

# Effects of Energy Commodities on CPI: An Analysis of Energy Commodities as a Factor of US Inflation

Daniel Chen<sup>1</sup> and Richard Yang<sup>#</sup>

<sup>1</sup>Prestige STEM Academy, Canada

<sup>#</sup>Advisor

## ABSTRACT

From 2021-2023, the US saw a period of unparalleled inflation. Prompted by the debate on the role of energy prices, this paper investigates the role of rising energy commodities in this inflationary trend. Focusing on the Consumer Price Index (CPI-U), we explore the direct and indirect effects of energy commodity price changes. Despite the sector's 3-5% CPI weight, energy commodities exhibit significant volatility, contributing to 30% of monthly inflation fluctuations on average. The study identifies Gasoline and Fuel oil, both crude oil derivatives, as key components. Additionally, we assess the secondary pass-through effects, mainly through the transportation and industrial sectors. This research provides insights into the substantial impact of energy commodities on inflation and encourages further exploration on this topic, which can enhance economic forecasts and possibly monetary policy forecasts.

## Introduction

Inflation is the general rise in prices in an economy (equivalently, a decrease in purchasing power of money). The most cited figure tracking inflation is the Consumer Price Index, tracked by the Bureau of Labor Statistics, with more technical splits of its population. The CPI is calculated for two groups of populations: All Consumers (CPI-U) and Urban Wage Earners and Clerical Workers (CPI-W). CPI-U is based on the expenditure of all families living in urban areas. CPI-W is a subset of CPI-U and is based on the expenditure of families living in urban areas who meet additional requirements related to employment. The Personal Consumption Expenditures Price Index (PCE) is an alternate measure of inflation for US households; however, it measures all households as opposed to urban households only and includes both direct and indirect consumer goods.

For purposes of this paper, we used the CPI-U as it is a better measure of direct US household inflation. In the CPI-U index, all consumer items are assigned a weight according to the percentage they make up in consumer spending. The Energy commodities sector generally weights 3% to 5%. It includes the items Motor Fuel and Fuel Oil. Motor fuel is the fuel used to power motors in motor vehicles and Gasoline is the most used type of Motor Fuel. Fuel Oil consists only of fuel oil number 2, used for home heating. Both categories are distillates of crude oil, whose prices are highly dependent on international trade of crude oil.

## A Comparison with the 1970s and 1980s Inflation

During 2021-2022, the high inflation in the US witnessed peak inflation rates rivaled only by the runaway inflation in the US in the 1970s and 1980s.

In the 1970s, inflation rates surged to unprecedented levels in many G7 countries, reaching double digits in some cases. The decade was characterized by a combination of economic challenges, including oil price shocks, high inflation, and stagnated growth.

The oil price shocks of the 1970s were a major driver of inflationary pressures. In 1973, OPEC imposed an oil embargo on several Western countries, including the United States, in response to their support for Israel during the Yom Kippur War. This resulted in a severe disruption in oil supplies, causing crude oil prices to skyrocket. For example, the price of oil surged from around \$3 per barrel in 1973 to over \$12 per barrel in 1974, and it continued to rise throughout the decade (Kramer).

The sharp increase in oil prices had a cascading effect on the global economy. As oil is a crucial input in various industries, the higher energy costs translated into increased production and transportation costs for businesses. These added costs were passed on to consumers in the form of higher prices for goods and services. In 1973, inflation increased drastically to 8.8%, and by 1980, the inflation rate had escalated to 14%. The Federal Reserve in the United States responded to the inflationary pressures by adopting tight monetary policies and raising interest rates to curb borrowing and spending. While these policies were successful in eventually bringing down inflation, they also led to economic slowdowns and recessions in many countries (Gómez-Loscos et al., 2012).

The recent inflation surge adopted many similar causes. Starting from around mid-2021, US inflation rose above the 2% target due to the monetary injections during the COVID-19 pandemic and the supply chain disruptions that incapacitated the supply chain. By February 2022, the war in Ukraine had erupted, causing global oil supply disruptions, and Brent Crude and West Texas Intermediate crude rose more than 20% soon following the incident.

