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Is the Oil Price-Inflation Relationship Transitory?

OIES ENERGY COMMENT

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Introduction

The relationship between oil prices and inflation has been widely discussed for decades, but its exact identity remains largely ambiguous. What makes the problem particularly difficult is that oil and inflation are highly intertwined. Their connections are difficult to disentangle using conventional statistical methods as frequent regime changes make the direction of causality difficult to pinpoint, producing results that are extremely sensitive to the sample selection. The difficulties in reaching robust conclusions give rise to many explanations of the transmission channels between oil and inflation.

The academic work on the impact of oil shocks on inflation has always been the topic of prime importance for policymakers.[1] More recently, attention has shifted to the analysis of inflation expectations, and whether highly volatile and easily visible gasoline prices at the pump may have a disproportional impact on forming short-term consumer beliefs about future inflation.[2] These consumer inflation expectations could then affect the actual inflation via the demand for higher wages, which makes oil prices an influential factor on monetary policy decisions.

The thesis by itself is subject to intense debate with numerous articles devoted to the subject, among which we highlight the recent work by Kilian and Zhou (2020)[3] at the Federal Reserve Bank of Dallas, who pointed out the methodological drawbacks of conventional static regressions. Instead, the authors applied a more robust statistical method of structural vector autoregression where the sensitivities of gasoline prices, realized inflation, and consumer inflation expectations are estimated jointly as the result of multiple structural shocks. Measuring consumer inflation expectations, however, is not an easy task. While traditionally it was typically done via surveys of consumers and professional forecasters, the recent trend among central bankers is to shift their attention to measures implied by the inflation market.[4]

In this Comment we contribute to the ongoing debate from the market perspective and outline less visible transmission channels established by the behavior of market participants that play an important role in reinforcing the feedback loop between the oil price and inflation. We argue that causality depends on the investment horizon resulting in simultaneous crosscurrents of financial flows between oil and inflation markets. In the short-term, highly volatile energy prices drive the realized measures of inflation, and the activities of cross-asset arbitrageurs tie short-term inflation expectations to energy futures curves. The short-term market-implied inflation expectations then propagate throughout the inflation forward curve with the help of interest rate carry traders. Surprisingly, the tight relationship persists even for a longer-term horizon where it can no longer be justified fundamentally. Long-term market-implied inflation expectations then return the favor and impact the financial demand for petroleum futures via portfolio allocations of large institutional investors, such as risk parity funds. The relationship becomes circular where the strength in one propels the other.

From Gasoline Prices to Inflation

The focus of this article is on U.S. inflation, for which there exists a well-developed market for inflation-protected bonds (TIPS) and derivatives, such as inflation swaps. The U.S. is also the country where

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[1] See, for example, B. Bernanke, M. Gertler, and M. Watson, (1997), "Systematic Monetary Policy and the Effects of Oil Price Shocks", Brookings Papers on Economic Activity, 1, pp. 91-157, and L. Kilian, and L. Lewis, (2011), "Does the Fed Respond to Oil Price Shocks", The Economic Journal, 141, pp. 1047-1072. For a comprehensive literature review we refer to M. Mohammed, (2020), "Five Decades of Modelling Oil Price Shocks: A Critical Review", International Review of Environmental and Resource Economics, 14, pp. 241-297.

[2] See O. Colbion, and Y. Gorodnichenko, (2015), "Is the Phillips curve alive and well after all? Inflation expectations and missing disinflation", American Economic Journal: Macroeconomics, 7, pp. 197-232; C. Binder, (2018), "Inflation expectations and the price at the pump", Journal of Macroeconomics, 58, pp. 1-18, and references therein.

[3] L. Kilian, L. Zhou, (2020), "Oil Prices, Gasoline Price, and Inflation Expectation: A New Model and New Facts, Working Paper 2025, Federal Reserve Bank of Dallas, available at https://www.dallasfed.org/research/papers/2020/wp2025.

