GREEN GANGES CAPITAL MANAGEMENT

THE CASE FOR COMMODITIES

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Traditional assets will face the worst downside pressures since the 1930s. We explain why commodities will be the best asset class of the 2020s.

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Macro Environment

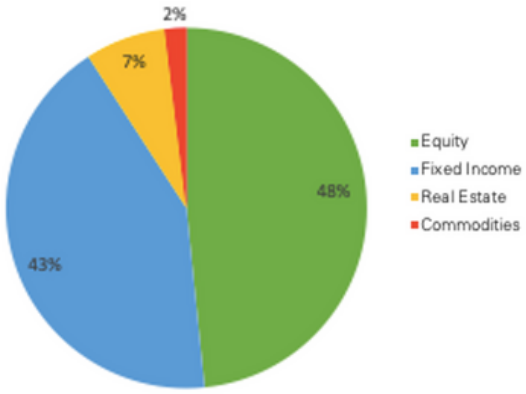
Global Paradigm Shift: A Decade of Stagflation

The US has one final round of easing left in its arsenal. They are likely to go for it in mid/late 2023 when rate hikes reach the 4.5% mark, as recession will be flowing through most of the economy by then.

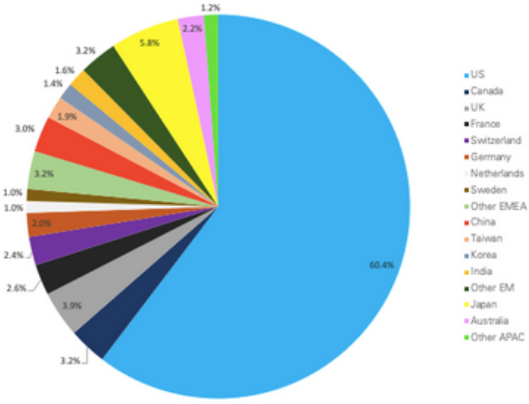
Where The Money Is Currently

- Over the last 40 years the global 60/40 (stocks/bonds) portfolio had good annualized return (8.19%) with relatively low risk (8.96%) in a deflationary environment.
- As of 2021, most global assets under management ($112.3 T) are in stocks & bonds (91%), and heavily concentrated in the United States.
- In 2021, stocks and bonds were again the most favored assets by flows, while US and Asian markets were favored over Europe.
- 75% of global portfolio risk is currently associated with equities.
- While inflation is much higher than the past, % of assets currently in commodity funds is much lower.

Global AUM by Asset Class (2021)



MSCI ACWI by Geography (2022)



Commodity Index Funds AUM by Year

Year	US Inflation Rate	% Of Global AUM
2011	3.1%	1.75
2021	4.7%	0.74

Fund Flows by Geography & Asset Class (2021)

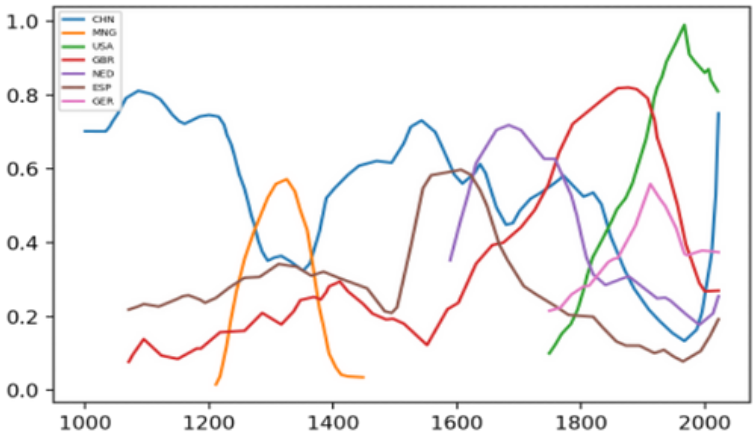
Asset Class	Flows ($B)
Equities	1018
Bonds	1233
Money Markets	545
Mixed Assets	523
Others	-13

Country	Flows ($B)
US	1268
China	800
Japan	104
Germany	44
UK	-34
France	-20
Korea	33
India	22

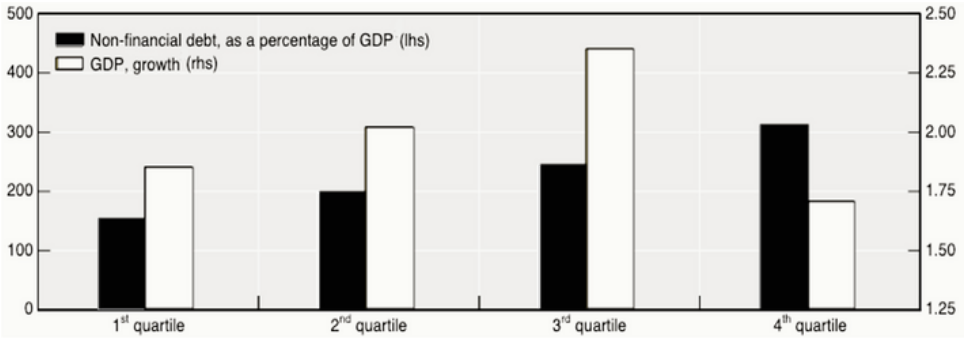
Patterns Through History

- The last 1000 years have had 6 different empires dominating the global economy for about 150 years each. The factors behind the rise and decline of these countries have rhymed (decline factors built into rise & vice versa.).
- Rise: Poor country→ Leadership consolidation→ Hungry/Competitive labor deployed→ High export volumes→ Skills obtained→ Innovation & Productivity→ Trade domination→ Currency power→ War with incumbent.
- Decline: Rich country→ High growth discounted→ Higher labor demands→ Lower output→ higher consumption met by imports→ Large debt issued to meet growth & consumption demand→ Inequality as consequence of debt reaching mostly the rich→ Division in leadership & population→ Inability to service debt→ Currency devaluation→ War with challenger→ Restructuring.
- Dutch Decline: Annual TFP growth from 2.5% (1565-1620: Golden Era) to under 1% (1750-1810). Third Anglo-Dutch War requiring debt financing. National debt ballooning to 140% GDP between 1690-1760, leading to Amsterdam Banking Crisis (1763). Guilder value vs gold dropped by 80% in 1790. Dutch stock price drawdown by 50% post banking crises, bonds restructured in 1814.
- British Decline: Labor productivity vs US declining by 30% (1850-1900) and financing of WWI & WWII, leading to 237% Public Debt/GDP. After WWII, Pound devalued by 30% vs USD. Negative real returns in British stocks and bonds for 10 years post war.

Relative Economic Strength by Country (1000-2020)



OECD Nations Debt & Growth

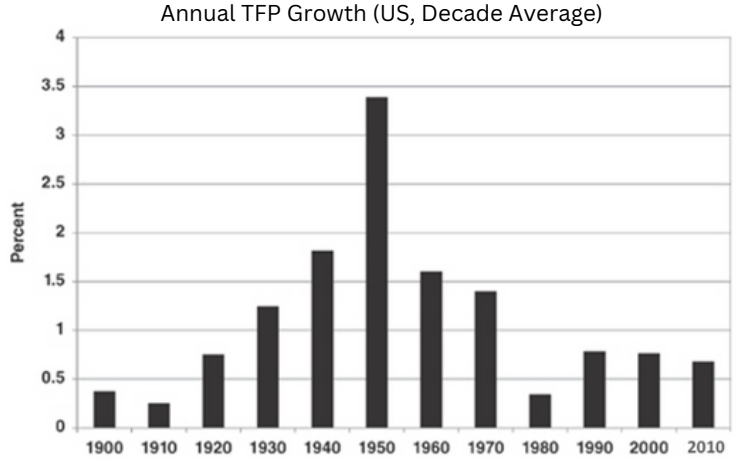


What is Happening Now: Productivity Decline

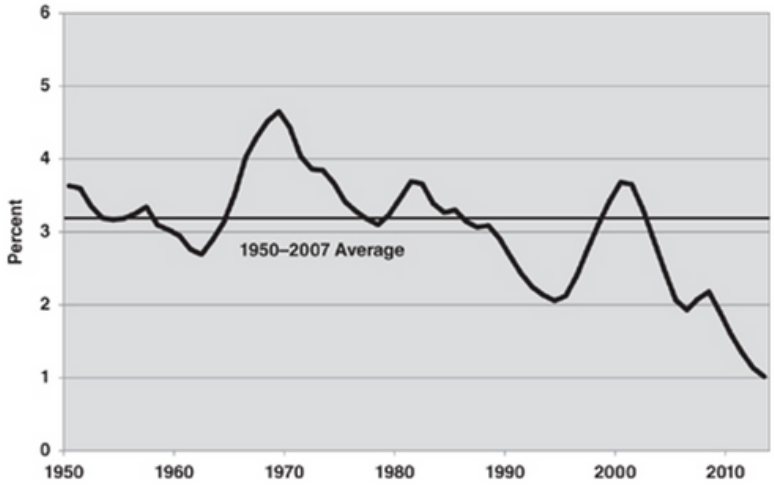
- Over the last 50 years, the economic fundamentals of the US have deteriorated.
- The generation that rebuilt the economy after Great Depression & WWII was replaced in the workforce. Newer generation spent more than they earned/produced.
- Steady decline in manufacturing capacity growth since 1980s, with temporary impact of ICT investment on capacity seen during the late 1990s now diminishing. Capacity growth declined from 3% in the 1970s to less than 1% in the 2010s, and removing the impact seen by ICT in the 1990s-2000s the 40 year average comes down to 0.3%.
- Net investment to capital stocks have declined by 70% since 1970.
- Debt led consumption demand met by other countries having wage advantage. Japan, Germany recovered their shares of the pie and the emergence of China.

- Easy debt reaching mostly the rich, creating inequalities in opportunity with negative real income growth for the bottom 90% since 1973.
- Better life expectancy and immigration controls creating ageing population. (Retirement age population as % of total: 7% in 1940, 11% in 1980, 17% in 2020.)

Annual TFP Growth (US, Decade Average)



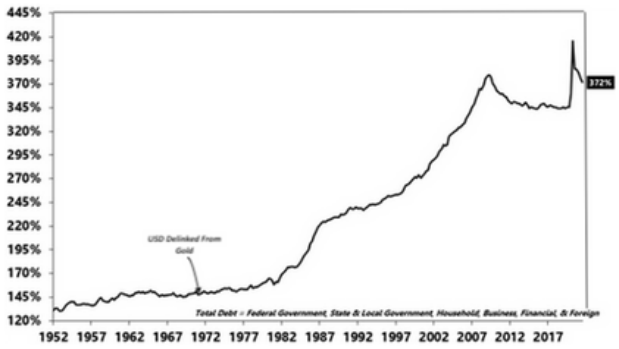
Net Private investment Ratio (US, 5Y MA)



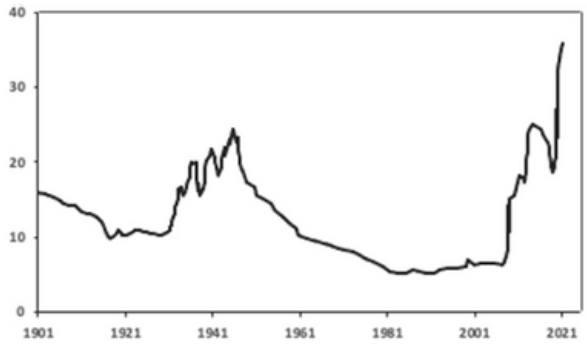
What is Happening Now: Unsustainable Debt

- Due to high growth expectations and low factor productivity growth, debt had to be issued to meet the difference.
- After debt financing of the Vietnam war in the 1960s, in 1971, USD was delinked from gold in order to issue restriction free debt. Since debt is a claim on future earnings, initially it is growth enhancing (or neutral) and eventually a drag on growth.
- As USD was the world's reserve currency, for which there was always demand, higher debt levels (with lower productivity) were sustained by lowering interest rates. Hence, over the last 50 years, debt was serviceable. Rate hike cycles had lower peaks and rate cut cycles had larger troughs till rates eventually fell to 0 in 2008.
- At this point, money (as 0 interest debt) was injected into the economy via QE for economic stimulation.
- In 2020, monetary stimulus started being used for fiscal spending (as this way it could reach the real economy rather than remain in financial assets). This facet of combined monetary and fiscal stimulus is producing high inflation.
- At current levels of real productivity the debt would become unserviceable were interest rates to rise significantly.

