

## 2023 Commodity Outlook

# An underinvested supercycle

- **A year when underinvestment bites.** Just as commodity markets have been dominated by the dollar in 2022, we expect them to be shaped by underinvestment in 2023. From a fundamental perspective, the setup for most commodities next year is more bullish than it has been at any point since we first highlighted the supercycle in October 2020. Despite broadly depleted working inventories (oil's build was mostly at sea) and spare capacity nearly exhausted across most markets, capital in 2022 proved to be unresponsive to near record prices as market positioning remained skewed for a recession. Spot prices retraced nearly to 2021 levels as financial deleveraging and physical destocking – both forms of short run underinvestment – combined with a disorderly Chinese reopening to pressure energy prices since October. Across commodity markets, the rapid rise in the cost of capital lowers the incentive to hold either physical inventories or paper risk, distorting price discovery as financial markets react faster than the real economy, creating markets that are simply unprepared for sequential growth in 2023.
- **No supply response in sight.** While markets are divesting today, what's more startling is the lack of investment in commodities for tomorrow. Importantly, the majority of the commodity deflation came from central bankers raising the cost of capital and draining market liquidity, both physically and financially, which is not a long-term fundamental solution. Without sufficient capex to create spare supply capacity, commodities will remain stuck in a state of long run shortages, with higher and more volatile prices. While investors remain concerned with the 2023 growth outlook – a large driver of the latest sell off – the global business cycle is far from over. Our economists argue that global economic growth is set to rebound with China seeing the reopening happening today, Europe improving its energy efficiency in a one-off decline in industrial activity and a slowing of the aggressive Fed rate hikes in the US. These underpin our expectation that commodities (S&P GSCI TR) will return 43% in 2023.
- **Best asset class 2-years running and likely again in 2023.** Despite the recent price declines, commodities will still likely finish the year as the best performing asset class in 2022 with c.23% returns (S&P GSCI TR) following 42% returns in 2021, as investors were able to bank the price spikes from earlier this year through the roll yield as spot prices were only up 6%. Commodity supercycles never move in a straight line; rather, they are a sequence of price spikes, with

**Jeffrey Currie**  
+44(20)7552-7410 | jeffrey.currie@gs.com  
Goldman Sachs International

**Samantha Dart**  
+1(212)357-9428 | samantha.dart@gs.com  
Goldman Sachs & Co. LLC

**Nicholas Snowdon**  
+44(20)7774-5436 | nicholas.snowdon@gs.com  
Goldman Sachs International

**Callum Bruce**  
+1(212)902-3053 | callum.bruce@gs.com  
Goldman Sachs & Co. LLC

**Sabine Schels**  
+44(20)7774-6112 | sabine.schels@gs.com  
Goldman Sachs International

**Mikhail Sprogis**  
+44(20)7774-2535 | mikhail.sprogis@gs.com  
Goldman Sachs International

**Daniel Sharp**  
+44(20)7774-1875 | daniel.sharp@gs.com  
Goldman Sachs International

**Hongcen Wei**  
+1(212)934-4691 | hongcen.wei@gs.com  
Goldman Sachs & Co. LLC

**Romain Langlois**  
+1(212)357-6395 | romain.langlois@gs.com  
Goldman Sachs & Co. LLC

**Aditi Rai**  
+44(20)7774-5179 | aditi.rai@gs.com  
Goldman Sachs International

**Daniel Moreno**  
+1(212)934-1001 | daniel.moreno@gs.com  
Goldman Sachs & Co. LLC

**Annalisa Schiavon**  
+44(20)7552-9421 | annalisa.schiavon@gs.com  
Goldman Sachs International

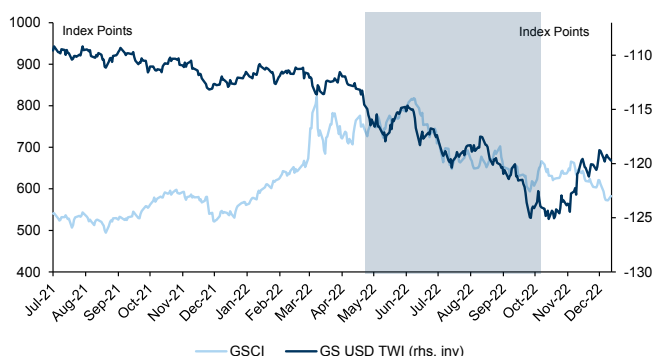
each high and low higher than the previous spike. Commodity prices, unlike financial markets, perform an economic function of balancing supply and demand, so once high prices have rebalanced the market in the short term, the high prices are no longer needed, and prices come crashing back down as we witnessed late this year. But ending one spike doesn't mean the end of the supercycle - long-run supply issues take years to resolve. We like to say that commodities, while short-run unpredictable, are long-run predictable. The exact timing of these short-term price spikes are difficult to forecast, as it was in 2022. Conversely, the long run state of the market is predictable as supply and technological trends are far more persistent, with all the conditions required for another spike present in 2023.

- **But will the new capex cycle take root in 2023?** The key development to watch in 2023 is whether we will see a new capex cycle begin to take root. This requires capital and only better relative returns will attract capital. With the drop in the valuation of the new economy and rise in commodity prices we are getting close to this rotation of capital. The 3-year moving average of the Sharpe ratios of commodities versus the NASDAQ are beginning to converge, and history suggests when these two cross, capital begins to flow, and historically it begins with rotation away from growth in big tech toward growing profits from energy and industrial firms. This three year track record is important - to see persistent capex, management must be rewarded for expansionary plans by investors. Put simply, if the stock offers higher returns than a project, they will favour buybacks over capex. Yet over the last cycle (2011-2020), US E&P's destroyed \$0.54 for every dollar they invested. Interestingly, the battery metal producers who have not been through prior supercycles have investors' confidence and so do not face such investor aversion and restrictions on production, underpinning our bearish medium-term view on those metals.
- **Return of capex will drive the next leg higher.** We would put a higher weight on a history of poor returns and extreme volatility over ESG considerations as to why investors have been slow to re-enter this space, and only sustainable higher returns in 2023 can confirm this. The first stage of the Old Economy's revenge occurred in 2022, through higher interest rates that drove down New Economy valuations. We expect 2023 to be a continuation of second stage, where persistent high commodity prices and Old Economy cash flows lead to outperformance, which is the only metric that will regain the trust of investors and once again reward capex in the space. Unfortunately, such capex will at first only create cost inflation as it did 2005-2008 given the extended period of underinvestment, which will serve to push commodity prices higher and producer margins lower. It will take years, as in previous cycles to debottleneck the Old Economy to absorb new capex that will be competing at the same time against the Green capex for the same resources.

# An underinvested supercycle

**A year when underinvestment bites.** Just as commodity markets have been dominated by the dollar in 2022, we expect them to be shaped by underinvestment in 2023. From a fundamental perspective, the setup for most commodities next year is more bullish than it has been at any point since we first highlighted the supercycle in October 2020. However, spot prices have retraced nearly to 2021 levels as financial deleveraging and physical destocking – both forms of short run underinvestment – combined to pressure energy prices since October. Across commodity markets, the rapid rise in the cost of capital lowers the incentive to hold either physical inventories or paper risk, distorting price discovery as financial markets react faster than the real economy. Yet, even after the latest sell off, prices remain high. Two years ago it seemed improbable that oil would be at \$80/bbl, copper at \$8500/t and corn at \$6.35/bu with the largest consumer of commodities and importer of oil essentially shutdown over covid, Europe in a recession and the US having just experienced the most rapid rise in rates on record. This is testament to the severity of the imbalances across these markets, as tight supply keeps prices high despite near-term growth concerns (see [Exhibit 1](#) and [Exhibit 2](#)).

