Goldman Sachs | Commodities Research

8 October 2021 | 9:05AM BST

Copper: Pricing to scarcity

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

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

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

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

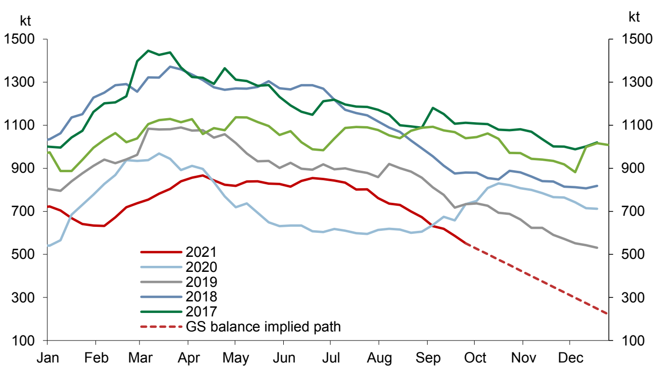
Macro risks are real, but copper is a real asset. In recent weeks, markets have been increasingly focussed on slowing global growth, rising risks in the Chinese property market and the growing global power crisis. Together, these macro risks have raised the possibility of commodity-driven stagflation in Europe and China, strengthening the dollar and acting as a headwind to copper. As the cross-asset investor's favourite barometer for global growth, copper often trades with shifts in broader macro sentiment. However, it is important to remember copper remains a physical good, whose futures price is ultimately tied to the ability to deliver physical units into the exchange. Its price is then inextricably tied to the availability of the underlying metal – so long as sufficient stocks remain to meet delivery demand, copper can price with any of other asset. Yet should those stocks deplete, its price must balance the market, regardless of what is occurring in the broader economy. We highlight this fact because copper is fast becoming the most mispriced commodity in the complex, in our view.

Market is overlooking the key upside catalyst. This mispricing is centered around rapidly tightening inventories – now drawing at the fastest rate on record and down nearly 40% over the past 4 months. With a significant metal deficit projected for Q4, global visible copper stocks could reach all-time lows by year-end and absent market adjustments driven by higher prices, deplete entirely by Q2-22. Falling inventories, when coupled with the need to deliver into futures contracts, will typically force copper prices higher. Investors' inattention to this potentiality – while understandable – in fact exacerbates the scarcity in our view, generating persistent downward price distortions that keep demand high and short-cycle supply artificially low. Eventually, we expect physical trading requirements will begin to dominate the front-end futures market and force up prices until the broader market is rebalanced. While Chinese property risks are real, we see most China-sensitive assets overpricing the left-tail risk. Indeed, absent a full-scale liquidity crunch among developers hitting completions, the immediate drag on copper demand should remain limited. On that basis, we remain highly convicted in our copper call, with an end-of-year target of $10,500/t.

Get long copper spreads on scarcity path. In our view, outsized returns are available to investors who trade copper like the commodity it is – get long when the inventory outlook tightens, trade it on the basis of its ability to physically deliver into the exchange, not purely on the back of the latest FOMC meeting or China property headline. The mounting evidence of a significant market deficit – alongside rising input costs – that is generating a rapid draw in inventory only reinforces our view that copper is underpriced and remains a bullish story. Of equal importance is the fact that we continue to project a deficit next year in the refined copper market (GSe 189kt), which provides an extension to the near-term scarcity path and persistent price support. In this context, we continue to hold our Long S&P GSCI Copper ER Subindex trade (up 45% since inception). However, we also launch an additional Long LME Copper Jan22-Jan23 timespreads trade to reflect our conviction on micro tightening path, with the additional expectation that such a spreads trade should outperform even if macro concerns, dollar strength restrain flat price upside momentum.

