Projecting commodity prices for a post-transition renewable energy economy

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Abstract

The most consistent trend in the economics of renewable energy, consisting of solar, wind, and hydroelectric energy, is that the costs of renewable energy decline as more renewable energy generation is brought online. These trends are thanks to the declining costs of producing the needed technology, their growing efficiency, their greater degrees of reliability, and their lack of need for the continuous input of a scarce, volatile source of energy. Recent research by Credit Suisse and the Oxford Smith School of Sustainability and Entrepreneurship suggests renewable energy is on track to reach a levelized cost of $0.01 kWh by 2025 in some places and $0.005 kWh by 2030 worldwide, a level that would represent some of the cheapest energy production in modern history. This paper seeks to examine the potential macroeconomic effects of replacing all energy needs met by oil with these significantly reduced prices of energy and uses commodity price data collected by the World Bank for constructing a model to estimate these impacts. The ultimate findings show the falling cost of renewables is expected to cause widespread reductions in price of all other commodity goods, a development with significant implications for the overall cost of production for any economies which transition to renewable energy.

Introduction

The most consistent tendency observed regarding renewable energy is how the cost of energy produced by sources like photovoltaic solar, wind turbines, and hydroelectric power continue to decline as greater quantities of renewable energy become available. Renewable energy has already, as of 2020, become cheaper in their price per megawatt and kilowatt hour and has continued declining since. These trends

have inspired analyses by researchers at Credit Suisse and Oxford's Smith School of Enterprise and Environment which show these declines will continue to accelerate as renewable energy adoption increases and this rate of adoption is projected to bring the cost of renewable energy per kilowatt hour to less than half a cent in US dollars by 2030. If renewable energy is, as this research suggests, expected to drop to the lowest recorded prices in human history, then it is necessary to ask how these proven trends will impact the price of other critical commodities which are essential to our modern global economy. This paper will provide a general estimate of this impact by using the commodity price data in the World Bank Pink Sheet to construct a data model which uses the average price of oil per barrel as a proxy for the future price of renewable energy.

The foundation of this work, which is the declining costs of renewable energy, is a product of the proven inverse correlation between overall renewable generating capacity and the levelized cost of energy (LCoE) produced by renewable means which is illustrated in Figure 1. As this data shows, increasing renewable energy generation capacity has consistently led to a reduction in the overall cost of that energy thanks to increases in the overall supply of steadily cheaper to produce electricity. According to the work conducted by Credit Suisse and the Smith School, this proven relationship between growing capacity and decreasing cost is only just beginning to realize its potential and increasing capacity, driven by the demands of climate change, is expected by Credit Suisse to decrease the average cost of electricity to an average of $5 per megawatt hour by 2030 and as per the Smith School team reach a range of $2 to $40 per megawatt hour for photovoltaic solar by 2050.[1] The Smith School study further

[1] Betty Jiang, Maheep Mandloi, Richard Carlson, Matt Hope, Mike Ziffer, Nick Campanella, Ariel Rosa, John Walsh, Andrew Kuske, Horace Tse, Sang Uk Kim, Vanessa Quiroga, John Roberts, Danielle Chigumira, Tayo Okusanya, Dan Oppenheim, Mark Freshney, Christopher Leonard, Curt Woodworth, Randy Abrams, Alex Liu, "Treeprint – US Inflation Reduction Act – A tipping point in climate action", Credit Suisse, (Zurich: 2022), 5; Rupert Way, Matthew C. Ives, Penny Mealy, J. Doyne Farmer, "Empirically grounded technology forecasts and the energy transition", Joule 6, September 21, 2022, 2058-59, 2066

estimates the global economy will save approximately $12 trillion dollars, a figure which includes the cost of transition, thanks to these declining costs consistently outpacing economic projections.[2]

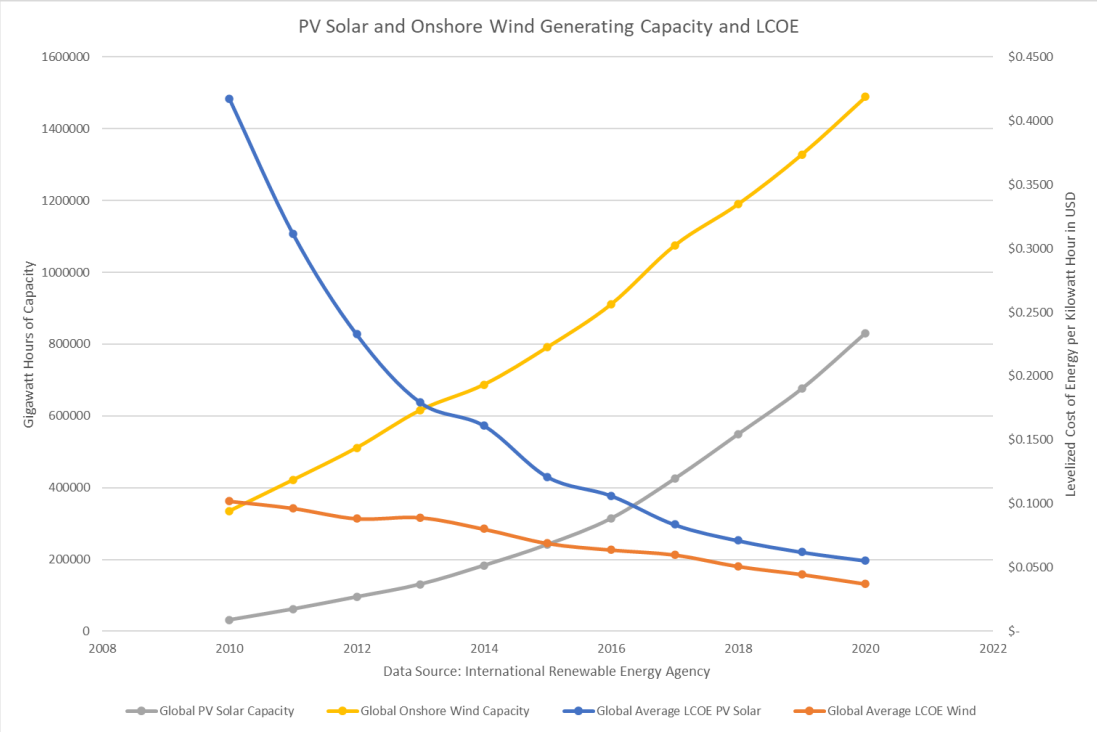


Figure 1: Photovoltaic and Onshore Wind Generating Capacity vs Levelized Cost of Energy per kWh

These projected decreases and cost savings are unlikely to remain confined to energy costs alone. This paper and the most effective method for estimating this impact on critical commodities is to use the price of oil as a proxy for the price of renewable energy. There are three main reasons why oil will be used as a proxy. First, oil will have to be replaced by renewable energy in any net zero emissions or other similar energy transition economy which can be simulated by reducing the price of oil per barrel in the projection model to the estimated cost of renewable electricity in kilowatt hours. Second, oil is a major source of energy for transportation, being responsible for providing an estimated 90% of all energy used by road transportation as of 2023, 94.5% of all energy used for maritime shipping as of 2021, and 99.9% of all energy used for air travel as of 2023, which means the price of oil or whatever

[2] Rupert Way et al, "Empirically grounded technology forecasts and the energy transition", 2071

replaces oil has significant pass-through impacts on the price of all other commodities which require any amount of modern transportation to produce or deliver to market.[3] Third, and finally, the data for oil prices and other key commodities is available on a long enough historical timescale to effectively model while electricity market data is less useful thanks to how utilities often blend the price of renewable electricity in with other sources of electricity.[4] The price of oil, by contrast, operates in a highly globalized market with a fairly consistent baseline price and six decades of monthly historical data. This makes it much easier to assess the relationship between any changes in the price of this specific energy source and the price of other major commodities.

This argument will be presented in four parts. The first section will examine the literature on the clear links between rapid increases in the price of oil and price inflation. The second section will further examine the relationships between oil price volatility and the volatility of other commodity prices based on data in the World Bank Pink Sheet with further historical context explaining the role of energy supply in creating the volatile conditions that have been the norm for oil prices since 1973. The third section will then show the results of the multiple linear and multi-vector autoregression projections of commodity prices conducted in the R programming language which are based on the prices predicted by Credit Suisse and the researchers at the Oxford Smith School and commodity price data procured from the World Bank Pink Sheet. The fourth and final section will conclude this analysis with a summation and final argument regarding the implications of these findings and the need for further research on the larger macroeconomic effects of the consistent decline in the cost of renewably generated electricity which will continue to unfold as capacity increases.