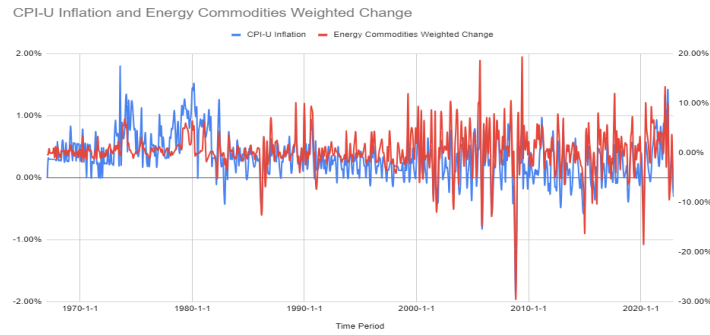
## Hypothesis

In this paper, we explore inflation through the lens of rising energy commodity prices, utilizing the data available. We believe that there is not only the direct effect of energy prices on the average consumer (specifically when the average consumer buys energy products like gasoline directly), but also secondary pass-through effects as transportation and other energy requirements of all other goods, and possibly services, get increased as well. We hypothesize that this secondary effect takes place through a longer period, potentially about 3 months, as prices of other goods and services increase to reflect the realities of rising energy prices.

The literature on the topic reveals a substantial body of research investigating the link between energy commodity prices and inflation. It is generally agreed that energy commodities have a significant and immediate impact on overall inflation, as noted by Federal Reserve Economic Research. When energy costs rise, consumers experience higher prices for fuel, electricity, and other energy-related goods, directly impacting their purchasing power and leading to cost-push inflation (Igan et al., 2022). This direct effect is well-explained by the cost-push model of inflation.

However, the secondary pass-through effects of rising energy commodity prices on other goods and services have garnered increasing attention in recent years. Most research agrees that rising energy commodity prices increase production costs and decrease the supply of many consumer goods, especially in the transportation sector. The increase in cost is then passed on to consumers. These pass-through effects are believed to be more gradual and persistent, leading to more prolonged inflationary pressures. According to the European Central Bank's 2014 December bulletin, as much as one-third of the impact of oil prices in the EU is transmitted through indirect effects, and a 10% increase in crude oil price is expected to cause 0.2 percentage points impact indirectly.

## Data



**Figure 1.** Graph of CPI-U Inflation and Energy Commodities Weighted Change (left axis is for CPI-U Inflation, right axis is for Energy Commodities Weighted Change)

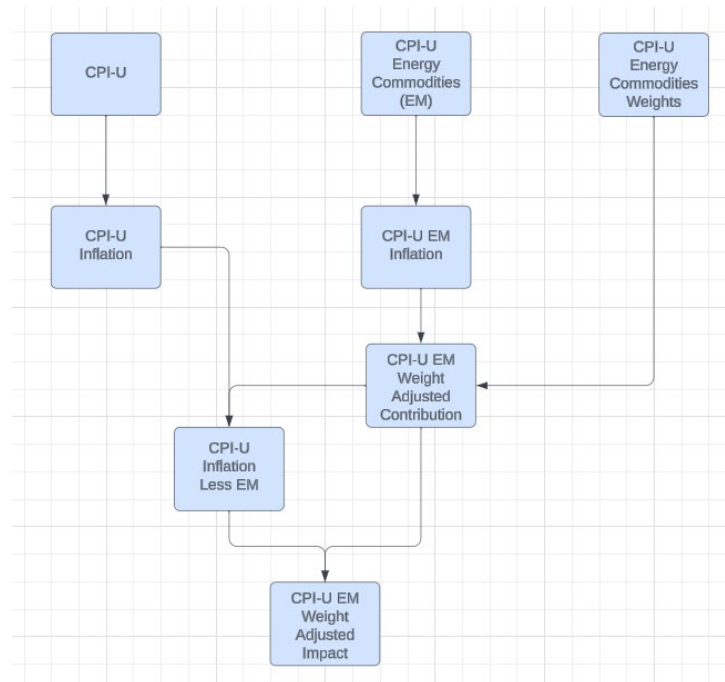
**Table 1.** Summary Statistics by CPI-U related series

