

Global Markets Analyst

UK Real Rates — Backcast To The Future

- With UK real rates trading at or near multi-decade highs, we introduce a backcast history of inflation-indexed Gilt yields back to the 1960s, to help put current yield levels and the relationship to inflation in context.
- Our estimated real rates and breakevens rose rapidly in response to the oil shocks and high inflation of the 1970s, embedding risk premia across the curve. Institutional reforms, such as Linker issuance, central bank independence and inflation targeting, helped to re-anchor inflation expectations and compress risk premia.
- Elevated inflation risk premia meant that nominal Gilts outperformed inflation-indexed yields in real terms for much of the 1980s-2000s, but the recent rise in real yields and well-contained inflation risk premia suggest that the hurdle is higher for nominal Gilts to outperform linkers over a long holding period.
- Benchmarking against the current macro environment, real yields do not screen as excessive, and we expect the current steepness to fade eventually, with 30y reals outperforming vs the front end.

Friedrich Schaper
+44(20)7774-7906 |
friedrich.schaper@gs.com
Goldman Sachs International

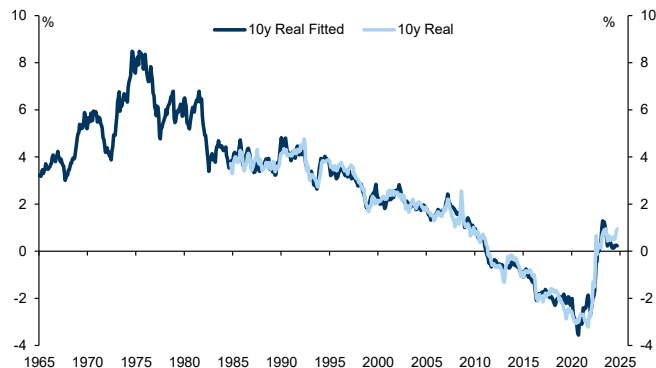
UK Real Rates — Backcast To The Future

UK real rates, measured by inflation-indexed Gilt yields, are at or near decadal highs following a significant increase through 2021-2023. The UK was one of the earliest adopters of inflation-indexed bonds, and so already has a long timeseries of *ex ante* (traded) real rates, dating back to the early 1980s. We use this time series to backcast real yields, drawing on an approach by the NY Fed that we have previously employed for the US. This backcast of real rates helps us interpret how real yields are currently trading amid ongoing elevated inflation.

To estimate the earlier history of real yields, we use a partial least squares (PLS) regression of traded real rates on a large set of macro variables from 1985 to today from the BoE's Millennium dataset. Once these real rates are calculated, we use the historical data of nominal Gilt yields to compute breakeven inflation estimates. The full method, including input variables, is described in the Appendix.

Exhibit 1: Real rates rose rapidly in response to the oil shocks and high inflation of the 1970s

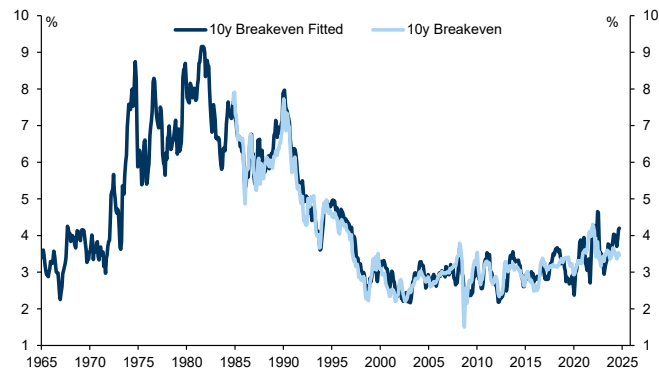
10y Inflation-Indexed Bond Yields, Actual vs Fitted



Source: Goldman Sachs Global Investment Research, Haver Analytics

Exhibit 2: Breakeven Inflation embedded higher inflation expectations and risk premia after the oil shocks

