (2021) and the EPU index from Baker, Bloom, and Davis (2016). The former reflects economic uncertainty mainly arising from the real economic activity as opposed to financial markets, and the latter shows uncertainty surrounding economic policy decisions that can have further impacts on the economy. These two measures, however, are indexes for the U.S. economic uncertainty, similar to VIX. We hence also consider two uncertainty indicators constructed for Korea, i.e., the VKOSPI (the volatility index of KOSPI200) and EPU for Korea. We obtain largely similar results using these alternative measures.

3-(b)); in the low-uncertainty regime, the supply shock in fact boosts the production of this sector substantially, while high uncertainty flips the sign of the responses and leads to a sizable drop. The large negative responses during highly uncertain times provide supports to the widely-discussed damaging impacts of oil price shocks in Korea. When the Korean economy is hit by supply shocks when economic uncertainty is high, this sector would face a considerable and long-lived drag, together with a large decline in the construction sector's IP (Figure 4-(b) and 7-(a)). In the case of the oil consumption demand shock, the responses show the opposite pattern across the two regimes, but in a much smaller magnitude (Figure 6-(c)). However, the responses to the economic activity shocks again do not show much diverging patterns across the regimes (Figure 6-(b)).

Third, considering the level of uncertainty would have implications along a different dimension for the construction sector as shown in Figure 7. While some responses differ in terms of their statistical significance or timing of the peak effects, one is unable to observe evident diverging patterns or contrasting signs, unlike the case of the mining and manufacturing sector. However, discerning the uncertainty regimes dose increase statistical significance to the responses to economic shocks. The IP in the construction sector's now appears to increase (in both regimes) when hit by the economic activity shock. Therefore, the state-dependent model renders the construction sector's responses to be more consistent with those of the aggregate economy as well as the mining and manufacturing sector.

To summarize, we conclude that it is important to consider state dependence according to the level of uncertainty in the oil and macro relation for the Korean economy. Accounting for the uncertainty would be especially crucial for the mining and manufacturing sector, but also for the construction sector. In addition, state-dependent responses are particularly notable for the case of oil supply and consumption demand shocks, while economic activity shocks do not induce much distinct patterns in the responses across regimes. Finally, the level of economic uncertainty at the time of oil shocks could be one of key factors for understanding a general perception on the effects of oil price fluctuations on the economic activity of Korea.

4 Conclusion

While oil shocks are known to deter the economic growth, a number of previous studies failed to find supporting evidence for Korea, though it imports most of energy sources. This paper revisits this finding by estimating the effects of structural oil market shocks on the Korean economy using a Local Projection method. We find that previous findings can be better explained once we distinguish the sources of oil shocks. In other words, oil shocks can be expansionary when it is demand-driven. Supply driven oil shocks, on the contrary, do not significantly affect the Korean economy. We also show that there exists substantial heterogeneity in responses of IP index across different industries. Lastly, by utilizing a state-dependent model, we present the importance of accounting for the level of uncertainty.

Interesting extensions of our work would be (1) to develop a dynamic stochastic general equilibrium (DSGE) model that can explain the heterogeneous effects of the structural shocks on the Korean economy and (2) to investigate if the policy reaction of the government, lowering fuel taxes as an example, can explain our finding that the supply shocks cannot drive recessions in Korea. We leave these as future works.

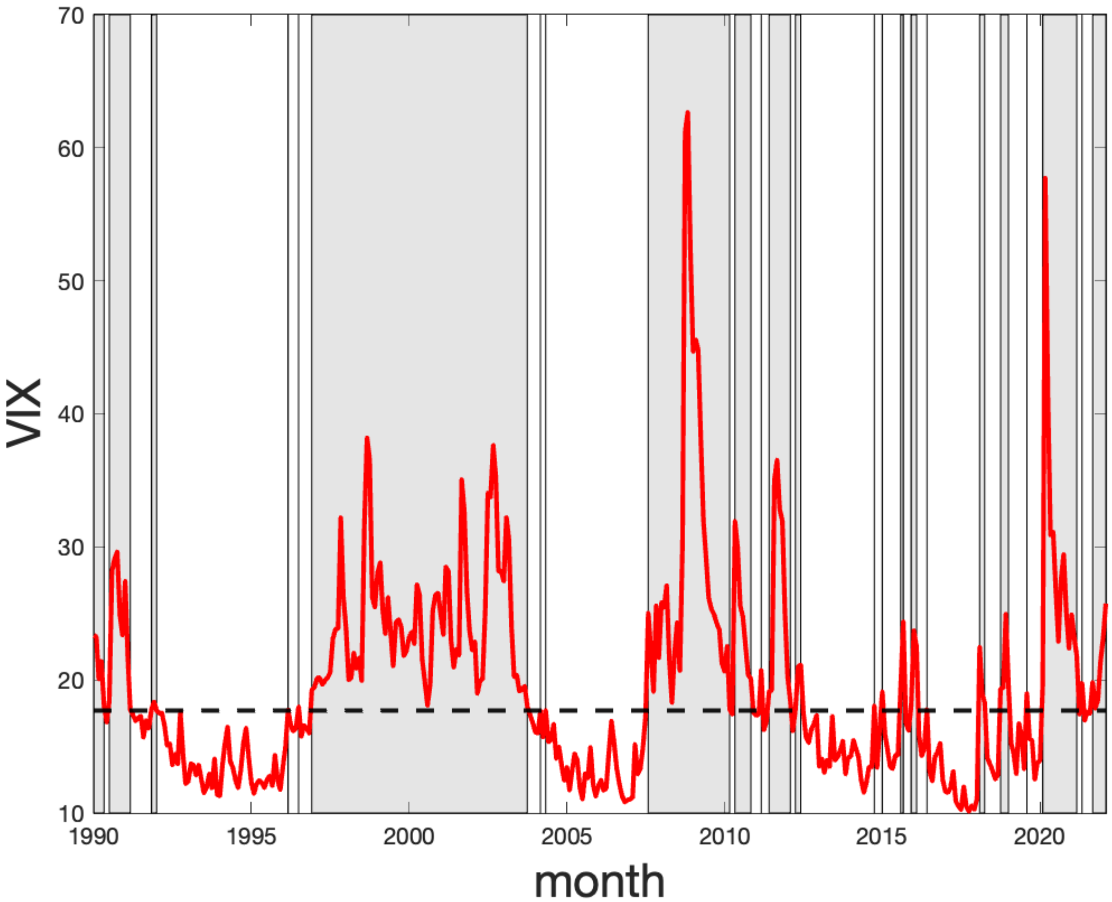
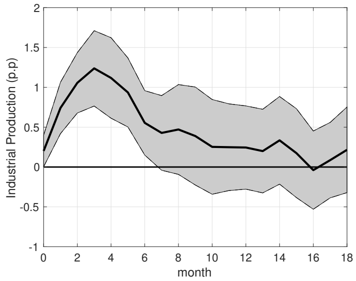
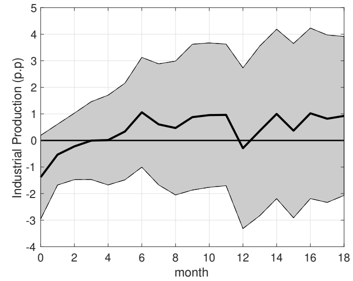


Figure 1: High- and Low-Uncertainty States

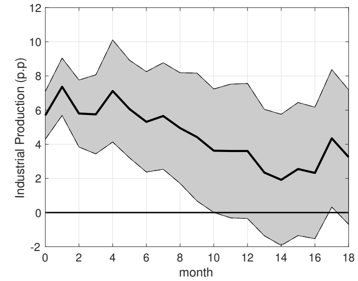
Note: This figure plots the VIX index over our sample period spanning from 2000M01 to 2022M02. The dashed horizontal line indicates the median of VIX; if the level of uncertainty in a month is higher (lower) than the threshold, that month is assigned to a high (low) uncertainty state. The shaded areas, hence, denote high uncertainty periods.