Data Set	Standard Deviation	Average	Period	Frequency
<b>CPI-U Inflation</b>	0.37%	0.33%	1967 - 2022	Monthly
<b>CPI-U Energy Commodities</b>	4.02%	0.48%	1967 - 2022	Monthly
<b>CPI-U Inflation Less Energy Commodities</b>	0.31%	0.32%	1967 - 2022	Monthly
<b>Absolute Impact of Energy Commodities on CPI-U</b>	0.12%	0.10%	1967 - 2022	Monthly

The Energy Commodities data and relative weights are sourced from the Bureau of Labour Statistics, and the CPI-U index is sourced from the Federal Reserve Economic Data. Note that the composition of the category Energy Commodities is found to be inconsistent in CPI reports, consisting of either Motor Fuels and Fuel Oil or Gasoline and Fuel Oil. Nonetheless, the value difference is found to be negligible in our analysis.

## Method

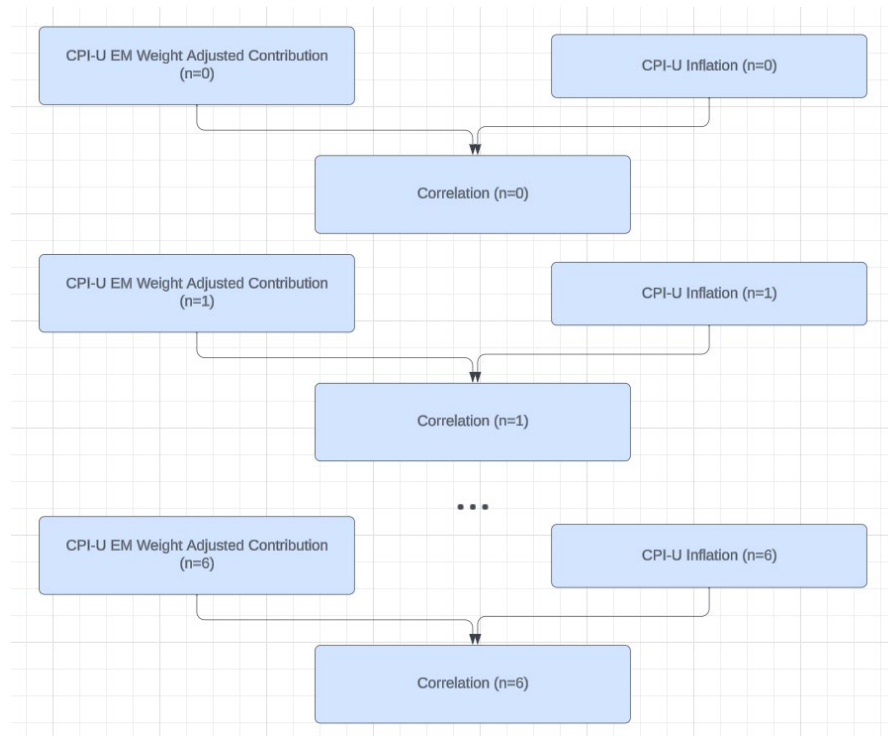
### Direct Effect



**Figure 2.** Flowchart for data processing of Direct Effect

Raw data is collected from the US Bureau of Labor Statistics of the CPI-U and Energy Commodities in index form and the weights of Energy Commodities. Then, we derived the monthly inflation for the CPI-U and Energy Commodities, and, using the Energy Commodities weights, found the weight-adjusted contribution of Energy Commodities. With it, we obtained the component inflation for CPI-U less Energy Commodities by subtracting the Energy Commodities inflation from CPI-U. Lastly, we attained the impact of Energy Commodities on the CPI-U using its contributions divided by Inflation Less Energy Commodities. Note that impacts are calculated in absolute terms to take into account impacts in both directions. The statistics are then interpreted to answer the hypothesis.

### Indirect Effect



**Figure 3.** Flowchart for data processing of Indirect Effect

Energy Commodities Inflation is graphed with CPI-U at months-delayed  $n=0$  up to  $n=6$ , and the results are examined to assess the indirect effect.

