LIQUIDITY CASCADES

The Coordinated Risk of Uncoordinated Market Participants

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"A central property of a complex system is the possible occurrence of coherent large-scale collective behaviors with a very rich structure, resulting from the repeated non-linear interactions among its constituents: the whole turns out to be much more than the sum of its parts."

- Didier Sornette

INTRODUCTION

Large and sudden drawdowns are a known risk feature for market historians. One would hope that as markets mature, volatility occurring from endogenous events would diminish. Yet from 2010's Flash Crash to February 2018's Volmaggedon and the more recent March 2020 Coronacrisis, these events appear to be occurring with greater frequency, not less.

Complementing these crises has been the rather unexpected melt-up of U.S. equities from 2010 through 2020, as well as the increasing struggles of non-market-capitalization-weighted investment strategies. Market participants have developed several theories as to why these events have occurred, including: (1) accommodative monetary policy, (2) the rise and influence of passive investing, and (3) insufficient liquidity in the face of increased leverage.

In this paper we aim to explore these individual arguments. Our main thrust is that, on their own, none are sufficient to potentially justify market behavior. All, however, share a latent risk factor: liquidity. More specifically, the S&P 500 acts as the keystone to a complex market system held together by arbitrage boundaries. When chaos ensues in one market, these arbitrage bounds can lead to knock-on effects. When these knock-on effects reach the S&P 500, the entire market structure can begin to break down.

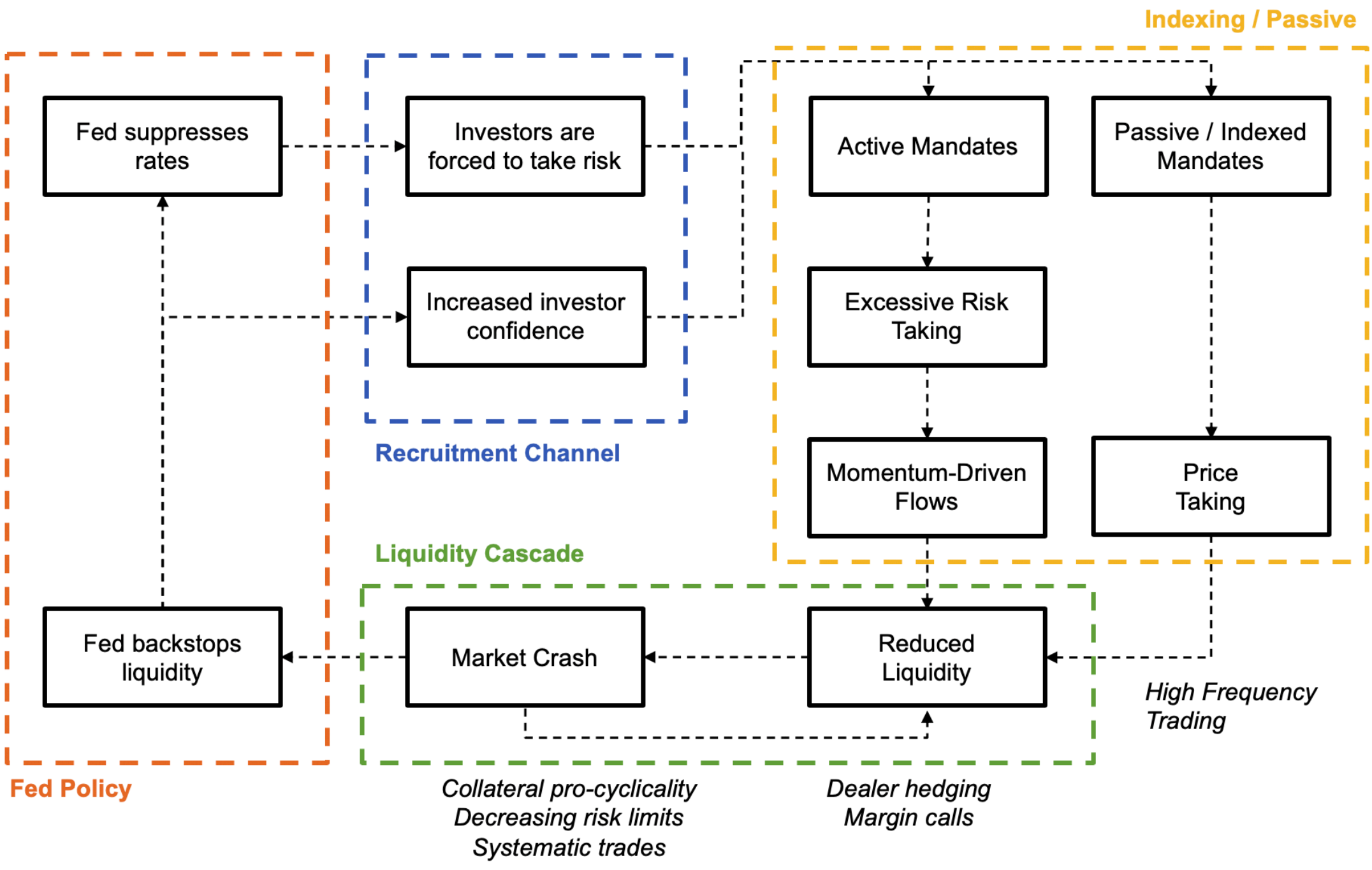
How these narratives fit together is depicted in Figure 1, which we call the "Market Incentive Loop." The Loop has no definitive start or end, though one might argue it was kicked into high gear with Federal Reserve policy decisions made during the 2008 financial crisis. These policies incentivized increased risk-seeking behavior among investors, buoyed by a confidence of the increasing role of central banks in ensuring market stability.

Within the equity space, investors pursue this risk through either active or passive mandates. Here we introduce a parallel narrative, exploring the cross-sectional and market micro-structure impacts from a growing share of passive and indexed strategies.

Finally, we must consider how strategies are executed within the market, where we discuss the role of high frequency traders as well as the potential influence of forced hedgers. It is in this last section that we find the pressures of increased risk seeking and a growing influence of passive investing may lead to increased pressures of liquidity keystones in the market. If that liquidity disappears during periods of stress, it can lead to cascades that send markets spiraling out of control.

In the final section of this paper, we will discuss investment implications and ideas for how investors might consider exploiting this reality for profit as well as protect themselves from it.

Figure 1: The Market Incentive Loop – A Pro-Cyclical Structure



A MARKET HELD ALOFT UPON THE BACK OF CENTRAL BANKS

In 2008, the U.S. Federal Reserve ('the Fed") and central banks around the world embarked upon an age of experimental monetary policy designed to stabilize markets and economies during the greatest global credit crisis in modern history. In this action, central banks moved from observers and referees to active – if not dominating – participants and players in financial markets. Their actions had two significant impacts: (1) by reducing short-term rates they provided the incentive for investors to bear greater risk, and (2) through market stabilization programs they provided investors with the confidence to do so.

The ability to transmit policy via monetary easing is explicitly acknowledged by the Fed and is referred to as the "recruitment channel." To quote Fed Governor Jeremy Stein (emphasis added),

> *Thus, according to this theory, an easing of monetary policy affects long-term real rates not via the usual expectations channel, but rather via what might be termed a "recruitment" channel -- by causing an outward shift in the demand curve of yield-oriented investors, thereby inducing these investors to take on more interest rate risk and to push down term premiums.*

In fact, evidence suggests that the Fed can even *export* its policy abroad via this channel, as investors pursue higher-yielding sovereign debt abroad, thereby driving prices up and yields down, particularly in dollar-denominated sovereign debt issued by countries with speculative-grade sovereign credit ratings.[1,2]

The cause of this transmission is obvious when we consider that many investors – including pensions, endowments, insurance companies, and individual investors – have fixed dollar liabilities and/or fixed percentage withdrawal plans. When return targets can no longer be met with U.S. Treasuries, investors must bear incremental risk to seek higher returns. Ironically, increased demand for higher risk assets may reflexively reduce risk premia, forcing investors even further out on the risk curve. In Figure 2 we can see how the blend of assets providing an expected 7.5% return has changed over time. An investor seeking to achieve a 7.5% return must now take nearly three times the risk (as measured in standard deviation) compared to an investor in 1995.

The impacts of investors moving up the risk curve can be explicitly measured in the reflexive distortions they make in doing so. Consider, for example, the substantial increase in call-overwriting ("buy write" or "covered call") and put under-writing programs adopted by institutions in the pursuit of yield. Benchmarked to CBOE's S&P 500 BuyWrite ("BXM") and PutWrite ("PUT") indices – whose very creation should indicate a growing interest in the space – these strategies typically sell short-term out-of-the-money puts and calls in order to harvest the volatility risk premium. We can see evidence of the increased demand in the retail channel as well. Both the assets and number of funds in the option-based space have grown dramatically, with less than 20 funds and $20 billion in 2010 to north of 150 funds and $80 billion today.

In Figure 3, we plot the opposite trade of many of these programs: the return from systematically *purchasing* short-term out-of-the-money puts and calls on the S&P 500. In theory, we would expect this trade to cost the volatility risk premium over time, creating a persistent return drag. Indeed, we see just this from 2005 to 2011. However, as call over- and put under-writing programs were adopted en masse in the early 2010s, the curve flattened.

While this evidence suggests investors have significantly moved up the risk curve in pursuit of returns, what gives them the confidence to do so? Here we argue it is risk perception, and specifically a confidence in the Fed's willingness to act as the lender of last resort and backstop market liquidity (colloquially referred to as the "Fed put"). In Figure 4, we demonstrate that this confidence is not wholly unfounded.