[3] IEA (2023), World Energy Outlook 2023, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2023, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A) , 264-265; "Net Zero Roadmap: A Global Pathway to Keep the 1.5˚ C Goal in Reach", International Energy Agency (Paris: 2023), 93-94; "Energy Efficiency of Ships", Marine Environment Protection Committee, International Maritime Organization, September 10, 2022, 5; Ian Shine, "What is sustainable aviation fuel and why are only 0.1% of flights powered by it?", World Economic Forum, November 29, 2023, https://www.weforum.org/agenda/2023/11/what-is-sustainable-aviation-fuel/

[4]

Oil and Inflation

Macroeconomically, energy price shocks in general and oil price shocks in particular have long been associated with economic contractions and recessions going back to Knut Anton Mork and Robert E. Hall's 1980 research into the relationship between energy price shocks and recessionary conditions experienced throughout the 1970s.[5] The Oil Shock of 1973 is particularly held up as the best example of this tendency for reasons illustrated by Luis Aguiar-Conraria and Yi Wen. According to Aguiar-Conraria and Wen, the 1974 to 1975 recession caused by the 1973 Oil Shock was especially deep in terms of declining economic activity and reduced investment thanks to the multiplier-accelerator effect of the sharp increase in the price of oil following the 1973 Embargo.[6] This multiplier-accelerator effect was thanks to how increases in the price of oil had further knock-on effects for the rest of the US economy thanks to how central oil was as a source of energy. Lutz Kilian further argues what made the declines experienced in 1973 especially sharp, macroeconomically, was because they exacerbated existing discrepancies between the demand for oil, the available supply, and related secondary consequences.[7]

According to Kilian, these patterns of escalating deprivation are thanks to how oil prices have both direct and indirect effects on economic conditions. In the immediate term, as per Kilian, oil price shocks cause what is effectively an adverse demand shock in terms of aggregate supply & demand while also increasing the cost of domestic output which effectively causes a further supply shock.[8] One consistent result of these patterns is increasing inflation, which has also been observed by Todd E. Clark and

[5] Knut Anton Mork and Robert E. Hall, "Energy Prices, Inflation, and Recession, 1974-1975", *The Energy Journal*, Vol. 1, No. 3 (July 1980), 31-32

[6] Luis Aguiar-Conraria and Yi Wen, "Understanding the Large Negative Impact of Oil Shocks", *Journal of Money, Credit and Banking,* Vol. 39, No. 4 (June 2007), 925-927

[7] Lutz Kilian, "The Economic Effects of Energy Price Shocks", *Journal of Economic Literature*, Vol. 46, No. 4 (2008), 871

[8] Lutz Kilian, "Oil Price Shocks: Causes and Consequences", *Annual Review of Resource Economics,* Vol. 6 (2014), 141

Stephen J. Terry.[9] Such shocks have further indirect consequences, according to Kilian, which often take the form of the re-allocation of labor and capital away from oil and energy-dependent forms of economic activity during times of positive price shocks coupled with increased economic uncertainty which further discourages new spending and encourages monetary responses intended to mitigate the underlying, direct consequences.[10]

Kilian and Robert J. Vigfusson further examined this relationship on a larger time scale, showing that five out of eight recessions experienced by the US economy after the 1973 Oil Shock saw oil price rises precede and influence subsequent economic contractions.[11] Though their work shows variation in terms of the time between positive price shock and recessionary tendencies, the overall pattern is of positive oil price increases preceding economic contraction. Further supporting this tendency is research by Khaled Mokni, Mohamed Sahbi Nakhli, Othman Mnari, and Khemaies Bougatef which demonstrates a consistent causal relationship between oil price shocks and declines in G7 stock markets.[12] They argue the three main transmission channels for translating oil price increases into stock market declines are through price changes impacting investor valuations of stock prices, how oil prices impact overall aggregate demand and investor confidence, and finally the tendency for higher oil prices to drive price inflation.[13] Sohrab Rafiq's research on oil price shocks and inflation in the United Kingdom provides

[9] Kilian, "Oil Price Shocks: Causes and Consequences", 142; Todd E. Clark and Stephen J. Terry, "Time Variation in the Inflation Passthrough of Energy Prices", *Journal of Money, Credit and Banking,* Vol. 42, No. 7 (October 2010), 1419-1420

[10] Kilian, "Oil Price Shocks: Causes and Consequences", 143-145

[11] Lutz Kilian and Robert J. Vigfusson, "The Role of Oil Price Shocks in Causing U.S. Recessions", *Journal of Money, Credit and Banking,* Vol. 49, No. 8, (December 2017), 1750-1751

[12] Khaled Mokni, Mohamed Sahbi Nakhli, Othman Mnari, and Khemaies Bougatef, "Symmetric and Asymmetric Causal Relationship between Oil Prices and G7 Stock Markets: A Boostrap Rolling-Window Granger Causality Test", *Journal of Economic Integration*, Vol. 36, No. 4 (December 2021), 719-721

[13] Khaled Mokni et al 720

further evidence for this tendency, show this has held true even though monetary and supply-side innovations have mitigated the impact of such shocks beginning in the 1980s.[14]

This tendency is a consequence of what is known as the pass-through effect, an economic phenomenon where changes in the price of one good are passed on to all other related goods.[15] Oil, thanks to its use as an energy source for producing electricity and its overwhelming use in transportation, is a common example of the pass-through effect in action. The reason why energy of all kinds has such a pass-through impact on the price of other goods is because the demand for energy, according to Kilian, is inelastic.[16] They argue this is because workers still need to drive to work, heat their homes, and pay for electricity which means they have little choice but to accept higher energy prices when they happen.[17] The same also holds true for businesses and other economic operations who need to pay for electricity to operate equipment and fuel for vehicles to move necessary goods. Such pass-through consequences are not unique to oil. As was argued by Christopher L. Gilbert, primary commodities generally possess such an impact thanks to how they impact consumers directly, through their purchasing of primary commodities, and indirectly, through how they impact the price of manufactured goods which require primary commodities to produce.[18]

This has remained true of energy in general and oil, specifically, even as the impact of oil on macroeconomic conditions has declined over time. According to Shiu-Shen Chen, the increasingly diverse energy mix of modern economies, increasing sophistication of monetary mechanisms, and changing labor markets have mitigated this effect somewhat fluctuations in the price of oil and cost of

[14] Sohrab Rafiq, "What Do Energy Prices Tell Us About UK Inflation", *Economica*, Vol. 81, No. 322 (April 2014), 293-294
[15] Shiu-Sheng Chen, "Revisiting the Inflationary Effects of Oil Prices", *The Energy Journal*, Vol. 30, No. 4 (2009), 142-143
[16] Kilian, "The Economic Effects of Energy Price Shocks", 874-875
[17] Ibid
[18] Christopher L. Gilbert, "Primary Commodity Prices and Inflation", *Oxford Review of Economic Policy*, Vol. 6, No. 4 (Winter 1990), 77-78

energy still have considerable impact on broader macroeconomic conditions.[19] Munechika Katayama, similarly, points to the same explanations for why oil shocks, specifically, have seen decreasing impact on economic conditions. Even though oil's impact on macroeconomic conditions has declined, Katayama still concedes that ten out of the eleven economic recessions experienced by the United States at time of publication in 2013 were preceded by significant shocks in the oil market.[20] The key example both cite is the case of the 2008 Financial Crisis, an economic contraction which was preceded by an oil price shock that began in 2006. As Chen and Katayama argue, the US and larger global economy did not truly enter crisis conditions until 2008 when the subprime mortgage bubble popped.

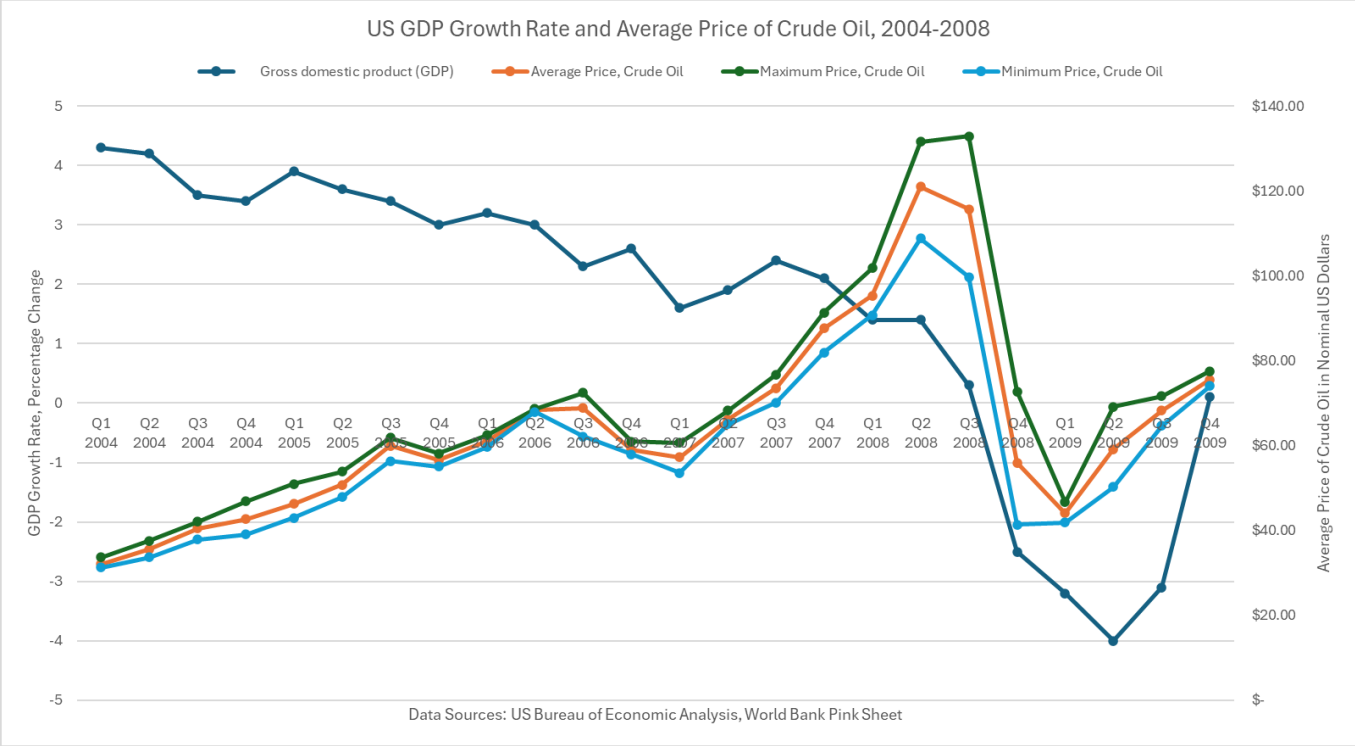


Figure 2: US GDP Growth Rate, 2004-2009

Such mitigating factors did not, however, eliminate the impact of oil price shocks on economic growth. The case of 2006 cited by Chen and Katayama does show a brief recession in the United States following