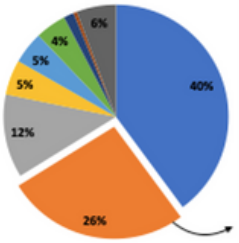
Total Debt/GDP (US)



Federal Reserve Balance Sheet (% GDP)



Holders of US Public Debt



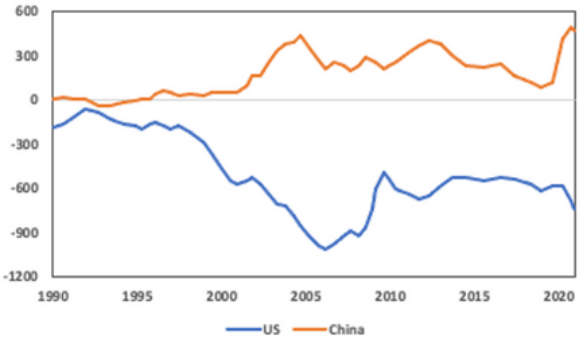
Japan	1304
China	1068.7
United Kingdom	647.4
Ireland	334.3
Luxembourg	323.5
Cayman Islands	261.9
Taiwan	251
Brazil	244.5
Hong Kong	225.7
France	224.4

Fed and gov't accounts · Foreign · Mutual funds
Depository institutions · State and local governments · Pension funds
Insurance companies · U.S. savings bonds · Other

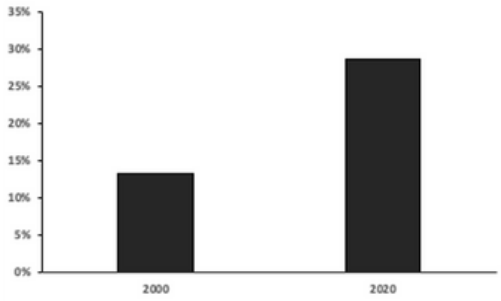
What is Happening Now: Rise Of A Challenger

- Through the middle ages China was the most dynamic and innovative economy in the world. By the early 1800s the Qing dynasty leadership had become weak and decadent and the Chinese finances were reeling after losing wars against Britain and later Japan. This combined with internal rebellion led to the 'Century of Humiliation'.
- In 1978, Deng Xiaoping came into power and set forth a 70 year plan to alleviate poverty and increase productivity, along with shorter term measurable targets. China would achieve goals set out in this plan by having a socialist market economy with Chinese characteristics. The Chinese used their philosophy of top-down governance, hard work and the collective being more important than the individual, along with principles of capitalism wherein people were incentivized to innovate and interact with the outside world.
- As the west was consuming by issuing debt liabilities, China was supplying to them (utilizing their lower per capita) and holding their debt assets; skilling their population along the way. While new capital stock and number of workers was important, it was the increased productivity of the two factors, that accounted for almost half of Chinese growth from 1978-1997 (25x Real Growth 1978-2021).

Real Net Exports ($B)



High Tech Exports (China, % Merchandise Exports)



What Will Happen: 15 Years of War

- Apart from military and currency, China has either equaled or bettered the US across all strategic fronts. While local currency debt in China was ballooning, the government took steps to stamp down on sectors such as Real Estate and Technology in 2021 which would create to short term pain but lead to cleaner balance sheets longer term. This would lead to a better 'internal circulation' economy in times of war.
- There is a high probability that the war will escalate between the US and China through the next decade in technology, trade, capital, military and currency. While a hot war on US/Chinese territory is unlikely, the strategic importance of Taiwan (logic chips) will lead to military involvement.
- China is likely to win the war due to:
  - Consolidated Leadership
  - Higher Productivity
  - Lower Debt Overhang
  - Influence via Trade
  - Eventual Technological Superiority
  - Control Over Strategic Assets
- The inevitable 'Thucydides Trap' leading to war will **depress global growth** over the next decade. Hence, stocks will be a low return asset during this period. Bonds will also see lower prices as countries will ease monetary policy to finance various types of war.
- As idicated by evaluating countries that abstained government action against Russia in 2022, alliances will form around the US and China. Governments will attempt to deglobalize, especially against enemies. This will lead to a rejig of global supply chains that have been formed over decades of trade. This will be an **inflationary process** and commodities as an asset class will benefit from it.

US vs China Measures of Strength w/ Trend

Measure	Indicator	US	China
Competitiveness	Cost Competitiveness (Z-score, Global Avg.)	-0.4→	1.2↓
Trade	Trading Hub (Share of Global GDP of Spokes)	17%↓	45%→
Technology	Global Patents Application Share	14%↓	58%↑
	Global R&D Spend Share	27%↓	23%↑
Productivity	Expected Growth (Real, 10Y)	1.4%↓	4.4%↓
Financial Position	Net Intl. Investment Position (% GDP)	-68%↓	11%↑
	Total Debt/GDP	372%↑	270%→
	Public Debt/GDP	137%↑	67%↑
Military	Military Spend (% Global)	38%↑	14%↑
Currency	Global Transaction Share Of Currency	40.7%↓	3.9%↑

What Will Happen: Unavoidable Stagflation

- The US is now near its **limits of debt financed growth**. Inflation is running at 8.6%, with interest rate hikes and Fed tapering having minimal impact, it is likely to remain above the target band for a sustained period due to fundamental factors.
- While strong austerity (sustained 4%+ rates, lower spending) will lead to inflation reduction through demand destruction, it will be highly painful to the economy and markets (propped up by easy money).
- Policymakers already under fire due to infighting (based on inequality) are unlikely to go this way.
- We believe that they will instead, chose the easier option for the short term as other leaders through history before them have.
- The US has one final round of easing left in its arsenal. They are likely to go for it in mid/late 2023 when rate hikes reach the 4.5% mark, as recession will be flowing through most of the economy by then.
- This time however, the dollar will face pressure as holders of US debt will want to sell if interest rates are lower than inflation. The fed will have to print to buy debt, even more than before. At the same time, sanctioned countries have already begun transacting in alternate currencies further eroding demand for dollars.
- This round of easing will create buoyant markets at first but eventually lead to even **higher inflation** combined with fundamental price pressures on resources. The **growth tap will have dried** and the dollar will crash with restructuring required.
- These factors are not just indigenous to the US, as Western Europe also finds itself in a similar situation. Low real growth across these large economies combined with the war scenario described before, will lead to growth downgrades across all major economies. Inflation will also be a global phenomenon.

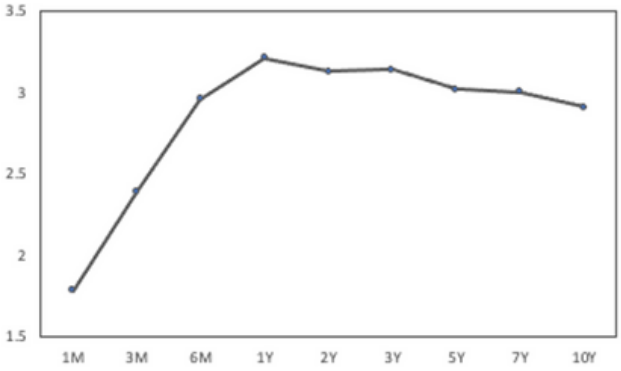
Catch-22 for US Policymakers

Option 1	*Consequences*	*Option 2*	*Consequences*
US Tightening to Dent Inflation		US Easing: Acceptance of Higher Inflation	
Fed Funds Target > 4%	Bankruptcies	FF Target Near Zero	Diminishing Demand for US Bonds
Tax Increases to Service Debt	Capital Flight	Deficit Funding via QE	Monetary Inflation
Fiscal Deficit Reduction	Civil Unrest		USD Freefall

Is Stagflation Priced In?

- Markets expect the Fed to tighten policy till mid 2023, at which point they expect a swift U-turn and immediate easing.
- The **markets have not priced in a persistent stagflation**. They expect interest rates of just over 3.5% by mid 2023 to significantly bring down US inflation to 2.5%, at which point rates can be lowered again.
- Markets are not expecting inflation to be stubborn and policymakers having to make a difficult choice.
- Rate hikes have lead to a correction in equity markets in the first half of 2022, however most prices only reflect a higher discount rate correction and not the persistent stagflation scenario we have described before which will be a drag on cashflow growth.
- Currently the financial assets to real assets ratio stands at over 6:1, as a result of overly easy monetary policy over the last 15 years. We believe that US financial assets (accounting for 60% of the global portfolio) have futher downside room of 35%.
- We expect funds to move from US financial assets into real assets such as commodities in the short to medium term. Eventually, over a longer horizon we expect investors to move into eastern geographies for diversification and growth benefits.

US Treasury Yield Curve



US Inflation Expectations

Indicator	Rate
TIPS Breakeven (5Y)	2.6
Michigan Survey (5Y)	2.9
SPF CPI (1Y)	3

Stagflation & Traditional Asset Classes

Stocks have been one of the worst performing asset classes during stagflations historically. Commodities on the other hand, have been the best performing asset class during these periods.

Stocks & Bonds

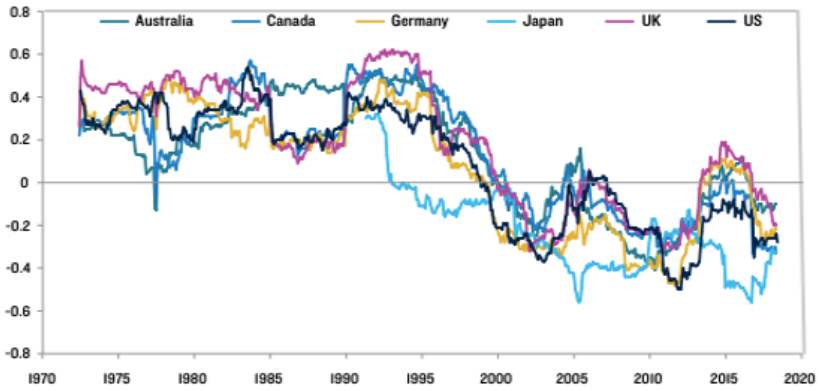
- Two factors drive asset prices: growth & inflation. During goldilocks and deflationary periods, growth is the primary driver; while during periods of stagflation and reflation, inflation is the primary driver.
- When growth is driving asset prices: bonds hedge stocks well, however when inflation is the primary driver, bonds and stocks move together.
- The mechanics behind this can be explained by looking at what stocks and bonds represent.
- Stocks represent all future cash flows generated by a firm discounted back to the present. When **growth is lower** than expected, absolute future cash flow projections are lower and the **price is revised downwards**. When **inflation is higher** than expected, the real value of future cash flows is lower and profit margins are also lower due to greater raw material and operating costs; again **driving prices down**.
- Bonds represent the expected yield to be earned by holding till maturity. Interest rates on newly issued bonds are closely linked to the central bank target rate. If the central bank hikes rates (to **control inflation**), holders of older bonds have to **adjust price downwards** to match the yield of the newly issued bonds. Whereas, sustained lower rates (to **promote growth**) can be highly damaging in an inflationary environment as they not only enhance inflation, but also lower the demand for bonds (low yield bonds lose money w.r.t. inflation).

- Stocks have been one of the worst performing asset classes during stagflations historically. Due to positive stock-bond correlation during stagflations, the 60/40 has also performed badly during stagflations. Commodities on the other hand, have been the best performing asset class during these periods.

Excess Return by Asset Class and Period (1960-2022)

	Period	
Asset Class	Stagflation (18%)	Other (82%)
Stocks	-10.2%	8.6%
Bonds	-1.2%	3.5%
60/40 Portfolio	-6.6%	6.5%
Real Estate	-13.8%	11.8%
Commodities	10.5%	2.4%

Stocks-Bonds Correlation (Trailing 5Y)

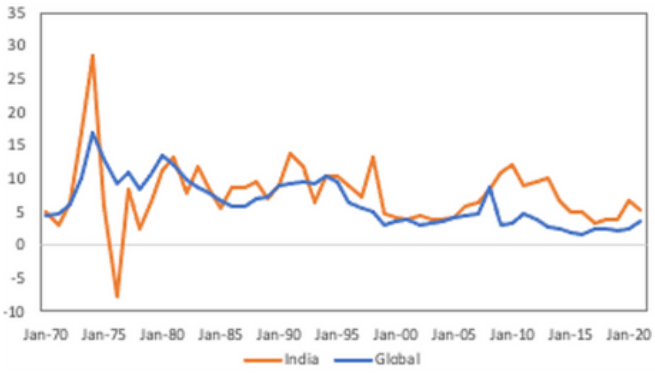


Global Stagflation & India

- Cost competitive labor gives India the avenue for strong potential of real growth over the next decade, which can offset its mildly high public debt (93% GDP) and fiscal instability. The drag of international war on growth can also be offset by attracting global supply chains using wage advantage and favorable international relations.