Figure 2: Walking Up the Risk Curve

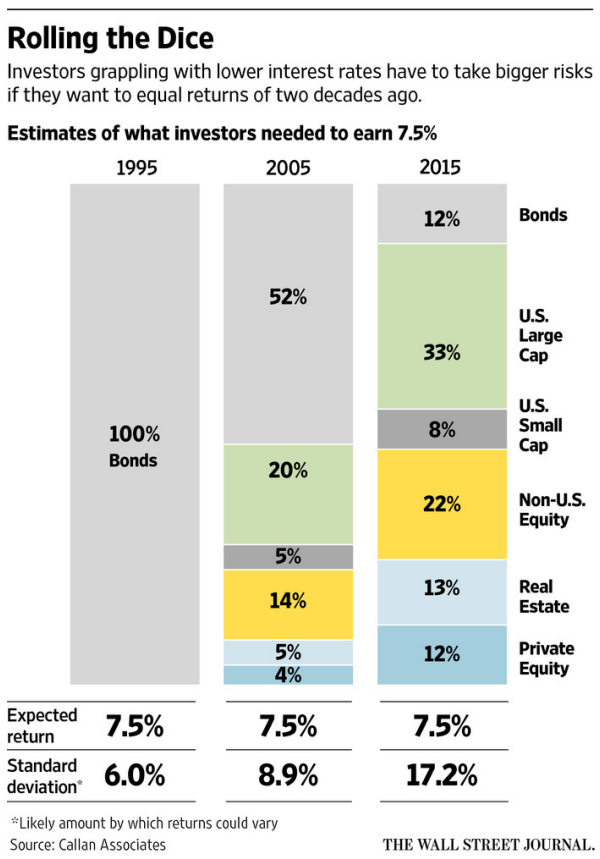
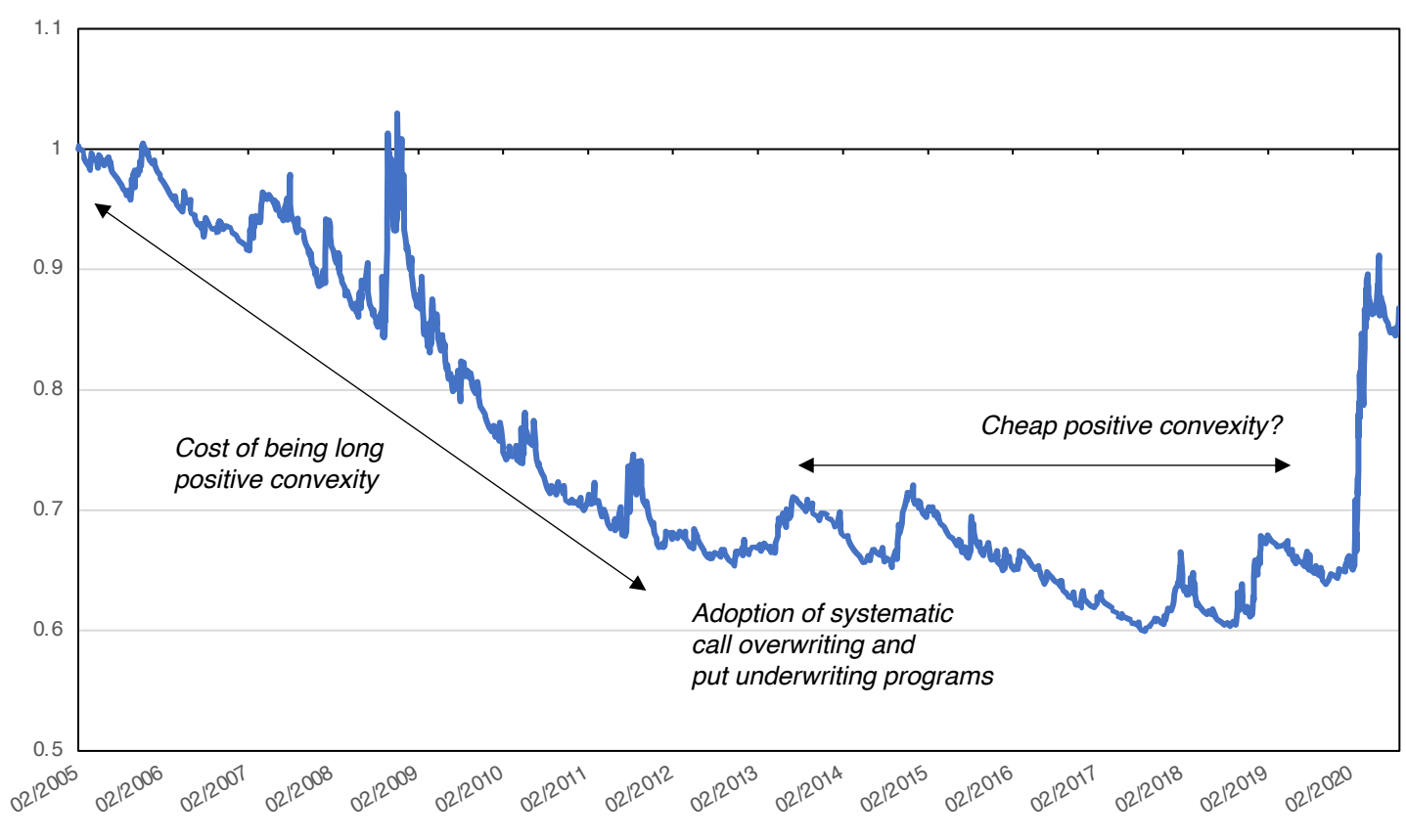
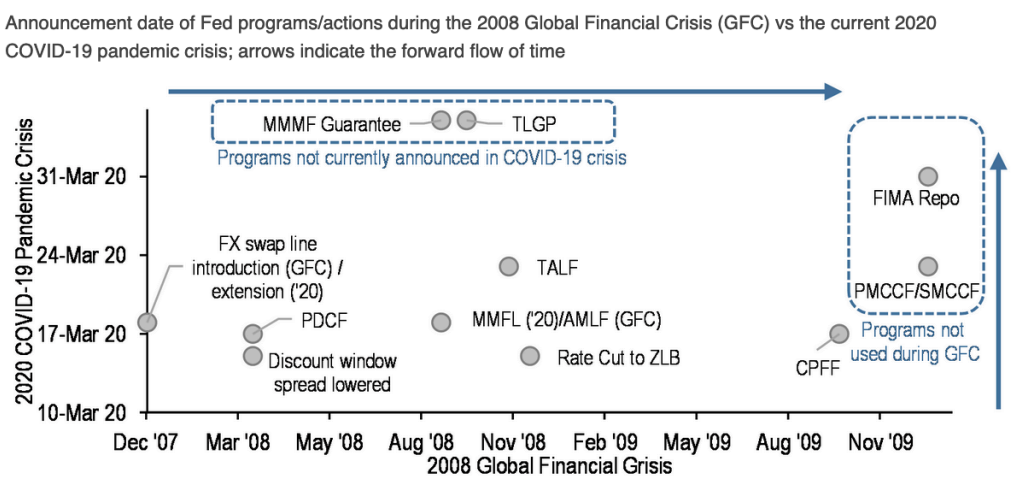


Figure 3: The Cost of Convexity (1-Month 25 Delta Strangle)



1. https://ideas.repec.org/h/chb/bcchsb/v24c08pp257-283.html
2. https://www.imf.org/external/np/res/seminars/2014/arc/pdf/gilchrist_yue_zakrajsek.pdf

Figure 4: The Fed Playbook



Source: Federal Reserve, J.P. Morgan

We can see that a significant proportion of the Federal Reserve playbook, originally developed in real time during the 2008 credit crisis, was rapidly adopted during the March 2020 Coronacrisis. What took over a year to put in place in 2008 was unfurled in less than a month in 2020. Arguably, with great success, considering that June 2020 topped the ten busiest months *ever* for high-yield debt issuance.

While in the name of stabilization, one recent study even found that Fed policy may be outright distorting markets, introducing a new risk factor for many hedge fund strategies. Quoting Guidolin et al: "not only do we find that each of the 10 strategies and the industry as a whole feature a number of structural change episodes in risk exposures, but we also find that most of the endogenously determined break dates match, or nearly match, the [unconventional monetary policy] announcement dates."[3]

The danger of increased risk adoption among investors is that it can lead to non-linear response functions related to market volatility. For explicitly levered investors, for example, increasing volatility can lead to forced de-risking either from internal risk budget limits or an increase in collateral requirements. For non-levered investors, these dynamics can still apply as higher risk can be thought of as a form of pseudo-leverage, causing investors to de-risk during periods of heightened stress (e.g. volatility targeting strategies designed to comply with post-2008 regulations applied to issuers of variable annuities).

These non-linear response functions are almost always procyclical with market stress. As market volatility increases and liquidity conditions decrease (concepts which we will argue later are intrinsically two sides of the same coin), investors seek to de-risk, putting further pressure on market prices and liquidity.

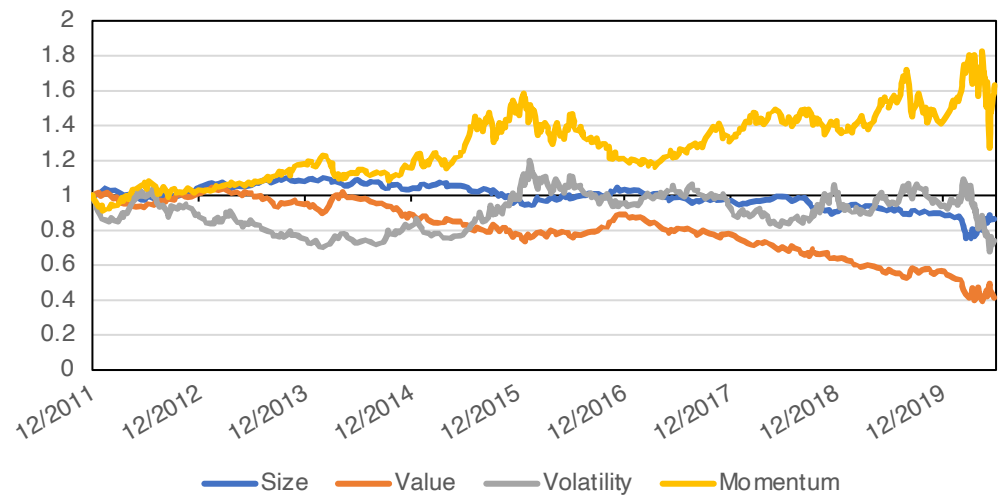
A core question becomes, "can the Fed ever extract itself from markets?" One of the problems of increased risk-taking behavior among investors is that it increases the "moneyness" of financial markets (i.e. the use of markets as a savings vehicle). The collateral effect is that the market and the real economy become increasingly tied, creating reflexivity between the two. Therefore, the Fed becomes an increasingly meaningful player in maintaining not just market stability, but *economic* stability, arguably making it harder for the Fed to reduce its role in short order.