[19] Chen 154

[20] Munechika Katayama, "Declining Effects of Oil Price Shocks", *Journal of Money, Credit and Banking,* Vol. 45, No. 6 (September 2013), 977-979

a sharp price increase brought on by disruptions to oil supplies from the Gulf of Mexico, as shown in Figure 1. What Chen and Katayama do not, however, address is how the retreat in oil prices shortly after the 2006 spike mirrored a brief rebound in US economic activity, as shown in Figure 1, which is in line with the larger pattern of the direct and indirect consequences of oil price fluctuations on larger macroeconomic conditions. Mahmoud A. El-Gamal and Amy Myers Jaffe further argue a similar speculative bubble had developed within oil futures which pushed a surge in crude oil prices, as shown in Figure 3, that imploded following the onset of the 2008 Global Financial Crisis.[21] Though oil and its fortunes did not directly cause the 2008 Financial Crisis, instability in oil markets nonetheless contributed to macroeconomic instability during this crisis through this combination of escalating financial speculation and the consistent impacts of increased oil prices on economic activity.

Overall, the literature is quite consistent in arguing that oil prices and oil supplies have a significant pass-through impact on price inflation across the economy. The only major points of disagreement tend to be over magnitude rather than nature or kind. Even those who argue futurization has reduced the impact of oil volatility on market conditions still concede the price of oil retains major influence over macroeconomic conditions and as el-Gamal and Jaffe demonstrate this volatility is further encouraged by financial speculation. This consensus reflects the underlying reality that oil's role as a major energy provider and how dependent, from an energy perspective, much of the world is on reliable oil supplies. It will also need to be totally replaced by renewable alternatives if the world is to have any serious chance of meeting the IPCC's recommended emissions reductions. This all makes oil a highly useful proxy for understanding the potential macroeconomic conditions of a renewable energy-dominated world.

[21] Mahmoud A. el-Gamal and Amy Myers Jaffe, *Oil, Dollars, Debt, and Crises: The Global Curse of Black Gold*, Cambridge University Press (Cambridge: 2010), 57-59

Oil and Price Volatility

The conclusions present in the literature on the topic are consistent with macroeconomic data on commodity prices. This is shown through the analysis of historical pricing data in the World Bank Pink Sheet from 1960 to 2023 which demonstrates the strong relationship between the cost of oil, and by extension the cost of energy, and the price of all other commodities. As is shown below in Table 1, oil has a very strong correlative relationship with all other globally-traded commodities. The main exceptions which exist in this data are for commodities like Mexican shrimp and plywood. Even these examples show some relationship to the fluctuations in the price of oil though they are weaker than critical industrial commodities like nickel, iron ore, and copper or agricultural staples like sorghum, maize, and wheat.

Commodity Name	Crude oil, average ($/bbl)
Crude oil, average ($/bbl)	1
Crude oil, Brent ($/bbl)	0.999459425
Crude oil, Dubai ($/bbl)	0.998799464
Crude oil, WTI ($/bbl)	0.996099346
Platinum ($/troy oz)	0.936515294
Copper ($/mt)	0.913774772
Barley ($/mt)	0.910739444
Iron ore, cfr spot ($/dmtu)	0.908440301
Liquefied natural gas, Japan ($/mmbtu)	0.905578679
Lead ($/mt)	0.894774748
Soybeans ($/mt)	0.88992676
Sorghum ($/mt)	0.884712564
Silver ($/troy oz)	0.881135213
Wheat, US HRW ($/mt)	0.880256659
Soybean meal ($/mt)	0.879544252
Maize ($/mt)	0.87904798
Groundnut oil ** ($/mt)	0.871171474
Soybean oil ($/mt)	0.865452961
Gold ($/troy oz)	0.85964718
TSP ($/mt)	0.857915481
Rubber, RSS3 ($/kg)	0.855801152
Tin ($/mt)	0.848793012
Urea ($/mt)	0.846977072
DAP ($/mt)	0.845367612
Palm oil ($/mt)	0.838372949
Tea, Colombo ($/kg)	0.834173031
Orange ($/kg)	0.83031663
Chicken ** ($/kg)	0.827982481
Beef ** ($/kg)	0.826132165
Tea, avg 3 auctions ($/kg)	0.824310624
Wheat, US SRW ($/mt)	0.819536501
Fish meal ($/mt)	0.816999056
Potassium chloride ** ($/mt)	0.81487066
Banana, US ($/kg)	0.813577871
Nickel ($/mt)	0.811211369
Rice, Thai A.1 ($/mt)	0.809381014
Lamb ** ($/kg)	0.800221856
Tobacco, US import u.v. ($/mt)	0.798188156
Logs, Cameroon ($/cubic meter)	0.795463511
Zinc ($/mt)	0.793773343
Aluminum ($/mt)	0.792115376
Sawnwood, Malaysian ($/cubic meter)	0.788797537
Rice, Thai 25% ($/mt)	0.786102733
Coal, South African ** ($/mt)	0.778571992
Rice, Thai 5% ($/mt)	0.770960579
Sawnwood, Cameroon ($/cubic meter)	0.768931014
Rubber, TSR20 ** ($/kg)	0.76305572
Tea, Mombasa ($/kg)	0.760972006
Sunflower oil ($/mt)	0.749301452
Coconut oil ($/mt)	0.744771557
Rapeseed oil ($/mt)	0.738488353
Logs, Malaysian ($/cubic meter)	0.737331895
Natural gas index (2010=100)	0.729961931
Natural gas, Europe ($/mmbtu)	0.718431283
Coal, Australian ($/mt)	0.715495757
Natural gas, US ($/mmbtu)	0.697525685
Phosphate rock ($/mt)	0.697444041
Sugar, US ($/kg)	0.686288852
Cotton, A Index ($/kg)	0.666705251
Tea, Kolkata ($/kg)	0.655116282
Groundnuts ($/mt)	0.651217065
Coffee, Arabica ($/kg)	0.647060225
Cocoa ($/kg)	0.641691767
Palm kernel oil ($/mt)	0.63210279
Sugar, world ($/kg)	0.594108508
Shrimps, Mexican ($/kg)	0.553200023
Rice, Viet Namese 5% ($/mt)	0.542831365
Banana, Europe ($/kg)	0.49211107
Plywood (cents/sheet)	0.467079857
Sugar, EU ($/kg)	0.386950706
Coffee, Robusta ($/kg)	0.305311046

Table 1: Correlations Between Oil Price per Barrel and Other Commodities, World Bank Pink Sheet

These patterns are consistent with those present in US CPI price data for gasoline as shown in Table 2 below. This data shows correlations of comparable significance between gasoline, a major oil product, and other consumer goods as those between crude oil and other commodities in the World Bank Pink Sheet.

Consumer Good	Gasoline, unleaded regular
Fuel oil per gallon	0.978335469
Bread, white per lb.	0.875411429
Electricity per KWH	0.874724272
Flour, all purpose	0.873240417
Utility (piped) gas	0.852406956
Milk per gal.	0.84805782
Bacon, sliced, per lb.	0.845612839
Ground chuck, per lb.	0.832593582
Rice per lb.	0.826577328
Chicken, whole, per lb.	0.822542967
Eggs per dozen	0.810590099
Ground beef, per lb.	0.807240356
Uncooked ground beef, per lb.	0.694756711
Chicken breast, boneless, per lb.	0.56034088
Bananas, per lb.	0.460404862

Table 2: US CPI Correlations of Gasoline with Other Goods, US Bureau of Labor Statistics

This relationship is also one which is especially strong compared to other commodities. As shown in Table 3 below, all forms of crude oil tracked by the World Bank Pink sheet were three out of the seven commodities with strong correlations with at least two thirds of all other commodities and further had no weak correlative relationships with any other commodity. The only other commodities with similarly strong relationships to the movement of global prices are agricultural staples like soybeans, groundnut oil, sorghum, and soybean oil.

Commodity Name	Percentage of Strong Correlations	Percentage of Weak Correlations
Soybeans ($/mt)	73%	0%
Groundnut oil ** ($/mt)	71%	0%
Crude oil, Brent ($/bbl)	69%	0%
Sorghum ($/mt)	69%	0%
Crude oil, average ($/bbl)	67%	0%
Crude oil, Dubai ($/bbl)	67%	0%
Soybean oil ($/mt)	66%	0%
Barley ($/mt)	66%	1%
Copper ($/mt)	66%	3%
Maize ($/mt)	64%	0%
Wheat, US HRW ($/mt)	64%	0%
Lead ($/mt)	64%	1%
Gold ($/troy oz)	63%	4%
Soybean meal ($/mt)	61%	0%
Iron ore, cfr spot ($/dmtu)	61%	1%

Table 3: Percentage of Strong and Weak Correlations for Strongly Correlated Commodity Prices

The same holds true of the relationship between the volatility of the price of oil and the volatility of all other commodity prices. As is shown in Table 4 below, crude oil's volatility exerts influence on the volatility of all other prices. This pattern is consistent with the data in Table 1 showing that oil's prices have a significant impact on the price of all other globally traded commodities. Exceptions to this pattern, like Mexican shrimp, further reinforce how critical oil is in shaping the stability of prices and actual prices of globally goods.