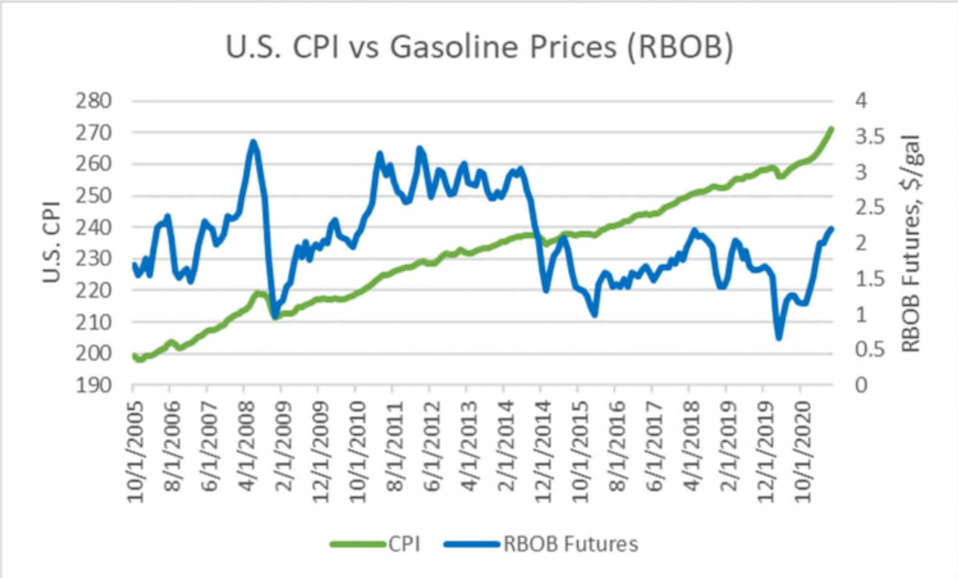
[4] J. Bullard, (2016), "Inflation Expectations are Important to Central bankers, Too", Federal Reserve Bank of St. Louis. https://www.stlouisfed.org/publications/regional-economist/april-2016/inflation-expectations-are-important-to-central-bankers-too.

the relationship between headline inflation and oil prices is the tightest driven by the impact of retail gasoline prices on the consumer price basket. Even though consumer expenditure on driving in many other regions is often even higher, the pass-through of market prices to inflation elsewhere tends to be lower due to the buffering effect of subsidies, taxes, and other non-tradable variables.

U.S. inflation is often measured by the Consumer Price Index (CPI) published monthly by the U.S. Bureau of Labor Statistics (BLS). CPI is the normalized index that represents the weighted average of prices for the aggregate consumer basket of goods and services with the reference base set at 100. Even though CPI index is technically defined as a change from the base reference level, it is essentially the measure for the aggregate price *level* in the economy. Inflation is then defined as the *rate of change* in the CPI index, typically reported on a month-over-month or year-over-year basis. The CPI index can also be viewed as cumulative inflation over a long period of time.

The distinction between price level and price changes is essential for interpretation of any statistical measures of the relationship between CPI and other variables. Figure 1 shows that at first glance the steadily rising level of the CPI index appears to have little to do with fluctuating gasoline (RBOB) prices in the futures market.

Figure 1: U.S. Consumer Price Index (CPI) versus RBOB futures

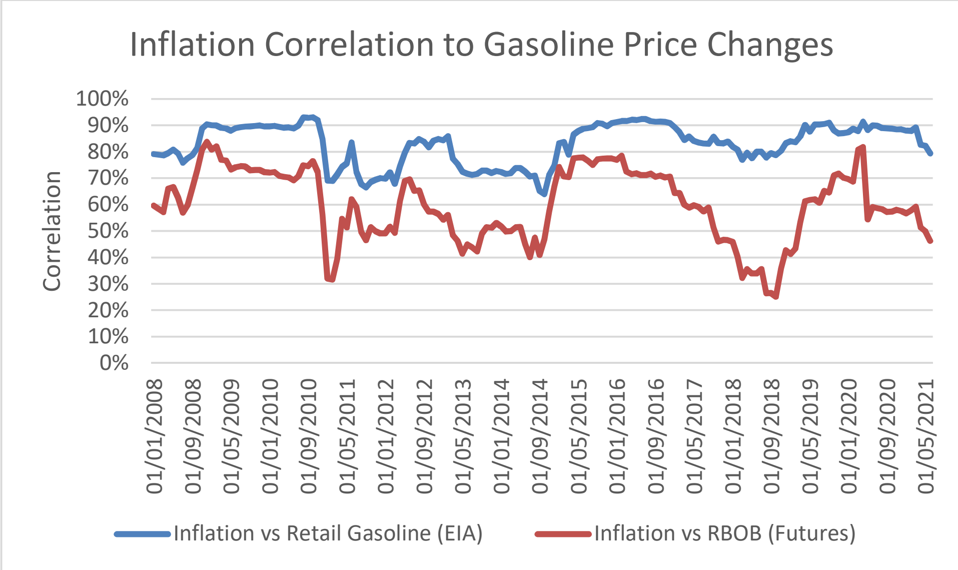


Source: Federal Reserve (FRED), EIA.