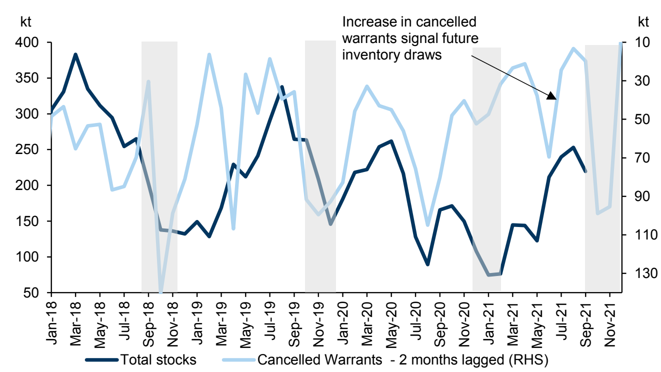
1. Stay focused on the physical. At the heart of our renewed bullish copper call – coming in spite of very real risks to the Chinese property sector and global growth – is the fact that the physical market is becoming increasingly tight, with minimal near-term risks to the balance in our view. Regardless of copper's traditional trading behaviour as a proxy for global growth, its price will remain ultimately dictated by the ability for short holders to deliver into the exchange and fulfill their contractual obligations. If they cannot – due to a lack of physical supplies – they will have to close out their shorts by going long. This would ultimately force up the price until more supplies – either from scrap, mine investment or invisible inventories – emerge to meet those obligations. Equally, a sharp fall in real physical demand – as the result of a Chinese credit crunch in the property sector – would limit the volume of long contracts needing delivery. Physical traders, unconcerned by broader macro risks in a portfolio, are beginning to cancel copper stocks on warrant (available for delivery), indicating either greater hording of the metal in expectation of future price rises, or increased off-exchange spot market trading. In either case, we believe such activity is an advanced warning of future inventory draws and supply tightness.

Exhibit 1: Visible global copper stocks are on a path towards a record low by year end
Global visible copper cathode stocks



Source: Wind, Goldman Sachs Global Investment Research

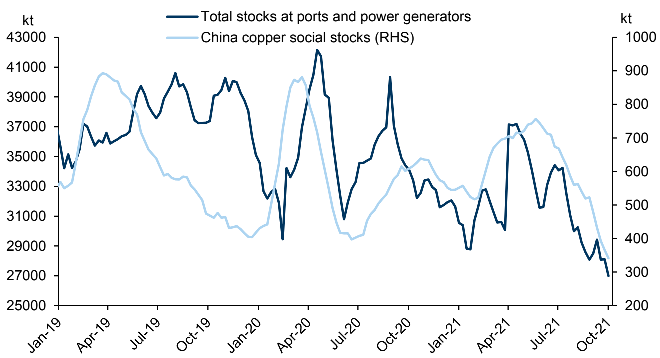
Exhibit 2: Surge in LME warrant cancellations points to a significant draw in LME stocks over Q4
LME copper total stocks and cancelled warrants



Source: Bloomberg, Goldman Sachs Global Investment Research

2. Power crunch is accentuating onshore scarcity. A key market preoccupation so far in H2 has been gauging the net impact of China power rationing on the domestic copper market. In our view, the evidence suggests that constraints on power supply onshore have accentuated the copper deficit. As Exhibit 3 shows, there has been a strong positive correlation between sharp declines in both China's thermal coal and copper inventories. Underpinning this accentuated tightening effect on China's onshore copper market are two key aspects to the episode: First, NBS energy consumption data shows a far more acute hit to the smelting sector (energy demand down 1% y/y since the start of the power issue) versus continued growth from the downstream manufacturing sector (energy demand up 10% y/y over the same period). This weighting of power rationing has in simple terms generated a greater cut to supply than demand. This should come as no surprise given that it has been the balance of impact on the three previous episodes of power tightness over the past decade (Exhibit 4). Second, the seasonality in China's copper market means that a much greater negative adjustment to demand (than supply) is needed to offset the seasonal tightening path seen in Q4. Over the 2015-19 period (pre-covid distortion), on average China's apparent copper demand grew 16% from Q3 levels into Q4, which compares to just a 9% increase in onshore refined output. In other words, China's demand would have to take materially greater hit than supply from power rationing to overturn the seasonal tightening path, which seems improbable on the evidence so far.