Commodity Name	Crude oil, average ($/bbl)
Crude oil, average ($/bbl)	1
Crude oil, Brent ($/bbl)	0.998728
Crude oil, Dubai ($/bbl)	0.997544
Platinum ($/troy oz)	0.879976
Iron ore, cfr spot ($/dmtu)	0.832821
Copper ($/mt)	0.783871
Lead ($/mt)	0.77758
TSP ($/mt)	0.764494
Wheat, US HRW ($/mt)	0.74642
Nickel ($/mt)	0.699161
Phosphate rock ($/mt)	0.691055
Aluminum ($/mt)	0.666941
Urea ($/mt)	0.661837
Palm oil ($/mt)	0.659533
Soybean oil ($/mt)	0.633523
Rubber, RSS3 ($/kg)	0.63023
Potassium chloride ** ($/mt)	0.626081
Zinc ($/mt)	0.607436
Soybeans ($/mt)	0.597388
Natural gas, US ($/mmbtu)	0.585183
Beef ** ($/kg)	0.581749
Tin ($/mt)	0.56851
Gold ($/troy oz)	0.55218
Orange ($/kg)	0.548715
Tea, avg 3 auctions ($/kg)	0.544289
Tea, Kolkata ($/kg)	0.534598
Tea, Mombasa ($/kg)	0.522301
Maize ($/mt)	0.506994
Coconut oil ($/mt)	0.5009
Rice, Thai 5% ($/mt)	0.489596
Soybean meal ($/mt)	0.479491
Sugar, EU ($/kg)	0.472978
Tea, Colombo ($/kg)	0.472459
Groundnut oil ** ($/mt)	0.461559
Chicken ** ($/kg)	0.461402
Silver ($/troy oz)	0.444936
Natural gas, Europe ($/mmbtu)	0.420965
Tobacco, US import u.v. ($/mt)	0.297352
Shrimps, Mexican ($/kg)	0.272154
Cocoa ($/kg)	0.271407
Cotton, A Index ($/kg)	0.242969
Sawnwood, Malaysian ($/cubic meter)	0.20743
Banana, US ($/kg)	0.206299
Coffee, Arabica ($/kg)	0.141512
Logs, Malaysian ($/cubic meter)	0.128591
Sugar, US ($/kg)	0.082323
Sugar, world ($/kg)	-0.00687
Coffee, Robusta ($/kg)	-0.00961

Table 4: Correlations Between Volatility of Oil Price and Other Pink Sheet Commodity Prices

This consistent pattern of energy volatility driving the volatility of other commodities and goods does, however, seem to be a feature that is only consistent beginning after 1971 and from 1960 to 1971 oil's prices, volatility, and availability were far more predictable than has been the case since. This period is often known as the tail end of what has long been celebrated by economists and historians as the Golden Age of Capitalism, an era characterized by sustained economic growth, widespread prosperity, and a more stable economy than has existed since the end of this period.[22] From 1960 to 1971, the price of oil is far more decoupled from the price of other commodities as shown in Table 5 with only 9% of the 55 commodities tracked during this period being strongly correlated with the price of oil, two of which are quite understandably the prices of the Brent and Dubai crude varieties of oil. One explanation for why this is the case, from a pricing standpoint, is the far greater degree of stability in the price of oil, as shown in the stark contrast between the behavior of commodity prices in the price of oil as shown in Figures 3 and 4 These prices were sustained even in the face of growing demand for and consumption of oil products, as shown in Figure 5, in contrast to the norm which developed following the end of Bretton Woods, the Nixon Shock, and the Tehran Agreement of 1971. In short, the price of oil had far less impact on movements in other commodities when its price was consistently low with a longer-term downward trend thanks to increasing capacity.

[22] Jeffry R. Frieden, *Global Capitalism: Its Fall and Rise in the Twentieth Century*, WW Norton & Co, (New York & London: 2006), 278-280

Commodity Name	Crude oil, average ($/bbl)
Crude oil, average ($/bbl)	1
Crude oil, Brent ($/bbl)	1
Crude oil, Dubai ($/bbl)	1
Tobacco, US import u.v. ($/mt)	0.989322778
Coal, Australian ($/mt)	0.989322778
Aluminum ($/mt)	0.629696987
Tea, Colombo ($/kg)	0.622598159
Tea, avg 3 auctions ($/kg)	0.582963865
Tea, Mombasa ($/kg)	0.515183214
Urea ($/mt)	0.514422046
DAP ($/mt)	0.512718518
Plywood (cents/sheet)	0.421725773
Tea, Kolkata ($/kg)	0.408442337
Sugar, world ($/kg)	0.389957164
Rubber, TSR20 ** ($/kg)	0.38892845
Phosphate rock ($/mt)	0.362634861
Soybean oil ($/mt)	0.292833598
Groundnut oil ** ($/mt)	0.237624026
Rubber, RSS3 ($/kg)	0.235594267
Palm oil ($/mt)	0.23539232
Shrimps, Mexican ($/kg)	0.230305887
Sugar, US ($/kg)	0.226753731
Chicken ** ($/kg)	0.179968508
Wheat, US SRW ($/mt)	0.099064693
TSP ($/mt)	0.000182851
Zinc ($/mt)	-0.017375119
Coffee, Robusta ($/kg)	-0.111014369
Natural gas, Europe ($/mmbtu)	-0.169825801
Soybeans ($/mt)	-0.182370143
Coffee, Arabica ($/kg)	-0.192915417
Tin ($/mt)	-0.193440409
Sugar, EU ($/kg)	-0.208624272
Lamb ** ($/kg)	-0.240676226
Natural gas, US ($/mmbtu)	-0.245857988
Nickel ($/mt)	-0.263083899
Potassium chloride ** ($/mt)	-0.270073121
Maize ($/mt)	-0.299904359
Banana, US ($/kg)	-0.304963884
Soybean meal ($/mt)	-0.316421471
Logs, Cameroon ($/cubic meter)	-0.348568099
Sawnwood, Cameroon ($/cubic meter)	-0.353036105
Barley ($/mt)	-0.370396309
Beef ** ($/kg)	-0.386811629
Banana, Europe ($/kg)	-0.40741508
Orange ($/kg)	-0.422678956
Sorghum ($/mt)	-0.444542522
Coconut oil ($/mt)	-0.47562608
Copper ($/mt)	-0.495685083
Cocoa ($/kg)	-0.495981364
Lead ($/mt)	-0.506148758
Gold ($/troy oz)	-0.546378598
Rice, Thai 5% ($/mt)	-0.59265059
Platinum ($/troy oz)	-0.635782125
Iron ore, cfr spot ($/dmtu)	-0.649245144