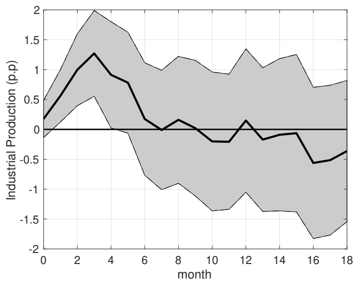
(a) RAC



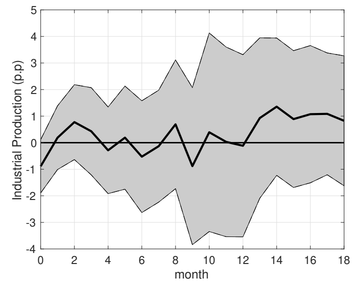
(b) Supply Shocks



(c) Economic Activity Shocks



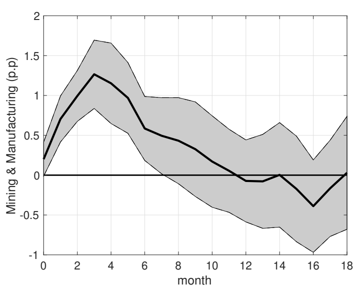
(d) Oil Demand Shock



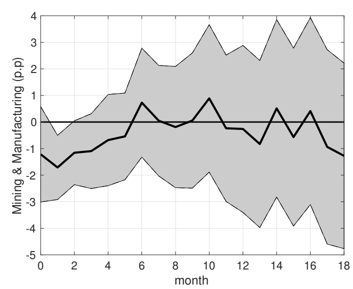
(e) Inventory Demand Shock

Figure 2: Responses of IP to Oil Shocks (1990M01-2022M02)

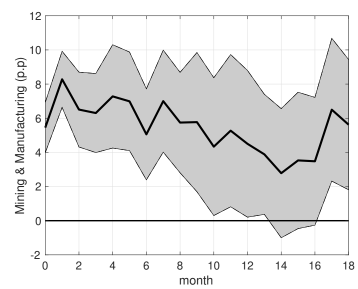
Note: This figure reports the impulse responses of industrial production to oil shocks, using data from 1990M01 to 2022M02. The grey-shaded area represents Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses in solid black lines. All structural shocks are normalized to elicit a 10% increase in the real RAC.



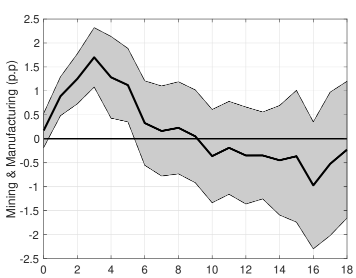
(a) RAC



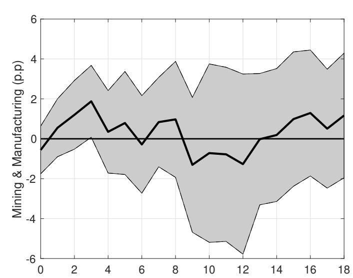
(b) Supply Shocks



(c) Economic Activity Shocks



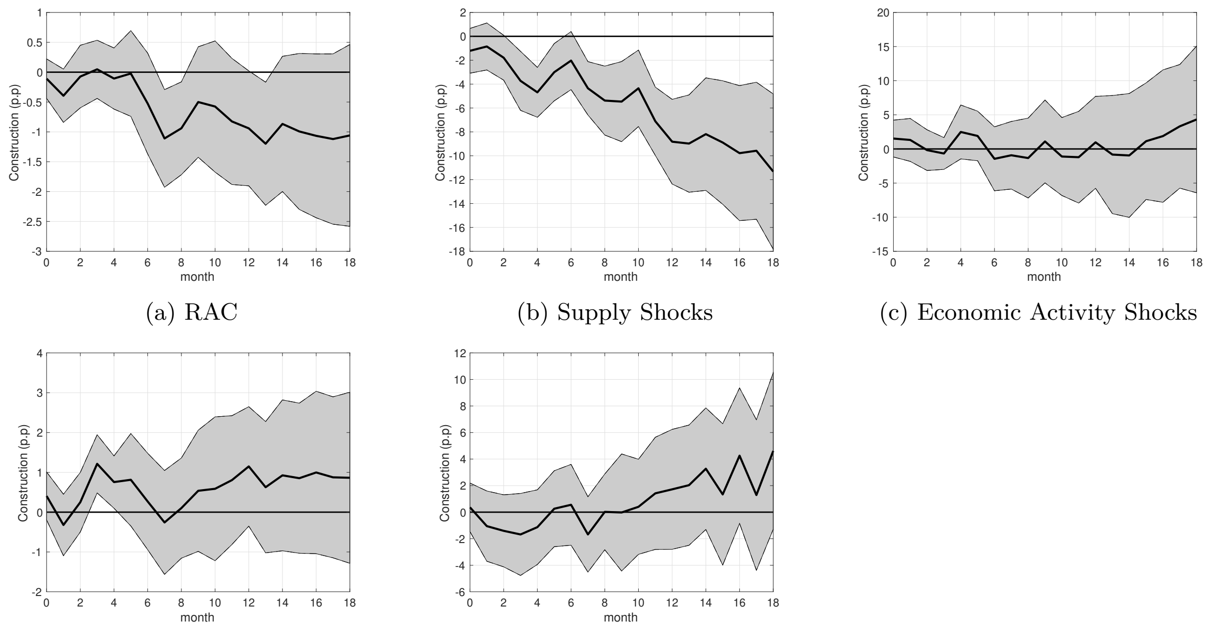
(d) Oil Demand Shock



(e) Inventory Demand Shock

Figure 3: Responses of the Mining and Manufacturing Sector's IP to Oil Shocks (2000M02-2022M02)

Note: This figure reports the impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The grey-shaded area represents Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses in solid black lines. All structural shocks are normalized to elicit a 10% increase in the real RAC.

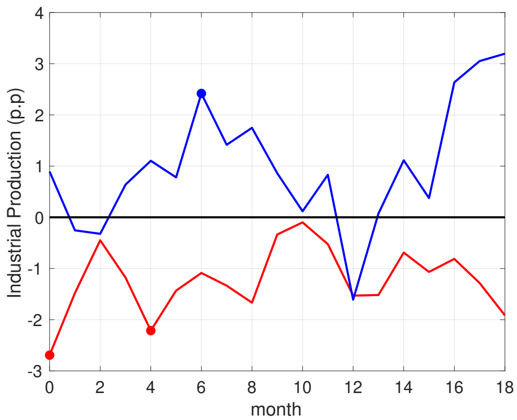


(a) RAC (b) Supply Shocks (c) Economic Activity Shocks

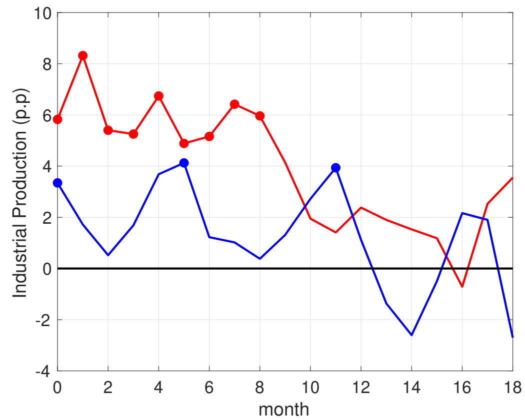
(d) Oil Demand Shock (e) Inventory Demand Shock

Figure 4: Responses of the Construction Sector's IP to Oil Shocks (2000M02-2022M02)

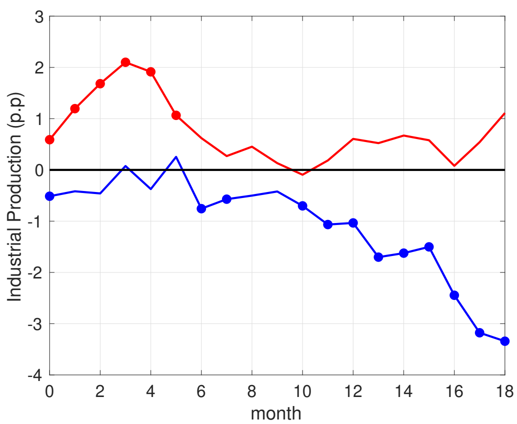
Note: This figure reports the impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The grey-shaded area represents Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses in solid black lines. All structural shocks are normalized to elicit a 10% increase in the real RAC.