THE ACTIVE INFLUENCE OF PASSIVE MANDATES

A second meaningful phenomenon to occur in markets over the last several decades has been the rise of passive investing. Vanguard estimates that passively-indexed funds have grown from approximately 10% of total assets in U.S.-domiciled equity funds to approximately 45% from 1993 to 2016.[4] The theoretical impact of this growing market segment can be decomposed into two effects operating at two different time horizons: the influence on cross-sectional security pricing and the influence on market micro-structure.

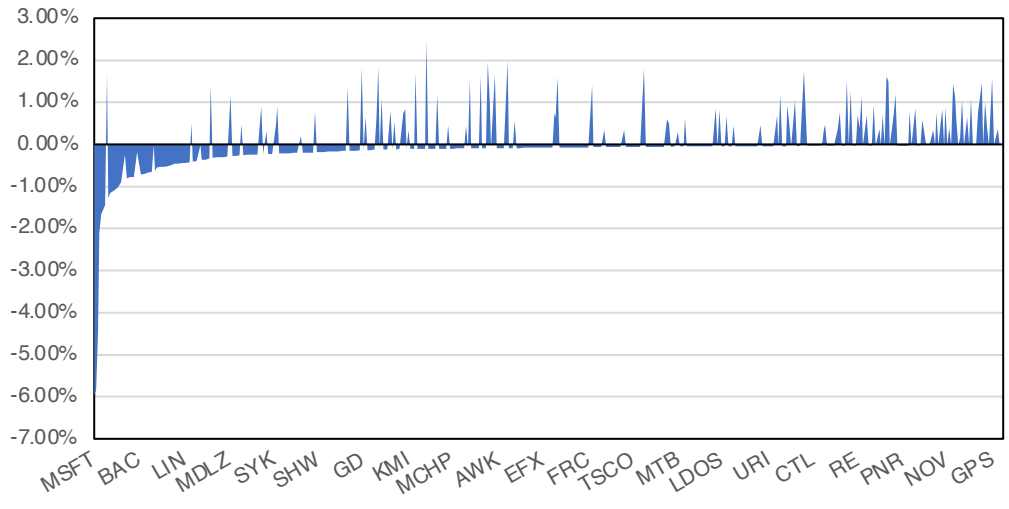
With respect to cross-sectional security pricing, there are two key influences. First, passive indexes have increasingly served as benchmarks to active managers. Studies suggest that increased benchmarking leads asset owners to "withdraw funds from underperforming managers causing them to sell shares that have mostly done badly." In contrast, "outperforming managers receive inflows and increase their holdings of assets that have been doing well."[5]

Figure 5: U.S. Equity Factor Performance Since 2012



Source: Sharadar. Calculations by Newfound Research. *Past performance is not an indicator of future results. Performance is backtested and hypothetical. Performance figures are gross of all fees, including, but not limited to, manager fees, transaction costs, and taxes. Performance assumes the reinvestment of all distributions. Parent universe reflects the top 1000 securities by market capitalization. The parent universe is the top 1000 US equities ranked by market-capitalization. SIZE ranks on market-capitalization; VALUE ranks on book-to-price; Volatility ranks on trailing 252-day realized volatility; Momentum ranks on trading realized 252-21 day returns. Long/short portfolios are rebalanced monthly. Long/short portfolios buy the top 20% of securities by rank and short the bottom 20% of securities by rank. Portfolios are equally-weighted and rebalanced monthly.*

Figure 6: Sell-to-Cover: Implicit Long/Short in Active Management



Source: SSgA; Invesco; Sharadar. Calculations by Newfound Research ETF weights as of 6/30/2020.

3. Guidolin, Massimo and Orlov, Alexei G., Are Unconventional Monetary Policies a Priced Risk Factor for Hedge Fund Strategies? (July 2020). BAFFI CAREFIN Centre Research Paper No. 2020-146, Available at SSRN: https://ssrn.com/abstract=3650981 or http://dx.doi.org/10.2139/ssrn.3650981
4. https://personal.vanguard.com/pdf/ISGBEL.pdf
5. Vayanos, Dimitri and Paul Woolley (2016), "Curse of the Benchmarks", London School of Economics, Financial Markets Group Discussion Paper, No. 747.

This behavior creates momentum in security prices, which is best exploited by momentum investors. When we evaluate the performance of different factor investors over the last decade (see Figure 5 on the prior page), we can see that momentum has been one of the only profitable approaches among traditional styles.

The second influence occurs when investors move from active into passive mandates. In doing so, they must "buy-to-cover" their implicit active bets. As an example of this, consider Figure 6 (prior page), which calculates the active bets of the S&P 500 Pure Value strategy.

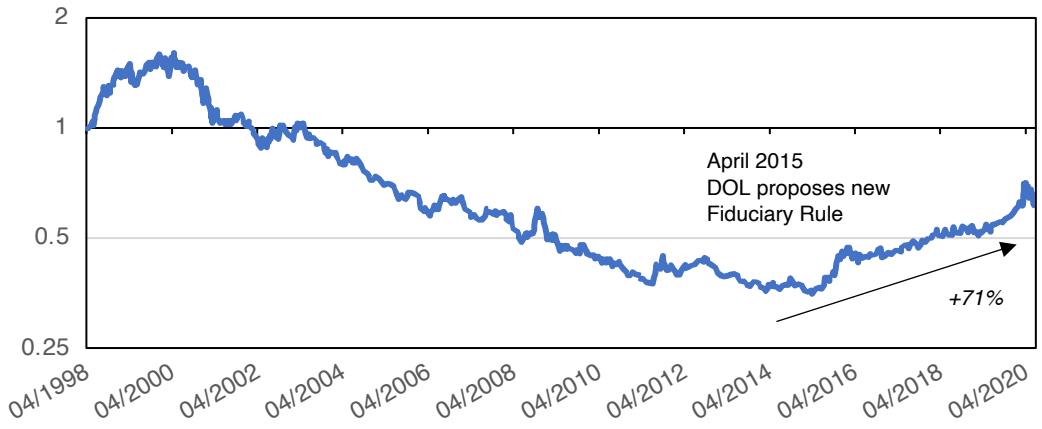
These implicit bets are calculated by taking the weights of the S&P 500 Pure Value strategy and subtracting the weights of the S&P 500. Those securities that the strategy is overweight will be positive and those securities that it is underweight will be negative (creating a dollar-neutral long/short portfolio). In Figure 6, securities are sorted on the x-axis by their weight in the S&P 500, with the largest holdings on the far left and the smallest holdings on the far right.

We can see that the S&P 500 Pure Value strategy is substantially underweight mega-cap names and over-weight smaller capitalization securities. By selling the S&P 500 Pure Value strategy to buy the S&P 500, we must neutralize these relative tilts by selling those securities we are overweight and buying those securities we are underweight. Here it is worth acknowledging that every security is held by someone, but the important consideration is where the marginal buying and selling pressure is emerging from, especially in the aggregate.

This value proxy is not the only strategy substantially underweight mega-cap names. By looking at the average holdings of size, value, quality, and momentum ETFs, we find that all are, on average, underweight the largest names in the S&P 500 (though momentum is the least underweight). And as the largest names become a larger part of the passive index, these active strategies become *more* underweight. In fact, we would argue that active managers are even incentivized to do so.

Consider that we can decompose a manager's portfolio into two pieces: their passive benchmark and the portfolio that captures their active bets. For an investor to realize alpha, the manager's active bets must first outperform the manager's fee. If the manager only takes small bets, outperforming the fee hurdle becomes more difficult. By taking larger bets (high "active share"), the manager can defend a higher fee. However, when the top 10 names of the S&P 500 comprise nearly 30% of the index weight, this almost certainly means being substantially underweight these names.

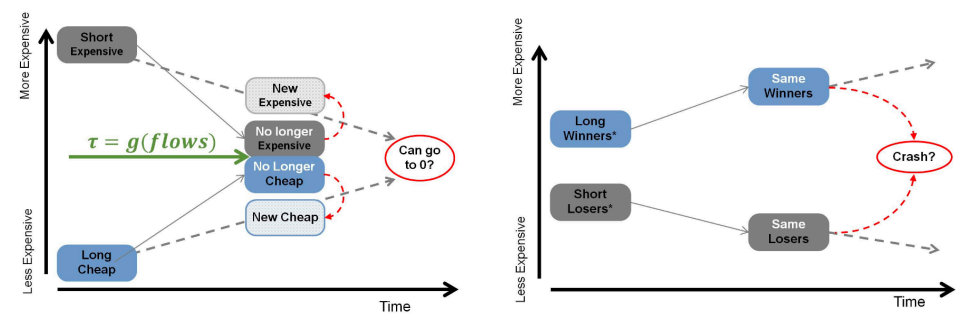
Figure 7: Top 10 Stocks vs Bottom 990



Source: Sharadar. Calculations by Newfound Research. *Past performance is not an indicator of future results. Performance is backtested and hypothetical. Performance figures are gross of all fees, including, but not limited to, manager fees, transaction costs, and taxes. Performance assumes the reinvestment of all distributions. Parent universe reflects the top 1000 US equities when ranked by market capitalization. Equity curve reflects the growth $1 invested in a dollar-neutral long/short portfolio that goes long an equal-weight portfolio of the top 10 securities by market-capitalization and short an equal-weight portfolio of the remaining 990 securities.*

Therefore, if a flight-to-passive were occurring within markets, we would expect to see marginal selling pressure in smaller market-capitalization names and marginal buying pressure in large-capitalization names. If sustained over time, this pressure could lead to the persistent out-performance of large-capitalization names versus small-capitalization names. This is precisely what we have seen since the early 2010s (Figure 7), as passive grew from half the asset share of active to parity.

