The Asymmetric Relationship between Conventional/Shale Rig Counts and WTI Oil Prices

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The number of active oil rigs in the US has been largely fluctuating in the last decade. Overtime, the us oil supply has been modifying its structure, observing a rise in shale supply which has progressively replaced conventional production. At the same time, the us benchmark price (WTI) has experienced a drop of oil price in 2014 (the oil glut) and a rise of price volatility afterwards. Moreover, the number of Developed but Uncompleted (DUC) wells has also been rising overtime up to spring 2020, falling again afterwards. This paper puts all these factors together by quantitatively assessing the relationship between rig count changes and oil price, taking into account possible structural changes as well as impacts of financial and economic variables. It does so by setting an econometric model that aims at testing whether the oil rig count/oil price nexus is affected by the nature of the oil extraction, distinguishing between conventional and shale oil rigs. It is studied if an asymmetry exists in the relationship between oil rigs count and oil price when considering positive and negative oil prices, and if such a relationship exhibits structural changes. Moreover, the reverse causality and feedback hypotheses of the oil price/oil rig nexus is studied, since the number of shale oil rigs can be influenced by oil price change, but also the opposite effect can occur if oil rig counts impact oil supply and through it the oil prices.

In order to perform the analyses, firstly, statistical properties of the time series are studied. Proper testing shows that three regimes are associated with the breaks occurring in oil prices, shale rig counts, and conventional rig counts series, spanning from 2011 to the end of 2021. Moreover, cointegration is not present at the subsample level. Therefore, a specific vector auto regressive (VAR) model is set up, that accounts for the possible asymmetric impact of oil price and oil production changes, controlling for the impact of control variables. Then, the impulse response functions (IRF) are analyzed, assessing the overall relationship between oil price and shale and conventional oil rig counts when the full system receives a shock to prices. Finally, a robustness check is performed, that considers the possible role played by the DUCs in the oil price-rig count relationship. The data is split between the Permian region, which is characterized by a large DUCs dynamics, and the Anadarko, Bakken, Eagle Ford and Niobara ones, where the number of DUCs has remained fairly stable overtime. The study is replicated and compared to see whether result significantly differ across regions.

The analysis shows that there are three endogenously determined subperiod, from 2011 to 2014, from 2015 to the end of 2019 (the beginning of COVID-19) and from then onward. The shale and conventional rig counts reacted differently in each subperiod to signed changes in oil price. In particular, in the first period, 2011–2014, the only significant reaction is the one of the shale rig count to a positive variation in the oil price returns. In the second period, the shale rig counts react more heavily to oil price changes, while conventional ones exhibit a more stable behavior. However, the shale counts react with a higher time delay, that is, after a quarter. Finally, the evidence for the

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COVID period is less clear. It is confirmed that the shale rig counts react more than the conventional ones to oil price shock; however, this reaction does not depend on the sign of the price shocks.

The IRF confirm the result and provide further insights. In the first subperiod, hardly any significant response is seen from both conventional and shale oil rigs to an impulse (either positive or negative) on the oil price returns. In the second subperiod, for conventional oil rigs, a very limited, slightly significant and moderate response to positive price changes is observed. The shale oil rigs respond more widely and for a longer period to impulses. In particular, the shale oil rigs' response to a positive oil price impulse reaches its maximum after eight weeks (two months) and maintains this level, for up to 14 weeks. The reaction of shale oil rigs is 75% higher than that of conventional oil rigs. Looking at the response after a negative oil price shock, a similar behavior appears, with a stronger response from the shale rigs compared to the conventional ones (which are also not significant). The negative peak for conventional rigs is reached after eight weeks, while the equivalent for the shale rigs is observed after 14 weeks; furthermore, the effect of a negative shock is more prolonged than that of a positive shock on the oil price. The evidence for the COVID-19 period is less significant and clear, probably because of the limited sample and the presence of confounding factors, such as policy measures adopted to reduce the contagions. The cumulated IRF show an even clearer picture of the asymmetric differences between positive and negative price shocks for conventional and shale oil rigs. The shale industry in the second subperiod responds to oil price returns such that, from 2015 onwards, a positive 1% WTI price increase (decrease) induces an overall effect after 30 weeks, which rises by 25 units (reduces by 20 units) the shale rig count. The response of the conventional industry, albeit quicker, ending up in about 20 weeks, is much smaller: a positive (negative) 1% shock induces an accumulated effect of 8.8 (6.7) conventional oil rigs. Finally, taking int account the specific shale regions, the behavior of cumulated IRF in the Permian basin and in the Anadarko, Bakken, Eagle Ford, Niobara (ABEN) basins altogether (grouped because of statistical reasons) shows similar patterns in the second subperiod. However, differences emerge across these two subsamples about the size and the significance of the response to oil price shocks. In particular, for the conventional rigs, the response to price shocks is significant in the Permian basin case only, and slightly larger after a positive price shock. Differently, in the ABEN case, the response is not statistically significant. For the shale rigs, both Permian and ABEN basis show significant reactions to price shocks, with comparable patterns, but with cumulated reaction larger after positive shocks for the Permian case and after negative shocks in the ABEN case. Comparing the behavior of cumulated IRFs of the full sample with the one of the Permian basin, on the one hand, an the ABEN basins on the other hand, it can be seen that the full sample pattern are closer to the Permian ones. Nevertheless, the differences between the behavior of rig count changes in the Permian basin, which has the largest DUCs' fraction, and the other four ones are limited, suggesting that the full sample results are only marginally impacted by the presence of DUCs.

The paper's findings can be of interest to the oil industry, in terms of performing more accurate estimates of drilling rig counts and the need for frac counts while considering WTI prices. The financial industry could also benefit by the information about the relationship between financial and economic variables, oil price and industry reaction. More broadly, the data offer valuable insights to all those interested in identifying and quantifying the determinants of conventional and shale oil rig count changes. Finally, the asymmetric rig count reaction to oil price changes between conventional and shale rigs can help shedding light to the potentiality of the US shale industry to cope with price variation and clarify to what extent the US shale supply can influence the oil price. On this regard, the results of this paper help clarifying the causality in the rig count - oil price relationship and quantifying the both the magnitude and the timing of such an impact, an information that can be of utmost importance for the whole world oil market.