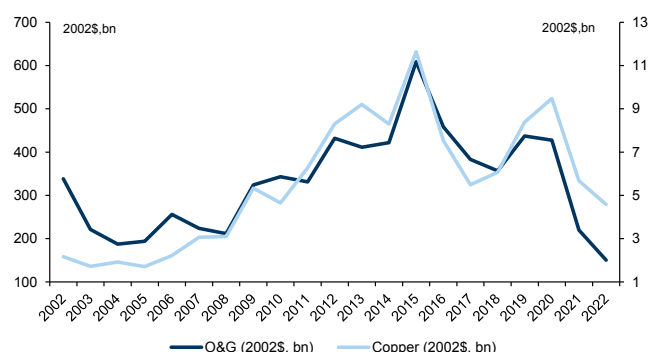
**Exhibit 1: Commodities have been dominated by the dollar in 2022**



Source: Bloomberg, Goldman Sachs Global Investment Research

**Exhibit 2: Capex across commodities continued to fall in real terms despite higher prices**

Oil & Gas and Metals and Mining (rhs) real capex in 2002 dollars

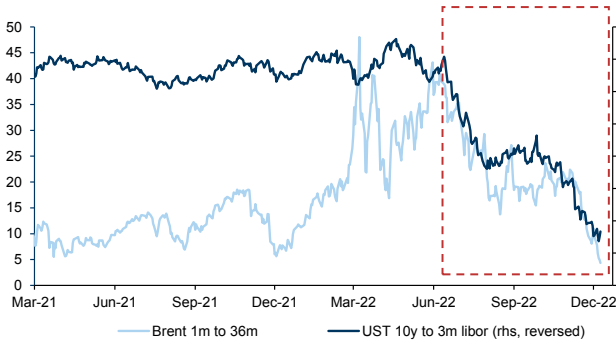


Source: Baker Hughes, Goldman Sachs Global Investment Research

**No supply response in sight.** While markets are divesting today, what’s more startling is the lack of investment in commodities for tomorrow. Despite a near doubling of many commodity prices by May 2022, capex across the entire commodity complex disappointed; we estimate that in 2022 sanctioned copper projects will amount to only 263kt, essentially the lowest approval volume in the last 15 years. In our view, this is the single most important revelation of 2022 – even the extraordinarily high prices seen earlier this year cannot create sufficient capital inflows and hence supply response to solve long term shortages. While investors rightly remain concerned with the growth outlook for next year – a large driver of the latest sell off – the global business cycle is far from over. It is clear today that recession risk is being increasingly priced into markets, with 1m-10yr yield spreads falling inline with oil time spreads (see [Exhibit 3](#)). Yet, our economists argue that global economic growth is set to rebound significantly

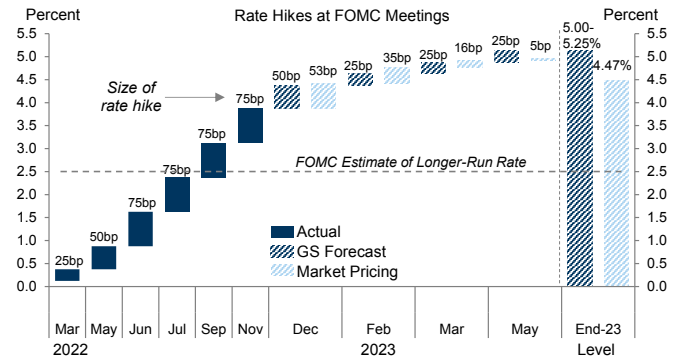
with China seeing the reopening happening today, Europe improving its energy efficiency in a one-off decline in industrial activity and a slowing of the aggressive Fed rate hikes in the US. These underpin our expectation that commodities (S&P GSCI TR) will return 43% in 2023.

**Exhibit 3: As investors have become increasingly concerned with recession risk, both the yield curve and oil curve have flattened**



Source: Bloomberg, Goldman Sachs Global Investment Research

**Exhibit 4: Next year should see far less rates volatility than 2022**

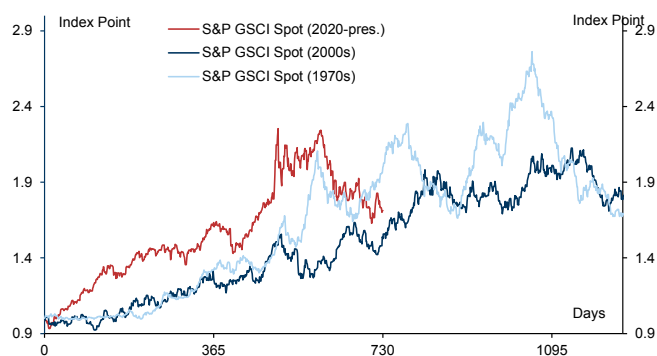


Source: Goldman Sachs Global Investment Research

**Commodities best performing asset class in 2022 (+20%).** Despite the recent price declines, commodities will still finish the year as the best performing asset class with c.20% returns (S&P GSCI), as investors were able to bank the price spikes from earlier this year through the roll yield. It is important to remember that commodity supercycles never move in a straight line; rather, they are a sequence of price spikes with each high and low higher than the last. Commodity prices unlike financial markets perform an economic function of balancing supply and demand, so once high prices have rebalanced the market in the short term, the high prices are no longer needed, and prices come crashing back down as we witnessed late this year (Exhibit 5). But it doesn't mean the supercycle is over as the long-run supply issues take years to resolve. We like to say that commodities are long-run predictable but short-run unpredictable. The exact timing of these short-term price spikes are difficult to forecast. In 2022, it was the Russian invasion of Ukraine that tipped an already extremely tight market. Conversely, the long run state of the market is predictable as supply and technological trends are far more persistent and predictable through capex flows. Crucially, as we go into 2023, we emphasise the persistent influence of these drivers as forming the required conditions for the next rally in commodity upside once the cyclical dip in Chinese demand is behind us. Yet before then, the conditions for a short-lived COVID-led winter correction in prices remain – when Omicron emerged in the west, prices fell 35% before recovering by mid-January. Accordingly, we recommend looking past 2023's bumpy start into 2Q where fundamentals improve and scarcity returns.

### Exhibit 5: Supercycles are a series of price spikes, not a smooth trend higher

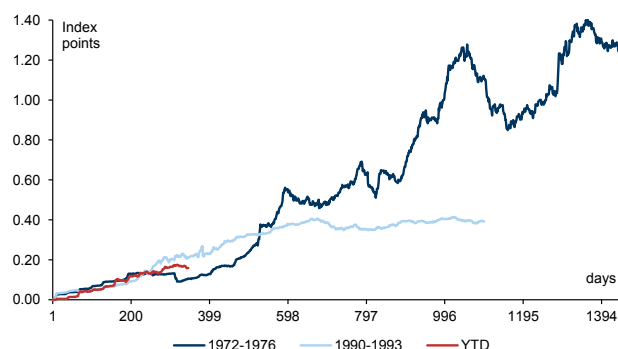
Indexed performance of the S&P GSCI across supercycles



Source: Bloomberg, Goldman Sachs Global Investment Research

### Exhibit 6: During periods of acute scarcity, backwardation allows investors to accumulate roll returns

Cumulative roll returns across each supercycle

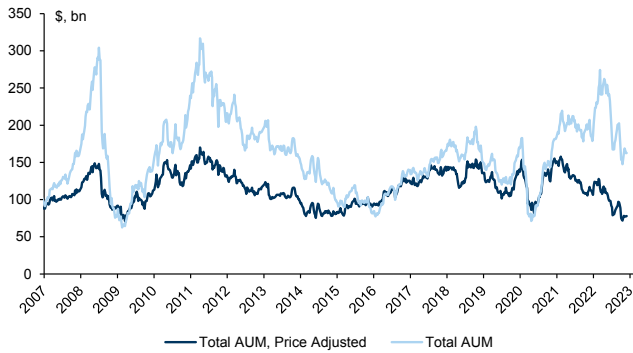


Source: Bloomberg, Goldman Sachs Global Investment Research

**Financial deleveraging and physical destocking drove recent deflation.** This year, the majority of the commodity deflation came from central bankers raising the cost of capital and draining market liquidity, both physically and financially. Indeed, under normal conditions, physical destocking is one of the disinflationary channels used by central bankers to cool an economy. When rates rise, so does the financing cost of inventories, incentivising additional selling and a fall in materials prices. Moreover, increased rates raise the expectation of recession, the rational response to which is destocking – just as we saw in European metals this Autumn. Yet pre-emptive destocking can raise subsequent scarcity risk if demand beats expectations and supply remains constrained. Financially, it was the attractiveness of a 5% risk free return in cash that led to an unprecedented drop in commodity liquidity ([Exhibit 9](#)). These twin pillars of physical and financial underinvestment are mutually self-reinforcing – higher volatility in commodity markets, as well as lower investor participation, both depresses the long run price and raise uncertainty for commodity producers, lowering management willingness to sign off on projects and investor willingness to hold their equity. Additionally, underinvestment in production leads to a depletion of inventories, removing a key buffer against fundamental shocks on prices, raising price volatility and lowering the willingness or ability of investors to get exposure to commodity derivatives—exactly as we saw in March this year.