## Analysis and Results

Rising Energy Commodity Prices: Commodities affect inflation in two ways: 1) directly as consumers buy the commodity products and 2) indirectly as commodity price increases pass onto the consumers.

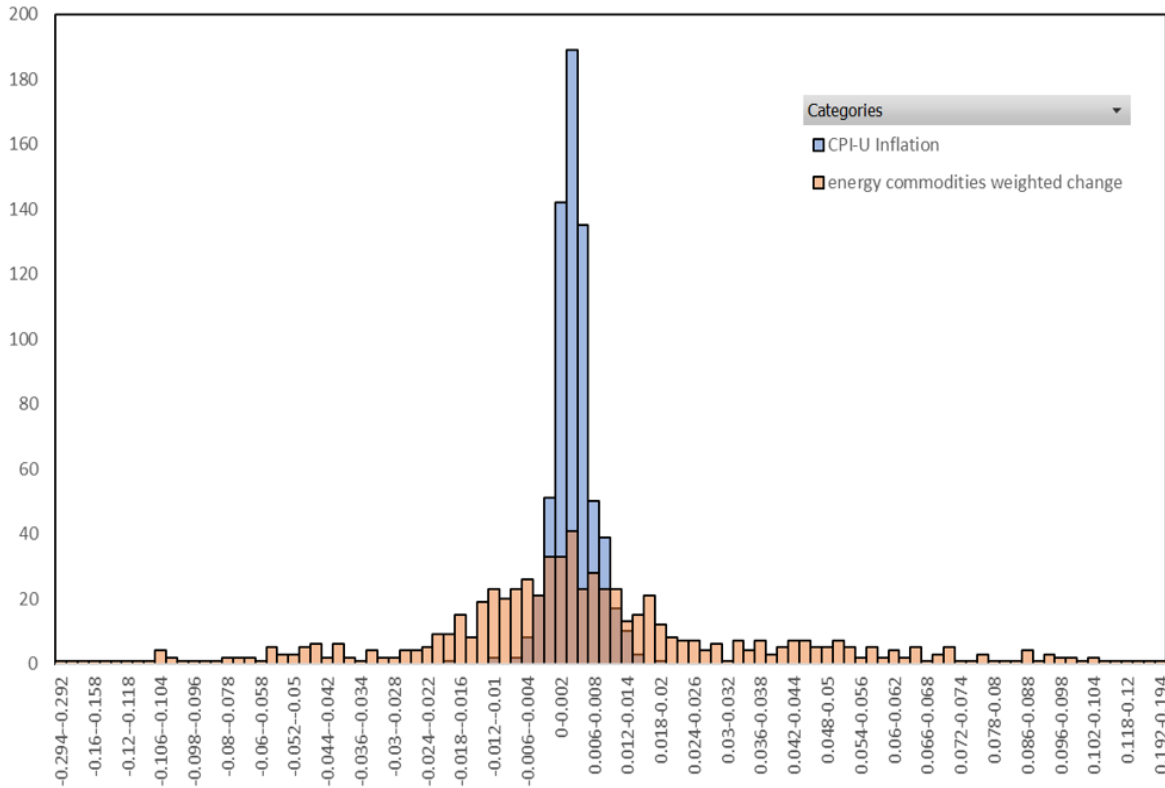
### Direct Effects

To analyze the direct effect of energy commodity price changes on CPI, we take into account 2 factors: 1) the weight of energy commodities within the CPI-U basket of goods and 2) the actual magnitude of price changes of the energy commodity basket (or the overall volatility of the energy commodity basket). The energy commodities basket includes items Gasoline (all types) and fuel oil, of which individual price changes and weights were used to determine overall price changes.

Generally speaking, the weight of energy commodities within the CPI-U is approximately 3%-5%, representing a relatively small slice of the basket. However, the volatility of energy commodity prices is much higher than that of the rest of the basket, with a standard deviation of 4.02 and 0.37 percentage points respectively.

The monthly contribution of Energy Commodities is calculated by multiplying Energy Commodities inflation with its weight. The absolute monthly contribution is a better measure of the impact, as large negative values, when not using absolute values, decrease the average impact even though it signifies a large impact in the negative direction.