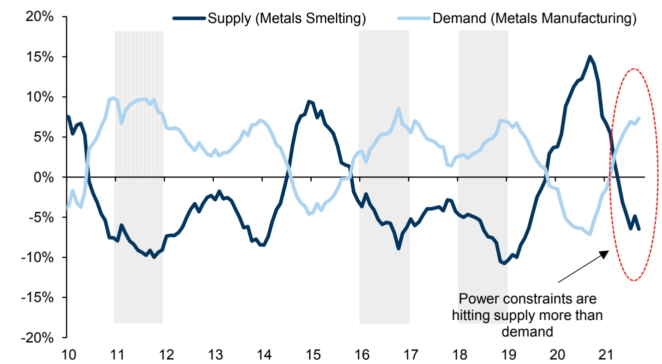
Exhibit 3: Sharp drawdown in China's coal inventories has been tightly correlated with copper stocks



Source: Bloomberg, Wind, Goldman Sachs Global Investment Research

Exhibit 4: Metals supply, not demand, has been hit so far by the power crunch

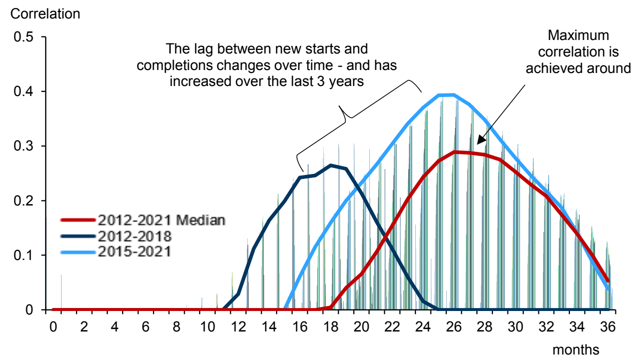
Change in % share of total energy demand from China metals value chain (incl. mining, not shown)



Source: Wind, Goldman Sachs Global Investment Research

3. China property is copper's red herring. An understandable concern for copper investors is the growing liquidity risk emerging in China's property market. Yet it remains only a left-tail risk to demand, and the concern that a restructuring of Evergrande will drive a further fall in onshore property activity and copper demand remains misplaced in our view. While construction and it associated sectors account for 40% of China's copper demand, construction itself accounts for 20% – over 90% of that demand comes from completions, not from new starts. Moreover, the time it takes to complete a building in China – and hence the delay in the expected copper demand slowdown – is itself changing over time. Over the last three years, the average completion time – as measured by the relative moves in new starts and completions – rose from 18 months to 24 months (see Exhibit 5). At the current rate, this means today's property slowdown should not impact copper demand for another 16-18 months – or until 2023. Accordingly – barring a collapse of Chinese property developers (which would affect new starts and completions simultaneously) – we believe copper demand related to Chinese construction is set to stay strong well into 2022 (see Exhibit 6). In this context, our latest China copper demand projection for 2022 is largely unchanged in this respect (GSe +3%, previously 3.5%). However, we have cut the respective 2023 estimate to reflect to the greater drag from property (GSe +2%, previously +3.7%). However, given tightening adjustments to the supply side, this has only marginally increased the 2023 global surplus (GSe 198kt, previously 129kt).