**Exhibit 7: Our estimates of total investor positioning have declined in 2022**

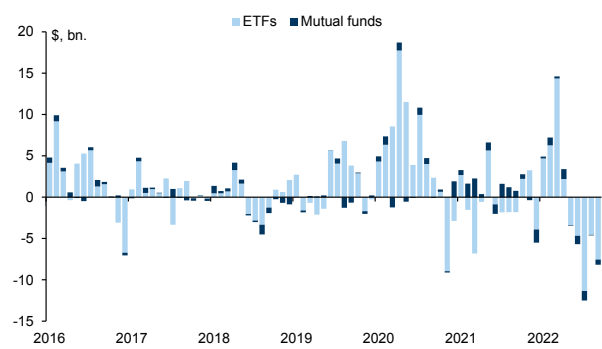
Estimates of index exposure using CFTC reported Feeder Cattle and Bean Oil volumes and their respective index weights



Source: Bloomberg, CFTC, Goldman Sachs Global Investment Research

**Exhibit 8: While commodity linked mutual funds have seen several months of net outflows**

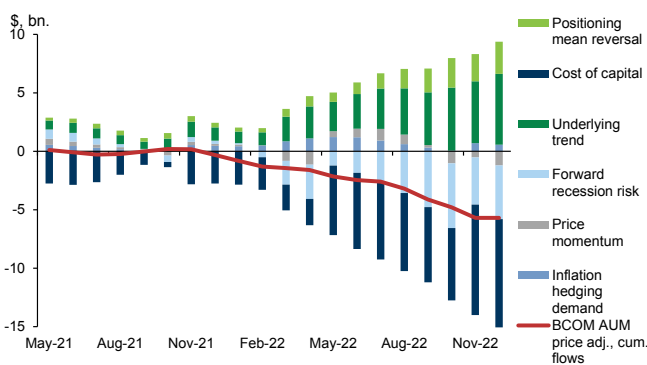
Net flows into EFPR covered commodity ETFs and mutual funds



Source: EPFR, Goldman Sachs Global Investment Research

The current investor exodus can be seen across markets, in estimates of index exposure (see Exhibit 7), CFTC report data and mutual fund data in both ETFs and Actively managed funds (see Exhibit 8). Indeed, since the highs in March 2022, we estimate investors have withdrawn \$68bn from commodity ETFs, \$32bn from active mutual funds and \$12bn from the BCOM commodity index (price adjusted total flows to estimate index flows). Importantly, this market backdrop of rapidly decreasing liquidity is not set to continue in 2023 given the dual mandate of central banks, nor is it a long-term solution to commodity imbalances and inflationary pressures. This remains one of central questions on many commodity investors’ minds going into 2023 – when and how will the broader financial community become engaged in the space? Modelling index positioning (Exhibit 10) as a function of price momentum, costs of capital and relative performance that while the monetary environment accounted for c. 65% of outflows in 2022, this drag is muting into the new year with cost of capital only off setting 35% of upside in positioning by 2H23.

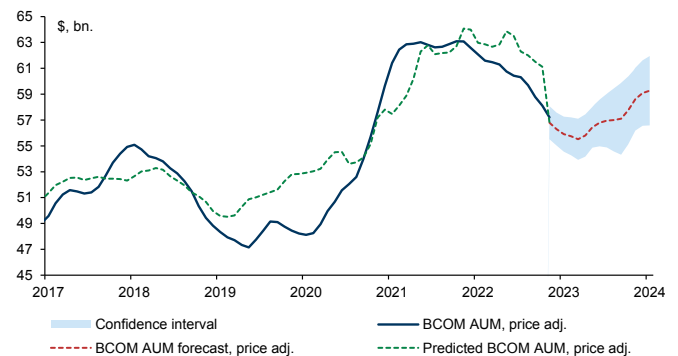
**Exhibit 9: Higher capital costs and recession fears drove the majority of commodity outflows this year**



Source: Bloomberg, CFTC, Goldman Sachs Global Investment Research

**Exhibit 10: After falling at the start of 2023, we expect index investor inflows to return as interest rate hikes slow and price performance returns**

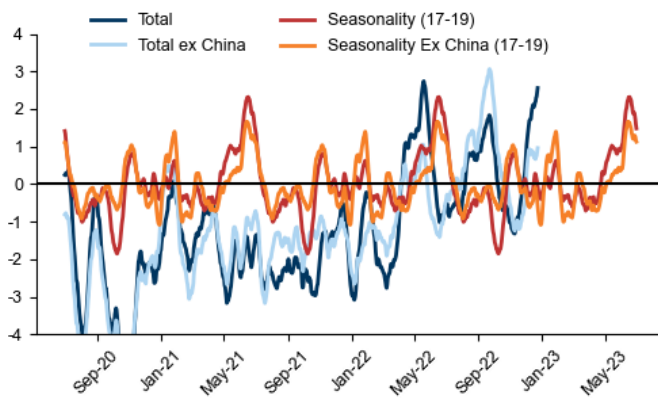
Insample model and out-of-sample projection of index investor flows as a result of 10yr yields, relative price performance and inflation expectations



Source: Bloomberg, CFTC, Goldman Sachs Global Investment Research

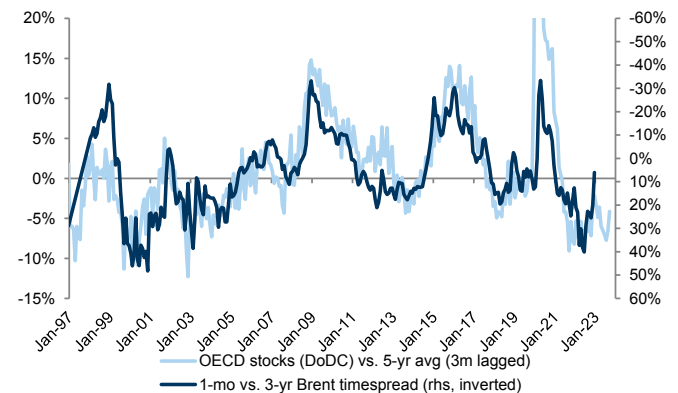
**Energy will have a new year inventory hangover.** While in our view the investor exodus from commodities has been more closely tied to the cost of capital, it is important to recognise the influence of upside surprises in oil supply on investor positioning into the new year. China demand remains down 1.2 mb/d versus our expectations from just a few months ago. Meanwhile, Russian supply continues to beat (by c.0.3 mb/d in Dec-22) and disruptions are normalising in Kazakhstan and even Nigeria. The additional inventories will protect shorts coming into the market from a physically led short squeeze. Indeed, the inventories being built today must also be worked through with an extended deficit to return the market to the same depleted state in 2Q23, giving the oil market an inventory hangover in both prices and positioning into 2Q23. Nonetheless, at \$80/bbl, current Brent pricing is reflective of flat Russian production and 0.5 mb/d lower China demand than our expectations over the next six months (c.14 mb/d). A feasible, but overly pessimistic, expectation in our view.

**Exhibit 11: Oil stocks have drawn sharply over the last month, with draws across most components, while China restocked crude**  
Global oil stock changes (28dma, mb/d)



Source: Kpler, EIA, ICIS, QQ, PJK ARA, Kayros, PAJ, Insights Global, Goldman Sachs Global Investment Research