Between 1967 and the present day, the average monthly change of prices in the CPI basket was merely 0.33%, while the average change in the price of energy commodities was 45% higher at 0.48%. As indicated in Figure 1, both the distribution of CPI-U and Energy Commodities are approximately normal and centered close to zero. Notably, the distribution of Energy Commodities is much flatter and slightly skewed to the right.



**Figure 4.** Histogram of CPI-U inflation and Energy Commodities Weighted Change

The average monthly contribution of Energy Commodities to CPI-U is 0.01076% (0.13 percentage points annualized), a measurable but small difference, indicating that the means of both distributions are very close. However, the average absolute impact of Energy Commodities on CPI-U, accounting for change in both positive and negative directions, is as much as 0.10390% (1.25% percentage points annualized), or an impact of 29.4%. This drastic difference indicates the unusually large volatility but not necessarily significant movement in the overall CPI index caused by the inclusion of Energy Commodities. Moreover, 30.5% of the time Energy Commodities accounted for over half the change in CPI-U. The surprisingly large impact of Energy Commodities on CPI-U resulted from the disparate range and variability of the two distributions, giving the Energy Commodities basket much more impact than expected from its category weight of 5%.

### Indirect Effects

While Energy Commodities price increase affects the CPI-U index directly, it also leads to increases in the price of other products that use crude oil in their production or distribution. The most significant area of crude oil usage is transportation. Making up 67% of petroleum products consumption, the transportation sector encompasses energy used by automobiles, trucks, buses, and other vehicles whose primary purpose is for transporting people or goods. The second largest oil-consuming sector is industrial, accounting for 26% of total petroleum

products consumption. It includes energy consumed for manufacturing, agriculture, forestry, fishing, hunting, and so on.

Primarily in the form of gasoline, an increase in Energy Commodities prices can increase the cost of transportation and industrial vehicles. Businesses that face this extra cost must then increase prices to account for either the increasing transportation cost or the decrease in short-term supply, thus passing on inflation to consumers. Since crude oil naturally loses its viscosity over time, it becomes unusable when stored for over six months. In addition, the transportation sector has an average inventory turnover ratio of 10.45, or roughly 35 days. We hypothesized that since most crude oil becomes unusable after 6 months, any effect of an increase in Energy Commodities should be practically negligible after six months and most effects should have diminished within about the first month since the largest sector consuming petroleum products is transportation, which has an a turnover period of about a month. The time and degree of the effect are analyzed by determining the correlation between Energy Commodities Inflation and Inflation less Energy.

We determined the correlation between the Energy Commodities Inflation and Inflation less Energy Commodities in subsequent periods (Energy Commodities Inflation(t) and Inflation less Energy (t+n)) up to 6 months, at which point the effect of Energy inflation is practically zero. The correlation (beta) and R-squared for t=0 were 0.0171 and 4.9% respectively, decreasing as the time interval grew. Interestingly, beta decreased drastically after the first month and decreased in an approximately linear fashion until it reached zero at around the 6-month interval.

**Table 2.** Summary statistics for correlation between Energy Commodities Inflation and Inflation less Energy Commodities

Period (month)	Beta	Change in Inflation (Less Energy Commodities)	Impact
0	0.0171	0.04%	12%
1	0.0109	0.03%	8%
2	0.00558	0.01%	4%
3	0.0048	0.01%	3%
4	0.00431	0.01%	3%
5	0.00322	0.01%	2%
6	-0.003	-0.01%	-2%

On average, Energy Commodities fluctuate by 2.53% monthly. Multiplying it with beta gives the expected change (in inflation) per month. As a percentage of the average monthly inflation, the Indirect effect drops from 8% in a 1-month delay to 2% in a 5-month delay.

Note, however, that a possible source of error in this methodology is that it does not take into account the autocorrelation in inflation (that is, the correlation between inflation itself in subsequent periods).

## Discussion and Future Directions

It has been shown that Energy Commodities have a surprisingly large impact on inflation. About 30% of monthly movement in inflation is caused by fluctuations in Energy Commodities due to their volatile nature; About another 4% of movement is transmitted through indirect effects within 6 months.