Figure 8: Convergent and Divergent Trading Strategies



Baltas, Nick, The Impact of Crowding in Alternative Risk Premia Investing (March 18, 2019). Financial Analysts Journal, vol. 75, no. 3 (Third Quarter 2019), Available at SSRN: https://ssrn.com/abstract=3360350

While the rotation either from active-to-active or active-to-passive may leave exploitable footprints (e.g. by buying momentum strategies or mega-capitalization names), they may also pose a meaningful risk to market stability.

Consider that strategies can be broadly classified into two categories: convergent and divergent. Convergent are those strategies which are anchored to a level (e.g. value or mean reversion) where investors sell when price is above the level and buy when it is below. Conversely, divergent strategies try to profit from price continuation (e.g. momentum or trend).

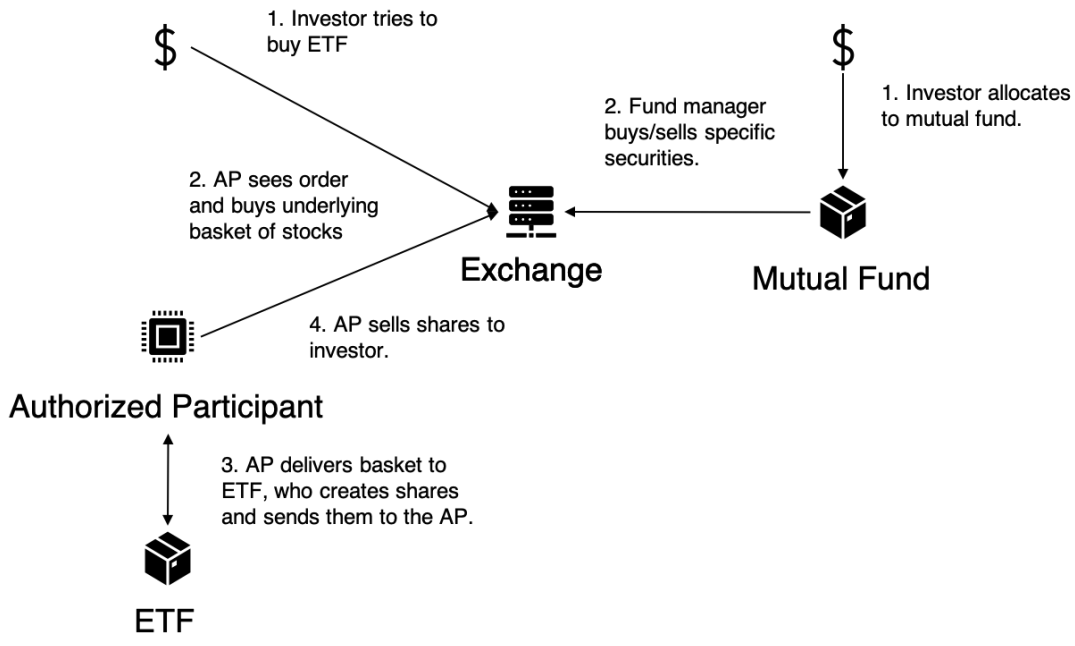
When market participants are crowded into convergent strategies, it has a stabilizing effect upon returns, as winners are sold and losers are bought. Crowding in divergent strategies, however, can have de-stabilizing effects, as winners are purchased and losers are sold. Here it is worth considering that passive and indexed strategies (including so-called "smart beta" ETFs) are divergent strategies with respect to new asset flows, as recent winners will reflect a larger proportion of the index and recent losers a smaller proportion. Therefore, we would expect an increasing flow from convergent to divergent (either momentum or indexed) strategies to have a destabilizing effect on individual and cross-sectional security pricing as positions become more crowded.

The second key effect to consider with passive strategies is their potential impact upon market micro-structure. Here we will extend our definition of passive to include all indexed ETFs, regardless of their weighting scheme (i.e. including "smart beta" products). The distinguishing characteristic to consider is whether asset flow is traded to track a basket or at the discretion of an active manager.

Flow traded to track a basket is incentivized not to identify the right value for a given security, but to minimize the impact of that flow in the market and execute the trade as efficiently as possible. This distinction is apparent in Figure 9, which demonstrates the difference between capital

6. A flight-to-passive may occur for a variety of reasons, including regulatory pressures, fee pressures, or performance pressures. Michael Green (Partner and Chief Strategist at Logica Capital) has suggesting a more benign source: demographics. Older generations hold a disproportionate amount of active mandates while younger generations disproportionately allocate to passive. While older generations harvest income (i.e. no longer reinvest dividends) as well as explicitly de-risk their portfolios (e.g. via glide paths), younger generates contribute to passive mandates, creating a net effective of active-to-passive across the market.

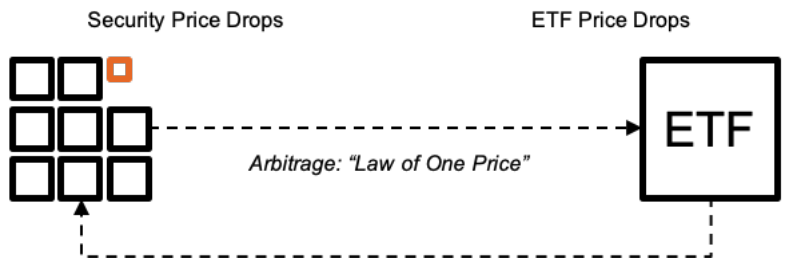
Figure 9: Market Cash Flow



allocated to an active mutual fund versus an indexed ETF. In the case of the former, the active manager will identify those securities they deem to be undervalued and use the new capital to buy those securities. In the case of the ETF, the authorized participant facilitates the flow of capital between the ETF and investors through the exchange, keeping the ETF price tied to its net asset value through arbitrage.

This distinction is important because in the latter case, the authorized participant knows the price of everything but the value of nothing. And as a larger percentage of market flow is directed towards basket trades, it may create a destabilizing influence upon markets. For example, studies show that baskets can lead to "information linkages" between securities in the same basket. This can lead to persistent distortions from fundamental value for individual securities, as "market makers cannot perfectly distinguish between price changes caused by factors pertinent to their assets, and other factors irrelevant to them." Further, market makers may not be able to instantaneously synchronize their prices, which may lead to further price distortion.[7] In fact, stocks with higher ETF ownership display significantly higher volatility, higher trading costs, higher "return synchronicity," a decline in "future earnings response," a decline in analyst coverage, and evidence even suggests that ETFs may even introduce a new source of noise to markets.[8,9]

Figure 10: Macro Model Repricing Risk



As an example of how this may occur, consider a simple macro pricing model where market makers adjust stale prices for securities based upon their sensitivity to market index changes. In Figure 10, we demonstrate how this dynamic may lead to pro-cyclical price decline. If a security in the S&P 500 loses value, it implies (by arbitrage) that the value of the S&P 500 must go down. However, if other securities in the S&P 500 are priced using changes to the S&P 500 as an input, a decline in S&P 500 prices will drive down other security prices in the S&P 500. This will, in turn, drive down the value of the S&P 500 again, and the cycle continues.

In healthy market environments, we would expect other participants to step in and reprice securities. However, in distressed market environments, there may not be sufficient liquidity (or willingness) to step in and correct this behavior. This may be further exacerbated if markets are dominated by basket traders, who cannot distinguish between the price of an asset and its value.

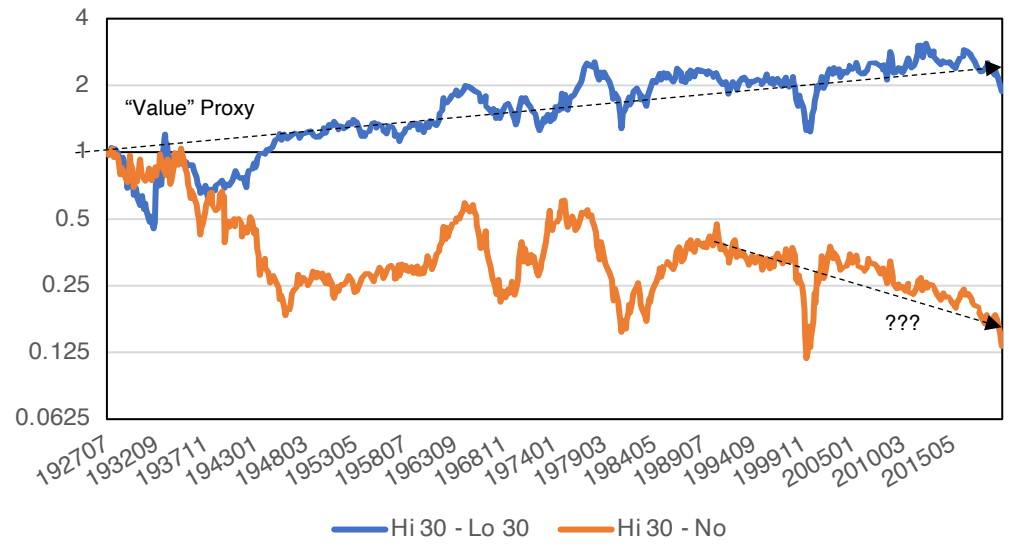
In theory, a healthy ecosystem of active managers help provide friction in orderbooks. While market makers sit at the top of the order book and facilitate flow, active managers should provide depth, with prices where they are willing buyers and sellers. If active managers play a diminishing role in markets, a significant imbalance in flow may lead to market makers rapidly re-setting price with little friction to prevent them from spiraling out of control.