- However, this advantage is being chipped away due to an inefficient bureaucratic system which doesn't allow for optimal allocation of resources, leading to low skill and capability development and thus a negative balance of trade. This creates pressure on the currency resulting in the inability to offer cost competitive capital for growth.
- We believe that these systemic deterrents will weigh more on growth in the medium term and prevent India from bypassing global stagnation. Our expected real growth for India is 5-6% for the next decade and trending down.
- A historically weak currency has also led to the RBI basing its monetary policy off global benchmarks. While India's monetary stimulus is far from inflationary (due to various avenues for productivity), the removal of liquidity is often involuntary and leads to lower growth. While we expect this linkage to be less influential in the long term, it will have significant impact on growth over the short to medium term.
- Historically, inflation in India has been more volatile than its global peers due to bottlenecks in supply of locally sourced agricultural commodities (storage, weather events). Nonetheless, India imports global inflation in the form of energy and gold. Hence, almost half of Indian CPI increases can be explained by global inflation.

Headline Inflation (CPI)



BTI Steering Capability Scores (2022)

	Prioritization	Implementation	Policy Learning
India	6	5	5
China	8	7	8
South Korea	8	8	8
Taiwan	10	10	10

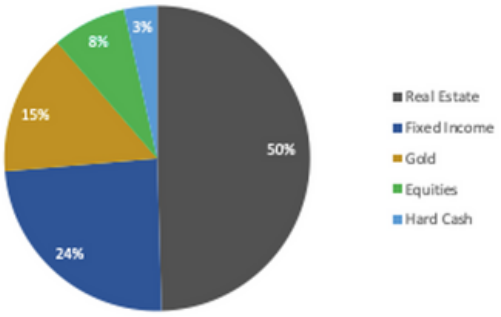
India Import Dependence

Commodity	Import Dependence
Crude Oil	85%
Natural Gas	45%
Coal	20%
Fertilizers	30%
Gold	85%

The Future of Indian Assets

- Indian holdings are heavily overweighted in real estate. Real estate has returned -13.8% and has been the worst asset class to hold during periods of stagflation, historically. Previously, poor property rights and land regulations have led to high urban vacancy rates (12.4%). This combined with a higher interest rate environment over the next 12 months followed by more hikes 18 months down the line will cause real estate prices across the board to fall over the next 3-5 years (adjusted for inflation).
- High growth expectations have buoyed Indian equity markets to slightly overvalued levels. Stocks are currently more expensive than 70% of time periods over the last decade. Although Indian equity markets are slightly cheaper compared to US and European markets, they are significantly more expensive than Chinese markets. While the opportunity to attract FPI exists, the market breadth is not wide enough to house large amounts of capital without going into grossly overvalued territory. Considering the lower growth scenario described previously, at current risk premiums a 14.3% required return is not going to be met over the medium term without a decline in prices. However, Indian markets have considerably low leverage compared to DMs, so a downturn would be smaller in magnitude and shorter in length.
- Indian bonds' medium term outlook is grim. With a majority of India's industries benefiting from nominal growth, RBI will have room to be more stringent and credit spreads will expand. Demand from banks and insurers (62% of holders) will dwindle as inflation persists (6%+), and unless covered by foreign capital (unlikely, due to red tape), prices will fall.
- To benefit from being long India over the long term it is important that investors don't lose money in the short term. Wealth is never destroyed, it is simply transferred to between assets. It is now more crucial than ever to hold a diversified portfolio of assets.

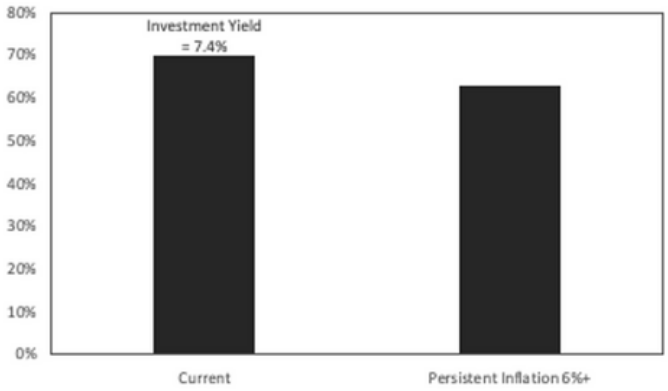
Indian Household Savings (2022)



Equity Market Cap/GDP

Country	Market Cap/GDP
Brazil	54%
China (+HK)	72%
India	94%
Japan	146%
France	108%
Germany	51%
Netherlands	134%
South Korea	91%
UK	100%
US	158%

LIC Bond Holdings (% of Investments)



Indian Asset Class Nominal Returns
During Stagflation (1993-2021)

Asset Class	Returns
Stocks	-10.5%
Bonds	1.3%
Real Estate	-8.2%

The Fundamentals

Demand Dynamics: Energy

Even under the most aggressive energy transition policy scenario, fossil fuel demand is expected to grow till 2025.

Prices Kept Artificially Low

- Central bank led influx of money and scarce supply has led to huge increases in energy prices over the last year. The EU has especially suffered due to its 39% natural gas and 21% crude oil dependence on Russia.
- From 2010-2020, a resident of the European Union spent 6.2% of his income on oil and gas on average, of which 42.9% was tax.
- The EU has committed to reducing its natural gas dependence on Russia by 2/3rd by Q2 2023, ban Russian crude imports via tanker (which accounted for 14% of crude consumption in 2021) by December 2022 and all petroleum products via tanker by February 2023.
- Under the REPowerEU strategy they expect to replace Russian oil and gas with fast-tracked renewables and using non-Russian sources of carbon. Despite attempts to scale up new hydrogen, wind and solar with more investment, it will not be till at least 3-4 years from now when a significant portion of this void can be replaced by renewables. With internal and African pipelines already at full capacity, the EU will need to compete with Asia for global LNG and crude. The best case scenario is replacing 35-40% of the void from non-Russian sources at higher prices by next year.
- Oil and gas bills are likely to reach 12% of income by 2023, which can cause human welfare and political crises. Governments have no choice but to prevent this from happening. EU governments have already started moving on price reducing measures via lower taxation & subsidies for consumers and windfall levies for energy producing firms.
- As prices are contained via these measures, **the demand for energy (over the short term) is not going to be dented** as consumption patterns can only change with higher prices sustained over a long period of time. Any measures of intervention via obligation for demand reduction will again cause political backlash (with EU being the most democratized part of the world) and hence, will not be sustainable.

EU Energy Prices & Income (Nominal % Change, Jun 20-22)

Commodity	Absolute	Annualized
Crude Oil (Brent)	177%	67%
Natural Gas	2242%	384%
Coal	642%	172%
Per Capita Income	19.2%	9.2%

EU Energy Usage (2010-2020)

Category	Share of Total Energy Consumed	Taxes	% Income Spent
Natural Gas	23.8%	23.60%	2.3%
Oil	35.4%	54.28%	3.9%
Electricity	24.7%	35.60%	3.8%

EU Energy Price Control Measures Implemented So Far

Measure	Number of Countries
Temporary Crisis Framework Aid	EU
Reduced Energy Tax/VAT	23
Retail/Wholesale Price Caps	12
Transfers To Households	25
State Owned Firms Mandate	7
Windfall Tax	EU + 5
Support To Business	10

Frictions In Government Led Transition

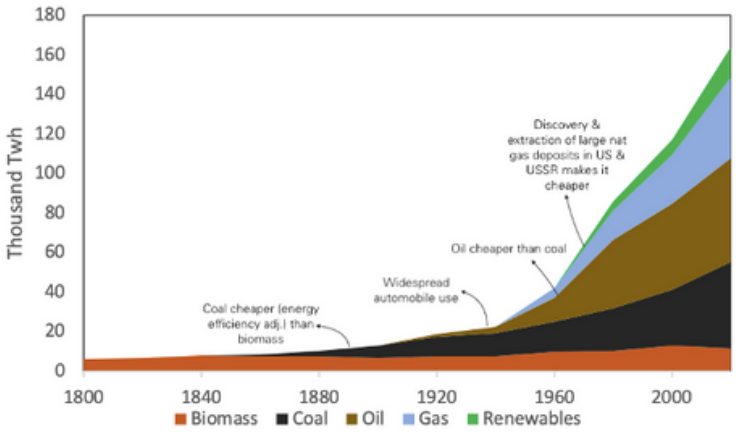
- 130 Countries have made high-level commitments under the Paris Agreement to achieve net zero emissions by 2050.
- Despite high-level commitments, tangible policies are not yet in place to achieve these emissions targets. At current prices and policies; oil, gas and coal demand will rise to new highs over the next decade.
- Through history, energy transitions were led by convenience and cost, hence relatively smooth. This is the first time that government policy will be driving it, and on an accelerated timeline by mandate. We expect lots of inefficiencies in achieving this through carbon taxation and subsidizing alternatives.
- Consumers will only move to alternatives if oil and gas get too expensive in comparison. Near term, alternatives carry much higher effective costs. Longer term, raw material supply constraints will keep EROI ratios of alternatives relatively low.
- Windfall gains in fossil fuels will tempt suppliers to produce more, bringing prices down in the medium term, thereby creating more demand. Therefore, no significant migration to alternatives can occur without aggressive government financial intervention.

- EMs are unlikely to cause growth disruptions via taxation or subsidy. Their share of fossil fuel use is at 60% and will rise.
- Most DMs leading the transition are in precarious financial positions. Subsidizing alternatives would mean taking on more debt, while taxing carbon will hamper productivity. In a high risk geopolitical environment, governments are less likely to take aggressive measures, especially in a synchronized manner required for a smooth transition.
- **Even under the most aggressive energy transition policy scenario, fossil fuel demand is expected to grow till 2025.**

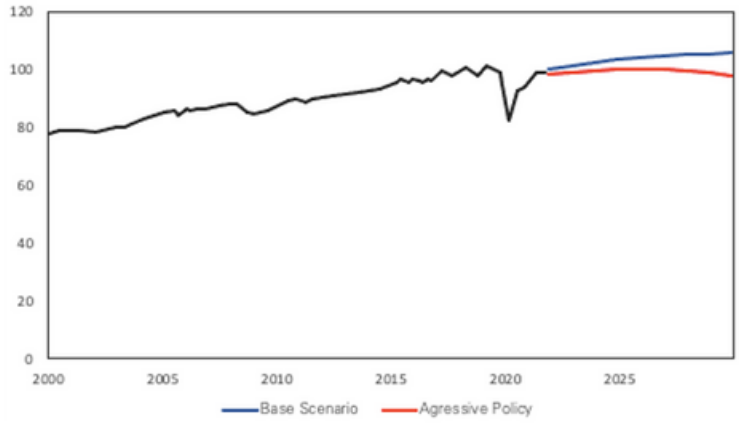
Net Zero Commitments by Region

Region	Share Of Energy Consumption	Net Zero Target Year	Commitment Type	Detailed Plan
China	25%	2060	Policy Document	Incomplete
US	15%	2050	Policy Document	Incomplete
EU	8%	2050	Law	Incomplete
India	6%	2070	Declaration	No Plan
Russia	6%	2060	Law	No Plan
Japan	3%	2050	Law	No Plan
Brazil	2%	2050	Declaration	No Plan
South Korea	2%	2050	Law	Incomplete

Energy Use by Source (1800-2021)



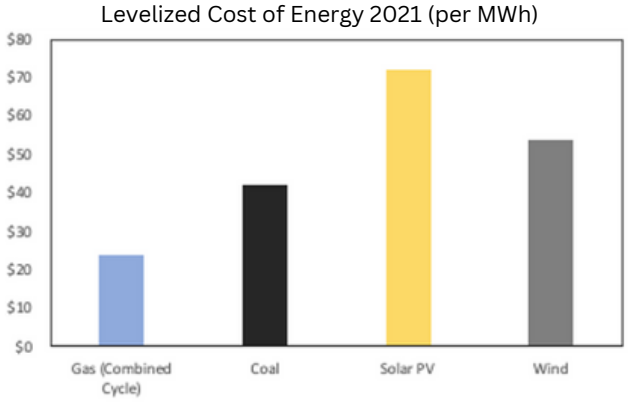
Crude Oil Demand (Global, MMbpd, 2000-2030)



Competitiveness Of Alternatives

- On a cursory basis, solar and wind are cost competitive with fossil fuels for power generation in some regions. However, their intermittent nature comes with costs of storage (capacity and reliability factors). Battery costs need to drop by around 90% from current levels to completely replace fossil fuels, even with the current volatility and elevated prices of hydrocarbon products. This is unlikely to occur within the next 10 years (costs will rise instead). Green hydrogen is further behind in its development and will only get cost competitive by 2050.
- Wind and solar are also nominally cheap due to low levels of penetration. As the transition moves along, the best locations for power plants will be used up. More raw material (aluminum, copper, nickel, lithium etc.) will be required to build the PV panels, modules, wind turbines and batteries to access power from solar and wind in geographies with less than optimal sunlight and wind. This will take nominal costs to much higher levels than fossil fuels. These industries will also be competing for raw materials with players who will build the infrastructure to harness renewable power, i.e., EVs & green buildings; further elevating costs. This will present big dilemmas for the companies and governments financing the transition and fossil fuels will be used as stop gaps.
- Hydropower, exploited more than any other renewable over the last century, has not seen much growth in its share of power generation since the 1960s. This is because hydro is only feasible in places with the right topography and water resources, and most of the easily accessible sources of hydropower have already been built. Same is the case for geothermal energy. Hence, these resources aren't scalable.