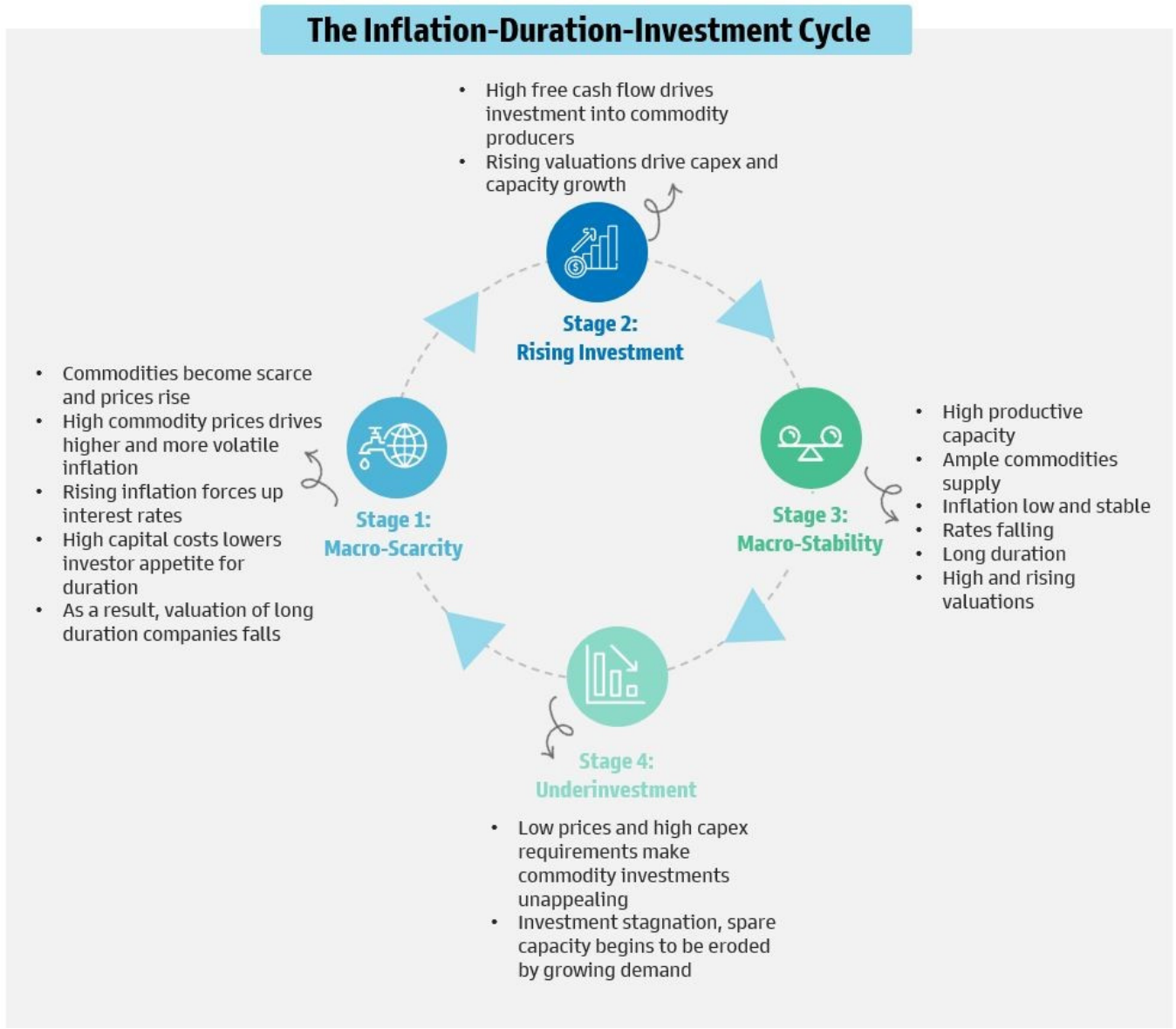
**Exhibit 12: Timespreads are already pricing a build of OECD stocks to their 2015-19 average**  
OECD commercial stocks in days of OECD demand coverage vs. 5yr avg (lhs) vs. 1-mo to 3-yr Brent timespreads (%), rhs, inverted



Source: IEA, ICE, Goldman Sachs Global Investment Research

**Underinvestment creates an unstable system.** To understand the pricing dynamic we expect in 2023, investors must understand the consequences of long term capital underinvestment. Physical underinvestment does not automatically reduce supply or create physical inflation. Rather, the system becomes vulnerable to demand shocks – such as LBJ’s Great Society in the 1960s, China’s admission to the WTO in the 2000s, or COVID stimulus in the 2020s. This demand shock raises commodity prices, creating the Old Economy’s Revenge via inflationary pressures, higher interest rates and through the cannibalizing of household budgets away from big tech earnings in advertising toward Old Economy free cash flow. Once in this constrained state, commodity prices spike when in scarcity and crash as demand destruction occurs and growth slows. Until persistent capex raises the productive capacity of the economy, any sequential growth in demand pushes the economy back up against those supply constraints, creating another price spike and another slowdown in demand. Precisely because Chinese demand is artificially depressed, we do not think commodities can sustainably rally until reopening occurs.

Exhibit 13: We remain in stage 1 of the inflation-duration cycle



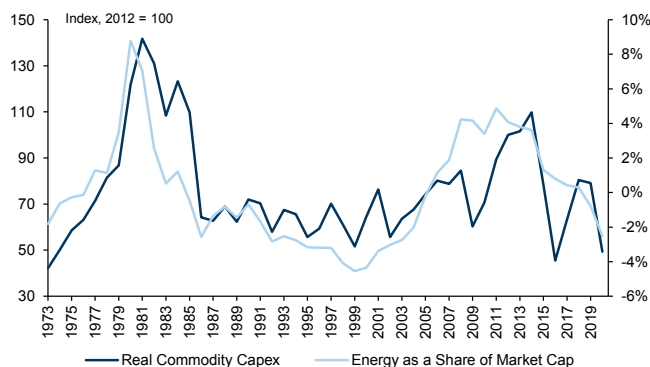
Source: Goldman Sachs Global Investment Research

**Commodities are calling for capital.** The dynamic of spiking prices and demand pushing up against supply constraints is part of the wider inflation-duration cycle that connects financial markets to physical capacity. High commodity prices are a signal of their relative scarcity, while outperforming commodity producers are a signal for investors to direct capital toward those sectors, raise supply and rebalance the physical economy. This call for capital is nothing new, having occurred in the 1970s, the 2000s and now again in the 2020s. To create the rotation, higher free cash flows and falling duration preference stimulate a new capex cycle as investors return to favour Old Economy companies. Yet to see persistent capex, management must be rewarded for expansionary plans by investors, seeing their book value greater than that implied by the spot oil price – a signal that investors are expecting growth. We believe this rotation will likely begin in earnest in 2023 as, without it, global growth will begin to struggle in 2024. However, this cycle is likely to be far more disorderly and prolonged as ESG investing



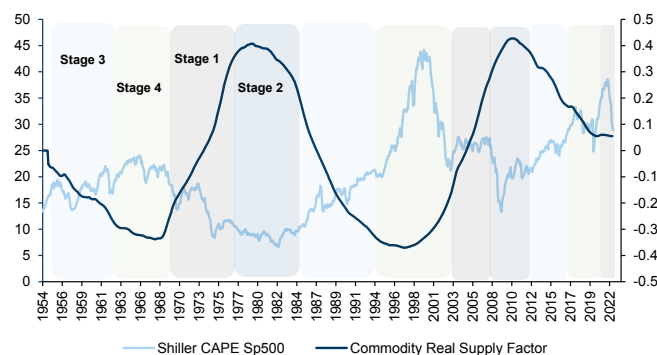
influences capital flows needed to stimulate the next round of investment. With 81% of global energy coming from fossil fuels still, the world still needs investment in these fuels, as green energy is not in a position yet to accommodate global growth alone and investment in green metals is critical to sustaining the growth in green energy investment.

**Exhibit 14: Commodity capex rises when producers see valuation rise**



Source: Bloomberg, Eikon Datastream, Goldman Sachs Global Investment Research

**Exhibit 15: Valuations fall when commodity capacity is binding**



Source: Bloomberg, Haver Analytics, Goldman Sachs Global Investment Research

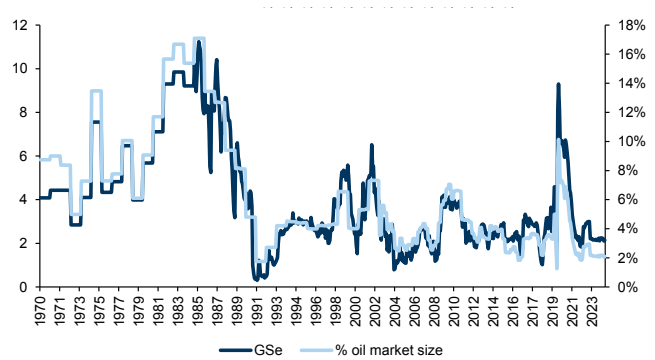
**The old economy will continue to take its revenge in 2023.** Beginning with oil, non-OPEC ex-US output is expected to permanently roll over in 2Q23 as not only will Russian production likely see further declines due to redirection frictions and a loss of foreign technology and investment, but long-cycle deepwater and conventional production are facing steepening decline rates due to the sharp decline in even maintenance capex. This leaves only US Shale and GCC output as the engines of oil supply growth for the foreseeable future with Shale also facing severe headwinds over both financial access and an aging geology. This suggests that in 2023 oil supply will struggle to reach 1.1 million b/d versus demand growth of 2.0 million b/d. All of this leaves core-OPEC’s market power potentially at the highest it has ever been since OPEC’s creation in 1960, evidence of which can be seen in their pre-emptive November cut which historically would have been met by both non-core OPEC production non-compliance and non-OPEC drilling, none of which are happening in scale. In fact, with the recent drop in oil prices to levels below production costs, such activity is slowing.