Table 5:Average Crude Oil Price Correlations from 1960 to 1971

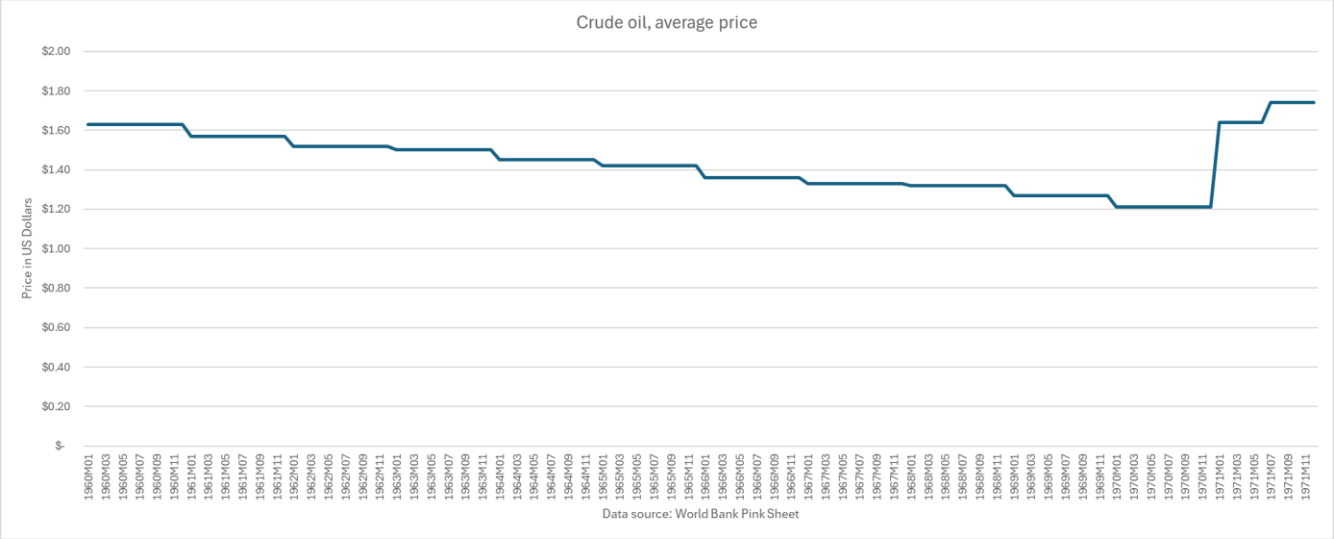


Figure 3: Crude Oil Average Price per Barrel in Nominal US Dollars, 1960-1971

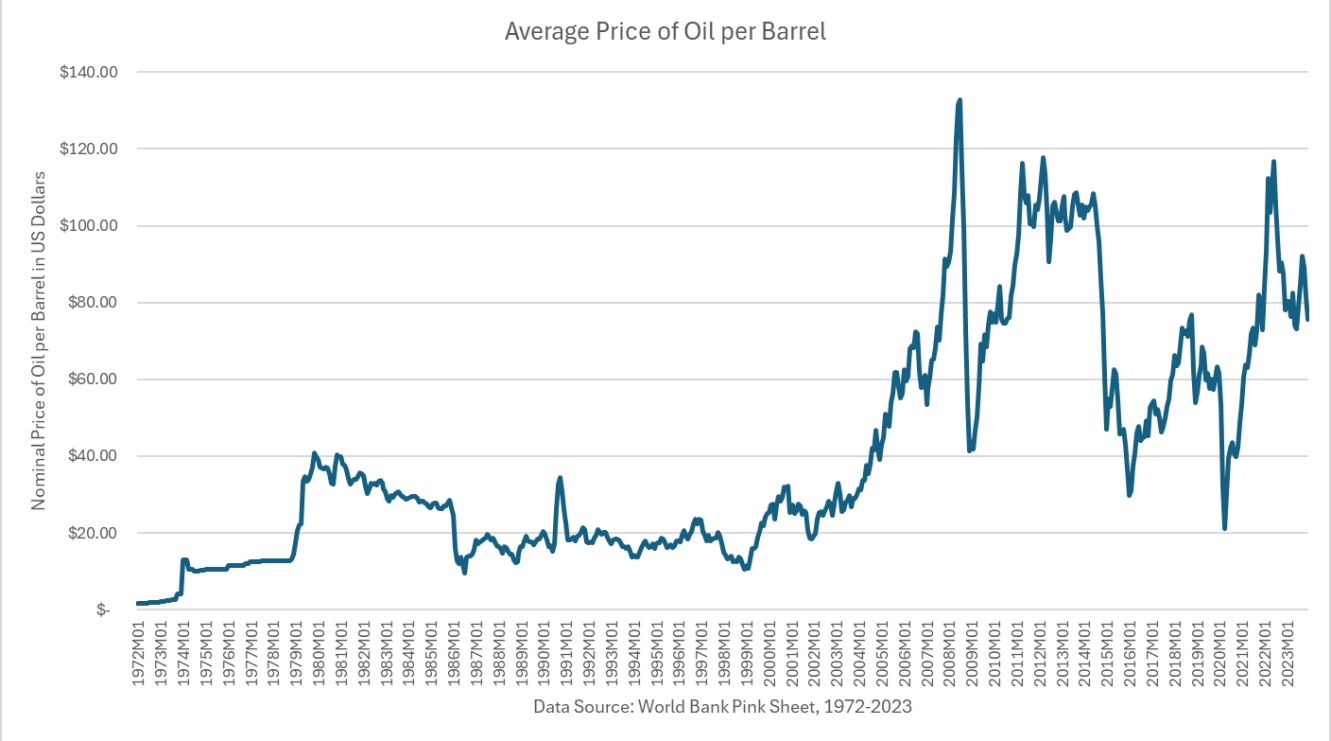


Figure 4: Crude Oil Average Price per Barrel in Nominal US Dollars, 1972-2023

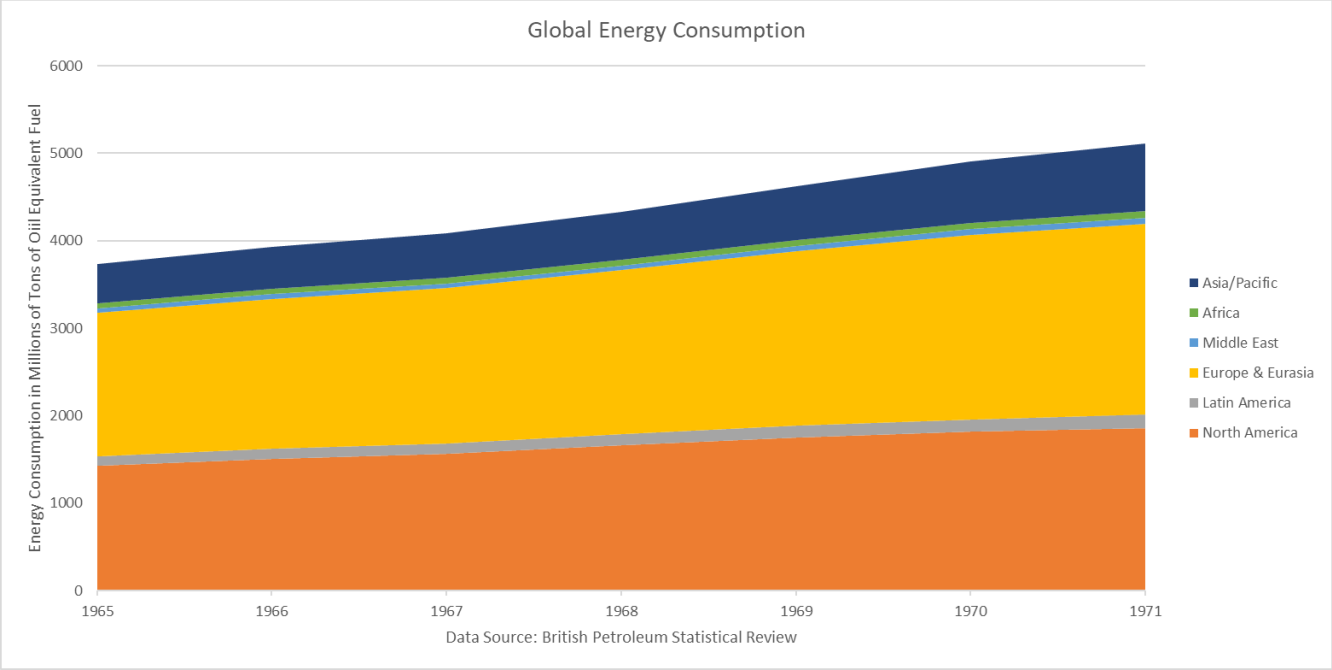


Figure 5: Global Energy Consumption in Millions of Tons of Oil Equivalent Fuel, 1965-1971

It is also essential to recognize the prolonged norm of high oil volatility, shown in Figure 6, which emerged following the 1973 Oil Embargo is the product of a structural global production deficit which ensured supplies would stay unreliable and volatile. As is shown in Figure 7, oil production has consistently been overtaken by oil consumption since 1982. Growth of consumption has also consistently, steadily increased while increases in oil production have fluctuated with far greater volatility and experienced significant, temporary declines. Even though, according to the BP Annual Statistical Review, the difference has been offset by additives and oil alternatives it still leaves a clear pattern of a global economy with a substantial, volatile oil deficit. The only exception was in 2020 when COVID-19 pandemic measures ground oil consumption to a halt, leading to massive overproduction and sending the price of oil futures crashing into the negative for the first time in history on April 20th, 2020.[23] This sudden crash was subsequently followed the so-called return to normal where consumption soared to its highest level since 1976 as oil production lagged behind, restoring the structural deficit. In

[23] "US oil prices turn negative as demand dries up", BBC, April 20, 2020, https://www.bbc.com/news/business-52350082

short, there has never been a sustained period since 1982 where the world's oil demands were totally met or exceeded by oil production and the supply of oil during that same period has been consistently inconsistent. Any improvements in the availability of oil and associated declines in prices were never sufficient to address this underlying deficit or the uncertainties that came with it, thoroughly disincentivizing reducing prices in line with the reduced oil costs of the moment.

