2 July 2020 | 5:02AM EDT

Modeling S&P 500 Returns using Investment Flows and Liquidity Data

John Marshall
+1(212)902-6848 | john.marshall@gs.com
Goldman Sachs & Co. LLC

Zach Pandl
+1(212)902-5699 | zach.pandl@gs.com
Goldman Sachs & Co. LLC

Rocky Fishman, CFA
+1(212)902-3396 | rocky.fishman@gs.com
Goldman Sachs & Co. LLC

Isabella Rosenberg
+1(212)357-7628 | isabella.rosenberg@gs.com
Goldman Sachs & Co. LLC

Arjun Menon, CFA
+1(212)902-9693 | arjun.menon@gs.com
Goldman Sachs & Co. LLC

Vishal Vivek
+1(212)902-2603 | vishal.vivek@gs.com
Goldman Sachs & Co. LLC

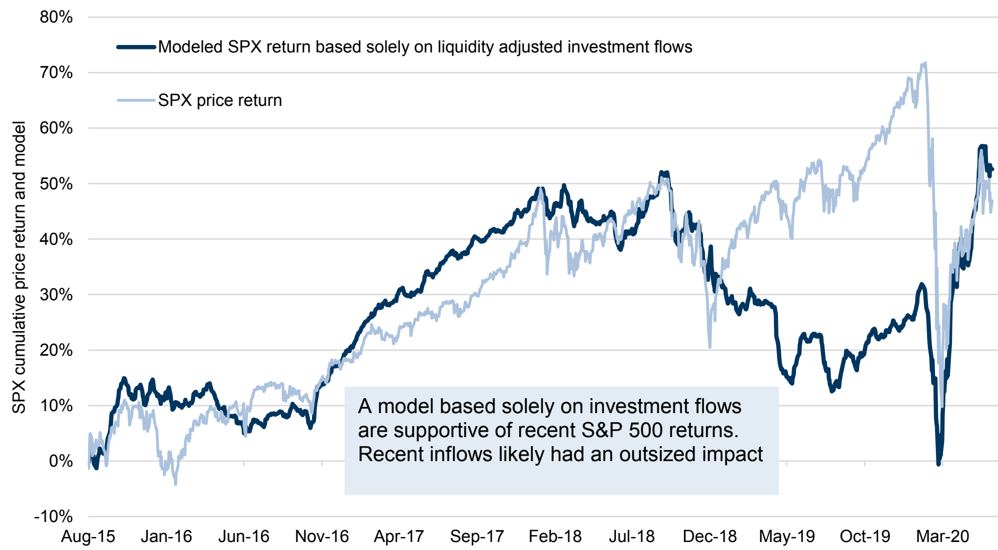
Arun Prakash, CFA
+1(212)934-6218 | arun.prakash@gs.com
Goldman Sachs India SPL

We believe investment flows are an important driver of equity returns. Changing fundamental views shape investor decisions, but it is the actual trading of securities that translates these views into price changes. While investors have used weekly and monthly investment flow information for many years to help triangulate positioning in the market, practitioners have not typically compared flows directly with equity price returns because the explanatory power of simple comparisons has been low. In our view, the difficulty of linking investment flows to equity returns has been driven by a lack of publicly available flow data, infrequent or delayed reporting of aggregated data and the challenge of using market liquidity metrics to model the variable impact of flows over time.

Our model leverages three new developments that greatly increase the ability to explain daily S&P 500 returns with investment flow data: (1) The ETF market now provides rich daily data on investment flows that can be used as proxies for broader flows from individuals and professional investors, (2) Proprietary data on Prime Brokerage flows and Funding spreads provide unique insight into hedge fund and asset manager flows, and (3) Our process of incorporating liquidity effects not only improves the fit through time, but also explains how inflows in an illiquid market (following a selloff) can drive a bigger increase than the drop caused by the same outflows that occurred when liquidity was stronger.