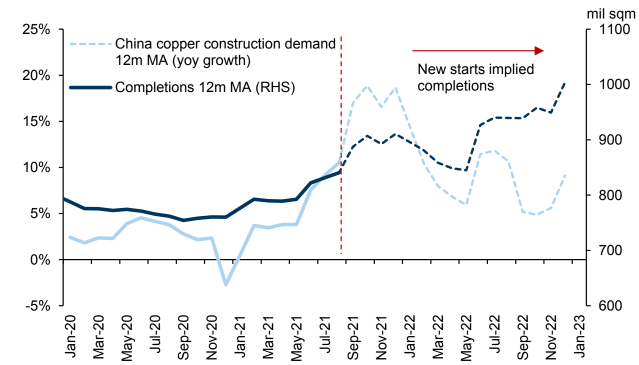
Exhibit 5: Completions, which contribute to 90% of China copper construction demand, are set to remain strong until 2023
The bars represent the correlation between starts and completions at different lags (x-axis)



We conduct a rolling cross-correlation analysis to capture the dynamic lag structure between housing starts and completions. Here the window size is 6 years and the sample range is from Jan-2012 to Aug-2021.

Source: Wind , Goldman Sachs Global Investment Research

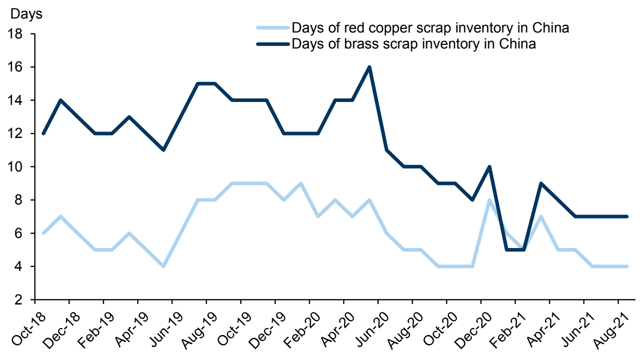
Exhibit 6: Strong completions to keep supporting China copper construction demand throug 2022



Source: Wind, Goldman Sachs Global Investment Research

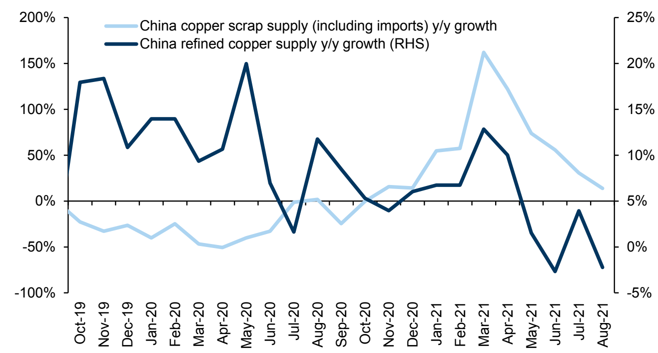
4. Scrap cannot provide short-cycle supply relief. The scrap market is the most important short-cycle influence on the copper market, accounting for 20% of global refined metal output and close to 30% of semi fabricator copper consumption. After a strong uplift in scrap supply at the turn of the year, conditions have tightened abruptly since then. Scrap discounts in both China and Western market have narrowed year-to-date and particularly so far in H2. China copper scrap supply, inclusive of both imports and domestic supply, has been on a sharp trend of deceleration from its peak in late Q1 to now nearing a y/y contraction (see Exhibit 8). China's scrap inventories (in days of consumption) have now fallen to multi-year lows. This tightness has reflected three factors: (1) strong synchronous uplift in scrap demand from both China and DM consumers, (2) rundown of supply chain scrap stocks after a prolonged price and demand induced destocking phase from Q3-20 through to early Q2-21, and (3) stricter rules regarding scrap import quality (for processing) in Malaysia placing constraint on volumes being shipped onward into China. In combination the trends have swung scrap from a net softening effect earlier in the year to now a source of tightness. Without scrap inventory to supplement supply, underlying scrap generation growth is running below demand and resulting in the tightening trend. Whilst a higher copper price would help to stimulate scrap supply, this would play out with a greater lag and more limited volume impact given the low stock starting point.