If we suspected a growing role of basket trading influencing prices in markets, one place we may consider looking for evidence is at the impact of dividends. When a company pays a dividend, its float-adjusted market capitalization declines, an event market makers will be aware of and appropriately re-price. When a passive or indexed ETF reinvests the available cash on an ex-dividend float-adjusted capitalization-weighted basis, the dividend paying stock will see proportionately less flows relative to stocks that did not pay a dividend.

The important point to consider here is that dividends will create a constant stream of capital that is reinvested in an increasing fashion among low- and no-yielding stocks. Of course, there is nothing inherently superior about no- or low-yielding stocks, and their retention of capital may be entirely destructive. In an efficient market with healthy participation among active managers, we would expect to see no impact from this dividend flow. In a market where prices are dominated by basket trading, however, we would expect to see low- and no-yielding stocks out-perform higher yielding stocks over time.

In Figure 11, we plot the performance of two long/short strategies. The first goes long high yielding stocks and short low yielding stocks, which is a classic proxy for value investing. We can see that since 1927 this has been a winning, albeit volatile, trade, with the exception of recent history.

Figure 11: High Minus Low versus High Minus No



Source: Kenneth French Database. Calculations by Newfound Research. *Past performance is not an indicator of future results. Performance is backtested and hypothetical. Performance figures are gross of all fees, including, but not limited to, manager fees, transaction costs, and taxes. Performance assumes the reinvestment of all distributions.*

7. Bhattacharya, Ayan and O'Hara, Maureen, Can ETFs Increase Market Fragility? Effect of Information Linkages in ETF Markets (April 17, 2018). Available at SSRN: https://ssrn.com/abstract=2740699 or http://dx.doi.org/10.2139/ssrn.2740699 .
8. Itzhak Ben-David, Francesco Franzoni, and Rabih Moussawi, 2018. "Do ETFs Increase Volatility?," The Journal of Finance, vol 73(6), pages 2471-2535.
9. Israeli, Doron and Lee, Charles M.C. and Sridharan, Suhas A., Is There a Dark Side to Exchange Traded Funds? An Information Perspective (January 13, 2017). Review of Accounting Studies, Vol. 22, Pages 1048-1083, 2017, Available at SSRN: https://ssrn.com/abstract=2625975 or http://dx.doi.org/10.2139/ssrn.2625975

The second strategy is long high yielding stocks and short no yielding stocks. Curiously, this is a volatile loser (suggesting that that no yielding stocks *out*-perform) until the early 1990s, at which point it became far less volatile. The consistent out-performance of no-yielders and growing out-performance of low-yielders may suggest a potentially growing, distortive impact of basket pricing.

It should be noted that while the strategies in Figure 11 are naïve cross-market sorts, the effect is consistent if we perform intra-industry sorts, suggesting that this is not simply an "Amazon" or technology sector effect.

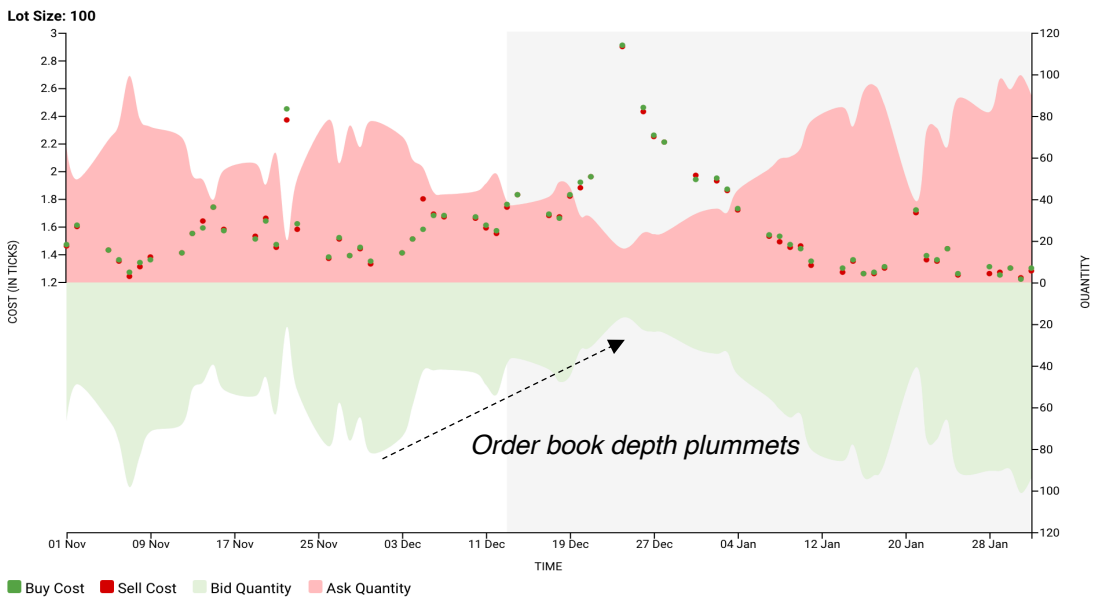
INSUFFICIENT LIQUIDITY AND CONVEX HEDGING PRESSURES

A driving feature of modern market structure is the role of electronic liquidity providers and high frequency traders ("HFT"). While supporters argue that HFT helps reduce bid/ask spreads and improve liquidity, thereby facilitating greater market efficiency through price discovery, detractors argue that HFT is unreliable and only provides "at will" (or "ghost") liquidity, contributing to further price volatility.

It is difficult to ascertain precisely the role and impact HFT has in market liquidity. History informs us, however, that in complex and nonlinear market networks, moving fast can sometimes lead to catastrophe. For example, a small programming error made by Knight Capital Group led to a $440 million loss on August 1st, 2012. Similarly, market networks can become rapidly unstable in certain conditions, as was the case during the May 6, 2010 and August 24, 2015 flash crashes. But these are largely "fat finger" events.

In defense of so-called "fickle" HFT liquidity, we should consider that these firms trade on substantial margin. Margin requirements can lead to a procyclical decline in available committed capital during tumultuous market environments. If increasing margin requirements are to blame, we might expect to see disproportionate impacts in stocks with higher HFT participation. Indeed, that is precisely what one study found: "the impacts are felt most acutely for liquid, index-constituent stocks."[10]

Figure 12: December 2018 Order Book Depth for S&P 500 Futures



Regardless of whether by design or constraint, a consistent feature of modern markets is rapidly declining liquidity depth during periods of market stress. As an example, we can examine the order book depth for S&P 500 e-mini futures contracts in December 2018 (Figure 12). We not only see a substantial thinning of the order book depth, but we can see a meaningful widening of the bid/ask spread.

Variable liquidity, in and of itself, is not inherently a problem. When substantially thinning liquidity meets high liquidity taking needs, however, there can be a catastrophic mis-match in the market. Who might need to be taking liquidity during periods of market stress? Systematic hedgers.

Here we return to the growing influence of options market over the last decade. An important feature of this market is that when an investor buys or sells an option, there is a good chance that the participant on the other side of that market is a dealer. That dealer is not looking to take a directional bet and therefore will seek to hedge their exposure.

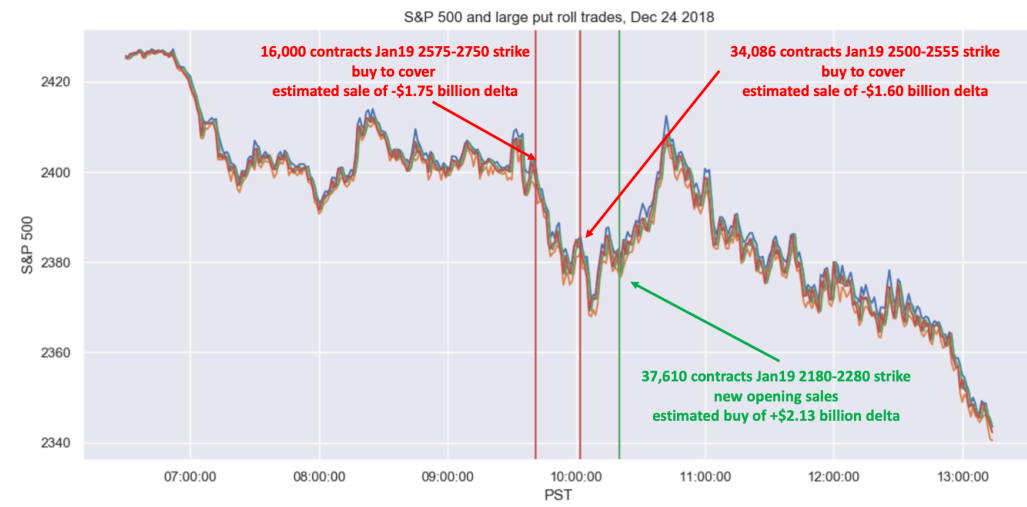
As a rule of thumb, at least at the index level, we can generally say that call options are sold by investors (e.g. as a covered call) whereas deep out-of-the-money puts are bought for protection. This means that dealers, who are on the other side, have to hedge their long call and short put positions.

In calm markets, the puts are sufficiently far out of the money and require little hedging. Instead, the dealer must actively hedge the calls they have purchased. To do so, they delta hedge their exposure, trading in the underlying index. As the index goes up, they sell exposure, and as the index goes down, they buy exposure. In this way, dealers act to stabilize markets as a convergent trade and dampen volatility.