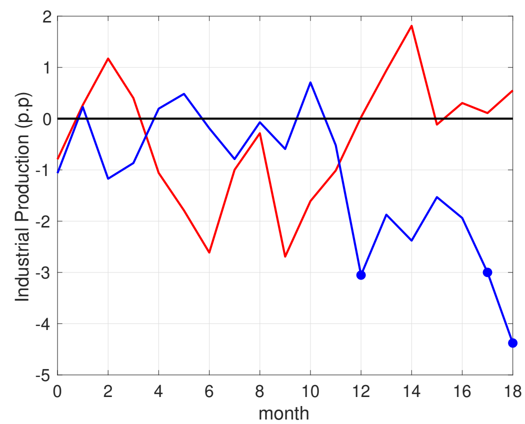
(a) Supply Shocks



(b) Economic Activity Shocks



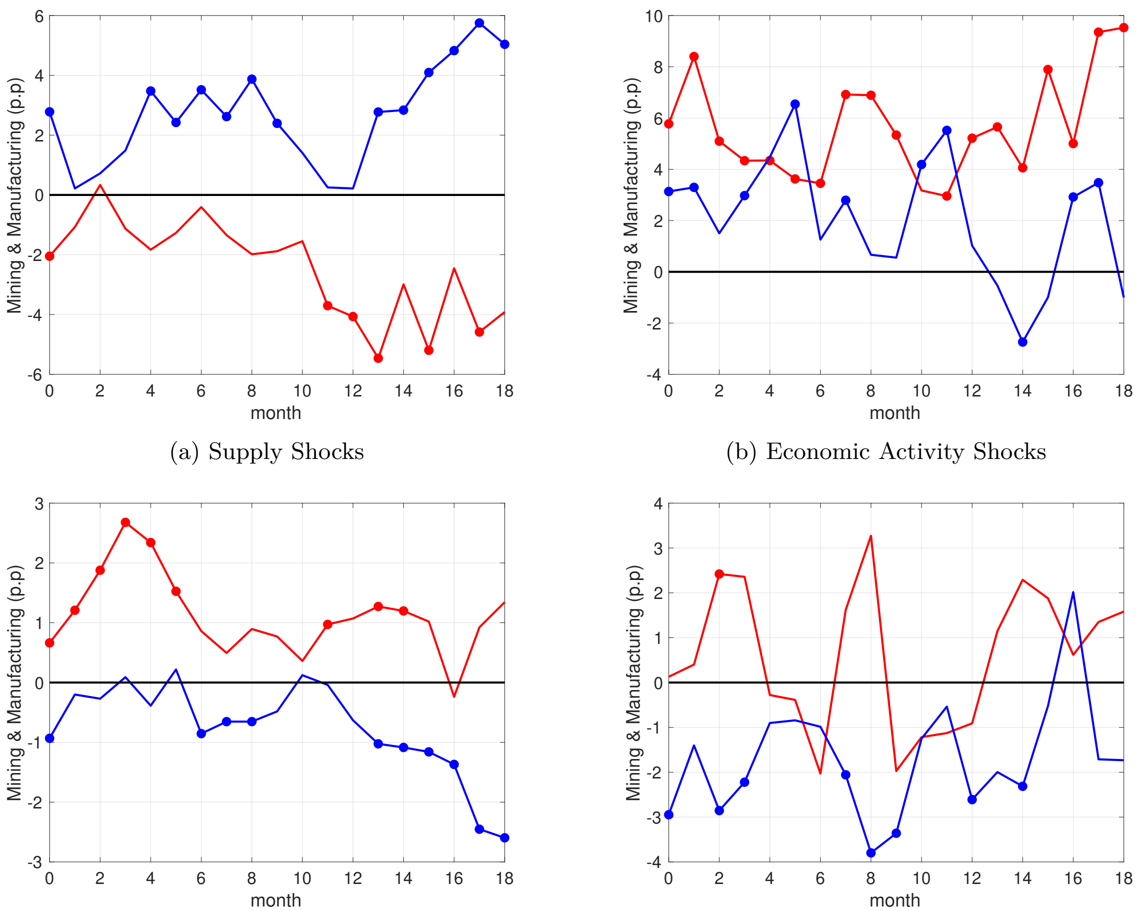
(c) Oil Demand Shock



(d) Inventory Demand Shock

Figure 5: State-Dependent Responses of IP to Oil Shocks (1990M02-2022M02)

Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 1990M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The VIX sample median of VIX was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



(a) Supply Shocks

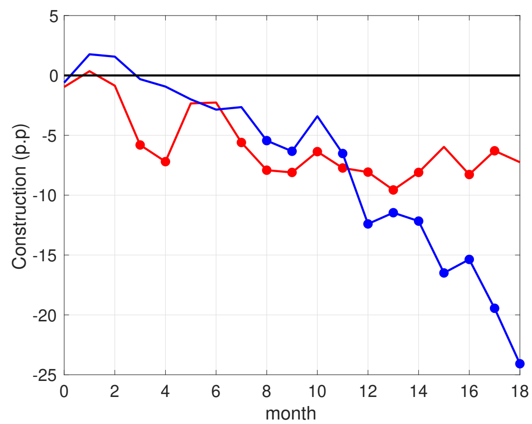
(b) Economic Activity Shocks

(c) Oil Demand Shock

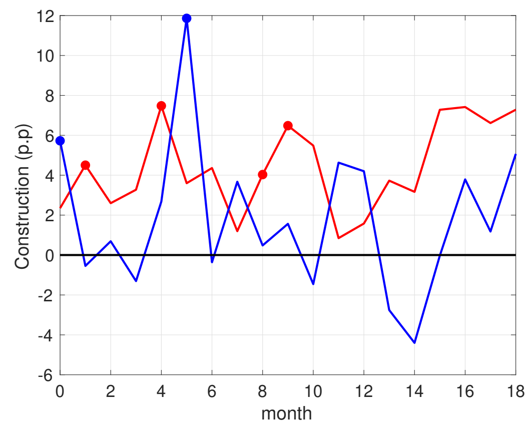
(d) Inventory Demand Shock

Figure 6: State-Dependent Responses of the Mining and Manufacturing Sector's IP (2000M02-2022M02)

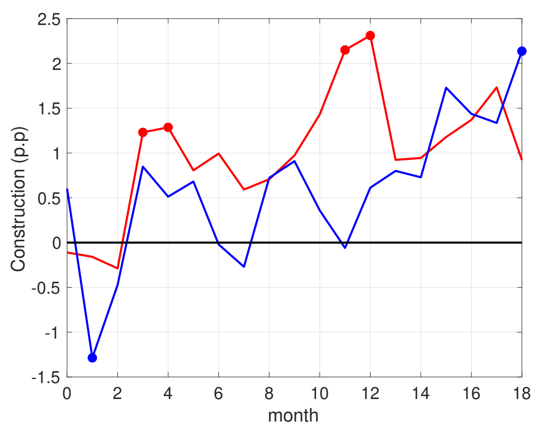
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The sample median of VIX was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



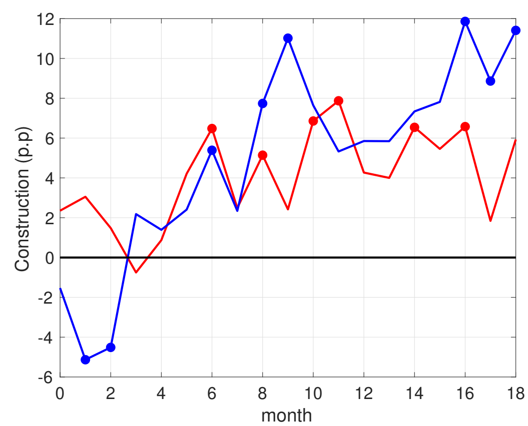
(a) Supply Shocks



(b) Economic Activity Shocks



(c) Oil Demand Shock



(d) Inventory Demand Shock

Figure 7: State-Dependent Responses of the Construction Sector's IP (2000M02-2022M02)

Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The VIX sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.