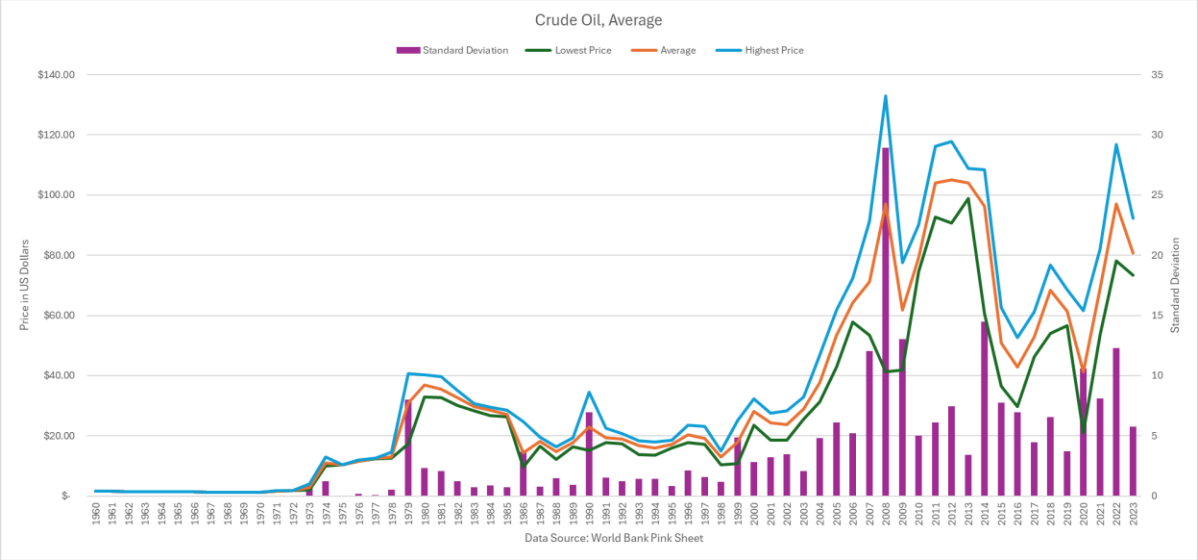


Figure 6: Crude Oil Price Volatility

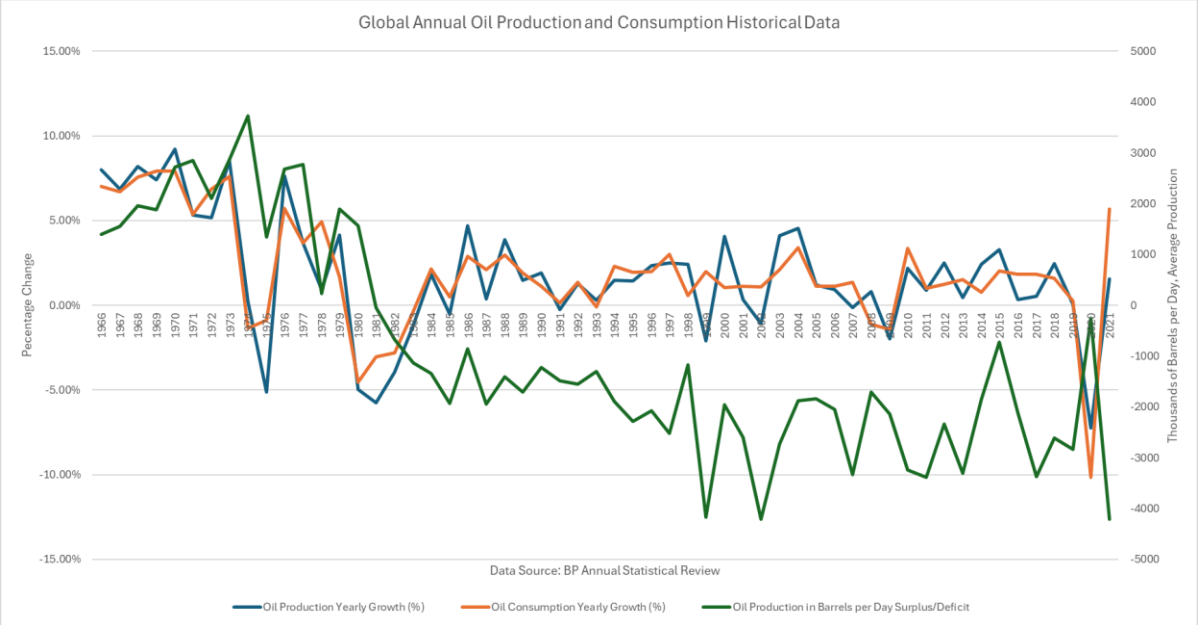


Figure 7: Global Annual Oil Production and Consumption Historical Data

These conditions stand in stark contrast to the available data regarding oil production prior to 1973 as shown in Figure 4 and as asserted Daniel Yergin.[24] This consistent availability of oil was so great that, according to Yergin, a 1967 attempt by OPEC to enact an oil embargo against US and Europe by OPEC as a response to their support for Israel during the Six Day War failed completely and mostly resulted in OPEC members suffering lost revenues due to their export cuts.[25] It was also, as shown earlier in Figures 3 and 5, a period where oil prices consistently declined even as demand increased thanks to oil production's capacity to keep up with the pace of consumption. The result, as argued earlier, was a more prosperous and less volatile macroeconomic environment founded on a consistent structural surplus.

Oil's structural deficit is a development which is also unlikely to occur with renewable energy thanks to significant differences in the production process. Central to renewable energy production is a dynamic where renewable sources produce significantly more energy during specific times of the day, due to the presence of wind, sun, or specific tidal flows, than others. This leads to overproduction of energy which, without proper storage, is wasted.[26] This variable production is mitigated by increasingly sophisticated, inexpensive battery technologies which capture the excess energy during peak production periods that can be used when production tapers off.[27] On the aggregate, this means renewable energy reliably produces more energy than end-users regularly consume.[28] Such production is also, unlike oil-powered technology, not subject to the impact of fluctuations in the supply of a commodity which must be continuously consumed to produce energy. The only regular inputs they need, in the forms of sunlight,

[24] Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, & Power*, Free Press (New York, NY: 2009), 523-524
[25] Yergin 538-540
[26] Wei-Chieh Huang, Qianzhi Zhang, Fengqi You, "Impacts of battery energy storage technologies and renewable integration on the energy transition in the New York State", Advances in Applied Energy, Vol. 9, (Feb. 2023), 2-4, 7-11
[27] Hafeez Ajibade, Chika Oliver Ujah, Kingsley C. Nnakwo, Daramy V.V. Kallon, "Imrovement in battery technologies as panacea for renewable energy crisis", Discover Applied Sciences, (2024), 6:374, 1-3
[28] Melissa C. Lott and Julio Friedmann, "Electrcity Oversupply: Maximizing Zero-Carbon Power to Accelerate the Transition from Fossil Fuels", Columbia Center on Global Energy Policy, October 2020, 1-4

wind, and tidal energy, follow daily patterns which are based on consistent, predictable patterns like day length, tides, and wind systems that are easily mitigated by energy storage technology. This is in stark contrast to oil, which historically has been subject to high degrees of volatility and consistent price fluctuations as shown in Figure 5.

Nothing better illustrates this stark contrast than the 2020 COVID-19 Pandemic. In the same year that oil prices crashed into the negative, renewable energy prices fell below that of oil, coal, and natural gas for the first time ever. [29] This decline, in contrast to oil's crisis, was the product of years of growing capacity, has continued ever since along the same trajectory, and is expected to remain the norm for the foreseeable future.[30] It is, therefore, likely the declining price of renewable energy will, as this new energy source is increasingly adopted and improved, create the ideal conditions for fostering prolonged, sustained declines in the price of all other goods. The lack of volatility, far more reliable supplies of energy, and long-term predictability will present economic actors with a set of conditions with far stronger incentives for cutting prices than keeping prices up as a hedge against future economic instability.

[29] "Majority of New Renewables Undercut Cheapest Fossil Fuel on Cost", IRENA, June 22, 2021, https://www.irena.org/news/pressreleases/2021/Jun/Majority-of-New-Renewables-Undercut-Cheapest-Fossil-Fuel-on-Cost

[30] Betty Jiang, Maheep Mandloi, Richard Carlson, Matt Hope, Mike Ziffer, Nick Campanella, Ariel Rosa, John Walsh, Andrew Kuske, Horace Tse, Sang Uk Kim, Vanessa Quiroga, John Roberts, Danielle Chigumira, Tayo Okusanya, Dan Oppenheim, Mark Freshney, Christopher Leonard, Curt Woodworth, Randy Abrams, Alex Liu, "Treeprint – US Inflation Reduction Act – A tipping point in climate action", Credit Suisse, (Zurich: 2022), 5; Rupert Way, Matthew C. Ives, Penny Mealy, J. Doyne Farmer, "Empirically grounded technology forecasts and the energy transition", Joule 6, September 21, 2022, 2058-59, 2066

Prices in a Renewable World

With these conditions established, it is now time to ask how replacing oil with renewable energy may potentially impact commodity prices. The price of oil per barrel for these projections was reached by multiplying the Credit Suisse estimates of $0.01 and $0.005 per kWh by the average of 1,628.2 kWh of energy contained in a barrel of oil to reach an estimated equivalent value of $17.00 and $8.50 per barrel of oil equivalent energy, respectively.[31] The data presented here was constructed using multiple linear regression predictions adjusted by the least-weighted squares method. The model assessed each commodity first based on their relationship with the average cost of oil to gain an approximate estimate. This estimate was then used for determining an estimated price for all commodities which, through weighted multiple linear regressions, were then further estimated to account for their price relationships which were independent of those they shared with oil. Strongly correlated relationships were incorporated into the regression models in addition to the average cost of oil.[32] These final predictions, labelled rem4 in the documentation, and their upper and lower bounds at a 99.9% confidence interval are presented in Tables 6 and 7.

