CLOSER TO ONE GREAT POOL? EVIDENCE FROM STRUCTURAL BREAKS IN OIL PRICE DIFFERENTIALS

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Overview

Although crude oil is often considered a homogenous good, it has a wide range of physical characteristics, such as density and sulfur content, which can lead to price differentials between different crude oils. These differentials are important for many oil market participants, including refiners, oil producers and those interested in understanding the workings of the oil market.

In 1984 Adelman famously wrote that ``The world oil market, like the world ocean, is one great pool." Yet, the fact that large differentials exist between crude streams of different qualities suggests that statement is not quite true. If all crude oil streams were equally substitutable for each other, then in the long-run the size of the price differential between any pair of crude oils should be relatively small, reflecting primarily transportation costs.

In this paper we investigate whether oil price differentials between crudes of different qualities have become smaller over time. That is, has the oil market become closer to one great pool over time? To do this, we construct oil price differentials between 12 different crude oils and use a structural breakpoint test to identify important shifts in their means. Previous literature has considered the importance of structural breaks that have affected oil price differentials related to important benchmark crude oils, such as Brent and West Texas Intermediate. Our paper focuses on differentials related to crude quality.

We find that a large number of price differentials between crudes have become smaller over time, with many experiencing a major structural break in their mean around the start of the Great Recession. Since then, the average size of many differentials has been about half their pre-break values and they have also become less volatile. Plausible explanations for the smaller differentials include a more complex global refining sector and the shale boom, which has boosted the supply of light crude oil.

Methods

Using daily price data we construct price differentials for 12 crude oils of different qualities from 1997 to 2018. We use the one-at-a-time, sequential breakpoint test of Bai (1997) to test whether there is statistical evidence for shifts in the means of those differentials over time. After documenting the breaks that are statistically significant at a 1 percent level, we then present results on how the means have changed over time. We introduce several possible explanations for why the shifts have occurred, including changes in the ability of the global refining sector to profitably process low quality crude oil and the shale boom. We present economic data on refining capacity, refining complexity and global production of different types of oil to discuss the merits of these explanations. We also use summary statistics to investigate whether volatilities have changed. At the end of the paper, we also use unit root tests to discuss whether the structural breaks we document might bias one towards concluding that the differentials are non-stationary, which would suggest a breakdown in arbitrage across quality.

Results

We find that almost all of the differentials we look at have experienced at least one break in their mean. In particular, a large number of the differentials between different types of crude oil experienced a significant break around 2007 and 2008. We then investigate how the means have shifted over time and find that most of the quality-related differentials have become smaller. In many cases, particularly those that experienced a break around 2008, the reduction in the mean has been accompanied by a major drop in volatility. After the break, the means and volatilities are often half their pre-break levels.

We also investigated whether oil price differentials between crudes of the same type, for example two light, sweet crude oils, have experienced a similar set of breaks, particularly around 2008. If that were true, it would suggest a broader change in the oil market not necessarily connected to quality. Overall, we do not find any evidence for this. We do, however, find that differentials between similar-type crude oils have experienced their own set of breaks. Many appear connected to changing market conditions in the United States, occurring either in the mid-

2000s or after 2010, and affecting numerous differentials related to crude oils in the U.S. Gulf Coast. A modest contribution on our part is to show that these breaks are more prevalent than previously documented in the literature.

The econometric procedure we use does not offer any economic explanations for the breaks we document. We investigate, using publically available data, four possible explanations: a more complex refining sector; the shale boom; a shift towards the use of residual fuel oil, which is found in greater proportions in low quality crude; and a potential weakening of environmental regulations that make low quality crude oil more costly to refine. The available data shows the first two are plausible explanations. The global refining sector has become increasingly complex over the last 18 years while the shale boom has unexpectedly increased the supply of high quality crude oil. Interestingly, environmental regulations have been tightened over time and demand for residual fuel oil remained stagnant, which should be pushing differentials apart, not driving them closer together.

Finally, it has long been known that structural breaks such as the one we document can affect tests of stationarity and as a final piece of analysis we consider whether this is an issue for the differentials we work with. We show this is indeed the case for many of the oil price differentials we consider. For differentials constructed using daily data, we find 5 out of 38 cases where a unit root test fails to reject the null of a unit root. With monthly data, we find 20 cases out of 38. Once we allow for a possible break in mean, the tests almost always reject the null of a unit root. Overall, these results show that some caution should be applied when using standard unit root tests to oil price differentials.

Conclusions

Crude oil can vary significantly in some key physical properties, making them imperfect substitutes for each other and leading to the existence of price differentials among crude oils. In a certain sense, these differentials reflect the limits to arbitrage that exist across crude oil quality. In this paper, we document that a large number of differentials between crude oils of different types have experienced structural breaks where their means have become smaller over time. A major decline in the average values of many quality-related differentials points to a change in the degree of arbitrage across quality, and also to the oil market being closer to “one great pool” than was previously the case. Our focus on structural breaks in the long-run averages contrasts with previous work in the literature, which has investigated how close the oil market is to ``one great pool" by testing the degree to which oil prices move together over time and space.

References

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