If markets suddenly sell off, however, the calls will move far out of the money and the puts will move closer to at-the-money. This means the dealer must now hedge the put position more actively. Remember that while the dealer was long the call, they are short the put, and therefore must take the opposite hedging action: as markets go up, they buy and as markets go down, they sell. This creates a potentially destabilizing force, acting as a divergent trade and further demanding liquidity when there is none. (See Appendix A for a more detailed walk-through.)

This means that the derivative tail can wag the index dog. For example, in Figure 13 we can see the impact of large put roll trades in the S&P 500 on December 24th, 2018.

Figure 13: Put Roll Trades on December 24, 2018



Source: QVR Advisors.

10. Foley, Sean and Kwan, Amy and Philip, Richard and Ødegaard, Bernt Arne, Contagious Margin Calls: How COVID-19 Threatened Global Stock Market Liquidity (July 8, 2020). Available at SSRN: https://ssrn.com/abstract=3646431 or http://dx.doi.org/10.2139/ssrn.3646431

At approximately 12:45PM EST, a systematic put seller decided to roll their options. The two trades (buying back and re-selling) forced dealers to sell approximately $3.35 billion of S&P 500 exposure into the market, driving prices down approximately -1.5%. Shortly thereafter, they re-sold the puts at a new strike, forcing hedgers to buyback some $2.13 billion in hedging exposure. We can see that in less liquid markets, the actions of a single trader can create substantial ripple effects due to forced hedging.

These pressures can play out on a slower time-scale as well. Consider the case of Figure 14. We begin with institutions selling call options to harvest yield. These calls are bought by dealers, who hedge their exposure in a way that drives down realized volatility. The second order effect is that as realized volatility goes down, many volatility-contingent strategies (e.g. target-volatility indices, CTAs, and risk-parity strategies), will increase their leverage. Figure 15 seeks to capture this relationship, plotting the estimated notional exposure in an S&P 500 strategy that targets constant 10% volatility versus an estimate of aggregate dealer hedging pressures (negative hedging pressures imply selling as markets go up and buying as markets go down).

Furthermore, as institutions sell calls, they drive implied volatility down, requiring subsequent investors to sell more calls to achieve the same yield. Lower implied volatility and increased call selling both lead to more dealer hedging, further suppressing realized volatility. Should markets suddenly drop or volatility spike, it can lead to a massive leverage unwind.

Figure 14: Reflexive Impacts of Option Selling

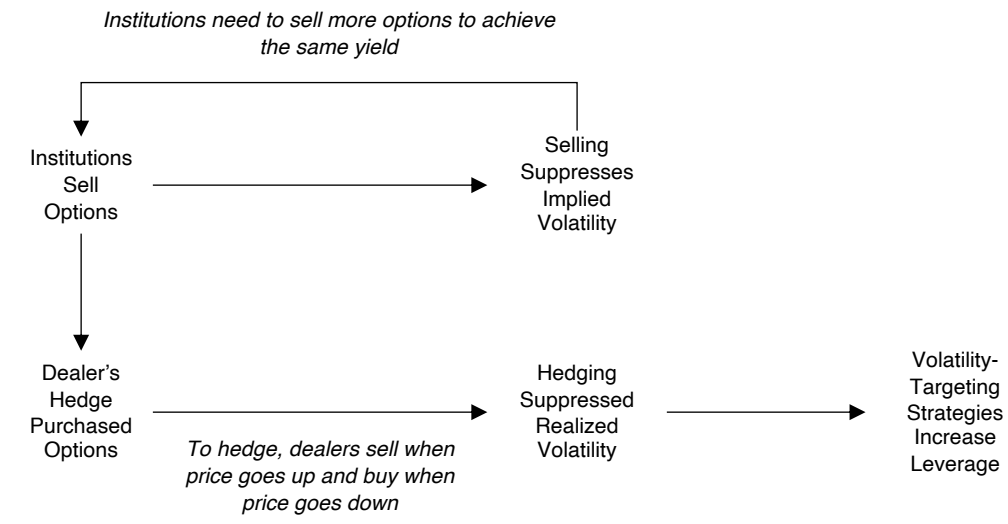
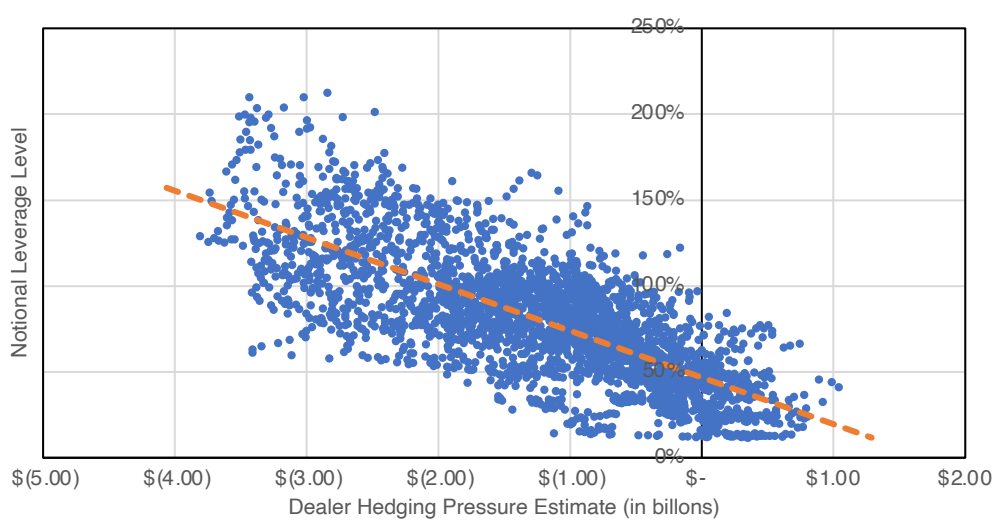


Figure 15: Approximate Notional Leverage in S&P 500 Target 10% Volatility Strategy versus Aggregate Dealer Hedging Pressure in SPX



Source: CBOE.

For a quiet year, 2017 was record breaking in many ways. Implied volatility in the S&P 500 dipped to 30% below its prior historical low and measured correlation across its components also declined to record levels as the index slowly climbed over 20%. Figure 14 provides the blueprint to explain this phenomenon.

But why was correlation among securities so low? Typically, we would think of index volatility as being a function of the volatility of the underlying components and their correlation. In other words, index volatility is low *because* correlation among its components is low. In a world driven by index-level basket trading, however, this relationship may become reversed. As dealers buy and sell index exposure, market makers will attempt to keep the index level and the underlying basket in line via arbitrage constraints. If dealer hedging has suppressed index-level volatility, but underlying components are still exhibiting idiosyncratic volatility, then the only reconciliation is a decline in correlation. This manifests via the purely mechanistic trading of market makers. Again, consider Figure 10: if the index level is pinned by dealer hedging and Google's stock price jumps due to earnings, then it must be the case that the price of other components have declined, and thus market makers price them accordingly.

The adoption of volatility selling by U.S. institutions is, by no means, the only contributor to these reflexive hedging impacts within the market. Another growing influence is the role of structured products issued in Asian and European markets. As interest rates around the globe have declined to, or below, the zero bound, generating a yield on a fixed-income style investment has become more difficult.

The answer many banks have provided are structured products that effectively sold options to generate a yield. One such structure that has grown in popularity is the autocallable. Available in a variety of flavors, the basic recipe involves the investor paying in principle to receive a fixed coupon, which is achieved by selling a deep out-of-the-money knock-in put option on an index. If the index falls below the put strike price, the investor is knocked out of the note and realizes the loss.

What happens if the knock-in strike is -30% and the underlying index falls just -25%? At maturity, the bank will still have to pay back the note holder their principal. The bank is not in the business of taking this directional risk and will therefore seek to hedge it out. For example, upon issuance the bank might turn around and sell far-dated put options on the underlying index.

From the bank's perspective, when the underlying index falls below the strike point and the investor is knocked into their loss, the associated directional risk disappears. The bank would, therefore, unwind their hedges.

The increasing issuance of these notes means that banks can find themselves in a suddenly crowded traded when markets sell-off and these knock-in barriers are breached. The banks will turn around and begin rapidly buying back the puts they sold.

Here we stop to recognize that the puts the banks have been selling and buying are, in turn, being hedged. As markets plummet, knock-in barriers are hit, and banks begin unwinding their hedge by purchasing puts, the dealers taking the other side of this trade will be hedging their risk by selling exposure in the underlying index!

As rates and implied volatility around the world have continued to fall, the notes have become increasingly complex to generate the same yield. For example, instead of being short a knock-in put on a single index, the investor may now be short a put that knocks-in when any one of a basket of indices falls below a certain level. Rather than simply being tied to the Hang Seng, the embedded put may now be tied to the Hang Seng, the Euro Stoxx 50, and the S&P 500. This creates an increasingly complicated, dynamic, and potentially frenetic hedging profile for banks.

Asian option markets are substantially less liquid than U.S. markets, however, which introduces another wrinkle to the problem. In response, some banks have looked to trade their exposure to Asian markets in exchange for exposure to the S&P 500 (with hedge funds on the other side of the trade), allowing them to hedge their risk in the more-liquid U.S. market. This also means that declines in global equity markets can now create knock-on effects in U.S. volatility markets.