Despite its relatively small weight, Energy Commodities have a large impact on inflation as it is one of the most volatile components of the CPI, prone to changes in a variety of factors, including seasonal trends, and geopolitical tension.

The connection between Energy Commodities prices and inflation can be of great utility when predicting inflation in the medium term. Under the Fed's dual mandate, namely stable employment and stable prices, understanding and quantifying the connection between Energy Commodities can develop more accurate forecasts of inflation and potentially of The Federal Reserve's policies. Possible direction furthering research in this direction can involve investigating and modeling the Fed's interest rate policies based on Energy inflation (especially crude oil).

## Conclusion

This study delves into the relationship between rising energy commodity prices and inflation. The analysis reveals a surprisingly substantial impact of energy commodities on inflation, both directly through their volatile nature and indirectly through the pass-through effects on related sectors, notably transportation and industrial production. Despite their modest weight in the Consumer Price Index, energy commodities significantly contribute to inflationary pressures, highlighting the need for understanding their role in economic dynamics. While quantifying the impacts of Energy Commodities on inflation, this research suggests potential avenues for refining inflation forecasts and predicting monetary policies. The findings prompt further exploration into the predictive power of energy commodity fluctuations and their implications on shaping Fed policies.

## Acknowledgments

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## References

- Baba, C., & Lee, J. (2022). Second-round effects of oil price shocks -- implications for Europe's inflation outlook. *IMF Working Papers*, 2022(173), 1. <https://doi.org/10.5089/9798400219351.001>
- Gómez-Loscos, A., Gadea, M. D., & Montañés, A. (2012). Economic growth, inflation and oil shocks: Are the 1970s coming back? *Applied Economics*, 44(35), 4575–4589. <https://doi.org/10.1080/00036846.2011.591741>
- Igan, D., Kohlscheen, E., Nodari, G., & Rees, D. (2022, May 18). *Commodity market disruptions, growth and inflation*. The Bank for International Settlements. <https://www.bis.org/publ/bisbull54.htm>
- The Investopedia Team. (n.d.). *What causes inflation?*. Investopedia. <https://www.investopedia.com/ask/answers/111314/what-causes-inflation-and-does-anyone-gain-it.asp#:~:text=Cost%2DPush%20Inflation&text=As%20a%20result%2C%20the%20added,they're%20major%20production%20inputs>



- Neely, C. J. (n.d.). *How much do oil prices affect inflation?*. Economic Research - Federal Reserve Bank of St. Louis. <https://research.stlouisfed.org/publications/economic-synopses/2015/05/11/how-much-do-oil-prices-affect-inflation/>
- Prices & inflation*. Prices & Inflation | U.S. Bureau of Economic Analysis (BEA). (n.d.). <https://www.bea.gov/resources/learning-center/what-to-know-prices-inflation>
- U.S. Bureau of Labor Statistics. (2024, February 13). *Consumer price index for all urban consumers: All items in U.S. city average*. FRED. <https://fred.stlouisfed.org/series/CPIAUCSL>
- U.S. Bureau of Labor Statistics. (n.d.). *CPI Handbook of Methods Appendix 2: Content of CPI entry level items*. U.S. Bureau of Labor Statistics. <https://www.bls.gov/cpi/additional-resources/entry-level-item-descriptions.htm>
- U.S. Department of Labor. Frequently Asked Questions - United States Department of Labor. (n.d.). [https://webapps.dol.gov/dolfaq/go-dol-faq.asp?faqid=98&theagencyid=BLS&faqtop=Agencies%2B%26%2BOffices#:~:text=Answer%3A%20The%20CPI%20measures%20the,%2C%20\(CPI%2DW](https://webapps.dol.gov/dolfaq/go-dol-faq.asp?faqid=98&theagencyid=BLS&faqtop=Agencies%2B%26%2BOffices#:~:text=Answer%3A%20The%20CPI%20measures%20the,%2C%20(CPI%2DW)
- U.S. Energy Information Administration - EIA - independent statistics and analysis. Use of oil - U.S. Energy Information Administration (EIA). (n.d.). <https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php>