Our analysis suggests the S&P 500 has underperformed liquidity-adjusted investment flows. Outflows primarily occurred during periods when liquidity was stronger and likely to have a limited impact on equity prices. Recent investment flows from hedge funds, corporate bond ETFs and individual investor ETFs have come at a time of low liquidity. We conclude that investment flows in the context of low liquidity are supportive of recent S&P 500 returns and would suggest further upside potential. While we make our investment recommendations based on fundamentals, we believe this analysis shows that recent investment flows have been more-than-sufficient to support the recent rally in equity prices.

Exhibit 1: Our model suggests that recent inflows in the context of low liquidity are supportive of the recent S&P 500 rally
SPX cumulative price return vs model based solely on investment flows and market liquidity



Source: Goldman Sachs Global Investment Research

Three key innovations in modeling SPX returns with investment flows

1. Exchange Traded Funds (ETFs) have become a large part of overall investment flows and provide a daily look at the activity of different types of investors. ETFs have been an important investment tool for more than a decade, but only in the past five years have the flows in/out of ETFs grown to a level that is meaningful enough to provide a proxy for broader flows. As the secular growth of AUM has matured, sentiment has begun to drive flows more than secular growth factors. Assets under management of ETFs exceeded the assets in Mutual Funds last year for the first time. Most ETFs report daily shares outstanding, allowing investors to see daily flows in/out of each strategy; this contrasts with mutual funds which typically report monthly data. While ETFs are broadly available to all investors, we find that features of some ETFs attract individual investors while others attract professional investor flows.

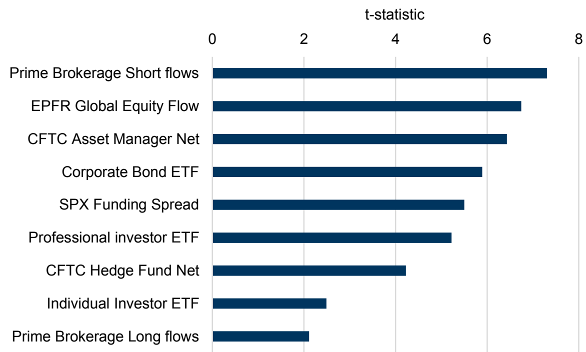
2. Proprietary flow data is useful: Funding Spreads and Prime Brokerage flows. Professional investors use a wide variety of listed and over-the-counter instruments to gain exposure to various securities and investment themes. For example, a hedge fund that would like to gain long exposure to equities can transact in many forms including buying stocks, futures, total return swaps, calls on stocks, calls on an index, structured notes or even selling puts. Depending on their choice of instrument, the transaction would be reported differently in the traditional flow data; however, their impact on "funding spreads" would theoretically be the same. The SPX funding spread is the cost above the risk free rate that the market charges for investors to gain long exposure to SPX futures. While each market maker may have their own funding spread assumptions across the maturity spectrum, the market's view of funding spreads can be backed out of the SPX futures curve. Separately, Prime Brokerage flows are another obvious source of proprietary data on professional investment flows. In our analysis, we focus on the daily flows in the long and short book rather than the "gross" or "net" exposure of the combined book which are influenced by the rise and fall of market prices. We find that funding spreads and the flows in the Prime Brokerage short book are two of the variables most highly correlated with SPX returns.

3. The Liquidity environment is an important factor for understanding how flows interact with prices. Our analysis demonstrates that the impact of a given investment flow depends not only on the size of that flow, but also on the liquidity environment on the day that the flow takes place. In fact, we find that the fit of each of our flow variables was improved when scaled using our proprietary single stock liquidity index. Our liquidity index estimates the percentage of the Russell 3000 market capitalization that could be traded over a day with a fixed market impact expectation of 10bps. This analysis suggests that flows that occur in low liquidity environments have a larger impact on asset prices than flows in highly liquid environments, which has big implications for the effect of flows during sell-offs and rebounds when market liquidity is most volatile.

