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Energy Quantamentals: Oil and Macroeconomic Feedback Loops

OIES ENERGY COMMENT

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Introduction

The relationship between oil prices and macroeconomic variables has been the subject of intense debate. This is particularly important in the current environment when market participants are trying to position themselves either for interest rate cuts or, alternatively, for interest rates staying elevated for much longer. Specifically, what does it mean for the oil market, and can the price of oil itself impact the highly anticipated monetary policy decision? This Energy Comment attempts to shed some light on how to look at such a complex relationship between oil and key macro-economic factors, including inflation, interest rate, and the U.S. dollar.

Oil and Inflation

Currently, inflation is the most important factor driving Central Banks' monetary policies. In the U.S., two commonly used measures of inflation are the Personal Consumption Expenditures (PCE) and the Consumer Price Index (CPI). They represent two baskets of consumer expenditures on goods and services but with different weights assigned to individual components. While the U.S. Federal Reserve Bank (the Fed) uses the PCE as a primary inflation benchmark and the market focuses mostly on the CPI, the two metrics tend to be highly correlated.[1] In this article, we use the CPI, as it allows us to illustrate various concepts using observable market-based variables.

The world's most liquid U.S. inflation market uses CPI as the underlying price index. To gain exposure to U.S. inflation, one can buy U.S. Treasury Inflation-Protected Securities (TIPS), which are linked to the CPI, and simultaneously sell regular U.S. Treasury bonds with the same maturity. The buyer is then exposed to the differential between nominal and real yields, which is known as the inflation breakeven spread. This spread is often used to measure market expectations of future inflation. While the Fed may set its formal inflation target in terms of the PCE, it also relies on market-based inflation breakevens to measure forward inflation expectations. Specifically, the Fed favors the so-called 5y5y inflation breakeven to complement various consumer surveys, which tend to be less reliable.[2] The 5y5y inflation breakeven represents the rate of five-year inflation, measured five years forward.

Oil prices impact realized inflation in different ways. The most direct impact is observed via the pass-through of retail gasoline prices to the CPI. The motor fuel component, which includes gasoline prices, represents less than 4% of the CPI, but it explains approximately 60%-70% of its variance.[3] **Figure 1** illustrates how closely year-over-year changes in the CPI track changes in WTI prices except for a more pronounced lag driven by the Covid-19 pandemic.

In fact, the explanatory power of retail gasoline has been even larger during the decade preceding the Covid-19 pandemic, which was characterized by overall low levels of inflation. This is because the largest components of the CPI basket, such as shelter or medical expenses, don't move as much on a monthly basis. The direct impact of oil prices on the nominal CPI can be calculated by multiplying changes in retail

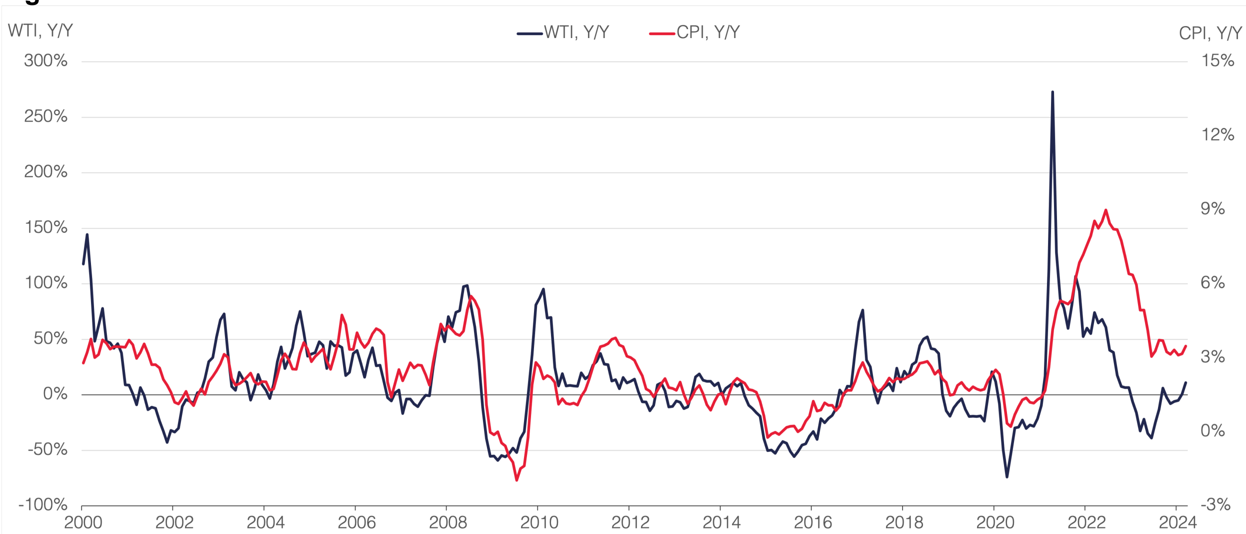
[1] See, for example, https://www.whitehouse.gov/cea/written-materials/2023/09/29/crosswalk-talk-whats-the-difference-between-the-pce-and-the-cpi. The largest difference between two inflation metrics is in the cost of housing, which has 33% weight in the CPI but only 15% in the PCE.