- Nuclear is cheap when in use, however building plants is expensive. More concerning is radioactive waste disposal, the costs of which, both monetary and regulatory, are astronomical. When governments aren't lending a hand, the feasibility of this resource diminishes greatly.
- Tidal and wave are still at experimental stages, with limited locations to scale and very high associated costs.
- While transitioning to new energy sources is critical, it is not straightforward. Therefore even as more money is driven into an accelerated transition, fossil fuels will fill trial and error gaps. Longer term, we are bearish on fossil fuel demand vs supply, but in the short to medium (2-3 years) term we expect prices to rise to record levels.



Powering Nominal Growth

- Even under the modest real growth scenario for EMs that we have modeled for the next decade, nominal growth will remain high. 500 million more people are expected to be added to the global population by 2030.
- At the backbone of EM economies is manufacturing in and for the secondary sector (chemicals, food, infrastructure, textiles etc.). Such 'ground' economy sectors are beneficiaries of nominal growth; even if real growth is modest. Being old economy sectors, they are not discounted to grow exponentially, hence their cashflows are not downgraded as much as some new economy sectors like digital and tech. Their cost of capital in EMs is already at a high so they do not feel as much pain from monetary tightening. Some of these also see margin expansion (being linked to commodity production).
- The secondary (manufacturing) sector is also highly energy intensive, consuming 4.5x more energy than the tertiary (services) sector.

- Of the 24 EMs identified by the IMF only 6 have net zero targets in policy documents or further, with the target dates being further than 2050 for all but 3. Almost none have laid out detailed plans or reporting mechanisms.
- EMs will not be able to afford or allow accelerated transitions at the expense of growth. Investments in traditional energy will yield better returns than investments in alternatives for EMs and that trade off will need to be made in the medium term. Their fossil fuel consumption will rise in absolute terms over the next decade. By 2050, increase in EM demand will cover 65% of the oil demand decrease from DMs.

Demand Dynamics: Metals

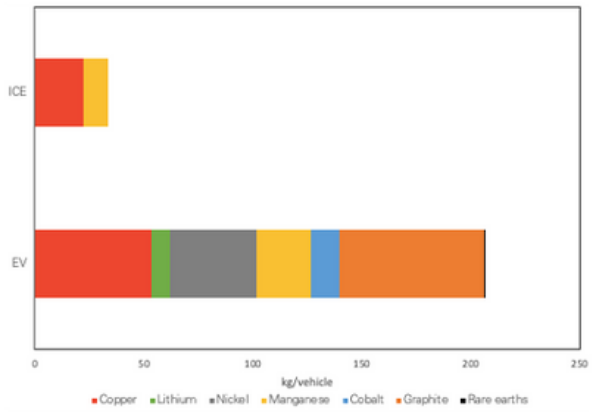
The next 2 decades will see high demand for lots and lots of raw materials to build and rebuild automobiles, batteries, buildings, factories, power plants and grids.

Raw Material for Energy Transition

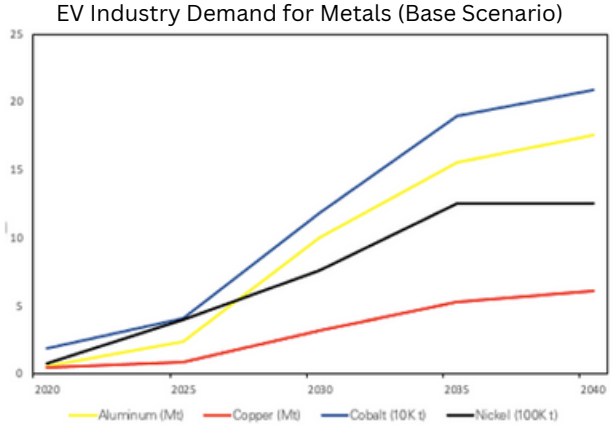
- CO2 concentration in the atmosphere has risen exponentially over the last 70 years. In order to have a 50% chance of limiting global temperature rise to <2°C by 2100, modelled under the four WEO scenarios, CO2 concentration needs to be kept under 450 ppm.
- Business as usual would see us breach that level by 2037. This is one of the biggest risks that the world faces as targets unmet or delayed will create an uninhabitable Earth. Fossil fuel use is responsible for 90% of these emissions. All stakeholders (governments, companies, individuals), have made commitments to replace fossil fuel use with clean energy alternatives.
- Investment in clean energy over the last decade was over $3 Trillion. However, this has not deviated the trajectory at all. Over the next 30 years, $125 Trillion of investments need to be made in transitioning to a sustainable energy system, with $35 Trillion required by 2030.
- Such large investments have chased software technology over the last 2 decades, which is scalable at low marginal costs. The era of new sustainable technology will require unprecedented physical infrastructure to be built from the ground-up, and costs will grow with scale.

- The next 2 decades will see high demand for lots and lots of raw materials to build and rebuild automobiles, batteries, buildings, factories, power plants and grids. As stated previously, the transition will not be smooth and fossil fuels will cover holes when needed. However, this will not be due to the lack of demand but the lack of supply of critical metals required.
- PV power generation requires up to 40 times more copper than fossil fuel combustion. While wind power requires up to 14 times more iron. BEVs use more than 3 times as much copper as traditional ICE vehicles.
- 20 critical energy transition metals including aluminum, copper, iron, lithium, nickel, silver and rare earths will face supply side pressures as the production of low carbon energy intensifies.
- Demand will not be met through material efficiency improvements, as focus will be placed on significant growth in resource extraction.

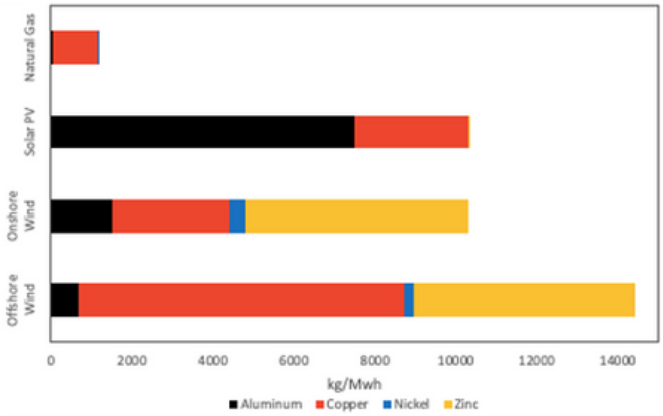
Materials Used In ICE vs Electric Vehicles



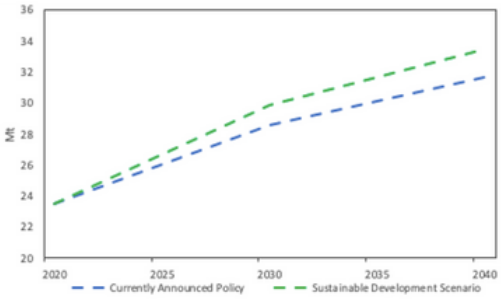
EV Industry Demand for Metals (Base Scenario)



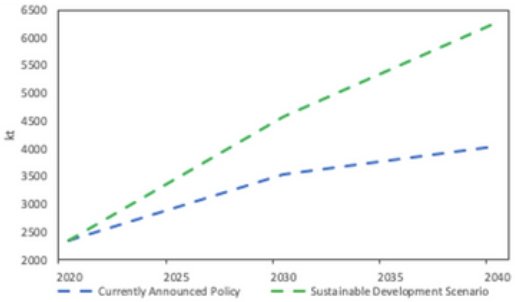
Materials Used In Power Generation by Plant Type



Total Copper Demand by Scenario



Total Nickel Demand by Scenario



Fiscal Spending Towards Infrastructure

- The instruments to perform monetary easing are financial assets, which are mostly owned by the rich. Therefore, easy money for over a decade has inflated financial asset values to much higher levels than real assets in DMs (6x in the US compared to a stable level of 2-3x). This has widened the wealth gap and created dissent
- In 2020, when monetary easing became ineffective on its own, governments started using monetary stimulus for fiscal funding. This would help the real economy and create jobs for the poor, rather than just balloon financial assets which were not being put to use in the real economy as investments by the holders. This new way of governments stepping in to invest easy money, rather than wait for the private sector to do so will be the norm for this decade.
- The most effective way that governments have the know-how and incentive to invest is by building new infrastructure projects. Since the start of 2020, over $5 trillion of public investment has been committed to infrastructure spending.
- EMs on the other hand, have a very low base in terms of infrastructure. So investment in the sector can yield great return for both the state and corporates. Better infrastructure can greatly reduce costs of production in the country while at the same time providing employment for unskilled labor.
- Naturally, fiscal spending causes inflation, but growing populist leaders across the world suggests that jobs for the poor will be prioritized and many leaders will be slow in curbing spending due to their blinders on in an extremist environment.
- 40% of base metal demand comes from physical infrastructure, and with sustainable infrastructure to be prioritized it is expected to grow.

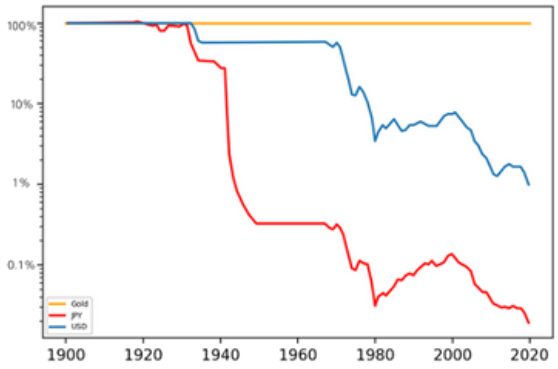
Public Infrastructure Spending Commitments by Major Economies So Far

Project	Country	Commitment	Priority	Announced	Timeline
Infrastructure Plan (NCP 2020)	China	$1.1 Trillion	Clean Energy, Rail, ICT	2020	2025
NIP	India	$1.4 Trillion	Energy, Roads, Rail, Urban Development	2020	2025
IIJA	US	$1.2 Trillion	Roads, Bridges, Water, Tranzit, Rail, Power, ICT	2021	2029
Global Gateway	EU	$350 Billion	Clean Energy, Transport, Health	2021	2027
PGII	G7	$600 Billion	Clean Energy, ICT, Health	2022	2027

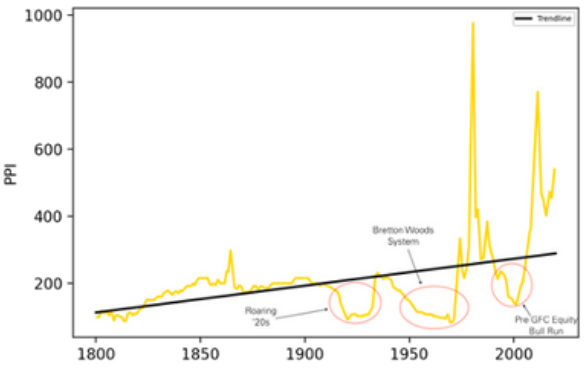
Portfolio Hedge

- Fiat currencies across the world are losing value against real goods. Every financial instrument is denominated in a fiat currency. So, in a volatile environment, not only is the return characteristic of the asset itself uncertain but the store hold of wealth characteristic of the denominated currency is uncertain as well.
- Gold has served as a strong long-term store hold of value over the last 200 years. It has maintained its purchasing power over other commodities and intermediate goods over most periods (barring equity market euphoria peaks and periods of currency pegging). Although prices fluctuate (based on interest rates and money supply), over a long enough period of time it always reverts to its historical purchasing power parity (overriding those effects).
- This is because it has designated historical status as a safety asset, hence, any level of economic dislocation prompts higher demand for gold.
- Store of wealth holdings account for 44% of gold demand currently with US inflation at 8.6%. In 2011, with inflation at 3.5% store of wealth demand accounted for over 50% of total demand for gold. Similarly, open futures positions on the COMEX in Q2 2011 (US CPI=3.43%) were 32% higher than Q2 2022 (US CPI=8.63%) on just nominal dollar terms (57% higher when adjusted for inflation).
- While gold has experienced a sell off over the past year based on rising interest rates, we expect this trend to reverse in 12 months time as the dollar begins to weaken. Investors are highly underweight gold in their portfolios currently. When the big downturn arrives in 12-18 months time, investors, like always would run to safety first (before looking at alternate return streams), driving up demand for gold in the medium term.