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A Appendix: State-Dependency of Oil Shocks with Alternative Measures of Uncertainty

A.1 Alternative Measures of Uncertainty In our benchmark analysis, we use VIX, the U.S. stock market volatility index for the identification of high- and low-uncertainty regimes. While the VIX index is a widely-used proxy of economic uncertainty in economic literature (e.g., Bloom (2009) and Caggiano, Castelnuovo, and Groshenny (2014)), a number of alternative uncertainty indicators are available.[16] These measures aim to capture different features of economic uncertainty and also are constructed in distinct ways. As noted above, we select two alternative uncertainty indexes among many others, and investigate how they affect our benchmark conclusion: the macro uncertainty index constructed in Ludvigson, Ma, and Ng (2021) and the EPU index from Baker, Bloom, and Davis (2016). The former reflects economic uncertainty mainly arising from the real economic activity as opposed to financial markets, and the latter shows uncertainty surrounding economic policy decisions that can have further impacts on the economy. These two measures, however, are indexes for the U.S. economic uncertainty, similar to VIX.

While Korea is a small open economy that is widely exposed to fluctuations in foreign uncertainty, it may face country-specific changes in terms of uncertainty. As such, we also extend our analysis to include two uncertainty indicators constructed for Korea: VKOSPI and EPU for Korea. The former is the Korean equivalent indicator of VIX, measuring the implied volatility for the KOSPI 200 index. The latter index is constructed in the same manner as the U.S EPU by Scott R. Baker, Nicholas Bloom, and Steven Davis, based on the article counts of six major Korean news papers.[17]

Macro and Economic Policy Uncertainty Indexes Overall, we find that our benchmark results are robust to the changes of the uncertainty measure to the macro uncertainty index as well as EPU, presented in Figures 8 to 13. As shown in Figures 8 and 11, a large share of the impulse responses of aggregate IP becomes statistically insignificant, except those to economic activity shocks. One notable feature in the case of the macro uncertainty index is that the benchmark responses become intensified and significant for more horizons for the mining and manufacturing sector (Figure 9; in particular, the state dependence of the responses to oil supply shocks become much more prominent (panel (a)). Little change is observed for the construction sector.

Financial and Economic Policy Uncertainty Indexes in Korea We turn to impulse responses obtained by using Korean uncertainty indexes next. At the aggregate level, the response remain largely unchanged as shown in Figures 14 and 17; state-dependence of the responses is slightly more notable in the case of oil supply and consumption demand shocks, while economic activity shocks present little difference across two uncertainty regimes. In the the mining and manufacturing sector, the responses remain similar to the benchmark case for the use of VKOSPI, as presented in Figure 15.

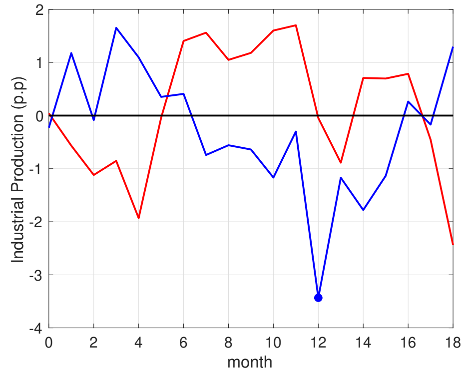
Interestingly, with the use of the Korean EPU index for identifying uncertainty regimes, we not only lose statistical significance for many horizons in the case of all of the four structural oil shocks, but also find little state dependence in their responses (Figure18). Related, Choi and Shim (2019) find in a cross-country study of six emerging economies including Korea that financial uncertainty have much larger and more significant impacts on the economic activity of these countries, compared to economic policy uncertainty. As such, the Korean EPU may not provide a clear distinction for identifying the uncertainty regimes, in particular, for the mining and manufacturing sector.

For the construction sector, the use of VKOSPI does not again have any material impacts in responses to all

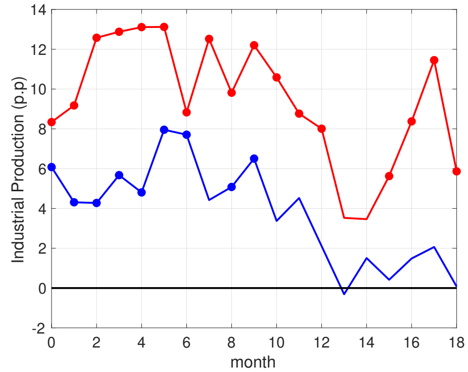
[16] See Caldara, Fuentes-Albero, Gilchrist, and Zakrajšek (2016) and Jo and Sekkel (2019) for a summary of various uncertainty measures.

[17] Details on the construction of the Korean EPU index as well as the index can be found at https://www.policyuncertainty.com/korea_bbd.html.

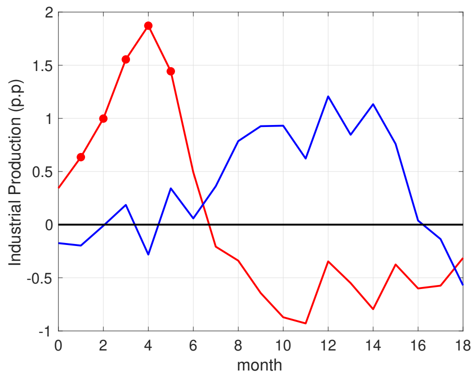
of the four oil shocks as shown in Figure16. However, surprisingly, the use of the Korean EPU index brings out state dependence in the responses to oil consumption demand and inventory demand shocks (Figure19), which has not been observed before with other uncertainty measures. Historically, the construction industry had played a very important role in the economic growth of Korea and been led by the central government. While the share of this industry has declined over time, the industry is still likely affected significantly by policy measures (Kim and Lee (2005)).



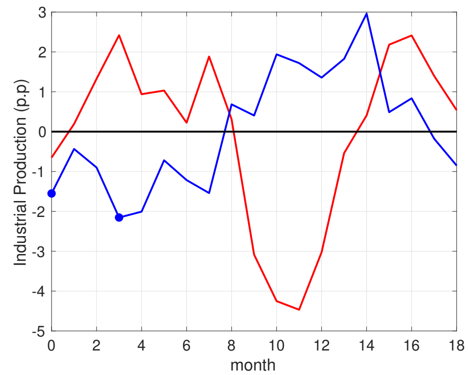
(a) Supply Shocks



(b) Economic Activity Shocks



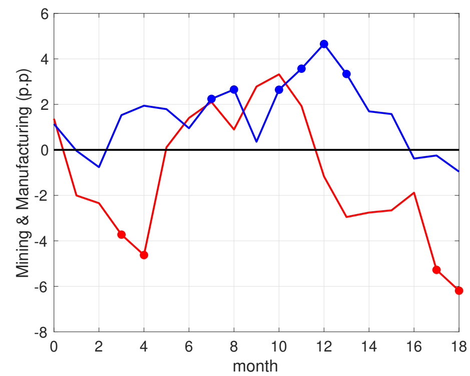
(c) Oil Demand Shock



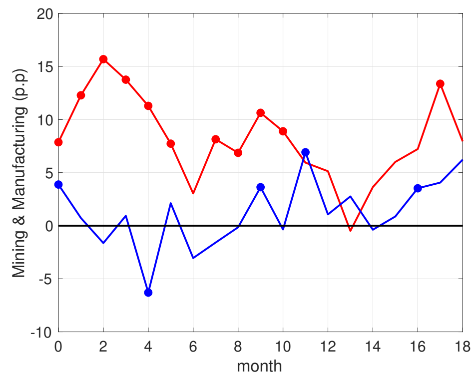
(d) Inventory Demand Shock

Figure 8: State-Dependent Responses of IP with Macro Uncertainty

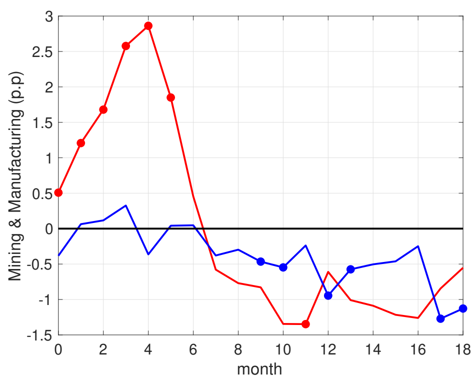
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 1990M01 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The Macro Uncertainty Index sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