[2] J. Bullard, (2016), "Inflation Expectations are Important to Central bankers, Too", Federal Reserve Bank of St. Louis, https://www.stlouisfed.org/publications/regional-economist/april-2016/inflation-expectations-are-important-to-central-bankers-too.

[3] The most recent weight of the motor fuel component in the CPI basket, as of December 2023, is 3.37% https://www.bls.gov/cpi/factsheets/motor-fuel.htm. See also I. Bouchouev, (2021), "Is the Oil Price-Inflation Relationship Transitory?", Oxford Institute for Energy Studies, https://www.oxfordenergy.org/publications/is-the-oil-price-inflation-relationship-transitor for further analysis of this relationship.

gasoline prices by the motor fuel weight in the CPI basket. Gasoline prices, in turn, are driven mostly by oil prices.[4]

Figure 1: Oil and U.S. Inflation



Source: OIES, Federal Reserve (FRED)

While the algebraic impact of oil prices on U.S. inflation is fairly straightforward, the impact of inflation on oil prices is more nuanced. This reverse causality channel is driven mostly by expectations. **Figure 2** shows the relationship between WTI prices and the 5y5y inflation breakevens, used by the market as a proxy for inflation expectations.

Figure 2: Oil and Inflation Expectations

Source: OIES, Federal Reserve (FRED)

[4] In practice, one needs to account for the lag between changes in futures prices and retail gasoline prices. This lag is also somewhat asymmetric, as retailers tend to raise their prices quickly in response to higher oil prices, but they attempt to decrease retail prices slower when oil price declines, naturally maximizing their profit margins.

This relationship is also surprisingly tight. There are plenty of examples of something working well in theory but failing in practice. The relationship between oil and the 5y5y inflation breakevens is a rare example of the opposite: a relationship which is based on rather shaky theoretical grounds, turns out to be performing reasonably well in practice. In fact, the analysis of this relationship is somewhat meaningless from the perspective of traditional statistics and economics. Since 5y5y breakevens represent changes in consumer prices and oil represents the price level, one should not even be studying any correlations between price changes, on the one hand, and price levels, on the other hand. Furthermore, from the economic perspective, the 5y5y breakeven refers to inflation in the future, measured five years from now, which should not impact the spot oil price today.

One can, of course, come up with various arguments to explain such a behavior. For example, one popular theory posits that consumers form their expectations about future price changes by extrapolating trends in retail gasoline prices, which are highly visible and very volatile.[5] Other theories point to a lagged pass-through of energy prices in the form of a feedstock for many manufacturing process, in which case energy inflation is expected to spill over to other industries over time.[6] The purpose of this article is not to debate possible explanations of this relationship. At the end, a popular trading joke even says that inflation is like physics, where one can explain everything after the fact. However, physics also gives us some other more valuable insights, which can actually be very helpful in understanding the relationship between the price of oil and the economy.