Model Variables and background

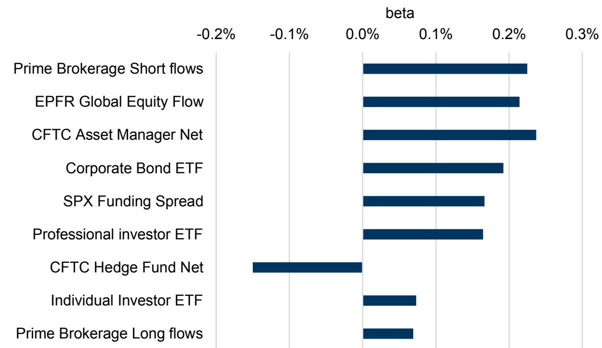
For this exercise, we aim to explain the daily returns of the SPX using investment flows (or proxies for investment flows) that occurred on the same day. Going forward, we believe this model is useful for understanding the gap between SPX performance and investment flows over the prior several days. We find that a wide variety of flow variables are useful for explaining price returns; we choose 9 which we have found are significant on their own and significant in the presence of other variables. We calculate the flows as a percentage of the S&P market capitalization each day to adjust for rising asset prices through the period. Using 5 years of history, we find these 9 variables plus the prior day's return of the SPX have had an R-squared of 24% in explaining the day's SPX return. **After adjusting each variable for the liquidity in the market on that day, the R-squared rises to 32%.**

Exhibit 2: Statistical significance of each flow variable shows a minimum T-statistic of two across the nine variables
Absolute value of t-statistic of nine variables in a regression of 5 year daily moves



Source: Goldman Sachs Global Investment Research

Exhibit 3: Beta of each liquidity adjusted flow variable
Standardized beta based on 5 year daily regression with daily SPX log returns



Source: Goldman Sachs Global Investment Research

Composition of investment flow variables

ETF Flows: We calculate the change in shares outstanding each day multiplied by the average price of the day to assess the daily inflow or outflow. We focus on ETFs that report their shares outstanding without a lag to ensure the timing is matched with stock returns.

- **Professional Investor ETFs:** Our experience and our analysis of SEC filings show that Professional investors typically use options on ETFs rather than ETFs themselves. Options activity is focused in the most liquid 20 Equity ETFs. In fact, the notional value of options outstanding on the 20 ETFs with the highest options activity is larger than the ETF shares market itself. We believe the daily changes in shares outstanding of these 20 ETFs represents the net delta owned by professional investors, as dealers create and redeem the ETFs to hedge the options that professional investors have traded with them.
- **Individual Investor ETFs:** We classify all equity ETFs not considered Professional Investor ETFs as Individual Investor ETFs. We include approximately 100 of the largest ETFs in this category, but in practice the top 5-10 drive the bulk of the flows over the period analyzed. We believe it is important to distinguish between Professional Investor and Individual investor positioning as they likely contain a different mix of forward-looking view and external factors. Further, we observe that Professional Investor positioning is far more volatile than Individual Investor ETF flows. Individual investor ETFs have generally seen positive inflows through the entire period as evidenced by the upward sloping line in both charts below.
- **Corporate Bond ETFs:** We include daily flows of the largest 20 ETFs focused on corporate bonds. This metric is positively correlated with equity returns over all of the major periods we tested, demonstrating the strong link between demand for corporate bonds and equity price moves.

Goldman Sachs Prime Brokerage investment flows: Our Prime Brokerage team calculates the daily net flow into long positions [($bought - $sold)/ net asset value of total long and short book on prior day] as well as the daily flow into short positions [($covered-$shorted)/net asset value of total long and short book on prior day]. We choose to focus on flows rather than the net exposure of the fund as it minimizes the impact of stock price movements on the assessment of positioning. This has been particularly important for analyzing flows during the recent market drawdown. Hedge funds increased exposure as the market declined and reduced exposure during the rally; however, a simple look at net exposure would suggest the opposite as net exposure numbers are influenced by price declines.