Gold vs Fiat Currencies (1900-2020)



Gold Purchasing Power (1800-2020)



Demand Dynamics: Agriculture

When people move from extreme poverty to low middle income, their consumption of cereals such as corn, rice and wheat rises significantly. Such scenarios are expected in populous EMs.

Global Population & Income Mix

- The biggest drivers of food demand are population and income.
- Global population is expected to grow at 0.9% annually till 2030 compared to 1.1% over the previous decade. Population growth for DMs is expected at 0.3%, whereas for EMs it is 1.1%.
- Despite slower population growth, demand for starchy agricultural commodities will rise. This can be explained by the fact that in developing economies such as India, Brazil and Southeast Asia, the bulk of population growth is expected to be at low income groups.
- When people move from extreme poverty to slightly better income levels (still part of low middle income, according to global standards), their consumption of cereals such as corn, rice and wheat rises significantly. Such scenarios are expected in populous EMs (similar to China in late 1990s & 2000s) as well as Africa and the Middle East through to 2030.

- On the other hand, China will move from middle income to high income over the next 10 years as per capita income of their rural towns moves into upper middle income territory. This will increase demand for income elastic commodities like sugar, animal based products such as beef, pork and milk as well as livestock feed such as soybeans.
- Finally, agricultural demand in DMs is highly inelastic and will remain flat through the next decade.
- Cotton demand is also highly positively correlated to rising income levels. Expanding textile industries in Vietnam, Indonesia, Bangladesh and Turkey will also lead to a 30% increase in cotton import demand by 2030.

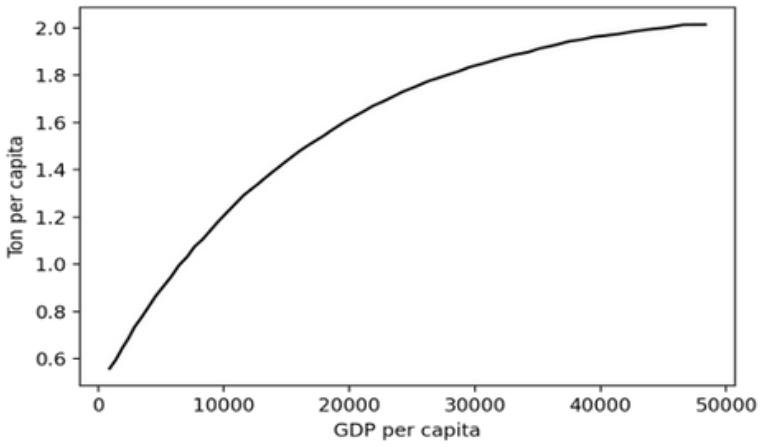
Food Demand Elasticity

Factor	Demand Elasticity
Population	0.98
Income	0.31
Agricultural Productivity	0.02

Income Elasticity of Demand of Animal Products by Region

Product	United States	China	South Asia
Beef	0.00	0.65	0.71
Pork	-0.03	0.67	0.43
Milk	0.02	0.17	0.35

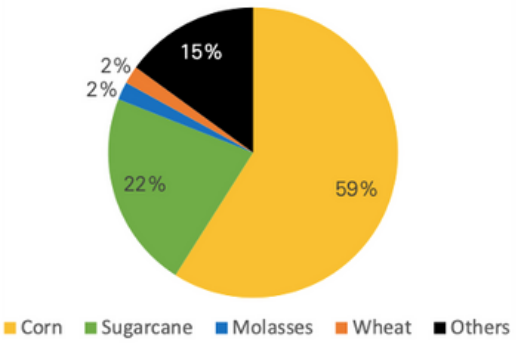
Annual Cereal Consumption by Income Level (USD)



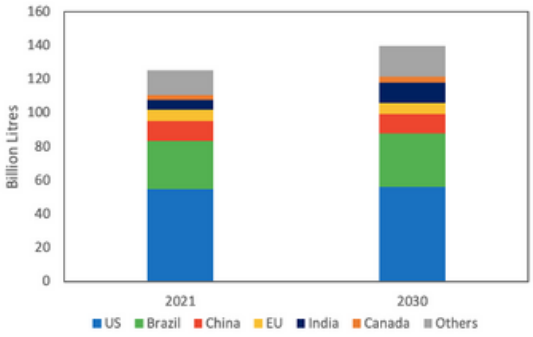
Biofuel

- Ethanol and biodiesel are the most used biofuels globally (combining for 93.5% of global biofuel demand). Ethanol is derived from starch (corn, wheat) or sugar feedstocks. Whereas biodiesel is derived from vegetable oil (soybean oil, palm oil) and animal fats (beef tallow).
- Biofuels are mostly used as a means of energy for transportation. Ethanol is blended with gasoline (petrol) and biodiesel is blended with diesel for use. Ethanol has 40% less net greenhouse gas emissions than gasoline. However, their energy conversion ratios are much lower compared to other energy sources as only 0.2% of usable solar radiation is converted into ethanol. Solar power systems can produce 100 times more energy per hectare than corn or sugarcane fields used to produce ethanol.
- The US (ethanol) and EU (biodiesel) are the biggest consumers of biofuel. Due to achievement of previous blend mandates and inefficiency of biofuel compared to other alternatives; their consumption is expected to remain flat. US is expected marginally increase its ethanol blend rate to 11%, while biodiesel use in the EU is expected to decline marginally due to palm oil (biodiesel) being under high ILUC risk in the RED II regime implemented in 2021.
- For EMs such as Brazil and India, biofuel presents an opportunity for energy independence despite lower conversion ratios. EMs are a long way from having infrastructure for clean energy, hence, ethanol can help bridge the gap. Brazil has a large 27% blend mandate for ethanol and has produced a large fleet of flex-fuel vehicles to achieve the same. India has accelerated its 20% ethanol blend mandate target from 2030 to 2025. **EM demand for biofuel is expected to increase around 30% by 2030.**

Global Ethanol Production by Feedstock



Ethanol Consumption 2021 vs 2030 (proj.)



Ethanol & Biodiesel Blend Mandates in Select Countries

Country	Mandate	2021 Blend Level
Brazil	E27	24.5%
China	E10	2.1%
India	E20	8.1%
Indonesia	B30	12.5%

Supply Dynamics: Energy

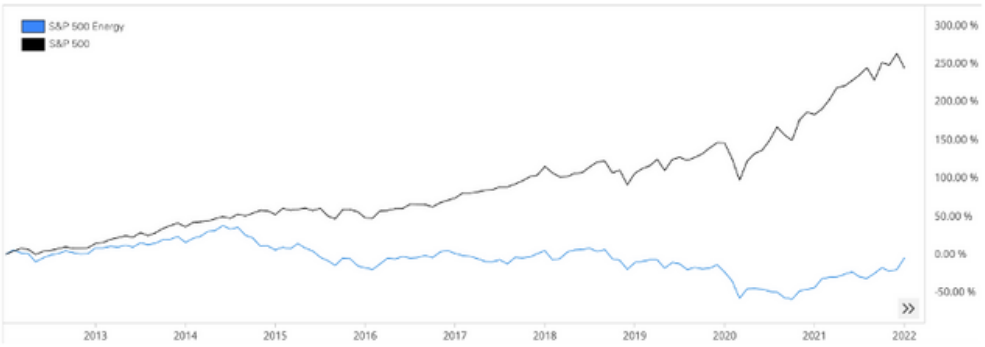
Unrealistic expectations for development of alternatives and a lack of contingency planning by stakeholders has led the world to this point, wherein spare capacity is 1.5% of global demand.

Underinvestment in Exploration & Production

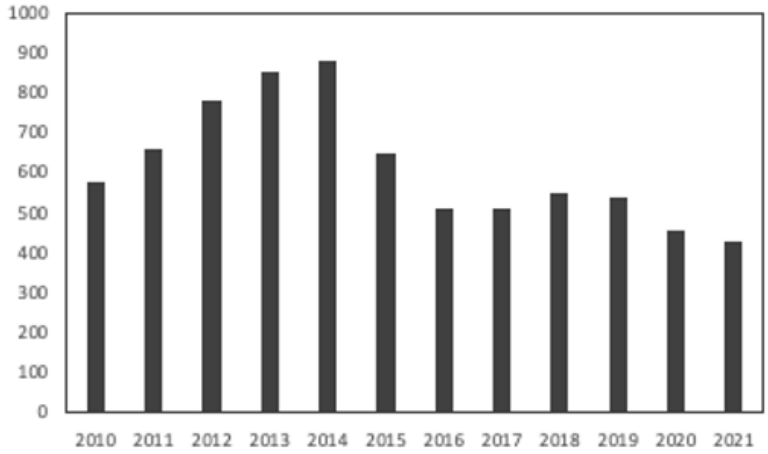
- Governments across the world have discouraged investments in exploration and production of oil and gas in order to achieve their climate goals on an accelerated basis. They imposed heavy taxes and regulation on new projects for production of fossil fuels, while scrutinizing the sector at every available opportunity.
- This combined with short term gluts caused by US shale production and geopolitical rivalries in OPEC in the early 2010s led to highly volatile oil and gas prices through the decade.
- The economics of the industry were lopsided with higher costs of production and uncertain revenue streams.
- Investors also came up with self imposed ESG mandates to reallocate funding from hydrocarbon producing energy companies to alternatives in clean energy technology. Investing in traditional energy producers was considered taboo by the community.

- Capital expenditure in E&P declined by over 50% from 2014-2021. While energy stocks had negative return, the broader market was up in excess of 250% over the last decade, reinforcing lower investment.
- Unrealistic expectations for development of alternatives and a lack of contingency planning by stakeholders has led the world to this point, wherein spare capacity is 1.5% of global demand.
- **Oil fields are declining at 6% per year on average and the increased investments made in 2022 are too little too late to meet demand that will still grow till at least 2025.**

S&P 500 vs S&P 500 Energy Performance (2012-2022)



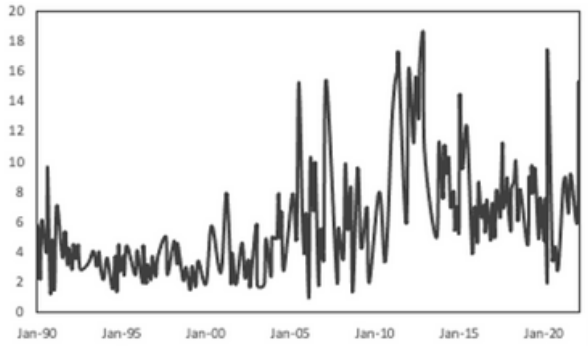
Energy Exploration & Production CAPEX (Global, $B)



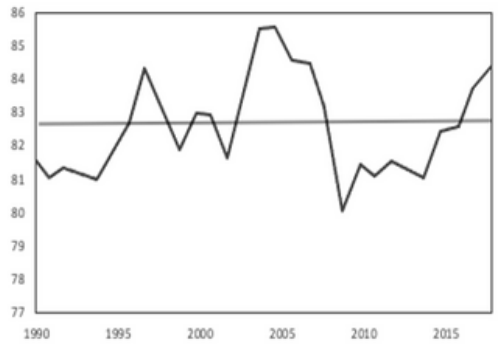
Refinery Capacity

- A simple distillation crude oil refinery with producing around 100,000 bpd costs around $3 Billion to build. However, these produce too much heavy oil which dampens profitability. A more complex refinery equipped with catalytic cracking, costs nearly double and even higher during periods of stringent emissions regulations.
- Refinery fixed costs are 2-3 times their variable costs. At full capacity, a newly built refinery with a conversion unit (to reduce heavy oil output) has total cost of over $10 per barrel, compared to historical inflation adjusted average of $3 per barrel.
- Since the GFC in 2007-08, with rising costs and falling prices, refinery margins have been more volatile than ever. With 62% volatility compared to 23% volatility for S&P 500 companies' margins, **refining has not been a stable business to be in over the last 15 years. This has discouraged investments into building capacity.**
- With environmental lawsuits against refiners also at all-time highs, old refineries have been shutting down across major economies over the last two decades. Facilities have also been undermaintained as outages have surged over the past decade.
- Governments are just waking up to the fact that all refineries currently under operation working at 100% capacity, will not be able to refine enough crude oil and natural gas to meet demand.
- However, green field refineries take around 5 years to come online, while retrofitting old refineries for expansion is a very expensive process. Hence, bottlenecks are expected to continue on the refining front globally for at least the short-medium term.