Since oil prices are generally not deemed to be stationary, statistical correlations applied to price levels could be spurious and must be interpreted with great deal of caution.[5] The proper way to quantify the relationship using standard regression models would be to compare inflation, or the rate of change in CPI, to the rate of change in the price of gasoline. We use two time-series for gasoline prices, the weekly average prices reported by retail gas stations and published by Energy Information Administration (EIA), the statistical branch of U.S. Department of Energy, and the daily RBOB futures prices that replaced its predecessor unleaded gasoline contract in October 2005. Both time series are aggregated into monthly data and their rate of change is compared to month-over-month CPI inflation. Figure 2 shows that resulting correlations between gasoline inflation and CPI inflation are extremely high. It should not come as a surprise that correlations are higher for retail prices which are more representative of consumers' actual expenditure than listed RBOB futures.

[5] This point is covered in many standard statistical textbooks, and for a particularly insightful discussion in the context of financial markets, we refer to C. Alexander, (2001), "Market Models: A Guide to Financial Data Analysis", John Wiley & Sons, Ltd, England.

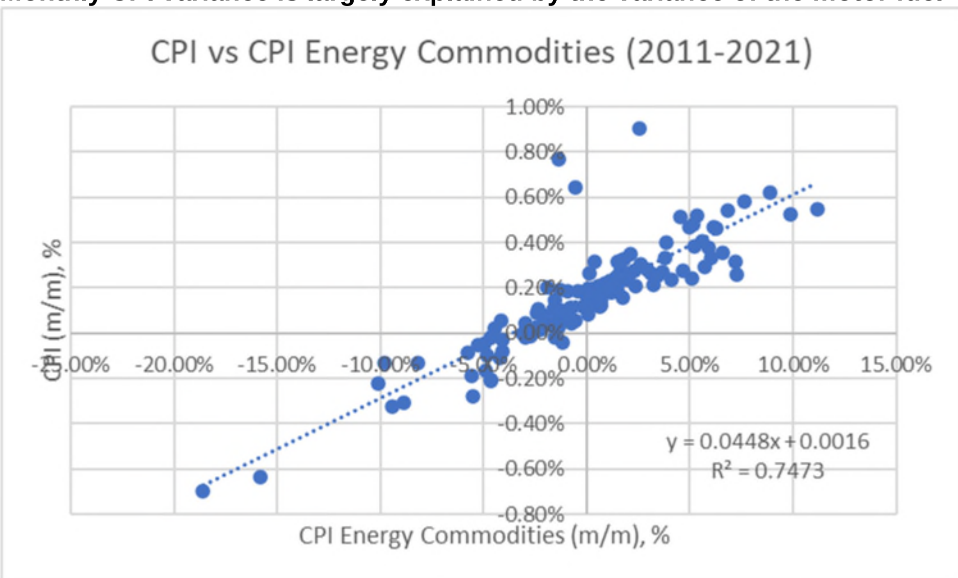
Figure 2: 2-year rolling correlation between inflation and gasoline (rate of change, monthly)



Source: Federal Reserve (FRED), EIA.

Consumers' driving expenditure is captured by the sub-component of CPI, known as motor fuel. Even though its relative importance, or the percentage weight in the overall consumer basket, is only around 3.00%,[6] this sub-component alone explained 75% of the overall CPI monthly variance over the last ten years, as many larger CPI constituents, such as housing or medical care, don't move as much on a month-to-month basis.

Figure 3: Monthly CPI variance is largely explained by the variance of the motor fuel



Source: Federal Reserve (FRED).