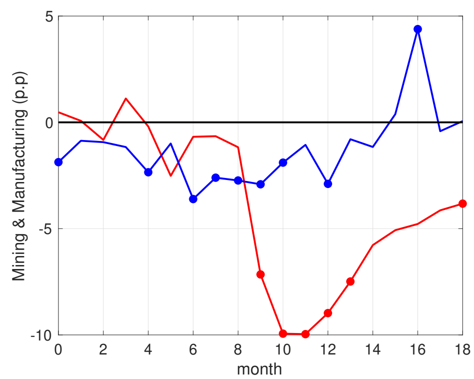
(a) Supply Shocks



(b) Economic Activity Shocks



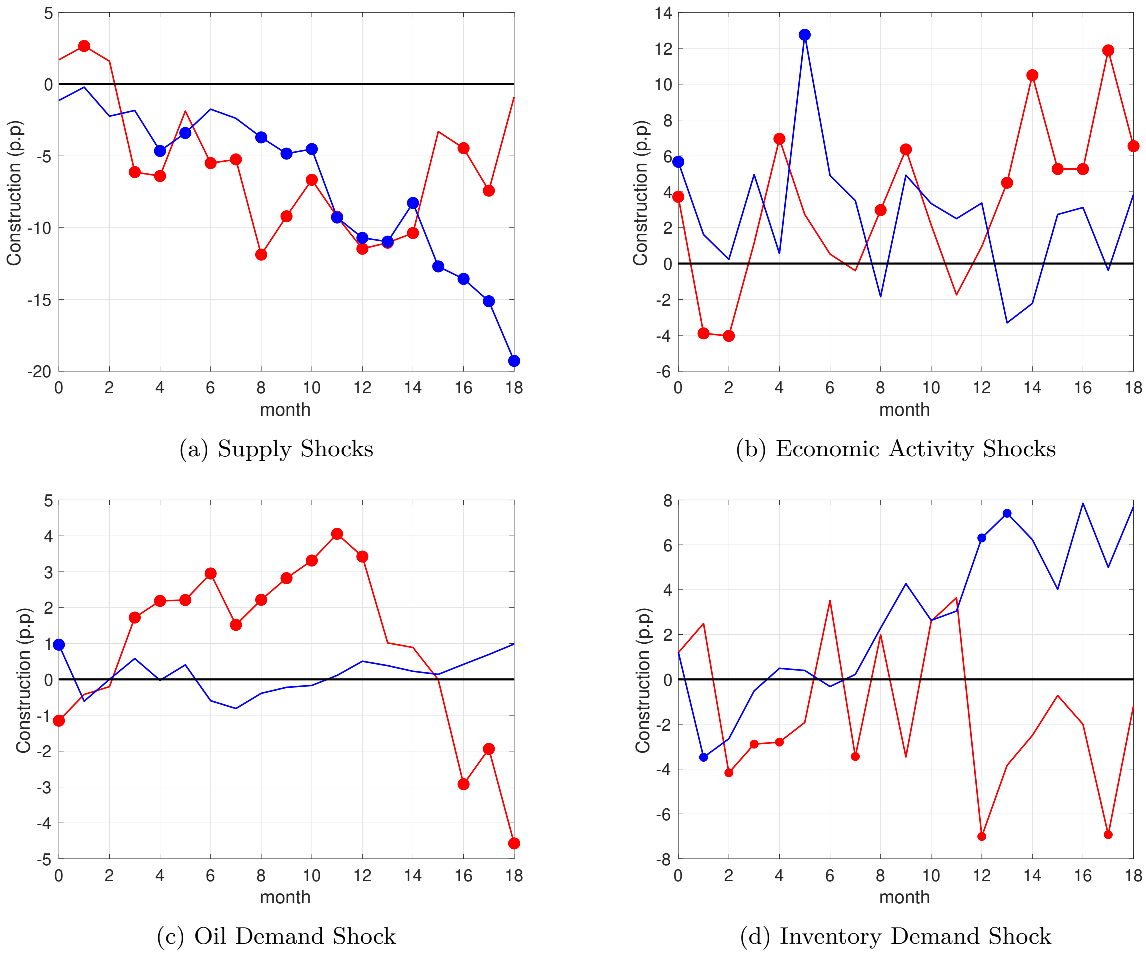
(c) Oil Demand Shock



(d) Inventory Demand Shock

Figure 9: State-Dependent Responses of the Mining and Manufacturing Sector's IP with Macro Uncertainty

Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The Macro Uncertainty Index sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



(a) Supply Shocks

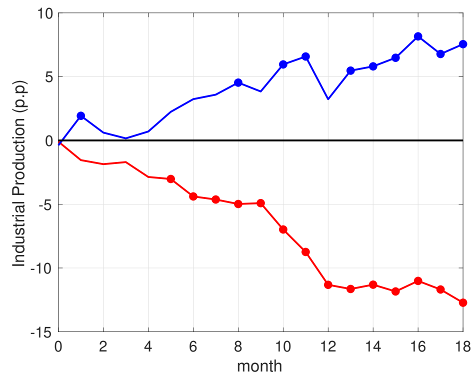
(b) Economic Activity Shocks

(c) Oil Demand Shock

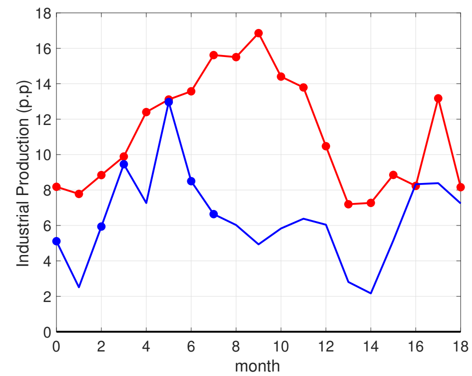
(d) Inventory Demand Shock

Figure 10: State-Dependent Responses of the Construction Sector's IP with Macro Uncertainty

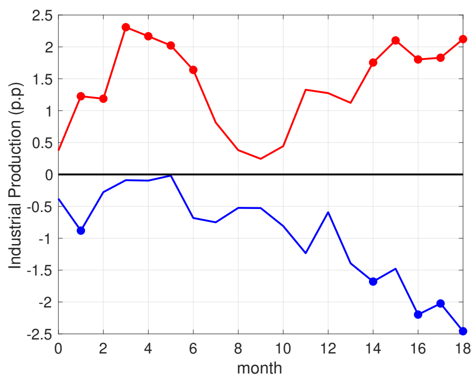
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The Macro Uncertainty Index sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