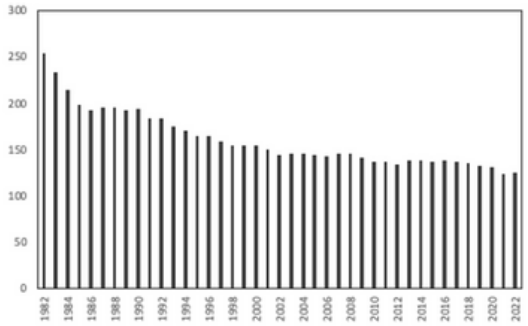
3:2:1 Crack Spread - Crude Oil Refining Margin (Infl. Adj. $)



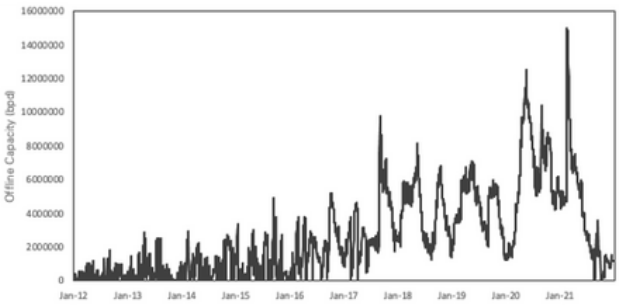
Global Refinery Utilization Rate (% Capacity)



Number of Operating Refineries (US)



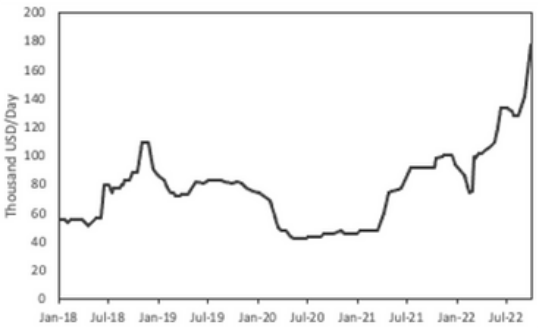
Global Refinery Outages (2012-2022)



Dispatch Infrastructure (Logistics)

- Much of the world does not have indigenous fossil fuels, therefore oil and gas must be delivered via pipelines and tankers. Pipelines tend to be the most efficient and handle the majority of oil and gas transportation, accounting for over 70% of crude and petroleum while tankers account for 22% of the same.
- Pipelines for cross ocean dispatch have not been deemed physically and economically viable. Regions with low availability like most of Europe and Asia have to import liquified gas, crude and petroleum products via tankers from areas with surplus like the US and the Middle East.
- The sanctions on Russian natural gas to Europe via pipeline has led to a global scramble for LNG tankers. Short term charter tankers are sparsely available while long term charters are not at all. **With Europe competing with Asia for the vessels, carrier day rates have surged to unprecedented levels.** 286 LNG carriers are on order globally till 2028, with 165 slated for delivery by 2025, however this will be too late to prevent soaring prices in the medium term.
- Pipelines and terminals across the world have also been facing increased scrutiny for damaging waterways and creating toxic waste, ever since the widespread protests against the proposed Keystone XL (transporting crude to refineries) in the early 2010s which lead to the Obama administration to reject the proposal, with the developer ultimately abandoning the project in 2021. More than 3000 miles of US pipelines face delays, shelving or cancellations.
- This combined with lack of financing for projects following low prices and utilization during the pandemic has led to a **pipeline shortage within key regions in the US**. As demand has recovered pipeline bottlenecks have led to soaring prices despite adequate supply for the time being from the Permian and Appalachian basins.

160,000 cu m LNG Tanker 1Y Charter Rates



Global Pipeline Capacity Shelved or Cancelled

Commodity	As % of Current Operating Capacity
Gas	23.4%
Oil	22.1%

Tight Oil & Gas

- The development of horizontal drilling and hydraulic fracturing technology (late 2000s) enabled producers in the US to extract oil and gas buried in deep shale rock formations previously thought to be inaccessible. However, these drilling techniques have much higher associated costs. So, ceteris paribus, shale oil is profitable at crude prices higher than $70/bbl and shale gas is profitable at nat gas prices over $4/mmbtu.
- Along with associated costs, these methods of drilling also have high environmental consequences such as high water use, groundwater contamination and methane leaks. Therefore, the tight oil and gas industry has higher regulations than traditional drilling, further adding to costs.
- In 2014 oil and gas prices dipped below breakeven levels for shale producers and remained low till the back end of last year. Between 2010-2019 the free cash flow for the US shale industry was -$300 Billion. Producers were focused on securing finance to be able to stay in business, with expansion not even on the agenda. The 2020 oil crash induced by the pandemic was a turning point, wherein many producers went under, while others were forced to lay down rigs and reduce workforce.
- Now, oil prices are at a point where there is big money in tight oil and gas. However, the industry having gone through the experiences of the back half of the previous decade is extremely weary and hesitant about increasing capital programs and expanding capacity, especially with the global uncertainty around energy use. With a left leaning government at this time it is also difficult to get environmental permits to do so.

- The industry has been using their higher profits this year to pay back debt and for dividends. Any **expansion plans are being evaluated under the highest capital discipline and most of the expanded production is coming from already drilled but unused wells.**
- Any change in stance by the government is expected to be short term, which would not be enough to entice the industry to bring more shale capacity online due to fear of getting burned later. Only 2-3 years from now, following major supply shocks, a change in government and sustained higher prices, will the industry expand capacity significantly.

Cashflow Reinvestment Rate of Largest US Shale Producers

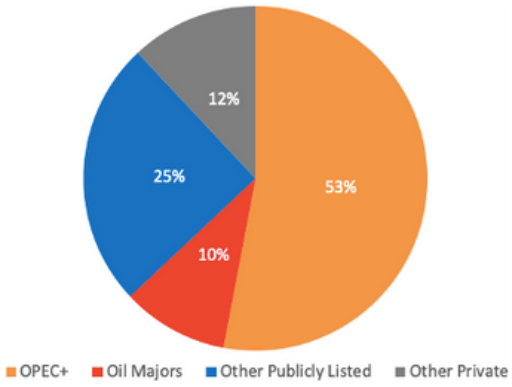
Producer	Reinvestment Ratio
Chevron	28%
EOG Resources	55%
ConocoPhillips	37%
Occidental Petroleum	28%

OPEC+

- OPEC+, consisting of 24 member nations, accounts for 44% of global crude oil supply and 39% of global natural gas supply as of Q2 2022. These nations rely heavily on revenues from oil and gas for fiscal expenditures.
- OPEC+ members have ambitions to create industries that can thrive in a future powered by clean energy, and this requires significant public spending. Therefore to finance this, they need oil prices to be above a certain floor.
- The 2020 oil price crash forced many influential members such as Saudi Arabia to drastically increase taxes and cut public sector pay. As a consequence they took capacity offline and imposed lower quotas on the likes of UAE which derailed their expansion plans. Over 10 million bpd of crude supply was taken off the market by OPEC during this time.
- Now, as demand has rebounded, OPEC+ has just over 1MMbpd of spare capacity (in Saudi & UAE) and inventories are continuing to decline. **Most OPEC members are failing to even get close to meeting their production quota limits.**

- Unlike US shale projects (6 months), OPEC+ drilling has a set up timeline of 5-10 years.
- Other than underinvestment; a sociopolitical crisis in Libya and economic sanctions on Iran, Russia and Venezuela have constrained the level of production. More output from these countries can go offline in the coming months due to the highly volatile nature of these events.
- Current prices ($90-100/bl) are at an acceptable floor for OPEC leaders, wherein they are only going to make symbolic cuts/increases. If prices rise, an OPEC+ output increase to full capacity will risk an even bigger panic were the likes of Libya to go offline. At lower prices, OPEC+ will most certainly cut production to gain more influence in terms of spare capacity as well as reach their fiscal breakeven.

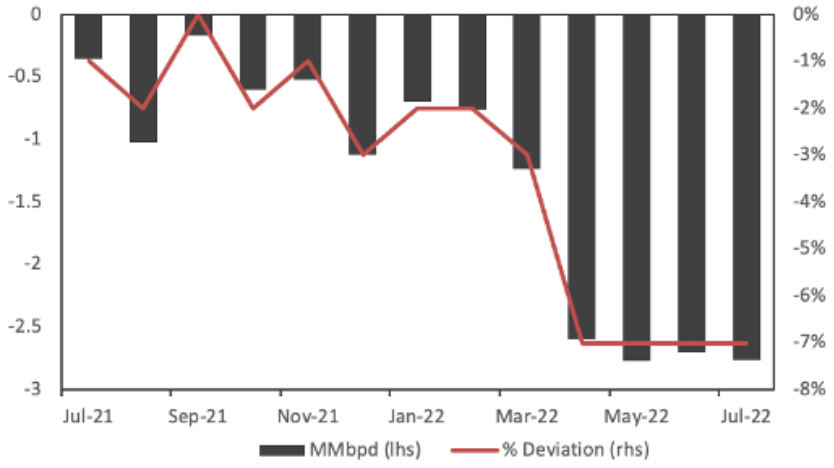
Share of Proven Oil Reserves



Fiscal Breakeven Crude Price (OPEC+)

Country	USD/bl
Saudi Arabia	70
Russia	129
UAE	115
Iraq	77
Iran	319

OPEC+ Monthly Deviation from Crude Oil Output Quota



Supply Dynamics: Metals

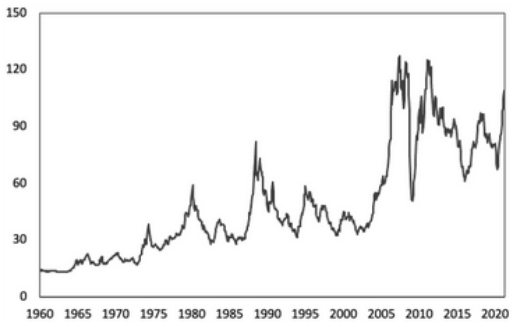
As of now, proven reserves of critical energy transition metals are nowhere near sufficient enough meet demand if the current generation of sustainable technology will be used for phasing out fossil fuels.

Production Economics

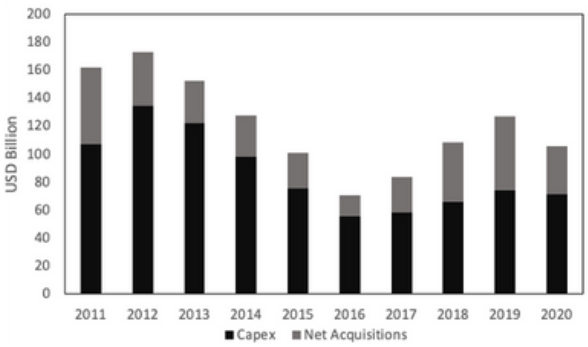
- After a bull run aided by surging demand from the development of the Chinese economy in the mid 2000s, base metal prices collapsed in 2011 and remained at depressed levels through most of the following decade.
- Like fossil fuel producers, metals mining and processing companies had engaged in a burst of M&A activity and project investment during the boom period, which resulted in bloated cost structures, capex blowouts and asset write-downs.
- The industry on aggregate, had negative free cash flow from 2012-2014 and razor thin margins till the last years of the decade.
- Investors were drawn away from the industry, especially with broad equity markets providing great excess returns.
- **As capital dried up, miners, refiners and smelters spent the back half of the 2010s cutting costs, repaying debts and repairing their balance sheets**. Many prefeasibility and conceptual projects were abandoned. Innovation in mining equipment and techniques were scrapped due to high costs.
- Over the last decade, just 2 significant copper mining projects were commissioned in Chile (accounting for 5% of their ore production in 2021) and only 2 significant bauxite mining projects were commissioned in Australia (accounting for 13% of their production in 2021). While more than half of the iron ore mines that were commissioned in Australia in the last decade, ceased operations as many of the companies that owned the mines were liquidated.