[6] As of December 2020, the relative importance of motor fuel category was 2.875%, out of which gasoline was 2.811% - see https://www.bls.gov/cpi/factsheets/motor-fuel.htm. In addition, BLS publishes separate aggregate indices for CPI-Energy and CPI-Energy Commodities with the latest respective weights of 6.155% and 3.02%. It is important to distinguish between them as the latter mostly corresponds to the motor fuel, while the former also includes other residential energy expenditures, such as electricity and piped gas. Since CPI-Energy Commodities data are available for much longer period than the data for the motor fuel, this time series is customary used by market practitioners for any statistical analysis of gasoline pass-through.

While we tend to think about CPI inflation as an economic data point, there is an active derivatives market in CPI swaps. Traders can place bets on future CPI monthly prints and then hedge their gasoline exposure by trading an equivalent amount of RBOB futures with corresponding maturity. This eliminates the largest risk component of CPI uncertainty and leaves traders with a position in ex-energy CPI which is much less volatile. When CPI swaps and RBOB futures diverge sufficiently, it allows traders to synthesize long or short positions in ex-energy CPI at levels that are deemed to be statistically attractive. The strategy generally follows standard techniques of cross-asset statistical arbitrage prevalent across financial markets. More advanced traders also eliminate volatile exposure to food prices by constructing an equivalent basket of agricultural futures.[7]

What makes this opportunity possible is the fact that inflation swaps and energy futures operate at different speeds. Inflation investors are often somewhat slow to react to rapidly changing oil prices which may lead to excessive persistence in CPI that may no longer be justified by rapidly changing energy fundamentals. However, the successful implementation of the strategy is not straightforward due to a non-trivial lag between retail gasoline prices and futures. The pass-through of futures does not occur instantaneously as gas station operators often link prices at the pump to the cost of wholesale purchases made earlier. To quantify the lag properly, one needs to have a solid understanding of the timing and mechanics of how the final gasoline product makes it way from the refinery to the gas station.

In addition, the trader must consider the impact of volatile basis between regional markets. Since the motor fuel component of CPI represents the national average of the finished gasoline, but RBOB is only a particular blending component to be delivered in the New York area against the futures contract, the spread between them can temporarily dislocate following isolated regional events, such as Gulf Coast hurricanes or the shortage of some blending components on U.S. East Coast.

The exact implementation of this quantitative statistical arbitrage strategy is kept highly confidential by arbitrageurs. However, the important implication is that their behavior keeps the short-term forward market for CPI index tied to energy futures curves, properly adjusted for complicated and non-linear pass-through of futures to retail gasoline prices. This fundamental connection only exists in the front-end of the inflation market curve. However, very surprisingly the relationship between CPI inflation and energy prices retains its strength even for longer-term inflation markets, where it is reinforced by different types of market participants.

From Inflation Expectations to Risk Parity and Back to Oil

The longer-dated inflation markets usually trade via so-called inflation breakevens that involve simultaneous purchase of TIPS and the sale of the same maturity U.S. Treasuries. The long position in breakevens is effectively the relative interest rate spread trade that pays the difference between the nominal yield of the Treasuries and the real yield of TIPS. 5-year and 10-year breakevens are the primary inflation traded benchmarks in the marketplace. Together, they are often combined into a so-called 5y5y forward breakeven that represents five-year inflation measured five years from now. 5y5y inflation breakeven became the most common barometer of market-implied inflation expectations used by central bankers and policymakers. Applying the standard algebra of forward interest rates, one can deduce that 5y5y breakeven is approximately twice the ten-year inflation breakeven rate minus the five-year breakeven rate.