[31] "Convert energy from boe to kWh", Unit Juggler, https://www.unitjuggler.com/convert-energy-from-boe-to-kWh.html (Accessed September 26, 20240)

[32] R Programming documentation used for constructing the model in this paper is available upon request

Commodity	Electricity at $0.01 per kWh, Mean Estimate	Percentage Change from August 2020 Prices for Mean Estimate	Electricity at $0.01 per kWh, Upper Bound	Percentage Change from August 2020 Prices for Upper Bound	Electricity at $0.01 per kWh, Lower Bound	Percentage Change from August 2020 Prices for Lower Bound
Cocoa ($/kg)	$ 1.97	-16.143%	$ 2.11	-10.4%	$ 1.84	-21.9%
Coffee, Arabica ($/kg)	$ 2.11	-41.513%	$ 2.34	-35.0%	$ 1.87	-48.0%
Coffee, Robusta ($/kg)	$ 1.24	-22.702%	$ 1.34	-16.1%	$ 1.13	-29.3%
Tea, avg 3 auctions ($/kg)	$ 1.90	-39.754%	$ 2.01	-36.2%	$ 1.78	-43.4%
Tea, Colombo ($/kg)	$ 2.59	-23.001%	$ 2.75	-18.3%	$ 2.44	-27.7%
Tea, Kolkata ($/kg)	$ 1.64	-59.772%	$ 1.76	-56.7%	$ 1.51	-62.8%
Tea, Mombasa ($/kg)	$ 1.93	-3.623%	$ 2.04	2.2%	$ 1.81	-9.5%
Coconut oil ($/mt)	$ 689.71	-29.715%	$ 778.50	-20.7%	$ 600.92	-38.8%
Groundnuts ($/mt)	$ 865.06	-55.173%	$ 961.37	-50.2%	$ 768.75	-60.2%
Fish meal ($/mt)	$ 804.31	-45.652%	$ 884.05	-40.3%	$ 724.57	-51.0%
Groundnut oil ** ($/mt)	$ 1,041.88	-44.491%	$ 1,126.70	-40.0%	$ 957.07	-49.0%
Palm oil ($/mt)	$ 387.59	-49.021%	$ 440.91	-42.0%	$ 334.27	-56.0%
Palm kernel oil ($/mt)	$ 537.33	-27.306%	$ 618.32	-16.3%	$ 456.34	-38.3%
Soybeans ($/mt)	$ 241.48	-37.205%	$ 265.26	-31.0%	$ 217.70	-43.4%
Soybean oil ($/mt)	$ 456.97	-47.289%	$ 513.07	-40.8%	$ 400.87	-53.8%
Soybean meal ($/mt)	$ 224.19	-40.207%	$ 247.99	-33.9%	$ 200.39	-46.6%
Rapeseed oil ($/mt)	$ 555.06	-39.769%	$ 607.36	-34.1%	$ 502.76	-45.4%
Sunflower oil ($/mt)	$ 475.61	-45.777%	$ 551.96	-37.1%	$ 399.27	-54.5%
Barley ($/mt)	$ 55.40	-31.081%	$ 66.66	-17.1%	$ 44.13	-45.1%
Maize ($/mt)	$ 82.46	-44.782%	$ 96.47	-35.4%	$ 68.45	-54.2%
Sorghum ($/mt)	$ 89.80	-52.608%	$ 102.23	-46.0%	$ 77.37	-59.2%
Rice, Thai 5% ($/mt)	$ 263.35	-47.851%	$ 291.04	-42.4%	$ 235.67	-53.3%
Rice, Thai A.1 ($/mt)	$ 196.46	-59.576%	$ 221.23	-54.5%	$ 171.69	-64.7%
Wheat, US SRW ($/mt)	$ 119.45	-75.159%	$ 133.08	-72.3%	$ 105.82	-78.0%
Wheat, US HRW ($/mt)	$ 113.17	-49.253%	$ 128.67	-42.3%	$ 97.66	-56.2%
Banana, Europe ($/kg)	$ 0.87	-3.562%	$ 0.90	0.3%	$ 0.83	-7.5%
Banana, US ($/kg)	$ 1.00	-20.330%	$ 1.04	-16.6%	$ 0.95	-24.0%
Orange ($/kg)	$ 0.69	11.630%	$ 0.73	18.5%	$ 0.65	4.8%
Beef ** ($/kg)	$ 2.71	-41.465%	$ 2.91	-37.1%	$ 2.51	-45.9%
Chicken ** ($/kg)	$ 1.63	8.945%	$ 1.69	13.0%	$ 1.57	4.9%
Lamb ** ($/kg)	$ 5.04	-27.989%	$ 5.49	-21.6%	$ 4.59	-34.4%
Shrimps, Mexican ($/kg)	$ 9.70	-22.807%	$ 10.29	-18.1%	$ 9.12	-27.5%
Sugar, EU ($/kg)	$ 0.46	18.824%	$ 0.49	26.6%	$ 0.43	11.0%
Sugar, US ($/kg)	$ 0.50	-16.720%	$ 0.53	-12.1%	$ 0.47	-21.4%
Sugar, world ($/kg)	$ 0.21	-29.257%	$ 0.23	-20.1%	$ 0.18	-38.5%
Tobacco, US import u.v. ($/mt)	$ 3,108.42	-28.597%	$ 3,286.32	-24.5%	$ 2,930.52	-32.7%
Logs, Cameroon ($/cubic meter)	$ 310.41	-25.017%	$ 324.01	-21.7%	$ 296.81	-28.3%
Logs, Malaysian ($/cubic meter)	$ 183.29	-34.720%	$ 194.85	-30.6%	$ 171.73	-38.8%
Sawnwood, Cameroon ($/cubic meter)	$ 532.48	-15.362%	$ 558.71	-11.2%	$ 506.25	-19.5%
Sawnwood, Malaysian ($/cubic meter)	$ 640.10	-10.550%	$ 663.36	-7.3%	$ 616.84	-13.8%
Plywood (cents/sheet)	$ 463.69	-9.963%	$ 478.28	-7.1%	$ 449.10	-12.8%
Cotton, A Index ($/kg)	$ 1.52	-1.118%	$ 1.66	7.8%	$ 1.39	-10.1%
Rubber, TSR20 ** ($/kg)	$ 0.76	-42.647%	$ 0.98	-25.7%	$ 0.53	-59.6%
Rubber, RSS3 ($/kg)	$ 0.88	-48.486%	$ 1.11	-34.7%	$ 0.64	-62.2%
Phosphate rock ($/mt)	$ 20.79	-72.953%	$ 39.24	-49.0%	$ 2.35	-96.9%
DAP ($/mt)	$ 173.22	-49.334%	$ 211.04	-38.3%	$ 135.40	-60.4%
TSP ($/mt)	$ 143.71	-47.978%	$ 184.53	-33.2%	$ 102.90	-62.8%
Urea ($/mt)	$ 138.06	-44.666%	$ 162.67	-34.8%	$ 113.45	-54.5%
Potassium chloride ** ($/mt)	$ 111.08	-53.788%	$ 141.30	-41.2%	$ 80.87	-66.4%
Aluminum ($/mt)	$ 1,566.92	-9.805%	$ 1,657.12	-4.6%	$ 1,476.73	-15.0%
Iron ore, cfr spot ($/dmtu)	$ 21.56	-82.196%	$ 31.55	-73.9%	$ 11.56	-90.5%
Copper ($/mt)	$ 2,643.21	-59.329%	$ 3,035.09	-53.3%	$ 2,251.33	-65.4%
Lead ($/mt)	$ 842.47	-56.478%	$ 970.82	-49.8%	$ 714.12	-63.1%
Tin ($/mt)	$ 8,865.77	-49.769%	$ 10,168.41	-42.4%	$ 7,563.14	-57.1%
Nickel ($/mt)	$ 9,804.17	-32.561%	$ 11,581.48	-20.3%	$ 8,026.86	-44.8%
Zinc ($/mt)	$ 1,515.80	-37.105%	$ 1,675.77	-30.5%	$ 1,355.82	-43.7%
Gold ($/troy oz)	$ 735.95	-62.616%	$ 826.73	-58.0%	$ 645.18	-67.2%
Platinum ($/troy oz)	$ 599.88	-36.205%	$ 677.31	-28.0%	$ 522.45	-44.4%
Silver ($/troy oz)	$ 5.91	-78.126%	$ 7.66	-71.6%	$ 4.15	-84.6%

Table 6: Multiple Linear Regression Modelling of $0.01 kWh Price of Energy Using Average Crude Oil and Strongly Correlated Commodity Prices, 99.9% Confidence Interval