Exhibit 7: Onshore scrap inventories have fallen to multiyear lows after strong demand generated sharp destocking



Source: Wind, Goldman Sachs Global Investment Research

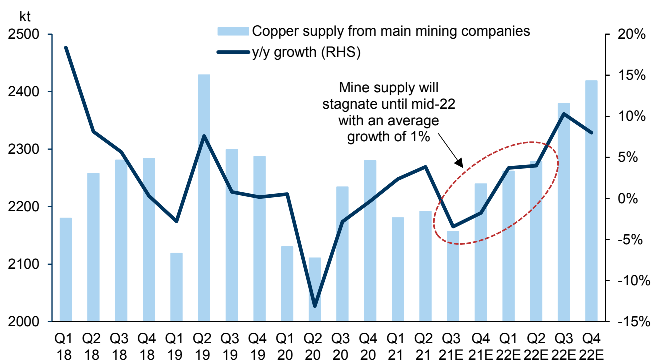
Exhibit 8: Scrap supply growth has fallen sharply from Q1 peak, as imports have fallen sequentially and inventories deplete



Source: Haver, Goldman Sachs Global Investment Research

5. Mine supply is entering a multi-quarter phase of stagnation. We believe one common misconception on the outlook for copper fundamentals is that the market is set to face an imminent 'wall' of mine supply. There is no doubt that global mine supply has grown at a healthy y/y rate during the first half of 2021 (+5% y/y), which compares favourably to our full-year expectation (GSe +1%). However, it is important to understand that this growth largely reflects the weak base of comparison in H1-20 when operational disruptions from Covid peaked. Absolute production levels have stabilised since Q3 last year, with output actually peaking in November/December last year before a modest sequential decline so far this year. We expect global mine supply growth to decelerate through H2 this year. In addition, even though we expect global mine production to grow ~5% y/y in 2022, the majority of the growth will likely be weighted towards H2-22 (see Exhibit 10). This means the market faces three quarters of supply stagnation from here before that growth phase. In this sequential context, the supply environment, particularly given scrap dynamics also, will tend toward tightening risk from a very low inventory starting point. Moreover, it is important to reiterate the near complete absence of new mine project approvals and increments in growth capex, which given feasible project timelines means we have cut potential greenfield project volumes until 2024 and brownfield until 2023.

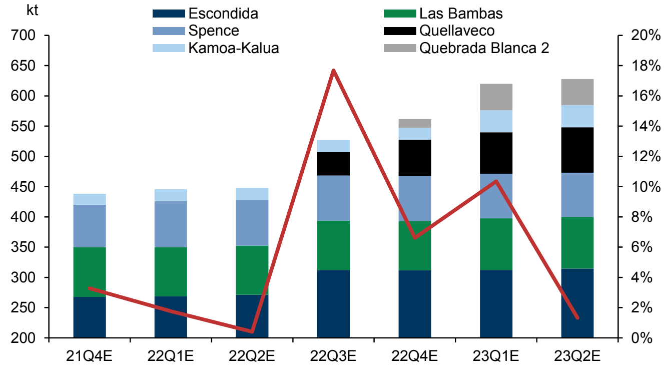
Exhibit 9: Global copper supply to remain below pre-Covid levels until the second half of 2022



Source: Goldman Sachs Global Investment Research

Exhibit 10: Copper won't now see a material sequential supply increase until H2-2022