**Exhibit 16: Following their cuts in 2016, OPEC market share steadily declined as competitors stepped up**  
OPEC share of total oil supply, %



Source: IEA, Goldman Sachs Global Investment Research

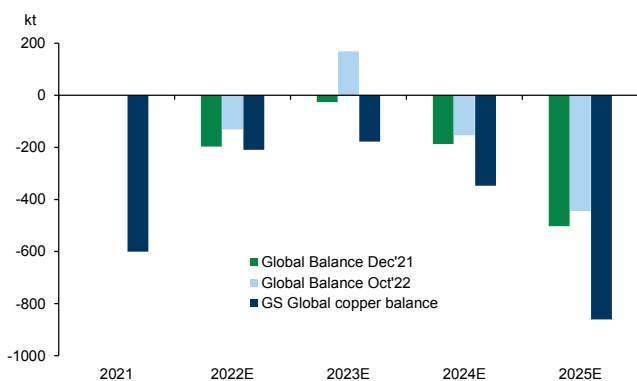
**Exhibit 17: Despite OPEC cuts, OPEC spare capacity remains very limited**  
Oil spare capacity (mb/d, lhs; %, rhs)



Source: IEA, JODI, EIA, Goldman Sachs Global Investment Research

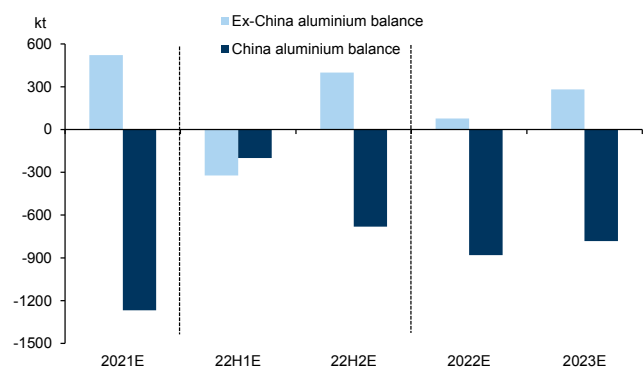
Turning to base metals, capital expenditure across mining companies in 2022 was nearly 50% below peak spend in 2010's while disruptions on the copper mine supply side are set to hit 1.6Mt this year, a record level, owing to a significant breadth of issues at mines particularly across Latin America. Specifically, operators cite the cuts to maintenance capex and activities (such as pre-stripping) as the key overarching factor that has left mines with much greater susceptibility to disruption and underperformance (Exhibit 18). Aluminum, the other key green metal, still faces energy production constraints in both Europe and China (Exhibit 19). Such constraints have also severely depleted zinc inventories at a time when weak European industrial activity masks such shortages, and this will only become more binding as demand recovers in 2023.

**Exhibit 18: Copper market is set to remain in deficit next year, with no surplus now anticipated on the forward fundamental horizon**  
GS global copper balance (current, Oct'22 & Dec'21)



Source: Goldman Sachs Global Investment Research, Woodmac

**Exhibit 19: Increasing deficit in China's primary markets is acting as a material offset to European demand headwinds and maintaining a global deficit into next year**  
GS aluminium balance, China & ex-China



Source: Woodmac, Goldman Sachs Global Investment Research

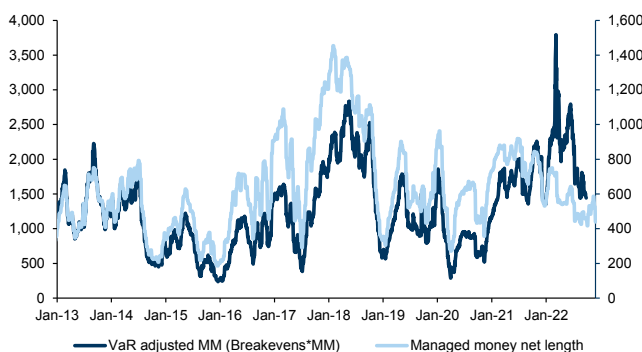
The agriculture supply story is limited acreage in the US with upstream agriculture yields increasingly sensitive to extreme weather, as higher energy and fertilizer prices lower application rates and hence crop resilience. These constraints on supply are occurring at the same time the demand for biofuels is expected to rise in 2023. Also, this US-centric view of agriculture obscures the point that to diversify itself away from the US, China stepped up its imports of Latin American agriculture products, creating further tightness

in non-US food supplies. Bottom line inventories and supplies on a global basis are tight as China begins to reopen and La Nina continues to threaten Latin America supply, particularly in Argentina. The upshot is, the world remains one bad crop away from new food price highs, and even without further Latam difficulties, this spring is likely to see additional volatility in an attempt for markets to stimulate more US planting.

**But will the new capex cycle take root in 2023?** The key development to watch in 2023 is whether we will see a new capex cycle begin to take root. This requires capital and only better returns will attract capital. With the drop in the valuation of the new economy and rise in commodity prices we are getting close to this rotation of capital. The 3-year moving average of the Sharpe ratios of commodities versus the NASDAQ are beginning to converge, and history suggests when these two cross, capital begins to flow, and historically it begins with rotation away from growth in big tech toward growing profits from energy and industrial firms.

This three year track record is important - to see persistent capex, management must be rewarded for expansionary plans by investors, seeing their book value greater than that implied by the spot oil price. Yet over the last cycle, from peak to trough, investors lost c.\$0.54 for every dollar invested in US E&P's. In the face of investors discounting new growth and undervaluing equities relative to cashflow, companies must hold greater amounts of cash on their balance sheet in lieu of easily accessible equity markets, further discouraging self-financed investment. Interestingly, the battery metals whose producers have not been through the prior supercycle have investors' confidence and so do not face such investor restrictions on production, underpinning our bearish medium-term view. To regain the trust of investors, the first stage of the Old Economy's revenge occurred in 2022, through higher interest rates that drove down long valuations, and we expect 2023 to be the second stage, where persistent high cash flows lead to outperformance and investors once again reward capital expenditure.

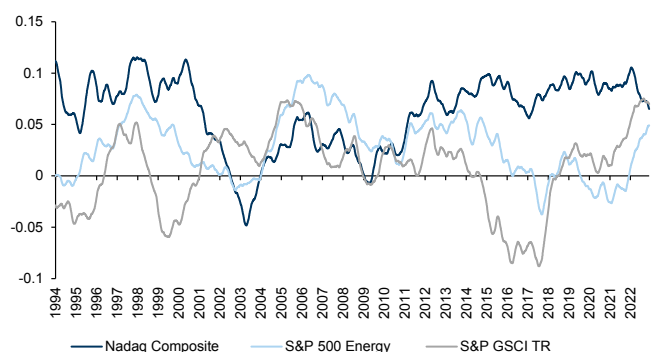
**Exhibit 20: Volatility keeps risk exposure high in USD terms, lowering barrel-equivalent exposure to commodity markets**  
Brent market VaR proxy (Managed money net length \* daily breakeven, \$m, lhs) vs Managed money net length (mb, rhs)



Breakevens calculated as  $[\text{flat price}] * \sqrt{\text{annualized volatility}/365}$

Source: ICE, Bloomberg, CME, Goldman Sachs Global Investment Research

**Exhibit 21: Commodities are close to a 3yr track record of outperformance**  
3m rolling sharpe ratio (3yr ma)



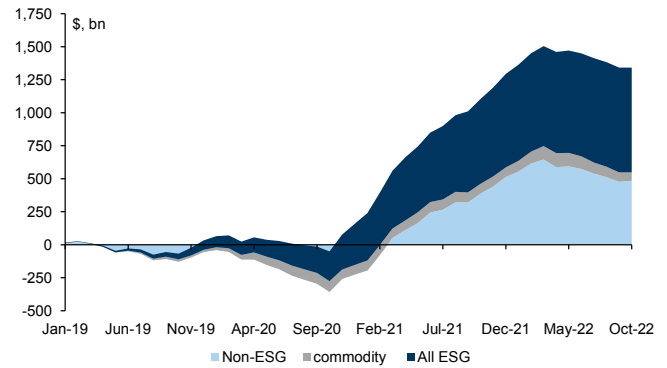
Source: Bloomberg, Goldman Sachs Global Investment Research

**Exhibit 22: Physical underinvestment is partly a function of capital destruction by commodity producers**  
EV/GCI of E&Ps



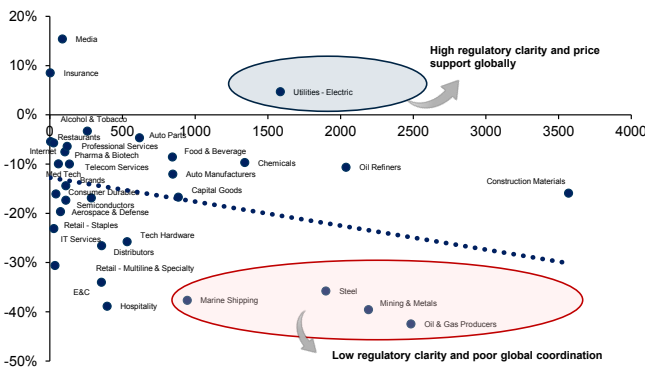
Source: Goldman Sachs Global Investment Research, Company data