Commodity	Electricity at $0.005 per kWh, Mean Estimate	Percentage Change from August 2020 Prices for Mean Estimate	Electricity at $0.005 per kWh, Upper Bound	Percentage Change from August 2020 Prices for Upper Bound	Electricity at $0.005 per kWh, Lower Bound	Percentage Change from August 2020 Prices for Lower Bound
Cocoa ($/kg)	$ 1.90	-19.103%	$ 2.04	-13.4%	$ 1.77	-24.8%
Coffee, Arabica ($/kg)	$ 1.94	-46.227%	$ 2.17	-39.8%	$ 1.70	-52.7%
Coffee, Robusta ($/kg)	$ 1.14	-28.904%	$ 1.24	-22.3%	$ 1.03	-35.5%
Tea, avg 3 auctions ($/kg)	$ 1.81	-42.494%	$ 1.92	-38.9%	$ 1.70	-46.1%
Tea, Colombo ($/kg)	$ 2.53	-25.003%	$ 2.69	-20.3%	$ 2.37	-29.7%
Tea, Kolkata ($/kg)	$ 1.54	-62.073%	$ 1.67	-59.0%	$ 1.42	-65.1%
Tea, Mombasa ($/kg)	$ 1.87	-6.254%	$ 1.99	-0.4%	$ 1.76	-12.1%
Coconut oil ($/mt)	$ 645.60	-34.210%	$ 734.38	-25.2%	$ 556.81	-43.3%
Groundnuts ($/mt)	$ 806.12	-58.227%	$ 902.43	-53.2%	$ 709.81	-63.2%
Fish meal ($/mt)	$ 742.91	-49.800%	$ 822.65	-44.4%	$ 663.17	-55.2%
Groundnut oil ** ($/mt)	$ 976.03	-48.000%	$ 1,060.84	-43.5%	$ 891.21	-52.5%
Palm oil ($/mt)	$ 328.33	-56.816%	$ 381.65	-49.8%	$ 275.01	-63.8%
Palm kernel oil ($/mt)	$ 490.15	-33.689%	$ 571.14	-22.7%	$ 409.16	-44.6%
Soybeans ($/mt)	$ 214.83	-44.136%	$ 238.61	-38.0%	$ 191.04	-50.3%
Soybean oil ($/mt)	$ 387.83	-55.264%	$ 443.93	-48.8%	$ 331.73	-61.7%
Soybean meal ($/mt)	$ 201.19	-46.341%	$ 224.99	-40.0%	$ 177.39	-52.7%
Rapeseed oil ($/mt)	$ 495.98	-46.180%	$ 548.28	-40.5%	$ 443.68	-51.9%
Sunflower oil ($/mt)	$ 403.28	-54.023%	$ 479.63	-45.3%	$ 326.94	-62.7%
Barley ($/mt)	$ 41.02	-48.972%	$ 52.28	-35.0%	$ 29.75	-63.0%
Maize ($/mt)	$ 68.66	-54.024%	$ 82.67	-44.6%	$ 54.65	-63.4%
Sorghum ($/mt)	$ 76.84	-59.450%	$ 89.27	-52.9%	$ 64.41	-66.0%
Rice, Thai 5% ($/mt)	$ 239.28	-52.618%	$ 266.96	-47.1%	$ 211.60	-58.1%
Rice, Thai A.1 ($/mt)	$ 172.66	-64.472%	$ 197.44	-59.4%	$ 147.89	-69.6%
Wheat, US SRW ($/mt)	$ 105.91	-77.974%	$ 119.55	-75.1%	$ 92.28	-80.8%
Wheat, US HRW ($/mt)	$ 94.91	-57.439%	$ 110.41	-50.5%	$ 79.41	-64.4%
Banana, Europe ($/kg)	$ 0.85	-5.988%	$ 0.88	-2.1%	$ 0.81	-9.9%
Banana, US ($/kg)	$ 1.00	-19.830%	$ 1.05	-16.1%	$ 0.96	-23.5%
Orange ($/kg)	$ 0.67	7.920%	$ 0.71	14.8%	$ 0.63	1.1%
Beef ** ($/kg)	$ 2.61	-43.613%	$ 2.81	-39.2%	$ 2.41	-48.0%
Chicken ** ($/kg)	$ 1.60	6.558%	$ 1.66	10.6%	$ 1.54	2.5%
Lamb ** ($/kg)	$ 4.87	-30.426%	$ 5.32	-24.1%	$ 4.42	-36.8%
Shrimps, Mexican ($/kg)	$ 9.56	-23.908%	$ 10.15	-19.2%	$ 8.98	-28.6%
Sugar, EU ($/kg)	$ 0.46	17.746%	$ 0.49	25.6%	$ 0.43	9.9%
Sugar, US ($/kg)	$ 0.49	-17.729%	$ 0.52	-13.1%	$ 0.47	-22.4%
Sugar, world ($/kg)	$ 0.18	-36.523%	$ 0.21	-27.3%	$ 0.16	-45.7%
Tobacco, US import u.v. ($/n	$ 3,001.88	-31.045%	$ 3,179.79	-27.0%	$ 2,823.98	-35.1%
Logs, Cameroon ($/cubic me	$ 295.40	-28.644%	$ 309.00	-25.4%	$ 281.80	-31.9%
Logs, Malaysian ($/cubic me	$ 170.98	-39.104%	$ 182.54	-35.0%	$ 159.42	-43.2%
Sawnwood, Cameroon ($/cu	$ 505.14	-19.709%	$ 531.36	-15.5%	$ 478.91	-23.9%
Sawnwood, Malaysian ($/cu	$ 615.42	-13.998%	$ 638.68	-10.7%	$ 592.16	-17.2%
Plywood (cents/sheet)	$ 450.49	-12.527%	$ 465.08	-9.7%	$ 435.90	-15.4%
Cotton, A Index ($/kg)	$ 1.51	-1.727%	$ 1.65	7.2%	$ 1.38	-10.7%
Rubber, TSR20 ** ($/kg)	$ 0.59	-55.379%	$ 0.81	-38.4%	$ 0.37	-72.3%
Rubber, RSS3 ($/kg)	$ 0.70	-59.113%	$ 0.93	-45.4%	$ 0.46	-72.9%
Phosphate rock ($/mt)	$ 14.04	-81.732%	$ 32.49	-57.7%	$ (4.40)	-105.7%
DAP ($/mt)	$ 143.05	-58.159%	$ 180.86	-47.1%	$ 105.23	-69.2%
TSP ($/mt)	$ 114.79	-58.446%	$ 155.61	-43.7%	$ 73.98	-73.2%
Urea ($/mt)	$ 116.94	-53.130%	$ 141.55	-43.3%	$ 92.33	-63.0%
Potassium chloride ** ($/mt	$ 86.84	-63.875%	$ 117.05	-51.3%	$ 56.62	-76.4%
Aluminum ($/mt)	$ 1,503.98	-13.428%	$ 1,594.18	-8.2%	$ 1,413.78	-18.6%
Iron ore, cfr spot ($/dmtu)	$ 10.55	-91.287%	$ 20.54	-83.0%	$ 0.55	-99.5%
Copper ($/mt)	$ 2,115.26	-67.452%	$ 2,507.14	-61.4%	$ 1,723.38	-73.5%
Lead ($/mt)	$ 707.94	-63.428%	$ 836.29	-56.8%	$ 579.59	-70.1%
Tin ($/mt)	$ 7,598.79	-56.947%	$ 8,901.43	-49.6%	$ 6,296.15	-64.3%
Nickel ($/mt)	$ 8,993.97	-38.134%	$ 10,771.28	-25.9%	$ 7,216.66	-50.4%
Zinc ($/mt)	$ 1,446.65	-39.974%	$ 1,606.63	-33.3%	$ 1,286.68	-46.6%
Gold ($/troy oz)	$ 678.76	-65.521%	$ 769.54	-60.9%	$ 587.99	-70.1%
Platinum ($/troy oz)	$ 508.82	-45.889%	$ 586.25	-37.7%	$ 431.38	-54.1%
Silver ($/troy oz)	$ 4.35	-83.878%	$ 6.11	-77.4%	$ 2.59	-90.4%

Table 7: Multiple Linear Regression Modelling of $0.005 kWh Price of Energy Using Average Crude Oil and Strongly Correlated Commodity Prices, 99.9% Confidence Interval

Model	Electricity at $0.01 per kWh	Electricity at $0.005 per kWh
Average Mean Estimate Percentage Decrease	-36.86287%	-41.69509%
Largest Mean Estimate Percentage Decrease	-82.19573%	-91.28715%
Smallest Mean Estimate Percentage Decrease	18.82388%	17.74597%
Mean Upper Bound Percentage Decrease	-29.11798%	-34.53304%
Largest Upper Bound Percentage Decrease	-73.94126%	-83.03268%
Smallest Upper Bound Percentage Decrease	26.64896%	25.57105%
Mean Lower Bound Percentage Decrease	-43.44207%	-48.85714%
Largest Lower Bound Percentage Decrease	-96.94095%	-105.71935%
Smallest Lower Bound Percentage Decrease	10.99880%	9.92089%

Table 8: Summary of Price Changes for Multiple Linear Regression Models, 99.9% Confidence Interval

As is shown in Tables 6 and 8, reducing the price of oil to a level comparable to $0.01 per kWh for energy leads to widespread reductions in the cost of all other non-energy commodities tracked in the World Bank Pink Sheet compared to the price of each good as of August 2020, the endpoint of the dataset. The $0.01 kWh model showed a mean decrease in estimated price of 36.86% falling between an average of 29. 11% and 43%. Tables 7 and 8 show even more substantial decreases in the price of commodity goods in a $0.005 kWh scenario, with a mean estimate decrease compared to August 2020 of 41.69% falling within a range spanning from price decreases of 34.53% to 48.85%. Chicken, oranges, and European sugar prices were the only commodities which showed price increases in either dataset, making them stark exceptions to a general rule of across the board, significant decreases in the price of all other commodities.

Conclusion

Based on this analysis of the World Bank Pink Sheet commodity price data, it can be argued the declining cost of renewable energy will have significant macroeconomic implications for all forms of commodity production. The consistent, significant estimated decreases in the price of nearly every commodity fits with the impacts of the larger pass-through effect of oil and other energy sources on the costs of production. Such declines are also likely to stabilize and lead to a long-term decoupling of the cost of commodity production from the cost of energy thanks to the consistency of the decline in costs and the reliability of any increases in the availability of renewably-produced energy. In short, any economy which commits to a full transition away from fossil fuels would likely, upon replacing the use of oil with renewable energy sources, enjoy significantly reduced costs of production, more reliable energy pricing and supply, and other secondary macroeconomic benefits comparable to those experienced by the United States and Western Europe that were thanks, in part, to the reliably low and consistently decreasing cost of oil during the 1950s and 1960s.

These findings further suggest the conversation regarding renewable energy transition needs to account for these larger macroeconomic effects. Any economy experiencing anything within the range of a 30% to 40% reduction in the price of all commodities is one which would enjoy significant competitive and comparative advantages over those which have failed to make such a transition. This would make such economies far more attractive to economic actors seeking to save on costs and such actors would be further incentivized to participate in renewable economies thanks to the greater predictability and reliability of those price reductions. In conclusion, any society or economy which embraces renewable energy technology would benefit from qualitative advantages which fossil fuel-based economies would notably and visibly lack.

Declarations

The author declares no competing interests.

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