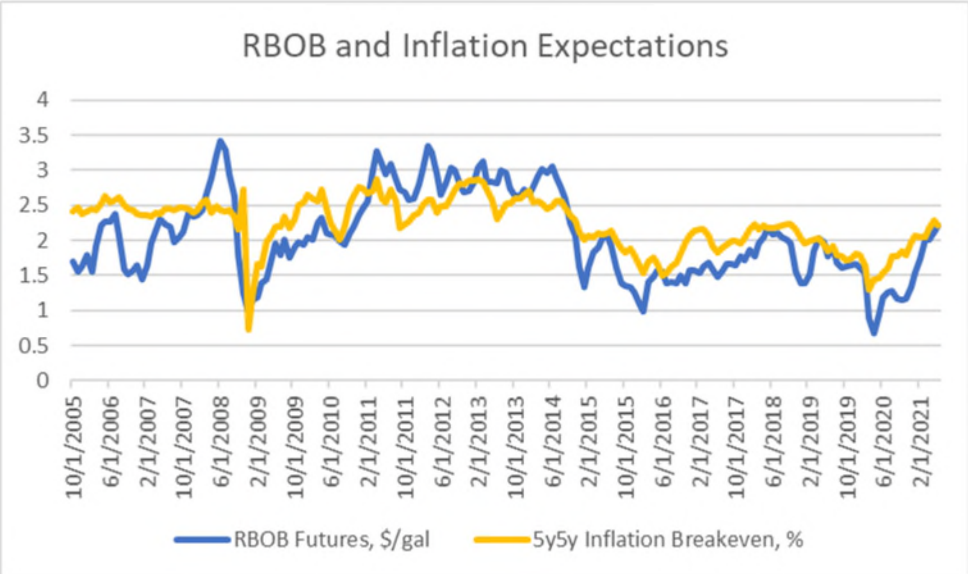
In theory, the fundamental relationship that exists between short-term inflation and gasoline futures should be fading away with time, and for 5y5y breakeven it should indeed be close to zero. In practice, however, it is not. To illustrate the theory first, let us assume that oil and gasoline futures jump 20% and stay there indefinitely. Using roughly 3% for the relative importance of motor fuel, and commonly used 60% of the gasoline pass-through to retail implies that one-year inflation should instantaneously

[7] M. Pond, and V. Weinblatt, (2019), “Capturing core breakevens”, Barclays Global Inflation-Linked Products: A User’s Guide, pp. 61-63.

increase by 0.20 x 0.03 x 0.60 = 0.36%.[8] If gasoline inflation is measured year-over-year, then its contribution disappears after the first year. In other words, the average annualized five-year inflation rate should only experience approximately one-fifth of the change in the initial gasoline price level, or 0.072% per annum, and the ten-year average annualized inflation rate should rise by one-tenth, or 0.036%, so that the impact theoretically should fade away rather quickly. Perhaps most importantly, the 5y5y forward breakeven rate should have zero sensitivity to the initial price change as the duration of a ten-year bond is approximately twice the duration of a five-year bond.

The data, as illustrated by Figure 4, is very different. The 5y5y inflation breakeven, which fundamentally should not have anything to do with short-term gasoline futures, happens to track futures remarkably well. Inexplicably, we can even retain the same axis and still see how incredibly close market-implied forward inflation measured in percent has been to RBOB futures priced in dollar per gallon.

Figure 4: 5y5y forward market-implied inflation versus RBOB futures



Source: Federal Reserve (FRED), EIA.

A similar relationship was noticed by central bankers in the aftermath of falling oil prices in 2014 and initially explained by the synchronized deterioration in the common global demand factor.[9] Such explanations, however, did not last long as oil prices, along with breakevens, started to decouple from the dynamics of a common growth factor leaving economists puzzled. An alternative hypothesis of an indirect impact of oil prices on long-term inflation via spill-over into energy intensive manufacturing costs has also been largely rejected, as the pass-through into core inflation directly via the cost channel has decreased over time and became negligible.[10] Finally, the argument of the structural risk premium embedded in TIPS does not resolve the issue either, as it would be impossible to envision any time varying risk premium that moves precisely in parallel with futures so consistently over time. In fact, the

[8] For the standard approach to the estimation of the gasoline pass-through, see, for example, M. Pond, V. Weinblatt, H. Skeoch, and K. Sooben, (2019), "Hedging energy risk in breakeven positions", Barclays Global Inflation-Linked Products: A User's Guide, pp. 64-69.