10y Breakeven Inflation, Actual vs Fitted

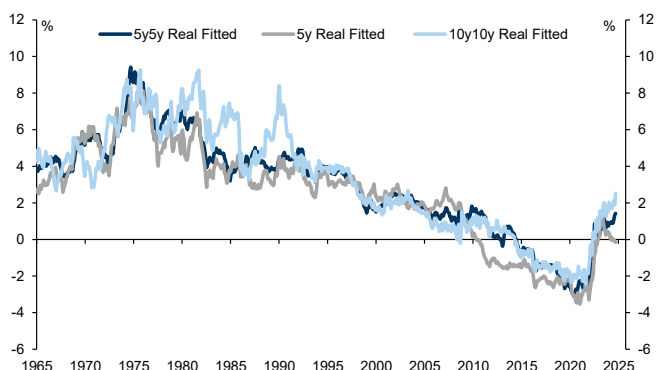


Source: Goldman Sachs Global Investment Research, Haver Analytics

We estimate that *ex ante* (traded) real yields rose rapidly, together with breakevens, after the first oil shock in 1973 and remained elevated for more than a decade ([Exhibit 1](#) & [Exhibit 2](#)). Real rates, similar to nominal rates, remained very volatile throughout the 1970s, partially due to rapidly shifting inflation expectations. From the early 1980s onwards – coinciding with the introduction of Linkers and all-time-high Bank Rate – inflation expectations dropped and ushered in a secular decline of real yields over the following decades. In parallel, breakeven inflation dropped back to its previous levels that had persisted, according to our estimates, before the inflation shocks. Other institutional advancements at the time, such as inflation targeting (1992) and monetary independence (in 1997), helped further anchor breakevens, and supported lower real rates.

Exhibit 3: Real rates initially rose in parallel across the curve in the 1970s

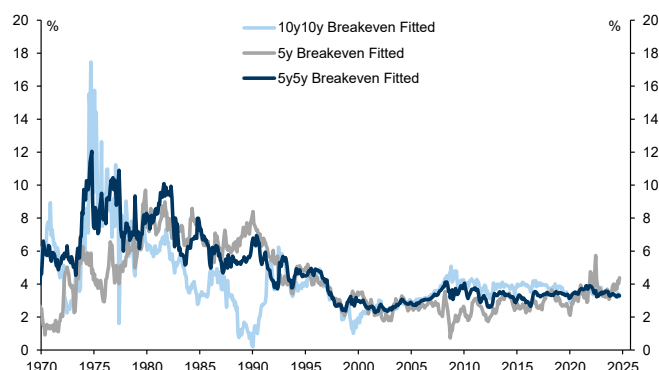
Inflation-Indexed Bond Yields, Fitted



Source: Goldman Sachs Global Investment Research

Exhibit 4: Inflation expectations remained elevated until the 1980s-90s

Breakeven Inflation, Fitted



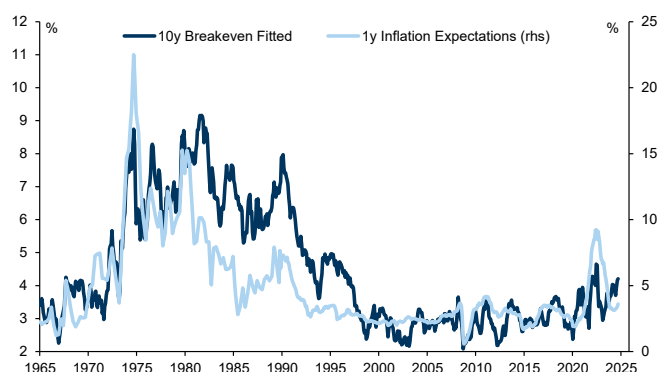
Source: Goldman Sachs Global Investment Research, Haver Analytics

To understand the shifting pattern of real rates during the 1970s, we look at the term structure of inflation and breakevens from our estimates. Our estimates suggest that the rise in real rates was roughly parallel across the curve ([Exhibit 3](#)). In contrast, the breakeven curve steepened significantly, with long-end breakevens rising by more than the 5y or 10y ([Exhibit 4](#)). Intuitively, investors demand to be compensated for higher

inflation uncertainty through inflation risk premia, i.e., the difference between inflation compensation and inflation expectations. While our modelling framework for inflation risk premia doesn't extend back to that period due to lack of data (estimates require the full term structure of inflation pricing), surveys generally suggest that investors do not have particularly differentiated expectations between 5y and longer-dated forwards of inflation. Thus, the curve shape should provide a reasonably good gauge of inflation risk premia. The steepening of the breakeven curve suggests a meaningful increase in inflation risk premium in the 1970s. This is consistent with the rise in breakeven inflation alongside short-term inflation expectations ([Exhibit 5](#)). It then took much of the 1980s for inflation expectations to catch down to short-term inflation expectations, a process we can see in the flattening of the breakeven term structure over that period.