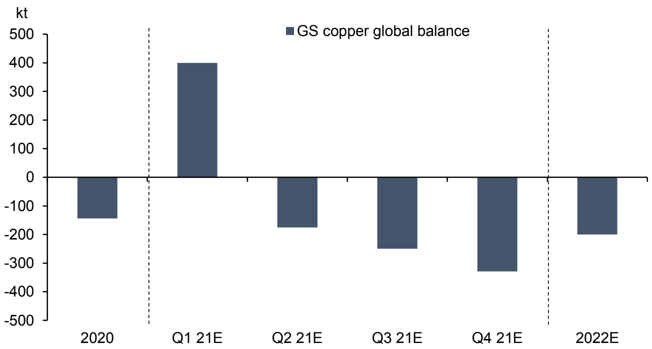
5 major copper mine projects' volumes



Source: Woodmac, Goldman Sachs Global Investment Research

6. Metal deficits to continue: Remain long copper and add spreads kicker. In our view, outsized returns are available to investors who trade copper like the commodity it is – get long when the inventory outlook tightens, trade it on the basis of its ability to physically deliver into the exchange, not purely on the back of the latest FOMC meeting or China property headline. The mounting evidence of a significant deficit dynamic at play in the copper market at current price levels reinforces our view that copper is underpriced. We project a 330kt deficit in Q4 alone, which implies a rundown in visible stocks to record lows by the end of the year. With supply chain buffers of cathode and scrap much reduced from relatively high levels in early 2021, high visibility on this tightness is expected over the months ahead. Of equal importance is the fact that we continue to project a deficit next year in the refined copper market (GSe 189kt), which provides extension to the tightening story beyond the Q4 scarcity risk. In turn this supports our continued bullish view on copper. In this context, we continue to hold our Long S&P GSCI Copper ER Subindex trade (up 45% since inception). However, we also launch an additional Long LME Copper Jan22-Jan23 timespreads trade to reflect our conviction on the micro tightening path, with the additional expectation that such a spreads trade should outperform even if macro concerns and dollar strength restrain flat price upside momentum.

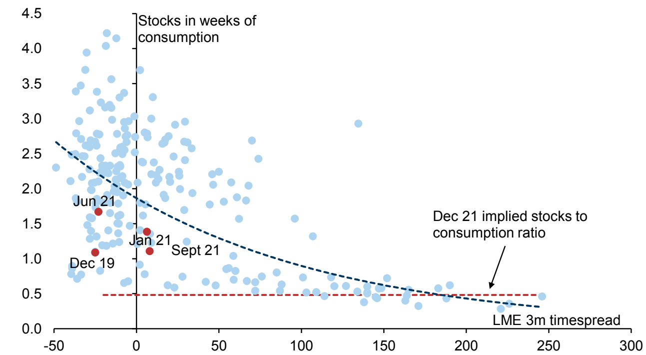
Exhibit 11: Copper market deficit in Q4 alone is expected at over 300kt, whilst another full-year deficit is expected in 2022



Source: Woodmac, Goldman Sachs Global Investment Research

Exhibit 12: Path lower in inventories increasingly points to a mispricing also in LME spreads alongside flat price

Global visible cathode stocks (in weeks of conusmption) vs LME copper spread



Source: Wind, Goldman Sachs Global Investment Research

The metal research team would like to thank Annalisa Schiavon for her contribution to this report. Annalisa is an intern with the commodities research team.