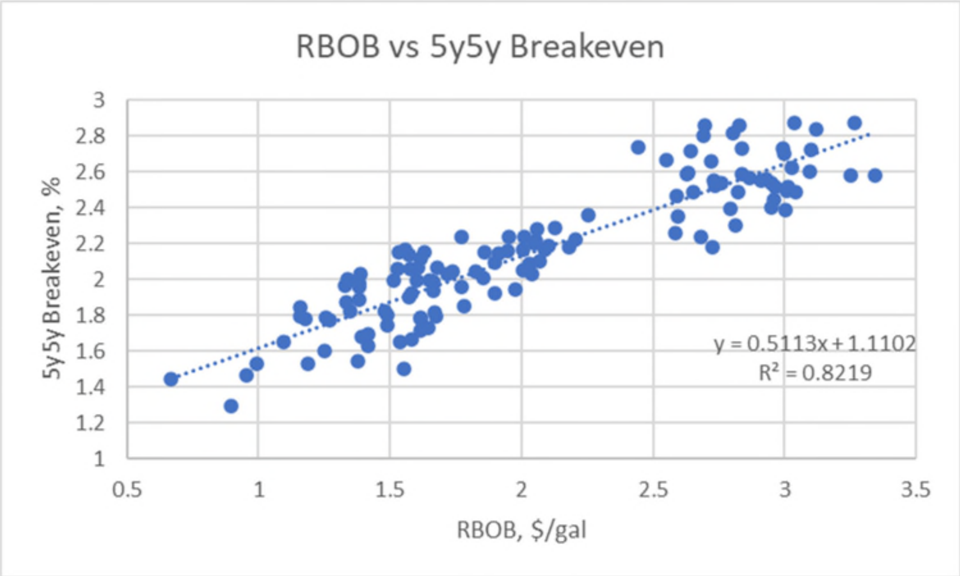
[9] See, for example, A. Badel, and J. McGillicuddy, (2015), "Oil Price and Inflation Expectations: Is There a Link?", Federal Reserve Bank of St. Louis, https://www.stlouisfed.org/~/media/Publications/Regional-Economist/2015/July/Oil.pdf.
D. Elliott, C. Jackson, M. Raczko, and M. Roberts-Sklar, (2015), "Does oil drive financial market measures of inflation expectations?", Bank Underground, a blog for Bank of England, https://bankunderground.co.uk/2015/10/20/does-oil-drive-financial-market-inflation-expectations/.
N. Sussman, and O. Zohar, (2015), "Oil prices, inflation expectations, and monetary policy", Bank of Israel, DP092015.

[10] 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. 1419-1433, and C. Conflitti, and M. Luciani, (2019), "Oil Price Pass-through into Core Inflation", The Energy Journal, 40 (6), pp. 221-247.

recent decomposition of U.S. breakeven inflation shows that the contribution of the risk premium has practically vanished.[11]

Figure 4 represents perhaps one of the biggest puzzles in the relationship between short-term oil prices and inflation. We are all so accustomed to seeing many elegant theories that fail to hold in practice. Here, we have a rare case of the opposite: the relationship clearly exists despite claims of economic theories that it should not. It defies not only the thesis of economics, but the norms of statistics as well: despite non-stationarity of futures prices and questionable comparison of CPI index changes to gasoline price levels, the correlation between monthly 5y5y implied breakeven and RBOB futures prices over the last ten years (since 2011) has reached 90% with a corresponding R-squared of 82%, as shown in Figure 5.

Figure 5: Correlation between 5y5y breakeven inflation and RBOB futures (2011-2021)



Source: Federal Reserve (FRED), EIA.

Financial markets are not driven by the laws of physics, where the observed phenomenon is the reflection of the fact and fundamental theories are fitted accordingly. The markets are behavioral and non-stationary. To obtain such high correlation between any market variables, one needs much more than a fundamental connection. It must involve some sort of an arbitrage. This is what storage carry does to keep together futures with different maturities, or what pipelines do for the cross-regional bases. The strength of the oil-inflation relationship could indicate the presence of some other invisible, but more mechanical and possibly computerized algorithmic force behind it. The root cause of this phenomenon should probably be searched for in the behavior of another large group of market participants, the systematic portfolio allocators, and factor investors.

To illustrate the argument, consider one of the popular asset allocation methods pioneered by Bridgewater's All Weather product that subsequently gave rise to an entirely new industry, dubbed 'the risk parity'.[12] The original concept of All Weather is based on the presumption that all assets are driven by two primary factors: growth and inflation. If we focus only on two main asset classes, equities, and bonds, then their sensitivity to growth is generally the opposite. Stocks perform well in a high growth environment and bonds do better when growth is low, so that the portfolio of stocks and bonds is viewed as naturally diversified with respect to growth.