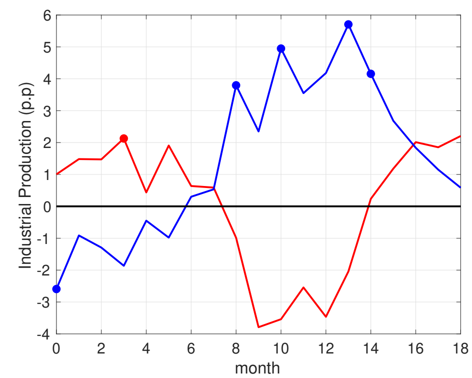
(a) Supply Shocks



(b) Economic Activity Shocks



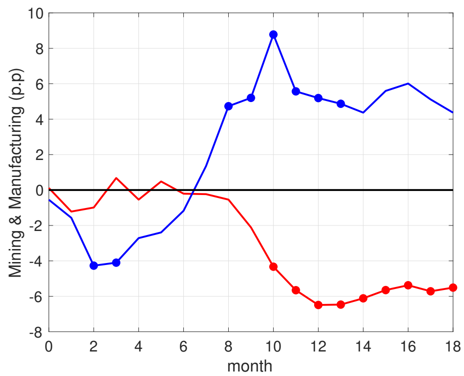
(c) Oil Demand Shock



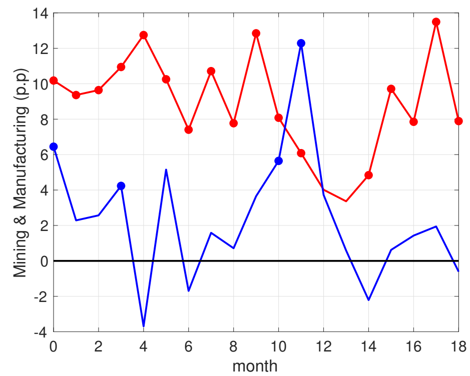
(d) Inventory Demand Shock

Figure 11: State-Dependent Responses of IP with EPU

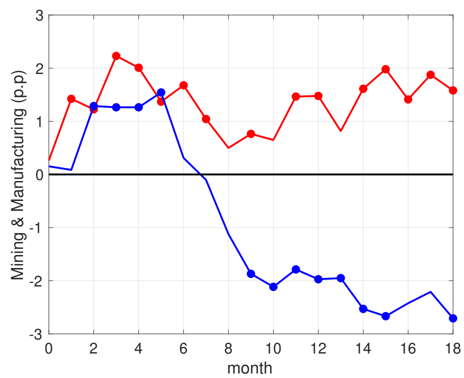
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 1990M01 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The US EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



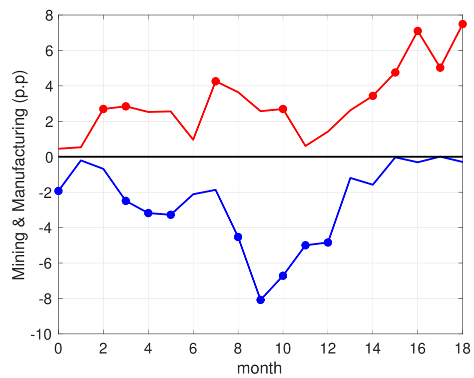
(a) Supply Shocks



(b) Economic Activity Shocks



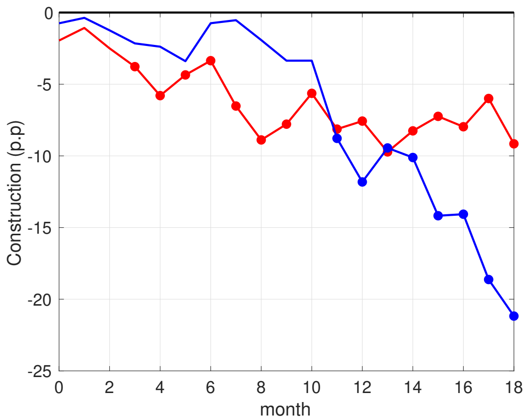
(c) Oil Demand Shock



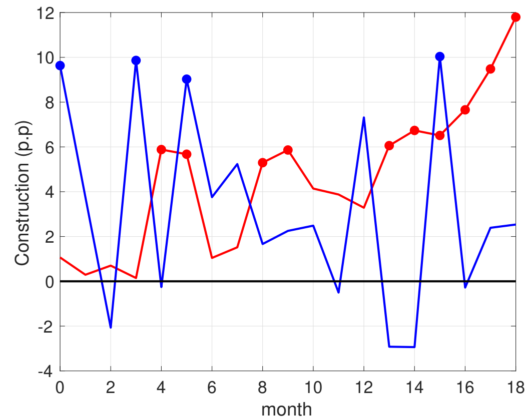
(d) Inventory Demand Shock

Figure 12: State-Dependent Responses of the Mining and Manufacturing Sector's IP with EPU

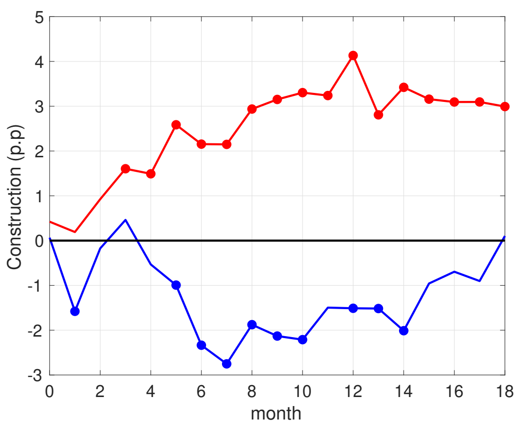
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The US EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



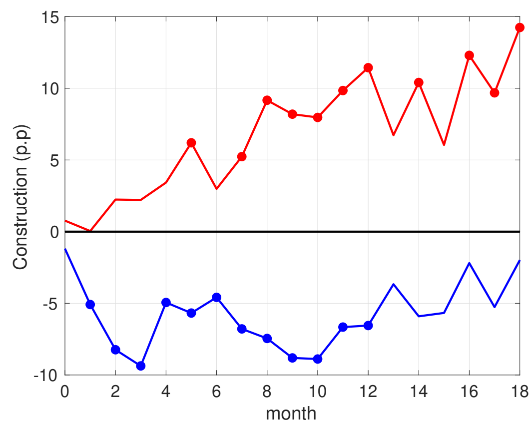
(a) Supply Shocks



(b) Economic Activity Shocks



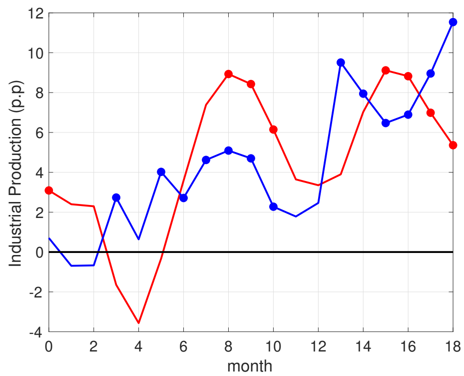
(c) Oil Demand Shock



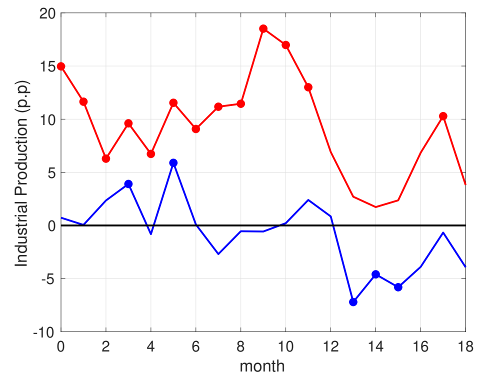
(d) Inventory Demand Shock

Figure 13: State-Dependent Responses of the Construction Sector's IP with EPU

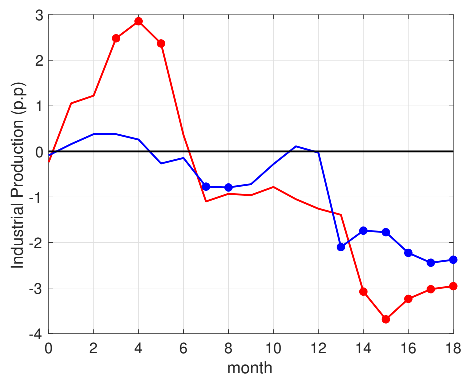
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The US EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