- Cashflows from operations have improved over the last year, however companies are now placing closer scrutiny on leverage in their decision making process due to past experiences. **We expect an adjustment period before capex expansion can really begin, even during which, timelines on new mining sites from feasibility to production is from 5-12 years.**

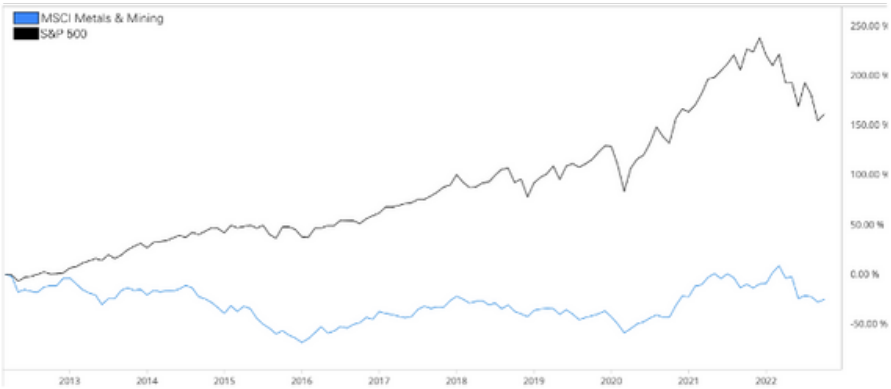
Base Metals Price Index



Metals Mining CAPEX & Acquisitions



S&P 500 vs MSCI Metals & Mining Performance (2012-2022)

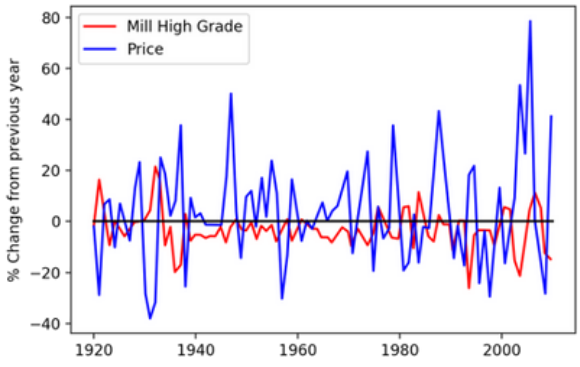


Inadequate Reserves & New Capacity

- Although proven ore reserves do not capture the true extent of mineralization, they are the only ore deposits considered to be of high enough grade and suitably accessible to be economically feasible.

- As reserves are depleted over time, they have to be replaced by delineation of new resources having lower grade ore. These new frontiers are explored and drilled via newer more sophisticated methods (diamond drilling in the 19th century; satellite imagery, geographic information systems and the rise of open pit mining using the Jackling method in the 20th century). While they lead to efficiency improvements, they none the less tend to be used in larger scale projects with high associated costs and by nature are used to mine lower metal content. Hence, conversion of new lower ore grade resources to reserves is strongly correlated to higher commodity prices.
- **As of now, proven reserves of critical energy transition metals are nowhere near sufficient enough meet demand if the current generation of sustainable technology will be used for phasing out fossil fuels.**
- Clean energy technology will improve over time with all the investment dollars poured in, however this will take decades to occur as the industry will first be met with a series of big supply shocks.
- Conversion of resources previously thought to be economically worthless to new reserves will be strongly considered by the industry as prices rise with constrained supply. However, this too will come with major ESG concerns as discussed in the following section.

Copper Ore Grade Mined vs Price (US)



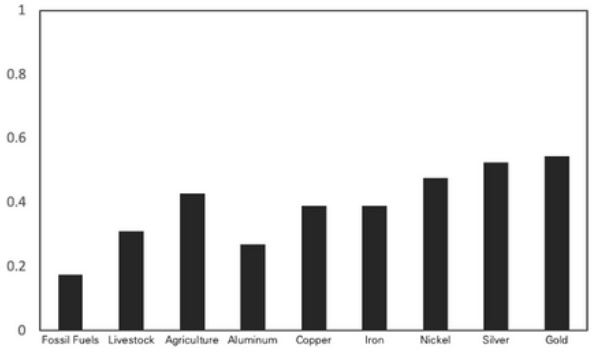
Critical Metals Reserve to Requirements for Energy Transition

Metal	Reserves/Requirements
Copper	20%
Cobalt	3.48%
Lithium	10%
Nickel	10%

Environmental Impact of Production

- Current mining and processing methods have major negative externalities such as landscape modification, deforestation, habitat loss, waste accumulation, soil and water contamination, energy consumption as well as intense carbon emissions. The industry is only behind fossil fuels in drawing severe criticism from governments and ESG activists.
- Large mining projects across natural resource rich nations such as Australia, China, Chile, DRC and the United States have been decommissioned through the last decade over ESG concerns. On aggregate, 15-20% of mining capacity of bauxite, copper, iron, gold, silver and zinc has been shelved or been under threat in these countries. Strict government regulation has also added to production costs.
- A more important factor is the greater environmental footprint of mining frontier resources (discussed in the prior section). Conversion of these undeveloped resources into reserves analyzed across ESG risk factors such as water, tailings, biodiversity, land pressure, community and GHG emissions reveals that the majority of them pose medium to high ESG risks that may prohibit future production. Over 90% of risk in these projects comes from ESG factors.
- Governments will have to weigh up sustainability benefits arising from the consumption of these resources against the unsustainable nature of their production. A simple **compromise on the ESG concerns is unlikely and supply will be constrained as projects fail to receive permits and existing projects are halted.**

Production Sustainability Scores by Commodity
(1= Highly Sustainable)

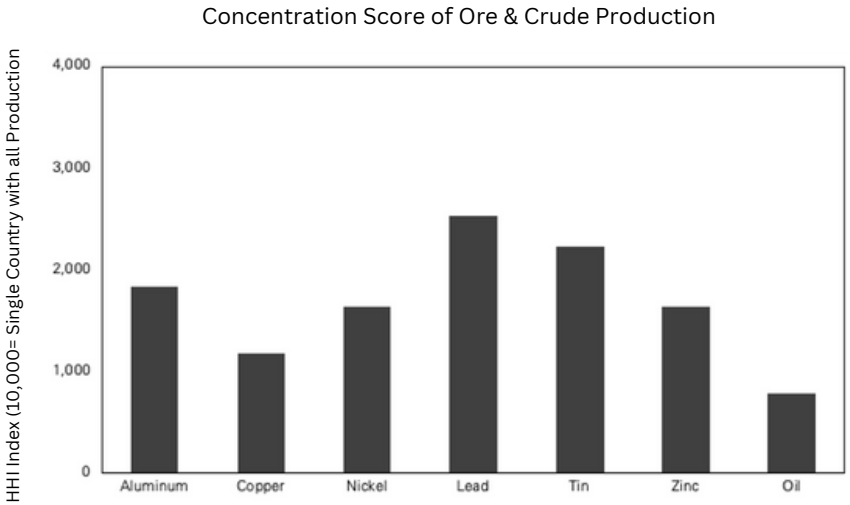


Share of Resource Under High ESG Risk

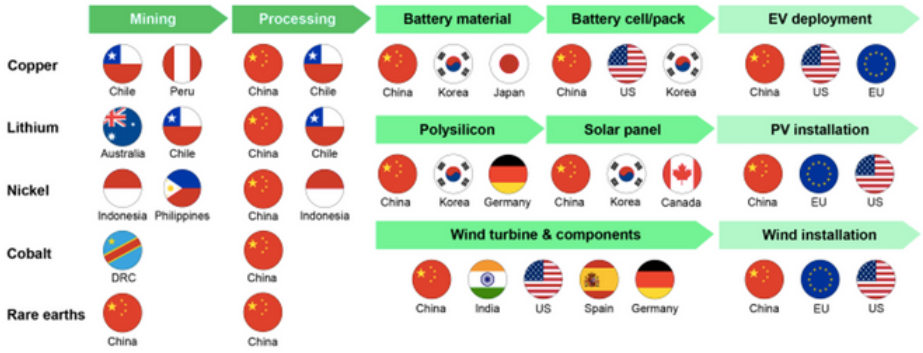
Projects	Share Under ESG Risk
Bauxite	88%
Copper	63%
Iron Ore	47%

Supply Chain Bottlenecks

- Mining of metal ore and presence of significant reserves is highly concentrated in certain regions of the world, even more so than oil and gas. The economic and political stability of many of these resource rich nations in Asia, Africa and South America is historically low, which presents a significant risk to supply especially with amplified future demand scenarios.
- **Metals are key strategic resources that will come into play as tensions between US and China escalate.** China can impose export bans on processed metal, like it has done for rare earths, which can invoke retaliation from the west to squeeze them on critical mineral ores. This could lead to huge supply bottlenecks with multiplier effects.
- Low energy availability, along with sustained higher energy prices for a 2-3 year period will also spill over to the metal mining and processing industry. Mining, refining and smelting units will likely suffer more outages for extended periods.
- Finally, fleet inefficiencies and higher commodity demand are leading to a huge surge in bulker prices. With geopolitical factors at play as well, high bulker prices and lower availability will weigh on metals supply till at least 2027.



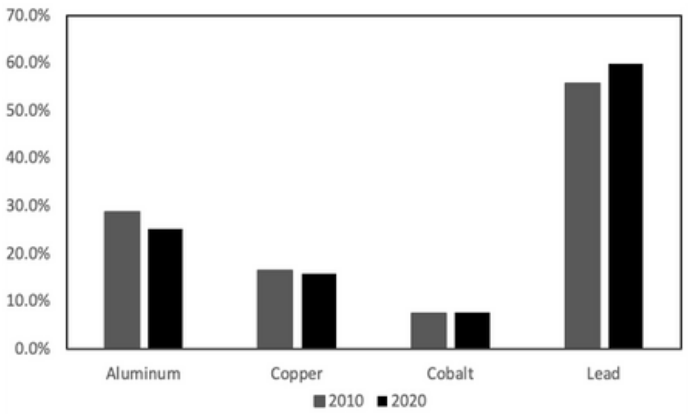
Supply Chain of Clean Energy Technology by Country Dominance



Secondary Sources (Recycling)

- For most metals the share of secondary input in total refined product consumption has remained stagnant over the last decade. This means that the growth in the rate of recycling has merely kept up with the overall growth in demand.
- Physical collection is a major constraint on recycling metal scrap. New age products that have shorter product lives such as personal electronics and alloyed materials are difficult to separate metallurgically. While, new clean technology devices by nature are being built to have longer product lifespans (25-30 years).
- Government mandates and incentives for recycling materials is the only way to achieve scale in recycling. However, economies consuming the bulk of these commodities are yet to realize the importance of scaling, which will be a time and capital consuming process once they decide to embark upon it. Companies across the value chain will need to be onboarded, which can risk depressing economic output due to associated costs.
- Even if major consumption economies achieve scale in recycling via policy intervention, it will not be enough to meet the surge in demand over the next two decades and the **share of secondary/scrap metal input in consumption is expected to fall.**

Share of Secondary Input in Refined Consumption



Supply Dynamics: Agriculture

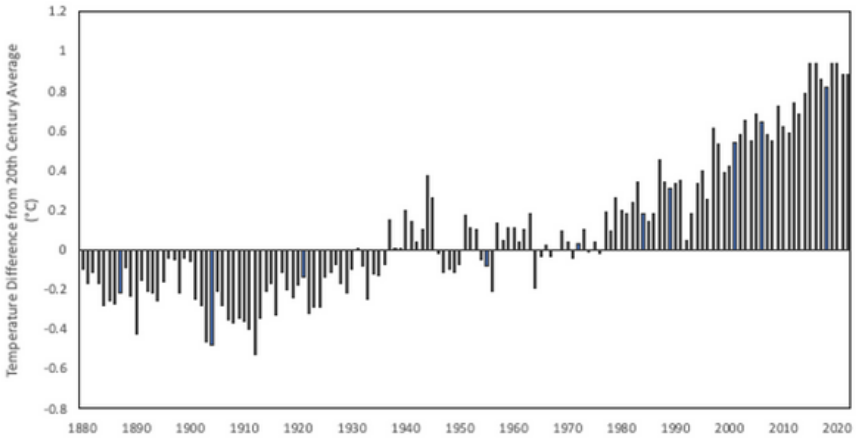
Higher frequency of extreme climate events pose a multitude of risks including extending typical growing seasons.