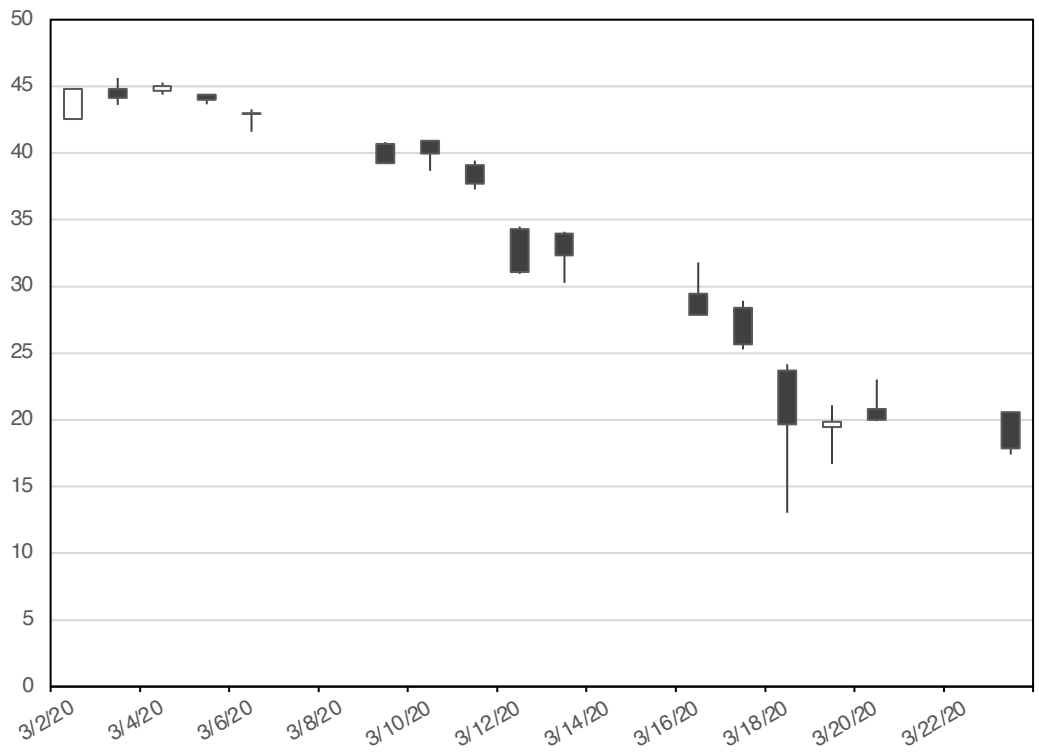
Other forced liquidity takers include levered and inverse exchange-traded products ("ETPs"). When markets go up, levered ETPs become under-levered, and therefore must buy more, whereas inverse ETPs become over-exposed and must buy-to-cover. Similarly, when markets go down, levered ETPs become over-exposed and must sell whereas inverse ETPs become under-exposed and must short further.

This hedging behavior therefore always follows the direction of the market. The dollar hedging pressures of these ETPs can be summarized with the equation: $D = AUM \times (L^2 - L) \times r\%$, where L is the leverage level and $r\%$ is the daily return.

As AUM goes up, leverage levels go up, or the magnitude of daily returns go up, the dollar pressures from hedging also go up. As markets become more volatile, these ETPs must hedge in greater magnitude in the direction of market movement, potentially further exacerbating price movement.

As an extreme example, we can consider the case of a complete liquidation of a levered ETP during an illiquid market. On March 18th, 2020, UBS announced the closure of MORL and MRRL, which both tracked the MVIS US Mortgage REIT Index with 2x leverage. The combined AUM of these products was approximately $1 billion, leading to $2 billion of selling pressure suddenly forced into the market.

Figure 16: 46% Peak-to-Trough Drawdown in mREITs on 3/18/2020

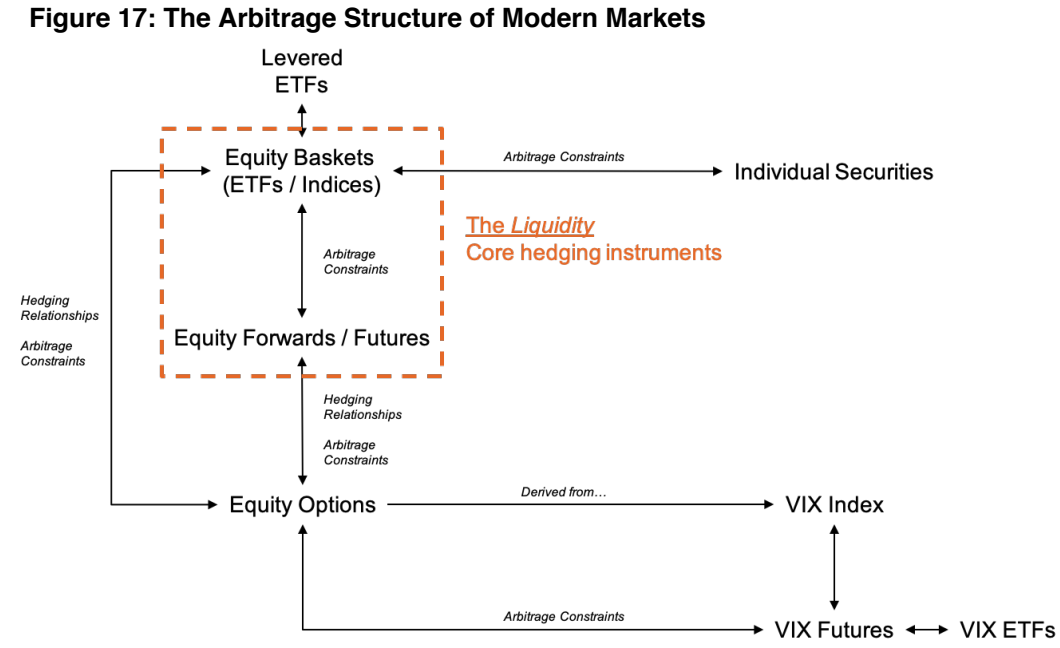


Source: Tiingo.

In Figure 16 we can see the impact of this fire sale. In an already illiquid market environment, dumping $2 billion into the market drove mortgage REITs down from a high of $24.16 to a low of $13.03, before stabilizing at $19.67 at the end of the day. While an unwind is an extreme scenario, it was not uncommon to see 10% moves in the days leading up to this point. Given the equation above, this would imply $400 million in buying or selling pressure entering the market near close every day.

In theory, what keeps the entire system in line is arbitrage. In Figure 17, we demonstrate how arbitrage is the backbone of modern markets. For example, an S&P 500 ETF price is dictated by the price of its underlying components. Similarly, futures and forwards on the S&P 500 will be kept in line by arbitrage constraints with the underlying basket. Puts and calls on the S&P 500 will further be priced by arbitrage (put-call parity) that includes the price of the S&P 500 itself. The VIX is derived from the S&P 500 option chain, creating an arbitrage constraint between VIX futures and that option chain.

Figure 17: The Arbitrage Structure of Modern Markets



We can think of the system almost like a spider's web, with different arbitrage bounds providing stability. Yet if we turn to history, we find that these arbitrage bounds have not always held. In October 1987, markets plummeted due to the program selling of portfolio insurance strategies. These strategies were designed to sell equity market futures to help buffer against losses as markets declined. However, as a crowded trade, under the right conditions it could spiral out of control, creating relentless selling pressure. But if the price was wrong, why did nobody step in to correct it?

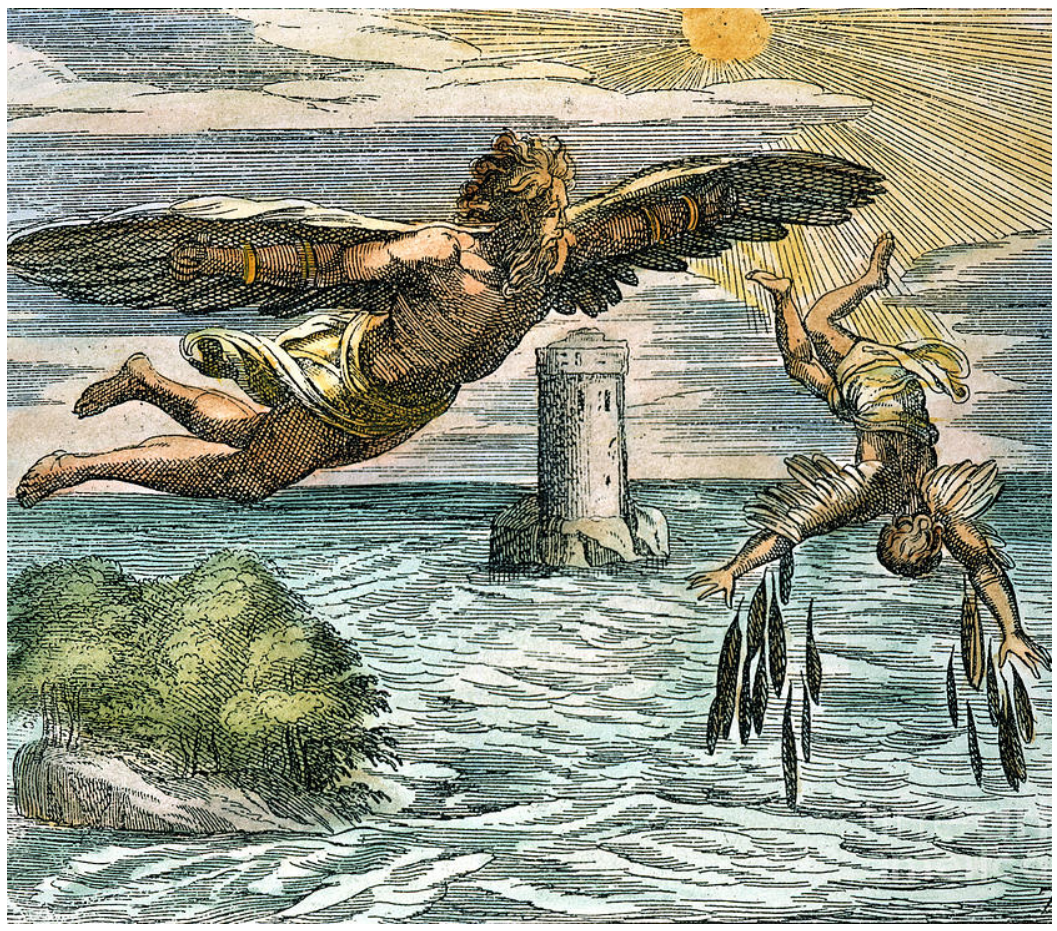
Arbitrage theory generally assumes perfect information and frictionless markets, neither of which are the case in reality. In 1987 in particular, there was fundamental uncertainty about what "true value" was. It was difficult to ascertain in real time, for example, how much selling was actually related to portfolio insurance and how much was from other market participants. Those providing liquidity – such as futures contract buyers – did so with a wide margin of safety and tried to hedge their positions by selling underlying stock, further exacerbating the sell-off.