Futures positioning: The futures market allows professional investors to trade large size in a short amount of time with a large amount of leverage, making it one of the most reactive to changes in professional investor sentiment.

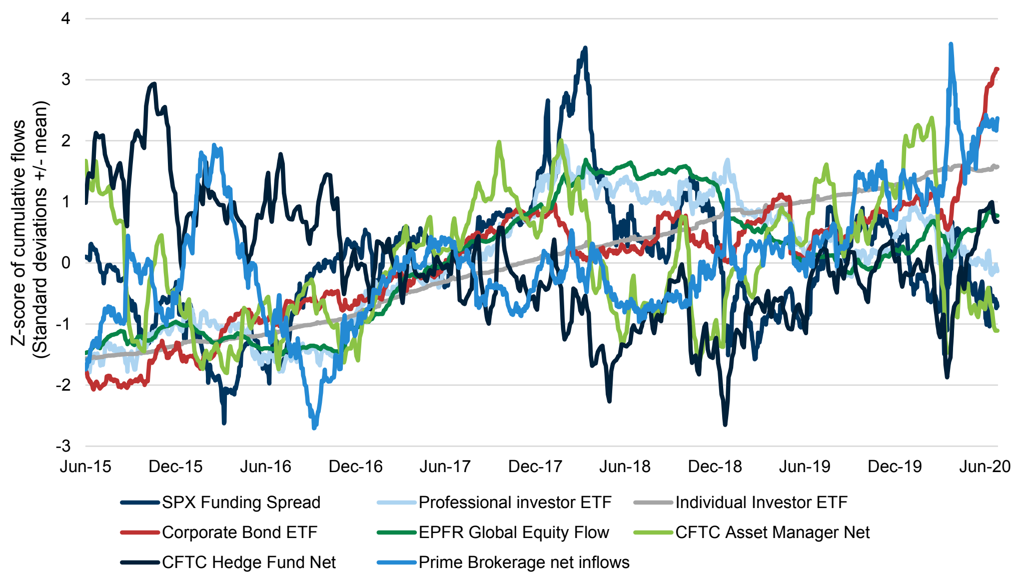
- **SPX Funding Spreads:** As demand for levered equity exposure grows relative to the supply of leverage, the cost of funding that leverage becomes larger. We are able to monitor day-to-day changes in the supply and demand of equity leverage by watching the SPX futures funding markets (the spread implied by SPX futures pricing minus the Fed Funds rate). Specifically, we choose to use the average of the three-month and six-month funding spreads rather than front contract funding spreads which are periodically distorted by the futures roll each quarter.
- **CFTC data on net exposure:** The CFTC reports long and short positions for Asset Managers and Hedge Funds each Friday (data as of the preceding Tuesday). For the purposes of our modeling, we assume that these flows occurred equally on the days between the two report dates. While it is clearly not possible to know these flows as they happen, this allows us to assess whether the information from these flows are important for SPX returns. We believe that net changes in asset manager positioning is a proxy for quantitative manager positioning as part of a broader asset allocation strategy. We believe that an increase in the net short futures position among Hedge funds is indicative of an increase in gross positioning among hedge funds (leading this indicator to be inversely correlated with S&P 500 price moves).

Global equity fund flows from EPFR: We find that broad, global fund flows are highly correlated with SPX returns. While most mutual funds report flows monthly and the EPFR data we use is reported weekly, we estimate that the flows observed occurred evenly across the days of the week prior. Despite this approximation, we find that EPFR global equity flows also have a statistically positive correlation with daily SPX returns.

SPX mean reversion: The SPX daily return has been inversely correlated with the prior day's return throughout our study period. We find that this mean-reversion factor is even more important when analyzing the impact of investment flows. The addition of "yesterday's returns" in the model increases the explanatory power of the other investment flow variables suggesting that information about flows is more useful when viewed in the context of recent price performance.