Financial Market as a Complex Dynamic System

We all live in the world of the so-called complex dynamic systems. Examples of such systems include the human body, the dynamics of the climate, or relationships within the family. These systems are made up of interconnected pieces, whose joint interactions generate certain forces which drive the behavior of the system itself. In such systems, everything depends on everything else, so that the direction of causality cannot be easily established, and the dynamics of the system is governed by multiple feedback loops fighting for dominance.[7] Financial markets represent another example of such a complex dynamic system, where oil plays a crucial role.[8]

This Comment uses the example of mutual causality between oil and inflation to illustrate two types of feedback loops operating in such systems. For simplicity, we focus again on the U.S. market. First, we assume that the price of oil increases because of supply interruptions due to an exogeneous event. Higher oil price then translates into higher price of the retail gasoline, which mechanically impacts nominal measures of U.S. inflation, such as the CPI. Increasing inflation generally leads to higher interest rates, and higher U.S. interest rates relative to the rest of the world stimulate demand for U.S. dollars (USD), which leads to USD appreciation. However, oil, for the most part, trades in USD, so its price expressed in USD is negatively pressured by stronger USD due to the denomination effect. This can also be observed from a fundamental perspective, as stronger dollar negatively impacts demand in non-USD denominated markets,

[5] For various econometric analyses of the impact of gasoline prices on inflation expectations, we refer to O. Coibion, and Y. Gorodnichenko, (2015), "Is the Phillips curve alive and well after all? Inflation expectations and the missing disinflation", American Economic Journal: Macroeconomics, 7 (1), pp. 197-232; C. C. Binder, (2018), "Inflation expectations and the price at the pump", Journal of Macroeconomics, 58, pp. 1-18; L. Kilian, L. Zhou, (2022), "Oil prices, gasoline prices, and inflation expectations", Journal of Applied Econometrics, 37, pp. 867-881, and references threin.

[6] See T. Clark, and S. Terry, (2010), "Time Variation in the Inflation Passthrough of Energy Prices", Journal of Money, Credit, and Banking, 42 (7), pp. 1419-1443; C. Conflitti and M. Luciani, (2019), "Oil Price Pass-Through into Core Inflation", The Energy Journal, 40 (6), pp. 221-247, and references therein. The period after the Covid-19 pandemic is analyzed in L. Kilian, and L. Zhou, (2022), "The impact of rising oil prices on U.S. inflation and inflation expectations in 2020-23", Energy Economics, 113, pp. 1-10.

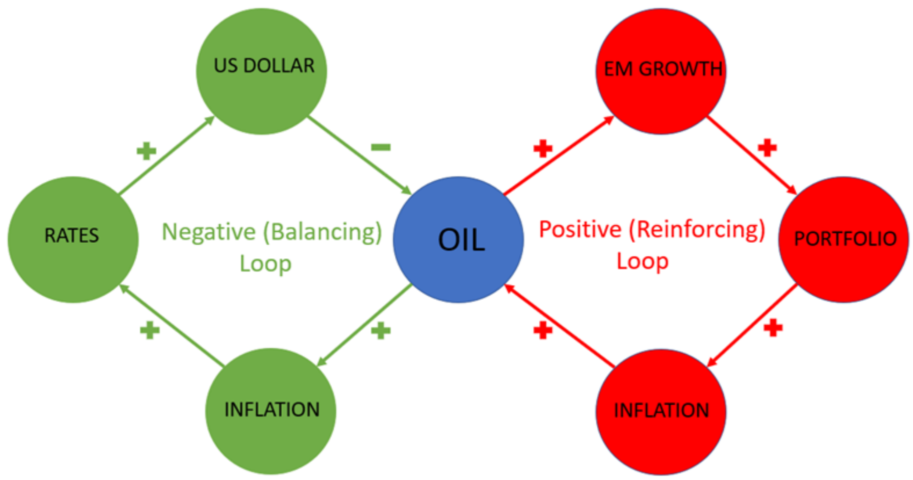
[7] For an excellent non-technical introduction to complex dynamic systems, we refer to D. H. Meadows, (2008), "Thinking in Systems: A Primer".

[8] In I. Bouchouev, (2023), "Virtual Barrels" (see https://link.springer.com/book/10.1007/978-3-031-36151-7), the author presents oil market itself as an example of a complex dynamic system, which is made up of prices, supply, demand, and inventories. This energy system represents one of many sub-systems nested within the broader system of financial markets.

and, at the same time, it also encourages supply from non-USD producers, whose costs are partially set in domestic currencies.

This loop is illustrated on the left side of **Figure 3**. It starts with a positive shock to oil prices, but it leads to financial forces which counter the initial shock. This type of a feedback loop, where the initial perturbation is suppressed by interaction among other factors, is known as a negative, or balancing, feedback loop. In the jargon of financial markets, it is typically associated with price mean-reversion.