Exhibit 5: Breakevens increased with short-run inflation expectations

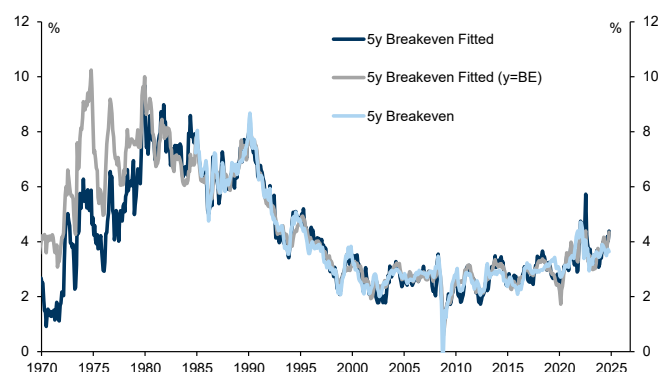
10y Breakeven Inflation, Fitted vs 1y Ahead Inflation Expectations



Source: Goldman Sachs Global Investment Research, Bank of England

Exhibit 6: Estimating breakevens (rather than real rates) gives even higher inflation values

5y Breakeven Inflation, Actual vs Fitted. Grey=Directly estimate Breakeven, Blue=estimate Real rate, Breakeven as difference to Nominal



Source: Goldman Sachs Global Investment Research, Haver Analytics

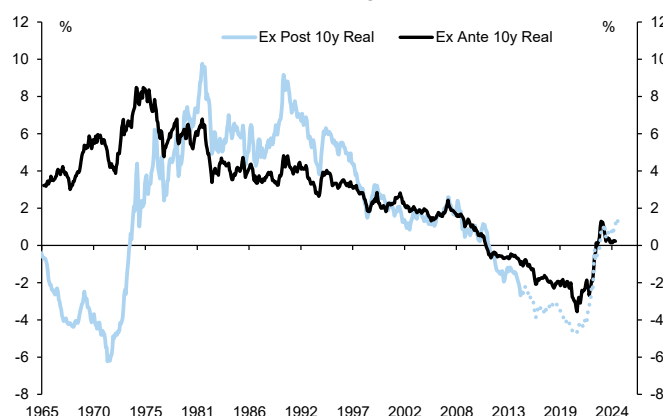
The change in policy regime around inflation after 1980 (Volcker, Linker issuance, eventual central bank independence) creates a challenge for our model estimation. We are not estimating a structural model, in which the relationship between spot inflation and inflation / real rate pricing is governed by a policy rule, such as a Taylor Rule. But our estimation window occurs after 1980, a period in which inflation stabilisation and central bank independence (eventually) becomes the policy consensus. This will implicitly embed a particular relationship between real rates and inflation such that higher inflation is likely to skew real rates higher than in prior regimes where competing policy priorities (e.g., growth or employment) may have resulted in a weaker link between inflation and (front-end) real rates.

To check this possibility, we re-run our estimates with the same explanatory variables, but with breakeven inflation as the dependent variable (instead of the real rate). We find that our estimates for 10y inflation are basically identical, which gives us confidence in these benchmark estimates. But for 5y breakevens, we find that inflation is estimated to be much higher in the 1970s than the implied breakeven from the prior exercise of estimating real rates ([Exhibit 6](#)). This suggests that the post-1980 estimates may embed too strong a relationship between front-end real rates and inflation levels, and that in fact front-end real rates in the 1970s were likely lower, and the real curve steeper than

the original estimates imply.