Exhibit 4: Cumulative flows from each source without liquidity adjustments

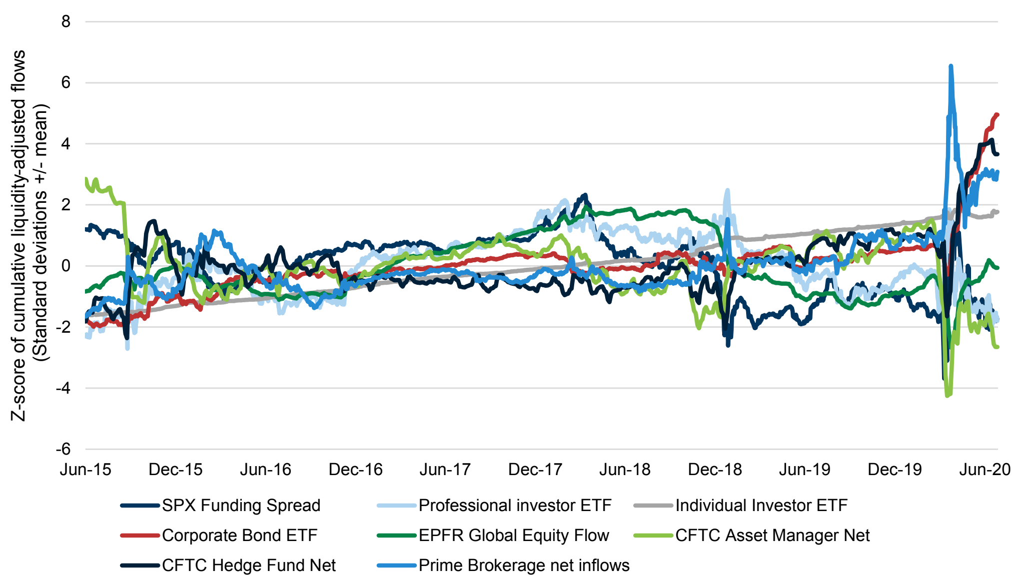
Z-score of cumulative flows from each source



Source: Goldman Sachs Global Investment Research, Goldman Sachs Group Inc., CFTC, EPFR, Bloomberg

Exhibit 5: Liquidity adjusted flows have had higher correlation with SPX returns and better explain the recent moves

Z-score of cumulative flows adjusted for liquidity



Source: Goldman Sachs Global Investment Research, Goldman Sachs Group Inc., CFTC, EPFR, Bloomberg

Exhibit 6: The flow variables have limited correlation with each other

Correlation of the daily change in standardized liquidity-adjusted flows

	Professional	Individual	Corp Bond	EPFR	CFTC HF	CFTC AM	PB net flow	prior SPX return
SPX Futures Funding Spread	(0.18)	0.11	(0.02)	(0.04)	0.04	0.06	0.05	(0.28)
Professional investor ETF flows		(0.12)	0.02	0.03	(0.13)	(0.08)	0.22	0.18
Individual Investor ETF flows			(0.00)	0.11	0.01	0.06	(0.16)	(0.01)
Corporate Bond ETF flows				0.12	0.33	0.32	(0.08)	0.31
EPFR Global Equity flows					0.05	0.25	(0.35)	0.21
CFTC Hedge Fund Equity Futures flows (net, inverted)						0.49	(0.05)	0.15
CFTC Asset Manager Equity Futures flows (net)							(0.14)	0.23
Prime Brokerage net flows								(0.30)