GS Copper Supply - Demand Balance

Exhibit 13: GS copper supply-demand balance

('000 tonnes)	2016	2017	2018	2019	2020	2021E	2022E	2023E	2024E	2025E
Consumption - DM										
US	2107	2113	2127	2155	2069	2234	2335	2417	2501	2585
% change y/y	*0.1%*	*0.3%*	*0.7%*	*1.3%*	*-4.0%*	*8.0%*	*4.5%*	*3.5%*	*3.5%*	*3.4%*
Europe	5040	5166	5259	5047	4694	4999	5224	5354	5488	5692
% change y/y	*0.3%*	*2.5%*	*1.8%*	*-4.0%*	*-7.0%*	*6.5%*	*4.5%*	*2.5%*	*2.5%*	*3.7%*
Japan	1405	1458	1450	1392	1295	1398	1468	1505	1550	1605
% change y/y	*-2.0%*	*3.7%*	*-0.6%*	*-4.0%*	*-7.0%*	*8.0%*	*5.0%*	*2.5%*	*3.0%*	*3.5%*
Other DM	2279	2328	2234	2089	1922	2047	2143	2186	2252	2331
% change y/y	*1.2%*	*2.2%*	*-4.1%*	*-6.5%*	*-8.0%*	*6.5%*	*4.7%*	*2.8%*	*3.0%*	*3.5%*
Sub- DM	10831	11065	11069	10683	9979	10678	11170	11462	11791	12212
% change y/y	*0.1%*	*2.2%*	*0.0%*	*-3.5%*	*-6.6%*	*7.0%*	*4.6%*	*2.6%*	*2.9%*	*3.6%*
Consumption - EM										
China	12816	13326	13710	13930	14320	14893	15340	15647	16179	16729
% change y/y	*3.1%*	*4.0%*	*2.9%*	*1.6%*	*2.8%*	*4.0%*	*3.0%*	*2.0%*	*3.4%*	*3.4%*
Other EM	4691	4769	4883	4963	4466	4801	5017	5238	5369	5536
% change y/y	*1.5%*	*1.7%*	*2.4%*	*1.6%*	*-10.0%*	*7.5%*	*4.5%*	*4.4%*	*2.5%*	*3.1%*
Sub- EM	17508	18095	18593	18893	18787	19695	20357	20885	21548	22264
% change y/y	*2.7%*	*3.4%*	*2.7%*	*1.6%*	*-0.6%*	*4.8%*	*3.4%*	*2.6%*	*3.2%*	*3.3%*
Global Consumption	28338	29160	29662	29576	28766	30373	31527	32347	33339	34477
% change y/y	*1.7%*	*2.9%*	*1.7%*	*-0.3%*	*-2.7%*	*5.6%*	*3.8%*	*2.6%*	*3.1%*	*3.4%*
Direct Global Scrap Use	*5756*	*6106*	*6136*	*6047*	*5140*	*5957*	*6281*	*6282*	*6480*	*6544*
Refined Global Consumption	22583	23054	23526	23529	23626	24036	24773	25580	26192	27071
% change y/y	*3.0%*	*2.1%*	*2.0%*	*0.0%*	*0.4%*	*1.7%*	*3.1%*	*3.3%*	*2.4%*	*3.4%*
Global Production										
Mine Production	20220	20118	20786	20929	20795	20968	22088	23257	23627	23611
% change y/y	*5.1%*	*-0.5%*	*3.3%*	*0.7%*	*-0.6%*	*0.8%*	*5.3%*	*5.3%*	*1.6%*	*-0.1%*
Refined Production	22742	22992	23472	23490	23461	23682	24584	25778	26335	26701
% change y/y	*3.2%*	*1.1%*	*2.1%*	*-0.4%*	*-0.3%*	*0.9%*	*3.8%*	*4.9%*	*2.2%*	*1.4%*
Global Balance	**159**	**-62**	**-54**	**-152**	**-165**	**-354**	**-189**	**198**	**144**	**-370**
Cash Prices (annual average)										
Current Dollars ($/t)	4862	6166	6532	6000	6067	9550	11875	12000	14000	15000
Current Dollars (c/lb)	221	280	296	272	275	433	539	544	635	680

Source: Woodmac, Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Nicholas Snowdon, Jeffrey Currie, Aditi Rai and Daniel Sharp, 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:** Goldman Sachs Canada Inc. is an affiliate of The Goldman Sachs Group Inc. and therefore is included in the company specific disclosures relating to Goldman Sachs (as defined above). Goldman Sachs Canada Inc. has approved of, and agreed to take responsibility for, this research report in Canada if and to the extent that Goldman Sachs Canada Inc. disseminates this research report to its clients. **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. 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. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by either Goldman Sachs Canada Inc. or 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, Portugal, 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 resolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de resolution and the Autorité des marches 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 SFSA 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 (Finansinpektionen) 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. 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.