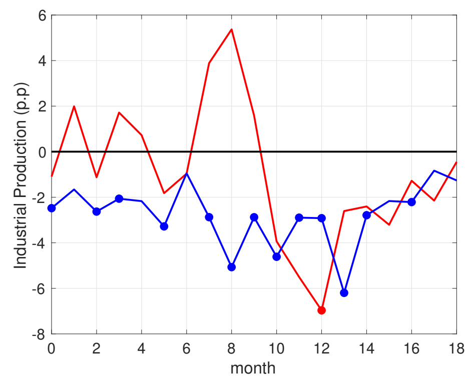
(a) Supply Shocks



(b) Economic Activity Shocks



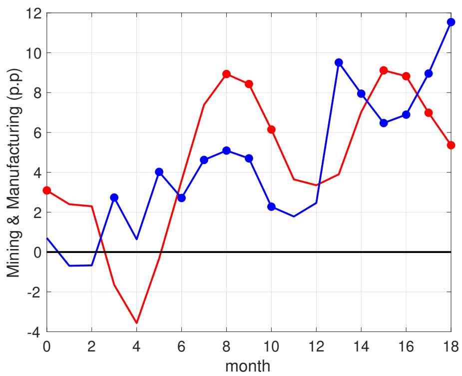
(c) Oil Demand Shock



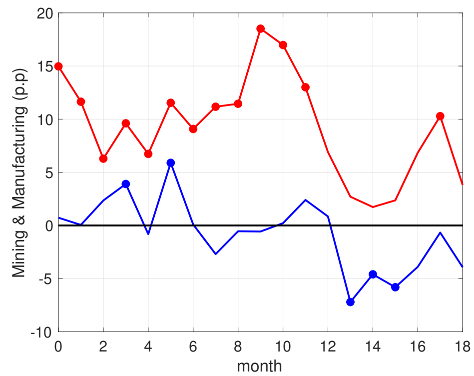
(d) Inventory Demand Shock

Figure 14: State-Dependent Responses of IP with VKOSPI

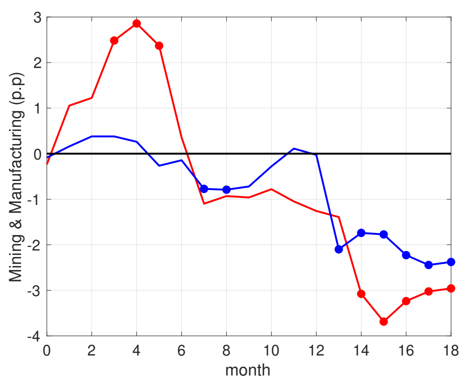
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2003M02 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The VKOSPI sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



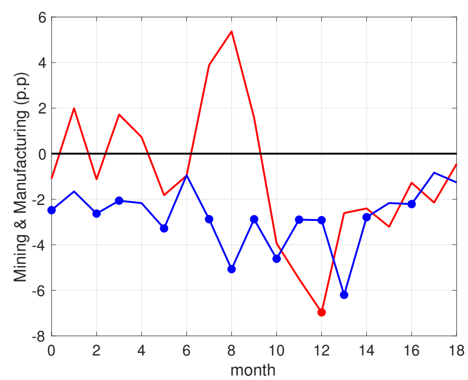
(a) Supply Shocks



(b) Economic Activity Shocks



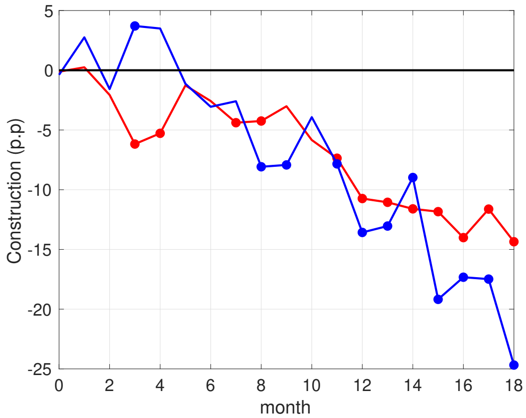
(c) Oil Demand Shock



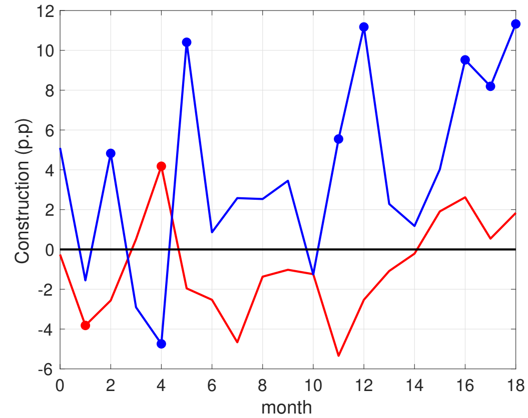
(d) Inventory Demand Shock

Figure 15: State-Dependent Responses of the Mining and Manufacturing Sector's IP with VKOSPI

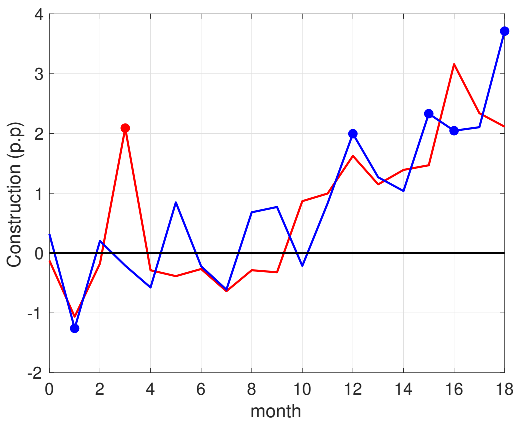
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2003M02 to 2019M12. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The VKOSPI sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



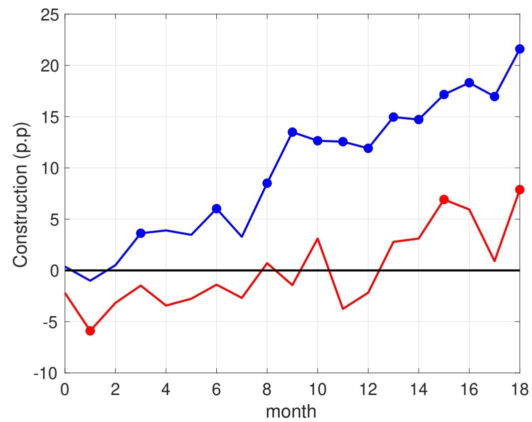
(a) Supply Shocks



(b) Economic Activity Shocks



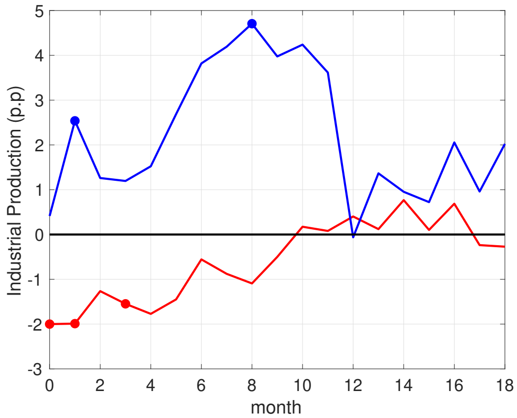
(c) Oil Demand Shock



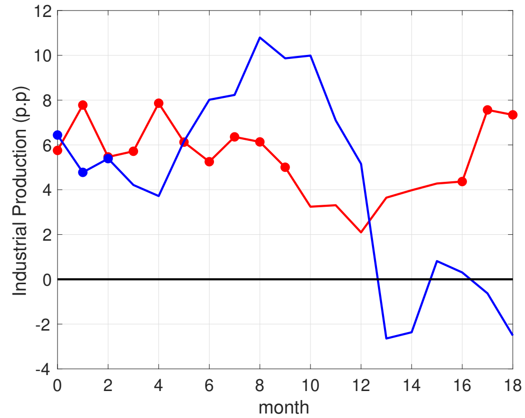
(d) Inventory Demand Shock

Figure 16: State-Dependent Responses of the Construction Sector's IP with VKOSPI

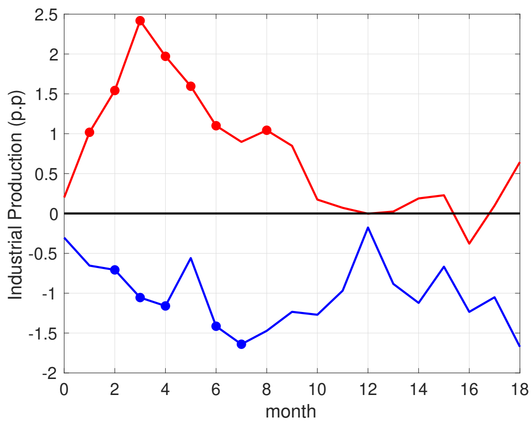
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2003M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The VKOSPI sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