Exhibit 7: Following the high inflation of the 1970s, nominal Gilts outperformed Inflation-Indexed Yields in real terms

10y Nominal Gilts - 10y Realized Inflation (Ex-Post) vs 10y Fitted Real Yields (Ex-Ante). Dotted=Realized Inflation using Forward



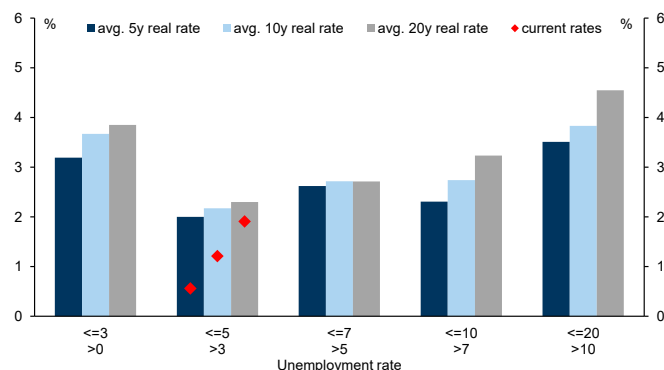
Source: Goldman Sachs Global Investment Research, Haver Analytics

Lessons for the current period — real rate curve too steep

Comparing *ex-ante* and *ex-post* real rates, we find – unsurprisingly – that the inflation shock of the 1970s led to deeply negative real returns to hold-to-maturity long nominal Gilt positions. However, the rise in real rates into the 1980s, alongside disinflationary policies, ushered in a period of substantial increases in *ex-post* real returns. This exercise shows that the high-inflation experience of the 1970s led investors to overprice inflation risk: throughout the 1980s *ex-ante* real yields were consistently below *ex-post* yields, implying that investors would have been better off owning nominal bonds and bearing the inflation risk (Exhibit 7). This led to significant interest expense savings for the UK DMO, which captured that premium through Linker issuance.

Exhibit 8: Current real rates curve steep vs history

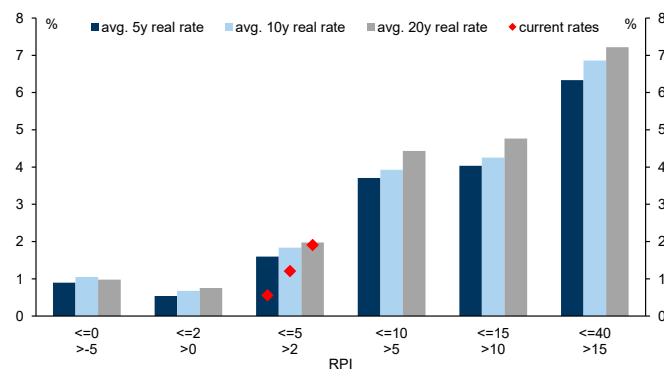
Average Real Rate (Fitted) across different unemployment regimes



Source: Goldman Sachs Global Investment Research, Haver Analytics

Exhibit 9: Although real rate levels broadly consistent with inflation

Average Real Rate (Fitted) across different inflation regimes



Source: Goldman Sachs Global Investment Research, Haver Analytics

Given the recent rise in real rates (and the likely deeply negative real returns to long Gilt positions in recent years), we could ask whether we will see a similar period of *ex-post* real gains from current longs. Our estimates suggest that the current levels of real rates, especially at the front end, are not excessive, despite the recent rise. Instead,

benchmarking real rates against inflation and unemployment, current levels of rates are consistent with the macro environment ([Exhibit 8](#) & [Exhibit 9](#)). In addition, the relatively flat inflation breakeven curve (even controlling for the likely adjustment of RPI towards the lower CPI embedded in long-end RPI forwards) suggests that inflation risk premium is well-contained in the UK curve. This does imply that the steepness in the real rate curve will eventually fade, with 30y reals outperforming vs the front end, and raises the hurdle for nominal Gilts to outperform Linkers over long holding periods.

The authors would like to thank Loïc Mathys for his contribution to this report. Loïc is an intern in the Markets team.