**Exhibit 23: Equities AUM - ESG in particular - outperformed commodities by a large margin**  
Sample from Morningstar funds data, net cumulative inflow into funds



Source: Morningstar, Goldman Sachs Global Investment Research

**Exhibit 24: Goods with high carbon emissions have faced greater uncertainty and lower investment**  
Reinvestment ratio % (2022E vs. 10 yr average) vs. Carbon intensities (Scope 1,2,3 emissions intensity per revenue (tnCO2eq/US\$mn))



Source: Company data, Goldman Sachs Global Investment Research

**Exhibit 25: Oil equities are substantially discounting the oil price, disincentivising management from growing capex**



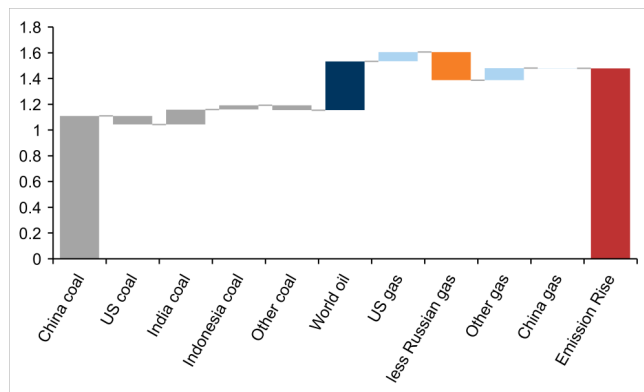
Source: Bloomberg, Goldman Sachs Global Investment Research

**The revenge of the old carbon economy.** Finally, it is important to reiterate the impact 2022 is having on the environment. In a zero interest rate world with abundant resources the costs of going green were very low; however, as scarcity bites and interest rates rise, the trade-off between carbon and costs rises sharply. With cumulative renewable energy investment not yet sufficient to meet demand globally, but less carbon intensive hydrocarbon investment (oil and gas) too little to meet the remaining demand, the resultant energy deficits force a return to the lowest-cost shortest-cycle energy sources – wood and coal – which emit far more CO2. This year the global economy is demonstrating its unwillingness to pay for less carbon voluntarily. Our analysis suggests emissions from hydrocarbons are likely to rise by c.4.3% (1.5Gt) this year, 70% larger than the additional energy consumed, with the lost Russian gas only directly accounting for c.4% of this fall in global efficiency. When considering the effect on additional coal capacity on emissions, it is important to understand the relative scale of Chinese coal in these emissions. Accounting for 1.1 of the 1.5 additional Gt of carbon emitted in 2022, we expect further growth in coal power in China in coming years, approaching 50 GW p.a. in 2022-25 - on par with the current total coal generation

capacity of the US. As we have argued, to solve climate change, governments would need to put a global price on carbon with rules and regulations, and measure to ensure compliance. Without such policy, the disorderly and prolonged nature of this inflation-duration cycle will be reinforced.

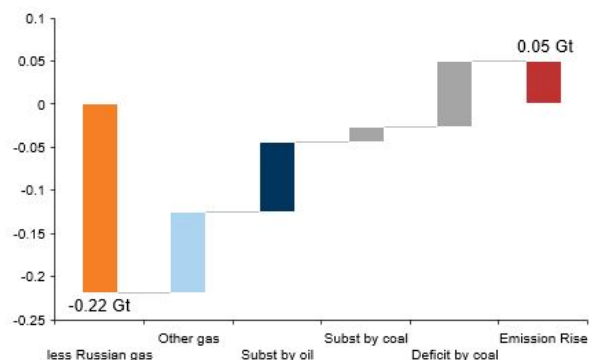
**Exhibit 26: The majority of rise in emissions comes from increased Chinese coal**

Change in global emissions from energy crisis, Gigatonnes



Source: Wind, Bloomberg, Reuters, WoodMackenzie, Goldman Sachs Global Investment Research

**Exhibit 27: To sustain its energy consumption using less efficient resources, NW European emissions will have to rise**



Source: Wind, Bloomberg, Reuters, WoodMackenzie, Goldman Sachs Global Investment Research

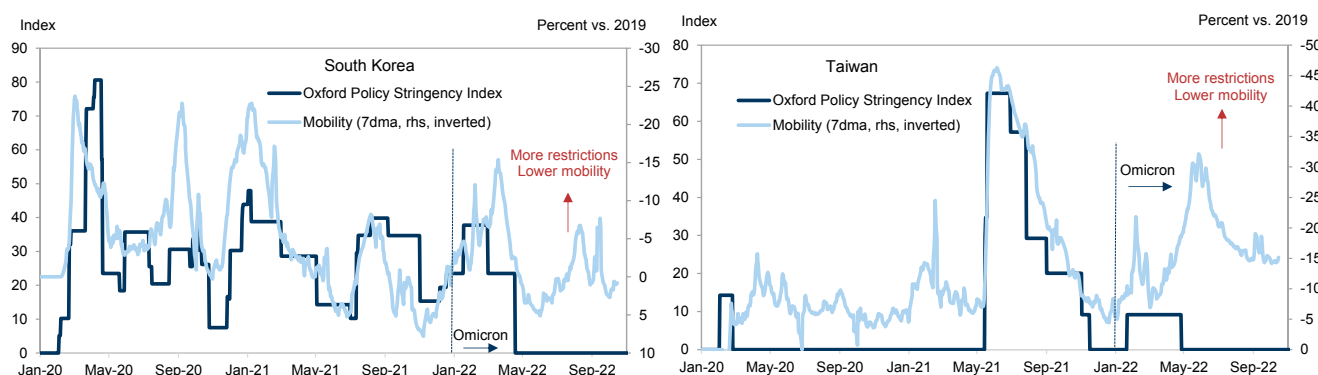
## Taking stock of the supercycle

Two years ago, we called for “*the beginning of a much longer structural bull market for commodities driven by three key themes*,” creating REV’d up demand (**R**edistribution, **E**nvironmentalism, **V**ersatile Supply Chains). Looking into 2023, these factors will continue to play a central role in pricing dynamics; 1) rising social need in China will drive reopening and stimulate demand, 2) environmental capex will accelerate, tightening commodities key for the transition further, 3) Russian geopolitical risk to continue with the full fallout of EU sanctions only being felt in 1Q23, and the need for versatile supply chains remaining top of mind. We assess how each of these key drivers will shape returns across the complex in 2023.

**China reopening will create a bumpy start to 2023.** While our economists now see China moving toward a “reopening with controls,” with virus spread still high, any new, higher tolerance for cases will eventually be breached before a full reopening, merely delaying inevitable regional lockdowns and creating more volatility in onshore fundamentals. In our view, any reopening would shift onshore fundamentals more in OPEX commodities — LNG, crude and soybeans — than in CAPEX commodities — ferrous, copper and aluminium. We find empirically that a 5p.p. change in our China Economists’ Effective Lockdown Index (ELI) is worth c.200 kb/d to oil demand, while the entire reopening only raises copper demand by 0.5%. Yet energy commodities are among the least-anticipatory commodities due to the challenges of storage, weakening the link between current and future availability of supply. Conversely, metals trade more closely with macro-economic sentiment, and are inherently more forward-looking. Specifically, as certainty around a reopening builds, we should see an increase of restocking demand across the supply chain to replenish depleted inventories across

metals, as well as energy. This could imply substantive restocking additions to onshore 2023 demand in aluminium (850kt) and copper (500kt). Consistent with this, GSCI Industrial Metals (+13%) has significantly outperformed GSCI Energy (-11%) since President Xi's re-election to a third term, as markets repriced a 2023 reopening even as Covid cases soared. Note, however, a reopening itself may be negative for growth and mobility — as was the experience in several other East Asian economies — as surging cases cause social distancing, even in the absence of government mandates.