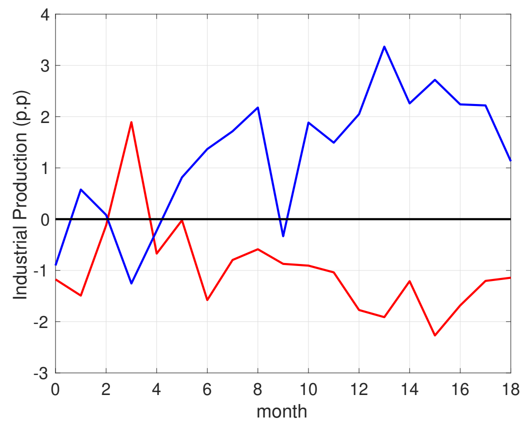
(a) Supply Shocks



(b) Economic Activity Shocks



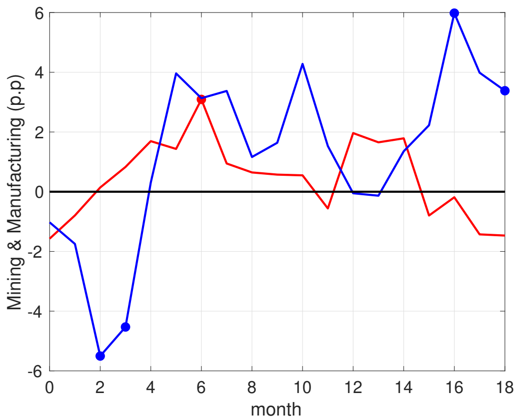
(c) Oil Demand Shock



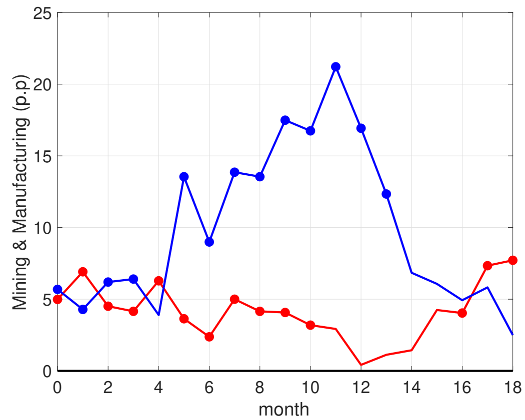
(d) Inventory Demand Shock

Figure 17: State-Dependent Responses of IP with Korean EPU

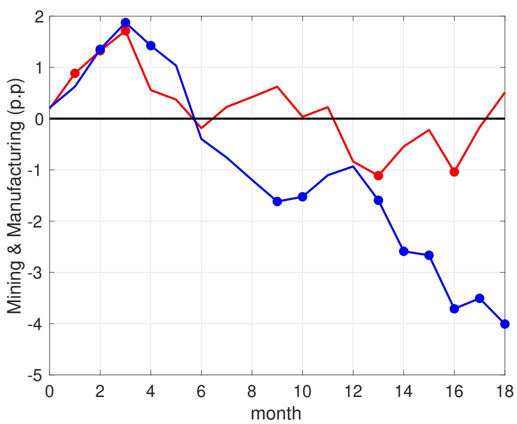
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 1990M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The South Korea EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



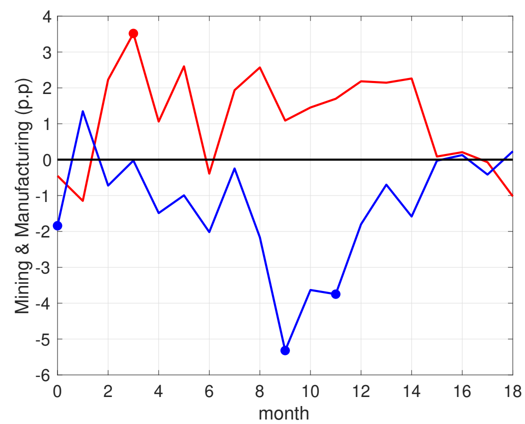
(a) Supply Shocks



(b) Economic Activity Shocks



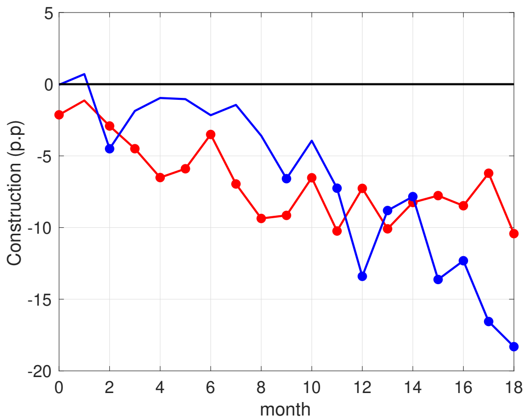
(c) Oil Demand Shock



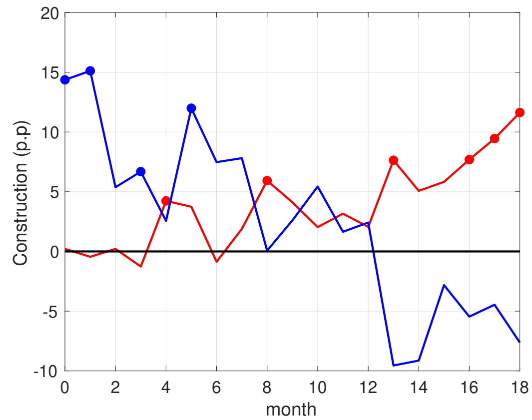
(d) Inventory Demand Shock

Figure 18: State-Dependent Responses of the Mining and Manufacturing Sector's IP with Korean EPU

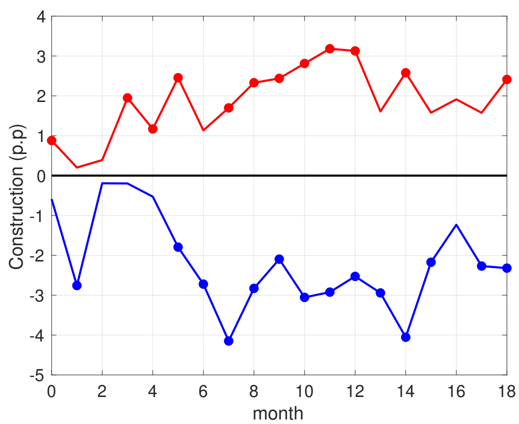
Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The South Korea EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.



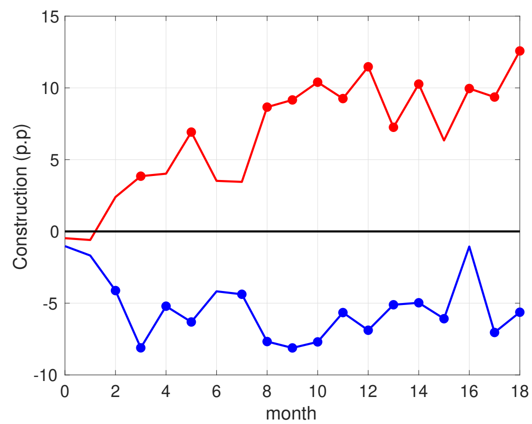
(a) Supply Shocks



(b) Economic Activity Shocks



(c) Oil Demand Shock



(d) Inventory Demand Shock

Figure 19: State-Dependent Responses of the Construction Sector's IP with Korean EPU

Note: This figure reports the state-dependent impulse responses of industrial production to oil shocks, using data from 2000M02 to 2022M02. The solid red line and the solid blue line correspond to the impulse responses under the high and low uncertainty states, respectively. The South Korea EPU sample median was used as the threshold to divide periods of high and low uncertainty. The markers on each line represent significant responses under the Newey and West (1987)-corrected 90% error bands of the corresponding impulse responses. All structural shocks are normalized to elicit a 10% increase in the real RAC.