Figure 3: Examples of Negative (Balancing) and Positive (Self-Reinforcing) Feedback Loops



Source: Author's illustration.

Now we will consider a different feedback loop. We start again with positive oil price shock, but this time it is assumed that it is driven by unexpected surge in demand for commodities in emerging markets. Such a demand shock could be viewed as inflationary globally. However, commodities, and in particular oil, are known to be among the best performing assets during periods of unexpected inflation.[9] Furthermore, given the close linkage between oil prices and inflation expectations, investors naturally allocate larger portions of their financial portfolios to oil.[10] This financial demand for inflation hedging effectively adds fuel to the fire, exacerbating the initial increase in oil prices.

The second loop, illustrated on the right side of **Figure 3**, is an example of a positive, or self-reinforcing, feedback loop. Here, interactions among components of the system amplify the initial perturbation in the price of oil. In financial markets such a loop is associated with price momentum. In a simple case of the market being driven by only these two loops, the direction of prices is determined by the tug-of-war between one balancing loop and one reinforcing loop. In the language of complex dynamic systems, these loops fight for dominance to determine whether mean-reversion or momentum prevails. The so-called shift in dominance is what ultimately determines the system's self-governed behavior which lasts until the next shift occurs.

[9] There is a large body of literature on this subject. See for example, H. Neville, T. Draaisma, B. Funnell, C. R. Harvey, and O. Van Hemert, (2021), "The Best Strategies for Inflationary Times", SSRN. The authors showed that among all asset classes and even systematically-traded risk premia trading strategies, simple long position in oil futures historically would have provided the best hedge against unexpected inflation.

[10] The oil-inflation linkage is further supported by cross-arbitrage trading strategies. One example of such a relative value strategy which trades RBOB futures versus short-term CPI swaps is described in detail in I. Bouchouev, (2023), "Virtual Barrels", Chapter 7.

It should be a simple exercise for the readers to conjure up many other negative and positive loops, which tie oil to other macroeconomic channels. In the recently published book “Virtual Barrels”,[11] the author listed a dozen of various channels which connect oil to USD, and one can construct various corresponding feedback loops around most of them. Since all of these loops operate concurrently, it becomes next to impossible to determine which one dominates at any point in time. They all fight for dominance and when the dominance shifts, which in the oil market happens rather frequently, the correlation between macroeconomic variables and the price of oil changes as well. This leads to extreme instability of many conventional statistical measures, such as correlations based on static linear regressions. It also highlights that any methodology with pre-determined direction of causality is unlikely to be suitable for describing the behavior of complex dynamic systems, where everything affects everything else.

What Does it All Mean Today?

The simple and intellectually honest answer would be that we don’t know. On the one hand, one can argue that higher interest rates are bearish oil. This could be supported, for example, by a possibility of a risk-off feedback loop, which could drag down equities and prices of many other financial assets, including oil. The negative impact can also be justified by the inventory loop via the higher cost of holding inventories and the desire by storers to unwind them, or by the negative impact of higher interest rates on global oil demand.

On the other hand, a prolonged period of elevated interest rates could be an indicator of stronger economy and inflationary pressures. This increases financial demand for inflation hedging from managers of diversified financial portfolios and from retail investors. For them, buying oil acts as a valuable diversifier, given its deep financial liquidity, an overall importance to the economy, and historically good performance during inflationary periods.

With so many loops concurrently pulling in opposite directions, it would be naïve to claim that the one will dominate consistently; in fact, most likely, none of them will, as the dominance in dynamic systems shifts frequently. To put it differently, the aggregate impact of interest rate policies will likely add a lot of noise but much less substance to the future direction of oil prices. This is because shifts in dominance in complex dynamic systems are usually characterized by an oscillatory behavior with fluctuations of a larger magnitude.

There will be many media stories, which will attempt to explain short-term price movements using various causal macroeconomic arguments of “if and then”. This is mostly done to satisfy the needs of their audience. Unfortunately, we all suffer from a human bias by trying to make sense of things and to explain them with various causal arguments. By and large, this is why many traditional theories of the relationship between oil and the economy don’t hold well in practice. The reality is that the causality in the world of complex systems we are living in is always mutual with numerous feedback loops competing for dominance, and the oil market is just one of such systems.

[11] See I. Bouchouev, (2023), “Virtual Barrels”, https://link.springer.com/book/10.1007/978-3-031-36151-7.