#### Exhibit 28: South Korea and Taiwan's experience shows mobility declines in the initial stage of reopening



Google Mobility Data is sourced from <https://www.google.com/covid19/mobility/> Accessed: 2022-10-17

Source: University of Oxford (covidtracker.bsg.ox.ac.uk), Google LLC "Google COVID-19 Community Mobility Reports"

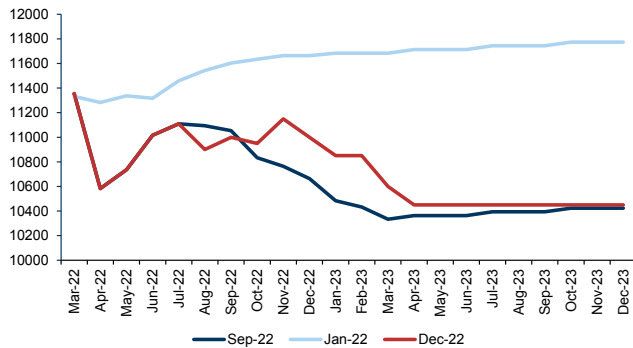
**Russia risk remains.** With both European crude sanctions and the price cap finally in place, commodity markets are now in the end game of Russian supply risk in 2022. With gas flows cut across almost all pipelines (bar those through Ukraine), and the grain deal secured for another 100 days, risks have been realized both to the upside (gas) and downside (grains), while the full effect of sanctions on oil are yet to be felt. It is unlikely there will be a formal announcement of counter-sanctions in oil, in our view. Rather, the market will gain increasing visibility about a lack of flows into the new year and beyond as ships divert from their usual transit routes. Russia's use of a "shadow fleet" delays the tracking of the Russian redirection until ships dock into Asian countries. It is important to remember that the price cap must remain dynamic for it to be effective. Should the price cap stay fixed, but global prices rise as a result of a China reopening, a backwards-bending supply curve might emerge, as Russian supply is actually reduced in response to higher prices. This backward bending supply curve is created when Russia is incentivised to use its "shadow fleet" of tankers selling oil at a price higher than the price cap but lower than crude spot prices. As crude prices rise to the point at which the Russian received price is materially above the price cap, there is an increasing incentive to lower supply by becoming non-compliant with the cap.

With weaker China spot demand dis-incentivising immediate retaliation but raising the risk of a partial retaliation later on, we believe this dynamic is likely to play out into 1Q23 next year. However, we would note that total non-compliance (with 0 flows adhering to the cap) remains quite unlikely. Note the potential reservoir damage results from sudden stops in production can be substantial. The Russian fields are old and low-pressure (in contrast to the Middle East) and have only partially been able to recover c.75-85% of the

shut-ins that occurred in both Apr-22 and during the initial deep pandemic cuts implemented in May-20. Accordingly, the optimal response from Russia is both dynamic and likely involves a mixed strategy - part subversion and part compliance with the price cap.

**Exhibit 29: We still expect Russia production to decline by 600 kb/d in the coming months following the EU embargos on crude and products**

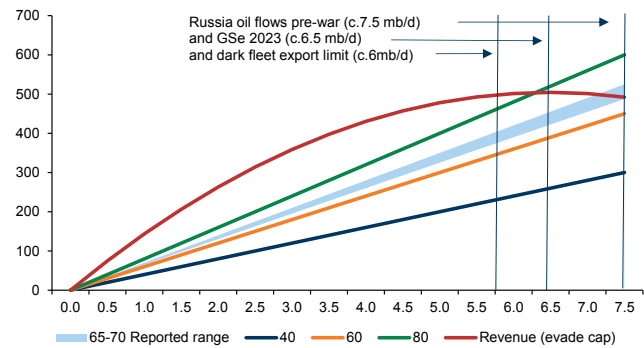
Russia production expectations as of various dates



Source: IEA, Goldman Sachs Global Investment Research

**Exhibit 30: The higher the price cap, the better the incentive for Russia to not curtail production**

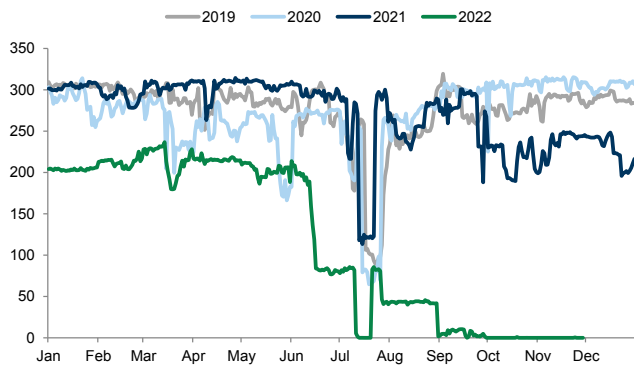
Daily Russian export revenue at different export levels (\$m) under different price cap scenarios or as discount (20%) versus global Brent prices



Source: Goldman Sachs Global Investment Research

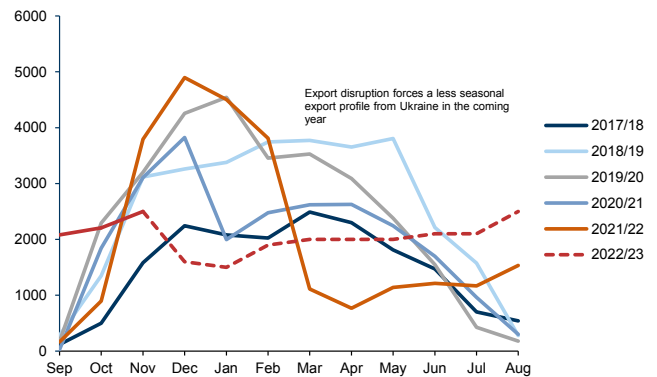
Unlike oil, we see the Russia risk to global gas markets as largely realized since its pipeline exports to NW Europe dropped to zero earlier this year, which we assume remains the case going forward. Despite there remaining Russian gas flows through the Ukraine at just over 40 mcm/d, we do not see this as a meaningful tightening risk for NW Europe, as (1) the Russian flows that move through the Ukraine go to Italy and Austria, which can import gas from Germany (2) even when Russian flows to Italy were completely interrupted earlier this year, the shortfall was met by Algeria pipeline flows, (3) even if German exports increased as a result of those cuts, LNG imports into NW Europe have remained stronger than our expectations. In grains, with the export corridor renewed on November 17th, Russia risk in agriculture moderated substantially as large volumes of Russian origin wheat keeps pressure on global export prices. Indeed, while Russia dominated grains markets throughout 2022, we see further blockades on Black Sea exports as moving to a possible tail risk. However, it is important to remember that the risks to Black Sea exports from the conflict have not disappeared completely, as extensive damage to energy infrastructure in Ukraine sustains logistical issues out of Black Sea ports, and has forced redirection of both corn and wheat toward western boarder export routes via rail.

**Exhibit 31: The risks to Russian gas are largely realized**  
Russian pipeline exports to Northwest Europe, mcm/d



Source: Bloomberg, Goldman Sachs Global Investment Research

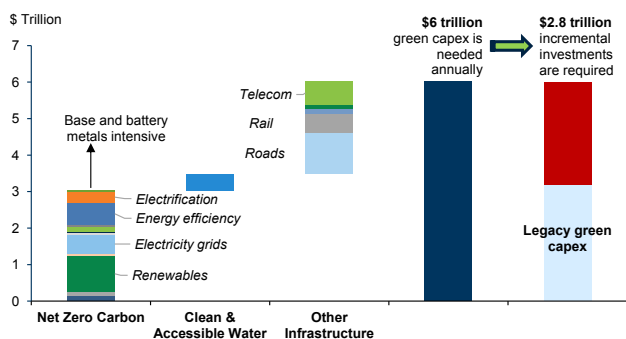
**Exhibit 32: Black sea logistical issues force a much smoother export profile from Ukraine into 2023**  
Ukraine corn exports, IHS



Source: IHS Markit

**Navigating the green transition.** When we first highlighted the growing impact of green demand on commodities, green investment was just \$3.2bn a year, with the predicted surge broadly theoretical as no major investment legislation had been passed. Since then, we have seen both RePowerEU and the Inflation Reduction Act (IRA) redefine the renewables outlook for the coming decade in both the US and EU respectively, while China has announced a 25% increase in its targets for renewables share in energy consumption by 2030. For 2022, we estimate green demand for copper increased to 2.1Mt (7% of global copper demand) and aluminium to 4.1Mt (6% of total demand). Indeed, this is driven by increased strength in solar deployments supported by \$470bn investments in renewables this year, which contributed to 1.26Mt of green copper and 1.8Mt of green aluminium demand globally. Globally, this structural rise in green demand is expected to near outweigh the cyclical slowdown, as next year we expect c.2% growth in copper and aluminium demand compared to a contraction in prior recessions. Over the long-term, we see copper benefitting the most from these policy changes given its higher usage in all clean energy technologies.