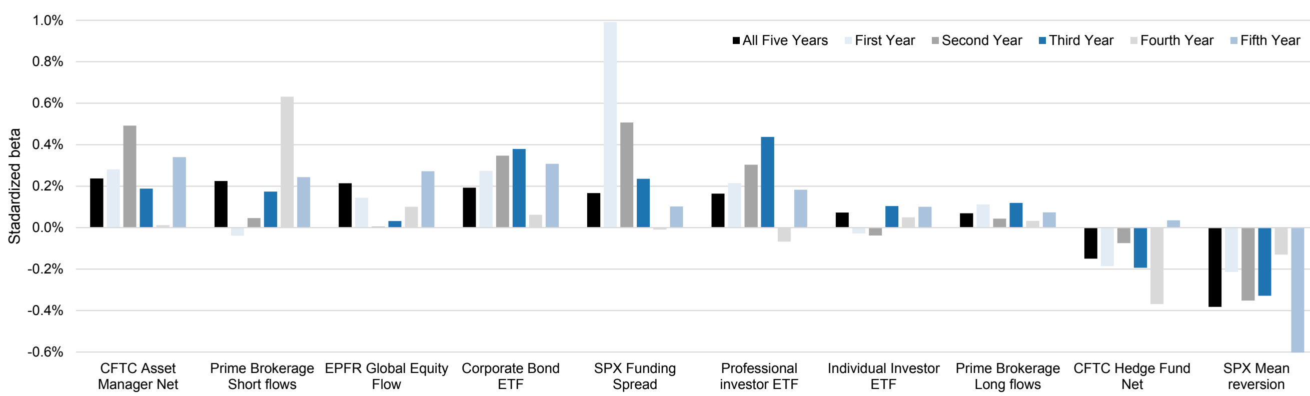
Source: Goldman Sachs Global Investment Research, Goldman Sachs Group Inc., CFTC, EPFR, Bloomberg

Estimating the relationship between Investment Flows and SPX returns through time

To estimate how the relationship between SPX returns and flows may have changed over time, we estimate the model dividing the 60-month analysis into five 12-month periods (N=252 for each). We find that the sign for the betas in the combined regression is the same for most of the variables even when broken into these brief periods. While the fit of the model for four of the years is similar to the 5-year results, the correlation between investment flows and SPX returns has improved in the past year (46% R-Squared as compared to 25-32% R-squared for other years); the unusually high volatility and increasingly significant daily mean reversion likely played a role in that improvement.

Exhibit 7: Standardized betas for sub-periods show general stability

Standardized betas for regression using daily flows over the full 5-year period and each of the 1-year periods separately

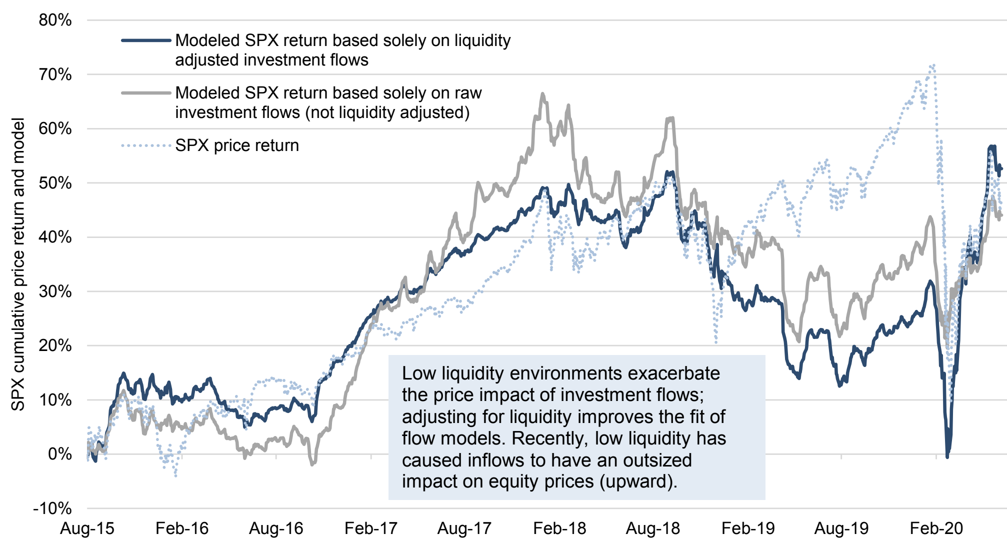


Source: Goldman Sachs Global Investment Research

Market liquidity plays a role in understanding how investment flows impact price moves. Flows that occur when the market is liquid have a smaller impact on price moves than flows that occur when the market is illiquid. In fact, the model fit was improved significantly by transforming each of the flow variables using our GS Proprietary Single Stock Liquidity Index (boosted R-squared from 24% to 32% over the period analyzed). Our liquidity index estimates the percentage of the market cap of the Russell 3000 that can be traded over a 1-day period (VWAP) while expecting to have a market impact of 10 basis points. Scaling each flow variable by size tradable for a given market impact has been particularly important in recent years because of the significant and rapid decline in liquidity in Feb-2018, Dec-2018 and Mar-2020.