Appendix

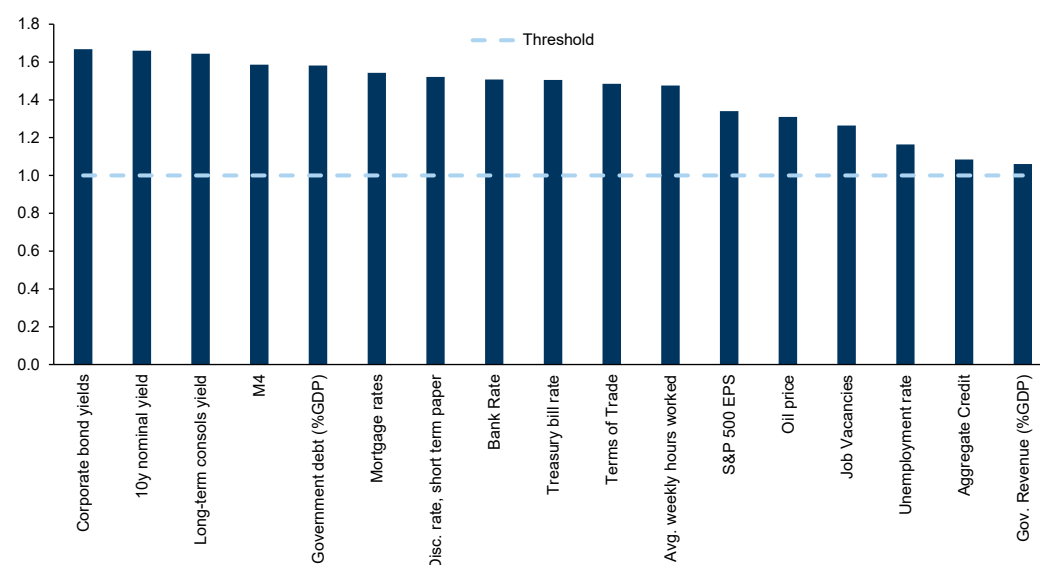
Leveraging the [Bank of England's Millennium of Macroeconomic Data](#) dataset, which provides ultra-long time series of relevant macro variables, we estimate the long-term history of UK real yields (5y, 10y and 20y) and their corresponding breakeven rates. This allows us to backcast yields and breakevens as far back as the 1960s.

We apply a backcasting methodology following an approach by the [NY Fed](#) and our [US colleagues](#), using Partial Least Squares (PLS) regression to mitigate multicollinearity and reduce dimensionality.

Using a ranking algorithm called Variable Importance for PLS (VIP) ([Mehmood et al. \(2012\)](#)), we can measure the importance of each variable's contribution – intuitively, corporate bond and nominal Gilt yields rank highly, as do monetary variables and measures of the fiscal stance.

Exhibit 10: Nominal yields, money supply, fiscal variables and labour market data most useful to backcast real yields

Scores > 1 suggest variable provides useful information for estimates



Source: Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

I, Friedrich Schaper, hereby certify that all of the views expressed in this report accurately reflect my 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 Global Investment Research 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. Investment in securities market are subject to market risks. Read all the related documents carefully before investing. Registration granted by SEBI and certification from NISM in no way guarantee performance of the intermediary or provide any assurance of returns to investors. Goldman Sachs (India) Securities Private Limited compliance officer and investor grievance contact details can be found at this link: <https://publishing.gs.com/disclosures/hedge.html> - /general/equity. **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 Type II Financial Instruments Firms Association, The Investment Trusts Association, Japan, and Japan Investment Advisers 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

Goldman Sachs Global Investment Research 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 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.

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 and the Republic of Ireland; GSI - Succursale de Paris (Paris branch) which is 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 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 (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 Global Investment Research. 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/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 Goldman Sachs Global Investment Research 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.

© 2025 Goldman Sachs.

You are permitted to store, display, analyze, modify, reformat, and print the information made available to you via this service only for your own use. You may not resell or reverse engineer this information to calculate or develop any index for disclosure and/or marketing or create any other derivative works or commercial product(s), data or offering(s) without the express written consent of Goldman Sachs. You are not permitted to publish, transmit, or otherwise reproduce this information, in whole or in part, in any format to any third party without the express written consent of Goldman Sachs. This foregoing restriction includes, without limitation, using, extracting, downloading or retrieving this information, in whole or in part, to train or finetune a machine learning or artificial intelligence system, or to provide or reproduce this information, in whole or in part, as a prompt or input to any such system.