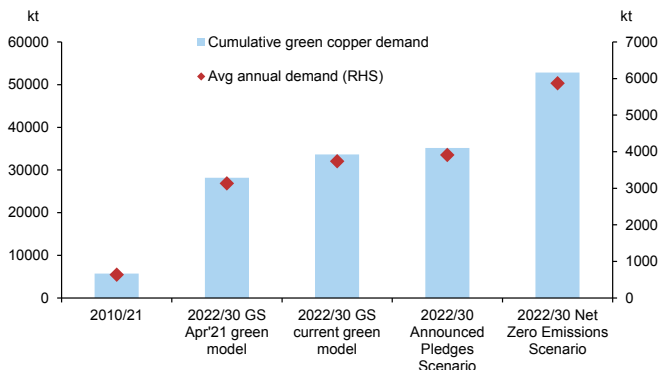
**Exhibit 33: \$2.8 trillion in annual investment is needed to meet zero carbon needs this decade**  
Annual investment required, 2020-2030



From the GS sustain note - Green Capex: Making infrastructure happen

Source: IEA, OECD, McKinsey & Company, Goldman Sachs Global Investment Research

**Exhibit 34: Upside risk to demand ... reaching Net Zero would require an additional 1.8Mty of copper**  
Green demand from solar, wind & EVs



The IEA Announced Pledges Scenario assumes that the announced ambitions and targets made by governments are met in full and on time. The IEA Net Zero Emissions by 2050 Scenario is a pathway for the global energy sector to achieve net zero CO2 emissions by 2050.

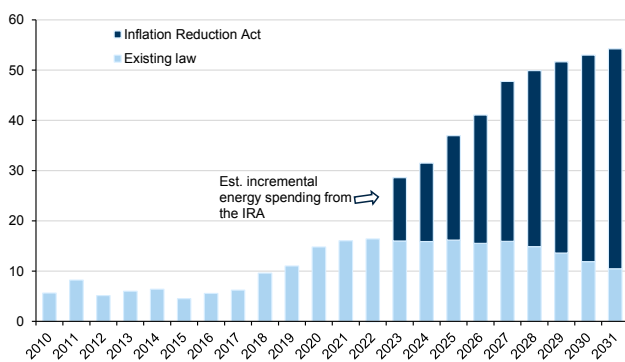
Source: IEA, Goldman Sachs Global Investment Research



Looking into 2023, while our expected size of green capex remains a powerful driver of commodities demand over the next several years, it is likely geographical distribution will change in the coming years. In our view, the center of renewables growth will remain in China (renewable Capex onshore is expected to be 5x Europe and 6x US in 2022) – for scale, the total renewable capacity stock of the US is 333 GW, but the *annual addition* of renewable power capacity in China was 126 GW in 2021, and our equity analysts see this growing to over 150 GW in 2022 and c.200 GW p.a. 2023-25. Going forward, however, we expect greater acceleration in North American green demand at the expense of Europe. Indeed, the European energy crisis has not only highlighted the prohibitive costs of private capex in Europe, but has also led to market-intervention measures by Governments across the region that might further discourage private-led green infrastructure builds. European policy proposals, including recent proposals to cap natural gas prices, increase the risks that current power and gas forward curves are not reliable for long-term hedging by those considering investing in energy infrastructure builds, effectively discouraging private investment in the sector. This reinforces the attractiveness of the US as a destination for green CAPEX. Importantly, the impact of the natural gas crisis in Europe on investment is not restricted to the power sector. We see increasing evidence that industrials currently struggling to remain operational in Europe might opt to reallocate operations and/or future investments elsewhere, with the US again appearing as a favoured destination for CAPEX. As our equity colleagues highlight, over half of Germany’s chemical producers would need to cut output in the coming six months (Ifo) in order to achieve further natural gas savings — with chemical utilisation rates already around 50% today (GFC trough levels), it remains likely parts of the European industry do not recover from their commodity constrained recession.

**Exhibit 35: The Inflation Reduction Act creates large incentives for investment in the US**

Budgetary effect of Federal energy tax incentives; US\$bn

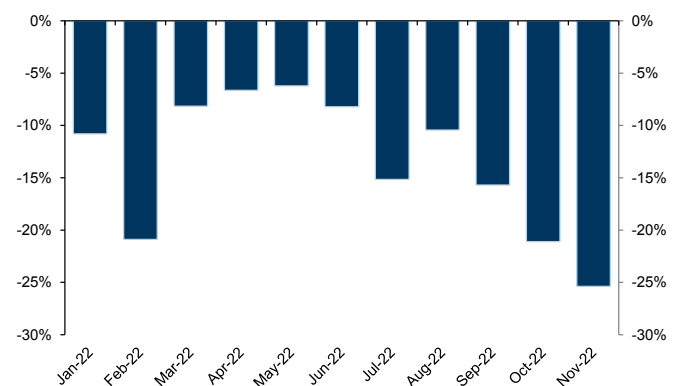


See GS SUSTAIN: Accelerating the Energy Transition: Stimulating capital and return on capital

Source: US Department of Treasury, Congressional Budget Office, Goldman Sachs Global Investment Research

**Exhibit 36: Sustained demand destruction may have a lasting impact on industrial activity**

Northwest Europe industrial and power demand for gas decline vs. 2017-2021 average; percent



Source: Bloomberg, Goldman Sachs Global Investment Research

# Disclosure Appendix

## Reg AC

We, Jeffrey Currie, Samantha Dart, Nicholas Snowdon, Callum Bruce, Sabine Schels, Mikhail Sprogis, Daniel Sharp, Hongcen Wei, Romain Langlois, Aditi Rai, Daniel Moreno and Annalisa Schiavon, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

## Disclosures

### Regulatory disclosures

#### Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage.

**Analyst compensation:** Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

#### Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of the Global Investment Research Division of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client's objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client's own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs' Australian Sell-Side Research Independence Policy Statement are available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Brazil:** Disclosure information in relation to CVM Resolution n. 20 is available at <https://www.gs.com/worldwide/brazil/area/gir/index.html>. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** This information is being provided to you for information purposes only and is not, and under no circumstances should be construed as, an advertisement, offering or solicitation by Goldman Sachs & Co. LLC for purchasers of securities in Canada to trade in any Canadian security. Goldman Sachs & Co. LLC is not registered as a dealer in any jurisdiction in Canada under applicable Canadian securities laws and generally is not permitted to trade in Canadian securities and may be prohibited from selling certain securities and products in certain jurisdictions in Canada. If you wish to trade in any Canadian securities or other products in Canada please contact Goldman Sachs Canada Inc., an affiliate of The Goldman Sachs Group Inc., or another registered Canadian dealer. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U74140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for "professional investors" within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither "registered banks" nor "deposit takers" (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for "wholesale clients" (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

**European Union and United Kingdom:** Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom's departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment

recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at <https://www.gs.com/disclosures/europeanpolicy.html> which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

**Japan:** Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan and Type II Financial Instruments Firms Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

## Global product; distributing entities

The Global Investment Research Division of Goldman Sachs produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or [contatogoldmanbrasil@gs.com](mailto:contatogoldmanbrasil@gs.com). Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou [contatogoldmanbrasil@gs.com](mailto:contatogoldmanbrasil@gs.com). Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Effective from the date of the United Kingdom's departure from the European Union and the European Economic Area ("Brexit Day") the following information with respect to distributing entities will apply:

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

**European Economic Area:** GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland, the Republic of Cyprus and the Republic of Ireland; GS - Succursale de Paris (Paris branch) which, from Brexit Day, will be authorised by the French Autorité de contrôle prudentiel et de résolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de résolution and the Autorité des marchés financiers ("AMF") disseminates research in France; GSI - Sucursal en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSÅ as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sw. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Sucursal en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinspektionen) disseminates research in the Kingdom of Sweden.

## General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by our Global Investment Research Division. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (<https://www.sipc.org>).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

We and our affiliates, officers, directors, and employees, will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research, unless otherwise prohibited by regulation or Goldman Sachs policy.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is focused on investment themes across markets, industries and sectors. It does not attempt to distinguish between the prospects or performance of, or provide analysis of, individual companies within any industry or sector we describe.

Any trading recommendation in this research relating to an equity or credit security or securities within an industry or sector is reflective of the investment theme being discussed and is not a recommendation of any such security in isolation.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur.

Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options and futures disclosure documents which are available from Goldman Sachs sales representatives or at <https://www.theocc.com/about/publications/character-risks.jsp> and [https://www.fiadocumentation.org/fia/regulatory-disclosures\\_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-pdf-version-2018](https://www.fiadocumentation.org/fia/regulatory-disclosures_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-pdf-version-2018). Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

**Differing Levels of Service provided by Global Investment Research:** The level and types of services provided to you by the Global Investment Research division of GS may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.

All research reports are disseminated and available to all clients simultaneously through electronic publication to our internal client websites. Not all research content is redistributed to our clients or available to third-party aggregators, nor is Goldman Sachs responsible for the redistribution of our research by third party aggregators. For research, models or other data related to one or more securities, markets or asset classes (including related services) that may be available to you, please contact your GS representative or go to <https://research.gs.com>.

Disclosure information is also available at <https://www.gs.com/research/hedge.html> or from Research Compliance, 200 West Street, New York, NY 10282.

© 2022 Goldman Sachs.

**No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the prior written consent of The Goldman Sachs Group, Inc.**