Climate Change

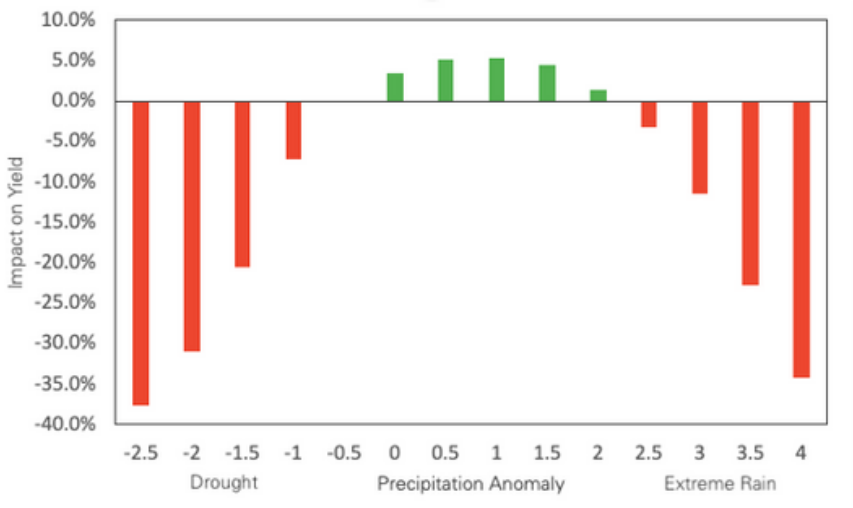
- Throughout history, seasonality has been the most prominent factor in analyzing agricultural commodity supply. However, over the last decade average global temperatures have risen to levels where predictable weather changes i.e. seasonality, will be secondary in evaluating future supply as **higher frequency of extreme climate events pose a multitude of risks including extending typical growing seasons.**
- Shifting precipitation patterns, increased frequency and duration of draughts and extreme rainfall associated with higher temperatures will lead to more intense wildfires reducing forage, deplete water resources for irrigation, damage crops, increase the rate of soil erosion and expand the incidence of pests and disease for crops and livestock.
- The impact will be more severe in EMs like Brazil and India where crop management and irrigation technology are limited.

- Acute supply shortages due to climate change will come into play in 5-7 years as crop yields of staple grains will decline by up to 30% and livestock supply will decline by up to 10%.
- Less severe impacts are being felt in the immediate term, however. In 2021, extreme weather events brought overall crop yield down 4% and cereal yields by 2%. Such events are expected to expand over the next few years and impact on specific agricultural commodities such as Brazilian sugar offer great investment opportunities.

Global Temperature Anomalies (Difference from 20th cent. average)



Extreme Weather Impact on Maize Yield



Pasture & Cropland Limitations

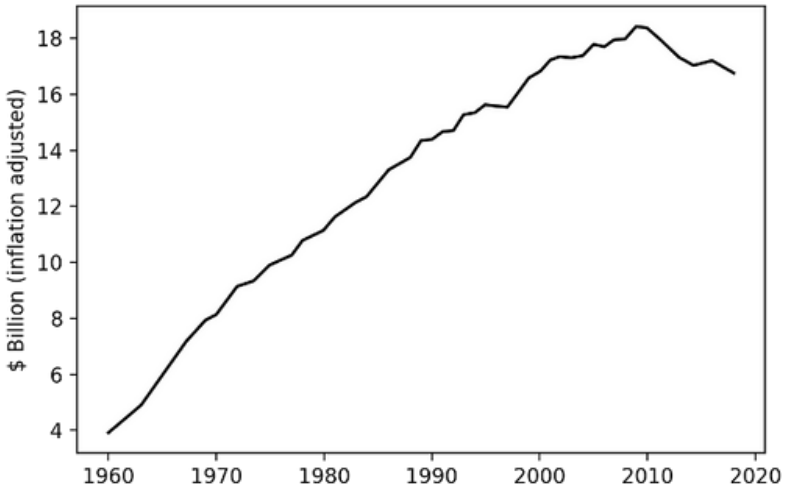
- Global cereal crop production has increased by 4.2% annually over the last 50 years with one of the primary reasons for the increase being land area expansion.
- As of today, most of the Earth's surface is under use. 71% of non glacier land is being used in the production of some form of agricultural commodity, 12% is barren and 1% comprises infrastructure for human settlements.
- This leaves only 16% of unused inhabitable land in the form of forests, grasslands and wetlands.
- These ecosystems are crucial in the battle against climate change because of their environmental benefits such as carbon absorption, water regulation, erosion control and natural disaster abatement.
- For these reasons more than 65% of governments worldwide have included land use change in their policy documents, noting cultivated area expansion (forests) and land used for grazing (grasslands) to be the most important causes of decrease in these ecosystems. Food security, on the other hand has only been noted as a concern, in a small share of the policy documents (<15%).
- With governments clearly prioritizing forest conservation, laws have been imposed against unused forest and ecosystem conversion for agriculture. **Land-use expansion, which has been crucial in providing majority of production gains over the last 5 decades, will be increasingly difficult.**

Global Land Use

Factor Productivity of Agriculture

- Total Factor Productivity growth in agriculture has been slowing over the past decade.
- Apart from climate change, the biggest reason for the the slowdown has been the **declining global agriculture R&D spends**, especially from high income countries (where frontier technological innovation comes from).
- Public R&D projects were prematurely withdrawn as public funds were refocused towards environment protection. Opportunities in agricultural productivity research were thought to be commercially viable and public research institutions with functions redundant with the private sector were merged or dissolved.
- The need for sustainable farming has driven private R&D efforts towards it. In the short term, sustainable farming has higher costs, knowledge barriers for widespread diffusion and will lead to yield declines.
- Private investment in this sector also relies critically on spillover effects from public research institutions. Therefore, private investment in agricultural R&D has only partially compensated for the declining investment from public institutions.
- Additionally, negative public attitude towards technologies such as genetically modified crops is slowing their adoption. Many high income nations are rarely permitting such technologies.

High Income Countries Public Agri R&D Spend



Impact Of Geopolitics

- The next 5 years will see the largest global food crisis since the 1970s. The most important factor behind this is the escalation of international tensions (leading to various types of war) which exacerbates the impact on an already tight food supply chain.
- The Russia-Ukraine war has already led to 25 million tons of agrifood exports vanishing this year, with both nations together accounting for 30% of global wheat exports.
- An even more severe impact of this will be the bottlenecks in fertilizer supply. Russia is the second largest producer of potash, which is used heavily as fertilizer in Brazil and India. The war is expected to shrink Russian potash production by 30%, which will lead to a global scramble and boost prices within 6-8 months.
- The biggest impact however, will come from escalations and war between US and China. China, the largest consumer of agrifood in the world, imports nearly 40% of it from US and its allies. Sanctions on supply will have large cascading effects around the world, as countries restrict exports to ensure self sufficiency (already seen in India with wheat and sugar).

Labor Scarcity

- 400 million farmers in China armed with increased factor productivity have been responsible for over 30% of the gains in food supply till the early part of the previous decade.
- However, the younger cohort of the population has been declining over the last two decades. The new generation of skilled Chinese workers have also been exclusively going after white collar jobs.
- A similar trend across the developed world has seen 200 million people leave the agricultural work force in the last 2 decades.
- In the long term, this trend will prove to be inflationary as labor from other EMs will not be enough to cover for the declines from China and other DMs.

Investing In Commodities

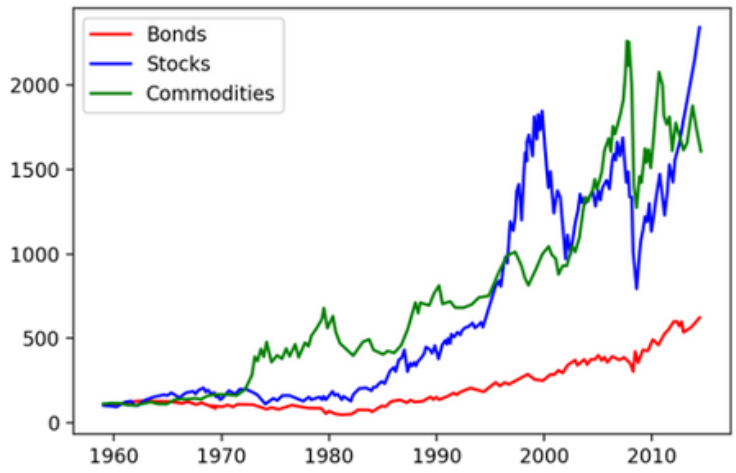
Myths About Commodity Futures

An equally weighted, fully collateralized (i.e. unlevered) commodity index has yielded almost as much inflation adjusted excess return as stocks, while having much less risk. It also has a much higher Sharpe ratio (risk adjusted return) than bonds over the last 150 year period.

- Holding commodities physically has high costs (storage, insurance, transport etc.). While holding stocks of commodity companies comes with idiosyncratic management risks and negate price return on commodities as these companies keep their price exposures hedged (low correlation to commodity prices, higher to stocks).
- The most efficient way to invest in commodities is by going long commodity futures. However, most investors wrongly perceive commodity futures to be assets with low risk adjusted return (i.e. Sharpe ratio) and high volatility.
- Looking at commodity futures over a 150 year time horizon (1870-2020) against stocks and bonds, yields results that would surprise most. Despite the period having more instances of macroeconomic conditions that favor stocks and bonds over commodities, it can be considered long enough to account for a full long cycle.
- **An equally weighted, fully collateralized (i.e. unlevered) commodity index has yielded almost as much inflation adjusted excess return as stocks, while having much less risk. It also has a much higher Sharpe ratio (risk adjusted return) than bonds over the last 150 year period.**

- Hence, the myth about volatility which arises from highly leveraged positions is debunked. Apart from having excess return as high as stocks, commodity futures have low correlation to stocks (0.04), negative correlation to bonds (-0.25) and are the only asset class with positive correlation with inflation (0.33) in the last 50 years.
- **It is therefore crucial to have commodity futures as part of your portfolio for their high risk adjusted return and diversification benefits in any environment let alone the stagflationary environment which we have entered.**

Commodity Futures Performance vs Stocks & Bonds (Infl. Adj.)



Asset Risk Premium (1870-2020)

Asset Class	Excess Return	Risk (σ)	Sharpe Ratio
Bonds	1.53%	6.67%	0.25
Stocks	5.31%	17.21%	0.39
Commodity Futures	4.35%	14.41%	0.37

The Problem With Current Commodity Funds

Commodity indexes on offer currently have been overly concentrated in energy.

- As mentioned earlier, stocks and bonds have had great returns over the last 50 years.
- Therefore, most large index fund providers offering exposure to commodities have been focused on those two lucrative assets instead. Commodities have been largely ignored by them due to lower returns in deflationary periods, as well as the perception of commodities being a volatile asset class.
- Due to this **commodity indexes on offer currently have been overly concentrated in energy**. This bias arose as the first commodity indexes were created in the early 1990s during the energy supply shock due to the gulf crisis. Since then oil and gas have provided the best returns amongst commodities which has greatly influenced fund managers to focus their research on them.
- **Almost all of these indexes are production weighted** (i.e. most produced and consumed commodities having higher share in portfolio). Since oil and gas flow through the economy more than any other commodity, this has reinforced the energy bias of said index funds. This method also leads to higher weights for non storable commodities (e.g. livestock) compared to storable ones (e.g. precious metals).
- This adds to **idiosyncratic risks** and doesn't benefit from a strong fundamental picture for commodities as an asset class**. Sustainable commodities are underweighted**, which will cause big issues in the medium term.
- Commodity index funds are also **passively managed** which erodes return over time.
- **None of them are accounting for the global paradigm shift** that is about to occur in the investment environment. This **leaves them exposed on their hedges and collateral yields.**

Major Commodity Indexes Weights & Weaknesses

Commodity Index	Agriculture	Industrial Metals	Precious Metals	Energy	Weakness
Goldman Sachs (GSCI)	28%	13%	6%	53%	Overweight Energy
Deutsche Bank (DBLCI)	22%	13%	10%	55%	Overweight Energy
ICE Bank of America (MLCX)	21%	12%	7%	60%	Overweight Energy
Bloomberg (BCOM)	35%	15%	20%	30%	Arbitrary Caps

Conclusion

- An unwinding of 50 years of monetary policy is now underway. The next decade will see an investment environment unlike any most people have seen in their lifetimes.
- There is a real threat of wealth destruction by holding a portfolio that has served investors well in the past by going long traditional asset classes.
- This period is akin to the end of most 150 year civilization cycles of the past.
- At the same time international war, a global energy transition and the need for fiscal spending met by monetary stimulus are creating fundamental price pressures on natural resources.
- It is therefore crucial to hold alternative assets like commodities as part of your portfolio, not just for the the added return but also to reduce risk.
- Yet as most investors have ignored commodities in the past, they do not understand them well. There is a lack of options for investors looking to gain efficient long term beta exposure to the asset class.

Disclosure