However, the exposure of stocks and bonds to the second inflation factor is often additive. Since both are valued as discounted future cash flows, any unexpected spikes in inflation decrease the present

[11] P. Williams (2020), "Inflation Expectations in U.S.: Linking Markets, Households, and Businesses", IMF Working Paper, WP/20/240, available at https://www.imf.org/en/Publications/WP/Issues/2020/11/13/Inflation-Expectations-in-the-U-S-49815.
[12] Available at https://www.bridgewater.com/research-and-insights/the-all-weather-story.

value of future cash flows. The effect is obvious for bonds even though it could become more convoluted for certain equities when inflation also raises a company's profit margins. This risk presents an urgent need for another asset that performs well when inflation jumps. Commodities have proven to be the best hedge that contributed to its recognition as the new alternative asset class.[13] Within commodities, energy futures have played a unique role. It turns out that oil not only has the highest contemporaneous correlation to realized inflation, but also acts as the best hedge against unexpected inflation.[14] Given how large financial markets are relative to the size of the energy futures, the inflation hedger quickly became the dominant force in the oil market.[15]

Facing the challenges of rolling long futures in predominantly contango markets, managers of financial portfolios with inflation hedging mandates became more dynamic. One notable example is provided in the forthcoming paper by Till (2021)[16] that highlights that adding the dynamic carry-driven position in Brent futures to the portfolio of stocks and bonds significantly outperforms standard investment benchmarks. Similar concepts are used to shift allocations between oil and inflation breakevens. While it is impossible to know exactly the trading strategies of large market participants in opaque inflation markets, the anecdotal evidence suggests that many institutional investors now routinely take advantage of short-term volatility by dynamically switching between breakevens and petroleum futures. The choice between the two is often made based on the relative value comparison blended with other quantitative factors, such as carry and momentum. If breakeven inflation becomes too expensive relative to oil, then more flows within the inflation hedging bucket shift to oil futures and vice versa keeping the markets once again closer to each other.

Our description is obviously an extremely oversimplified picture of the real market. The cross-asset switching within the inflation bucket is usually the result of sophisticated portfolio optimization models where the rebalancing occurs frequently based on computerized algorithms. Conceptually, however, such behavior is not too different from that of energy traders in the front end of the CPI curve. The main difference is that in the forward markets the relative value signals are applied as an overlay on top of passively long allocations to the inflation sensitive basket, much like currency overlay strategies are added to optimize global equity portfolios.

The mysterious market channel that links oil prices and market-implied inflation is arguably more powerful in explaining forward inflation expectations than that which can be deduced from surveying consumers based on their perception of gasoline prices at the pump. Instead of being pegged to the inflation targets of central banks, long-dated inflation expectations are more closely mimicking and sometimes even driving oil prices. This completes the behavioral transmission circle that starts with energy traders linking up short-term market-based inflation that is carried into longer-term expectations and spills back to oil via portfolio rebalancing channels. The causality goes both ways simultaneously as two markets operate in tandem.

Summary

The information contained in market prices cannot be ignored in the ongoing debate about the elusive relationship between oil and inflation. The behavior and economic incentives of various market participants could create the feedback loop that makes it difficult to disentangle two markets using

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[13] M. Ashton, and B. Greer, (2008), "History of Commodities as the Original Real Return Asset Class", in Inflation Risk and Products, Incisive Media, pp. 85-109.

[14] H. Neville, T. Draaisma, B. Funnell, C. Harvey, and O. Van Hammert, (2021), "The Best Strategies for Inflationary Times", SSRN working paper, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3813202, May 25, and M. Hinds, H. Shan, J. Currie, (2018), "Commodities are the still the best hedge against rising inflation risks", Goldman Sachs Commodities Research, March 21.

[15] I. Bouchouev, (2020), "From risk bearing to propheteering", Quantitative Finance, April 20 (6), pp. 887-894.

[16] H. Till, (2021), "Commodities, Crude Oil, and Diversified Portfolios", Global Commodities Applied Research Digest, Winter, 6 (2), forthcoming, available at http://www.jpmcc-gcard.com/digest-uploads/docs/GCARD%20Till%20Forthcoming%202021.pdf.

conventional economic theories and statistical techniques. In the short-term, inflation and oil prices are coupled by energy arbitrageurs trading around the mechanical pass-through of retail gasoline prices to the consumer expenditure basket. In the long-term, the baton is passed to portfolio allocators and risk parity funds with the direction of causality flipping from inflation expectations back to oil prices. The relationship becomes circular where the strength in one propels the other.