Liquidity adjustments are important for explaining the asymmetric effects of flows on SPX returns in drawdowns vs rebounds. Using the recent drawdown as an example, the model that does not account for liquidity effects would have suggested an SPX decline of 23% from 19-Feb to 18-Mar, while the model including liquidity effects suggested a 33% decline (SPX actual decline was 29%). The effect was even larger during the flow rebound; from 18-Mar to 19-May without liquidity effects would have suggested a rebound of 24%, while adjusting for liquidity effects suggested a 53% rebound. This shows how incorporating liquidity effects not only improves the fit through time, but also explains how inflows in an illiquid market (following a selloff) can drive a bigger increase than the drop caused by the same outflows that occurred when liquidity was stronger.

Exhibit 8: Liquidity adjustments are critical for explaining the impact of flows on equity price
Modeled cumulative SPX price return based on liquidity adjusted flows



Source: Goldman Sachs Global Investment Research

A note on retail investor flows directly in stocks and options

We have received many questions about the role of individual investors in the recent rally. We track the percentage of "small trades" that are executed in shares and options markets as a proxy for the intensity of retail activity on a daily basis. Our initial finding is that elevated individual investor activity in stocks and options have been associated with declines in SPX prices over the past 18 months that we studied. Either SPX declines attract individual investor activity or individual investor activity drives SPX declines. On its surface, this runs counter to the hypothesis that individual investors are boosting stock prices. Although it is possible that the high cash levels and the belief that the recent economic weakness is temporary has led to an unusual increase in "buy-the-dip" sentiment among individual investors. Given the difficult-to-explain negative correlation and the limited relevant history of the phenomenon, we leave individual investor single stock or option activity metrics out of this longer-term oriented model.

Disclosure Appendix

Reg AC

I, John Marshall, hereby certify that all of the views expressed in this report accurately reflect my personal views about the subject company or companies and its or their securities. I also certify that no part of my compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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

Disclosures

Option Specific Disclosures

Price target methodology: Please refer to the analyst's previously published research for methodology and risks associated with equity price targets.

Pricing Disclosure: Option prices and volatility levels in this note are indicative only, and are based on our estimates of recent mid-market levels(unless otherwise noted). All prices and levels exclude transaction costs unless otherwise stated.

General Options Risks – The risks below and any other options risks mentioned in this research report pertain both to specific derivative trade recommendations mentioned and to discussion of general opportunities and advantages of derivative strategies. Unless otherwise noted, options strategies mentioned in this report may be a combination of the strategies below and therefore carry with them the risks of those strategies.

Buying Options - Investors who buy call (put) options risk loss of the entire premium paid if the underlying security finishes below (above) the strike price at expiration. Investors who buy call or put spreads also risk a maximum loss of the premium paid. The maximum gain on a long call or put spread is the difference between the strike prices, less the premium paid.

Selling Options - Investors who sell calls on securities they do not own risk unlimited loss of the security price less the strike price. Investors who sell covered calls (sell calls while owning the underlying security) risk having to deliver the underlying security or pay the difference between the security price and the strike price, depending on whether the option is settled by physical delivery or cash-settled. Investors who sell puts risk loss of the strike price less the premium received for selling the put. Investors who sell put or call spreads risk a maximum loss of the difference between the strikes less the premium received, while their maximum gain is the premium received.

For options settled by physical delivery, the above risks assume the options buyer or seller, buys or sells the resulting securities at the settlement price on expiry.

Distribution of ratings/investment banking relationships

Goldman Sachs Investment Research global Equity coverage universe

	Rating Distribution			Investment Banking Relationships		
	Buy	Hold	Sell	Buy	Hold	Sell
Global	46%	39%	15%	65%	57%	52%

As of April 9, 2020, Goldman Sachs Global Investment Research had investment ratings on 3,023 equity securities. Goldman Sachs assigns stocks as Buys and Sells on various regional Investment Lists; stocks not so assigned are deemed Neutral. Such assignments equate to Buy, Hold and Sell for the purposes of the above disclosure required by the FINRA Rules. See 'Ratings, Coverage Universe and related definitions' below. The Investment Banking Relationships chart reflects the percentage of subject companies within each rating category for whom Goldman Sachs has provided investment banking services within the previous twelve months.

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 Instruction 598 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 Instruction 598, 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:** Further information on the covered companies referred to in this research may be obtained from Goldman Sachs (Singapore) Pte. (Company Number: 198602165W). **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: 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 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.

Ratings, coverage universe and related definitions

Buy (B), Neutral (N), Sell (S) -Analysts recommend stocks as Buys or Sells for inclusion on various regional Investment Lists. Being assigned a Buy or Sell on an Investment List is determined by a stock's total return potential relative to its coverage universe. Any stock not assigned as a Buy or a Sell on an Investment List with an active rating (i.e., a stock that is not Rating Suspended, Not Rated, Coverage Suspended or Not Covered), is deemed Neutral. Each region's Investment Review Committee manages Regional Conviction lists, which represent investment recommendations focused on the size of the total return potential and/or the likelihood of the realization of the return across their respective areas of coverage. The addition or removal of stocks from such Conviction lists do not represent a change in the analysts' investment rating for such stocks.

Total return potential represents the upside or downside differential between the current share price and the price target, including all paid or anticipated dividends, expected during the time horizon associated with the price target. Price targets are required for all covered stocks. The total return potential, price target and associated time horizon are stated in each report adding or reiterating an Investment List membership.

Coverage Universe: A list of all stocks in each coverage universe is available by primary analyst, stock and coverage universe at https://www.gs.com/research/hedge.html.

Not Rated (NR). The investment rating and target price have been removed pursuant to Goldman Sachs policy when Goldman Sachs is acting in an advisory capacity in a merger or strategic transaction involving this company and in certain other circumstances. **Rating Suspended (RS).** Goldman Sachs Research has suspended the investment rating and price target for this stock, because there is not a sufficient fundamental basis for determining, or there are legal, regulatory or policy constraints around publishing, an investment rating or target. The previous investment rating and price target, if any, are no longer in effect for this stock and should not be relied upon. **Coverage Suspended (CS).** Goldman Sachs has suspended coverage of this company. **Not Covered (NC).** Goldman Sachs does not cover this company. **Not Available or Not Applicable (NA).** The information is not available for display or is not applicable. **Not Meaningful (NM).** The information is not meaningful and is therefore excluded.

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.; Ombudsman Goldman Sachs Brazil: 0800 727 5764 and / or ouvidoriagoldmansachs@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Ouvidoria Goldman Sachs Brasil: 0800 727 5764 e/ou ouvidoriagoldmansachs@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 and European Union.

European Union: Goldman Sachs International authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority, has approved this research in connection with its distribution in the European Union and United Kingdom.

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.

The analysts named in this report may have from time to time discussed with our clients, including Goldman Sachs salespersons and traders, or may discuss in this report, trading strategies that reference catalysts or events that may have a near-term impact on the market price of the equity securities discussed in this report, which impact may be directionally counter to the analyst's published price target expectations for such stocks. Any such trading strategies are distinct from and do not affect the analyst's fundamental equity rating for such stocks, which rating reflects a stock's return potential relative to its coverage universe as described herein.

We and our affiliates, officers, directors, and employees, excluding equity and credit analysts, 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.

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 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.