Note above that the S&P 500 is the keystone of the entire hedging complex. Functional liquidity in the S&P 500 ultimately makes or breaks markets.

For example, while many consider the VIX to be a measure of market volatility, it is arguably also a measure of market liquidity. This can be seen when we consider what happens in markets when we buy an option. If we buy a put option, the dealer is going to try to hedge that put option. In thin market environments, the cost of hedging (both explicitly and implicitly from uncertainty) will go up. Therefore, the dealer will demand a higher price. As option prices and implied volatility are intrinsically connected, a higher price implies a higher implied volatility. As the VIX is calculated using the implied volatilities of the S&P 500 option chain, we can see that liquidity of the S&P 500 itself will ultimately impact the level of the VIX. That is not to say that fundamental uncertainty does not impact option prices (look no further than implied volatility surrounding the 2020 election), but a lack of liquidity can rapidly drive the VIX higher.

The key consideration is that hedging – particularly derivative hedging – is often a convex function and in many cases will demand increasing liquidity as markets decline (e.g. see Appendix A). Contrast this with the supply curve of liquidity, which is concave with respect to market stress. Taken together, they paint a picture where the growing scope of the derivatives market, and its associated leverage, manifests explosive liquidity demand in tail events, further exacerbating market stress.

ICARIAN TRADES



[W]hen the boy began to rejoice in his bold flight and deserted his leader, and attracted by a desire for the sky he took his path [went] higher. The vicinity of the sun softens the fragrant wax, the chains of the feathers; the wax melted: he shook his bare arms and lacking oarage he takes up no air, and his mouth shouting his father's name is swept up in the blue sea, which takes its name from him.

Let us return to Figure 1: The Market Incentive Loop. We begin with the impact of Fed policy, driving investors up the risk curve both by necessity and confidence. In stressed market environments, this potentially creates non-linear response functions, as investors seek to de-lever and de-risk their over-risked portfolios.

In the second part of the Loop, we ask, "how are investment decisions impacting markets?" We find that the increasing role of passive and indexed investing may be creating distortions at both a macro and micro level. At the macro level, both benchmarking and a flight-to-passive may lead to cross-sectional momentum effects in security pricing. This may potentially lead to significant cross-sectional and market-level volatility, as crowds pile into a divergent trade.

At the micro level, increasing flows into passive and indexed exposures leads to an increasing role for basket trading. Evidence suggests that basket trading potentially introduces new sources of noise to the market and can lead to both temporary and permanent price distortions due to "information leakage" across securities. As mentioned prior, it may be fair to say that basket traders know the price of everything but the value of nothing.

Many of these basket traders are electronic liquidity providers and high frequency traders. In complex, nonlinear environments, moving fast may lead to a risk of procyclical spirals, especially as markets become more and more concentrated among a few larger trading firms. While it has been argued that HFT liquidity is fickle, it is possible that it is simply constrained, relying on leverage to provide liquidity and therefore having to reduce capital committed due to risk budget constraints in volatile markets.

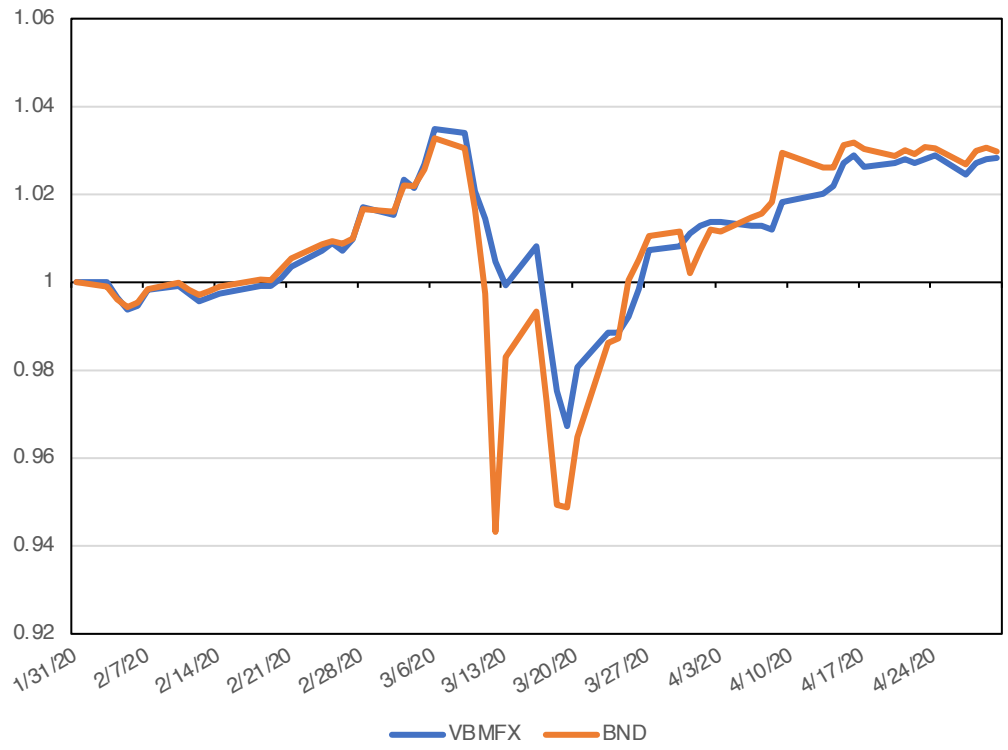
Regardless of cause, a feature of current markets is a dramatic mismatch in liquidity needed versus liquidity available during periods of market stress. This leads to a structural imbalance when it is met with the systematic, and often convex, hedging pressures of options markets, levered and inverse ETPs, and more. These imbalances can lead to liquidity cascades, as the hedgers are liquidity *takers* during periods of liquidity stress.

When the Fed steps in to fix this liquidity stress, the cycle begins anew.

If we have faith in this narrative, there are a number of structural tilts and cyclical trades we might consider.

For example, we may be able to exploit liquidity mis-matches in the fixed income market by purchasing a fixed-income mutual fund and then jumping into an equivalent ETF during periods of significant price dispersion. In March 2020, as seen in Figure 18, we saw the Vanguard Total Bond Market ETF trade over 6% below the equivalent mutual fund, despite reflecting identical underlying! Similar trades were possible in municipal bonds and both investment-grade and high-yield credit. For speculators willing to take some basis risk, the return spread between the Vanguard Intermediate-Term Tax Exempt Bond Fund (VWITX) and the VanEck Vectors AMT-Free Intermediate Municipal Index ETF (ITM) peaked at over 15% over the same period.

Figure 18: March 2020 Performance Dispersion Between Vanguard Total Bond Market Mutual Fund and ETF



Source: Tiingo. Calculations by Newfound Research.

Structurally, we might consider tilting into momentum, mega-cap, and non-dividend-paying securities, depending upon our conviction in each trade. Doing so may front-run prevailing market trends but does lean heavily into divergent trade structures and may subject an investor to substantial cross-sectional (i.e. tracking error) and absolute volatility.

Conversely, rather than front-running an equity sea change, we can consider taking the other side of an already crowded trade. For example, if we believe that institutions will continue to be structural sellers of short-dated options (which is highly likely, as this crowd of investors tends to move quite slowly due to their consultant and committee structure and are performance insensitive in the short term), buying those options may provide us with convexity (to both the up- and down-sides) at much cheaper premiums than historically available.

And if we believe that the Fed is permanently entrenched as a player within markets, for investors with a long-enough time horizon, the simplest trade may simply be to apply leverage to their portfolio. While they should expect a substantial increase in short-term volatility, the stabilizing effects of the Fed will allow them to adopt this leverage with little risk.

We have illustrated, however, that these new forces will lead to bouts of volatility suppression and explosion, as market participants and hedgers migrate from convergent to divergent trades in increasingly illiquid markets. Exploiting these trades to the fullest may find us playing Icarus, soaring higher and higher in our risk profile. And should the Fed (or regulators at large) prove unable to fix liquidity dynamics, support may melt and we may find ourselves plunging into the waves below.

THE PATH OF DAEDALUS

While many know the story of Icarus as one of warning, few recall the advice given to Icarus by his father Daedalus:

> *I warn you to travel in the middle course, Icarus, so that the waves may not weigh down your wings if you go too low, and so that the sun will not scorch your wings if you go too high.*

Like Daedalus, we would argue for the middle course. In this case, the middle course is an explicit recognition that while liquidity cascades may be an increasing risk of modern markets, other fundamental risks have not necessarily subsided. For example, in Figure 19 we outline historical market crises and try to map them to their relative speed as well as the degree to which they were exogenous or endogenous market shocks. Those strategies appropriate for an endogenous liquidity event may not be appropriate for an exogenous economic event.

We would suggest that a sustainable investment plan should provide balance in its risk-management across varying economic regimes and market shocks. In the case of an equity-centric portfolio, we would suggest that this balance should focus upon both the axes of exogenous versus endogenous market shocks and the speed of the event. Those strategies and tactics which may be effective for a sudden, liquidity-driven sell-off may be ineffectual in a slow-burning, recessionary drawdown.

Protection in and of itself is not sufficient, however. After all, we could simply move our portfolio entirely to short-term TIPs if all we cared about was capital preservation. Rather, to exploit these trends, we believe we must look for so-called “positive carry, anti-carry trades”: those trades with positive expectancy in normal environments that also potentially provide a convex hedge in times of stress.

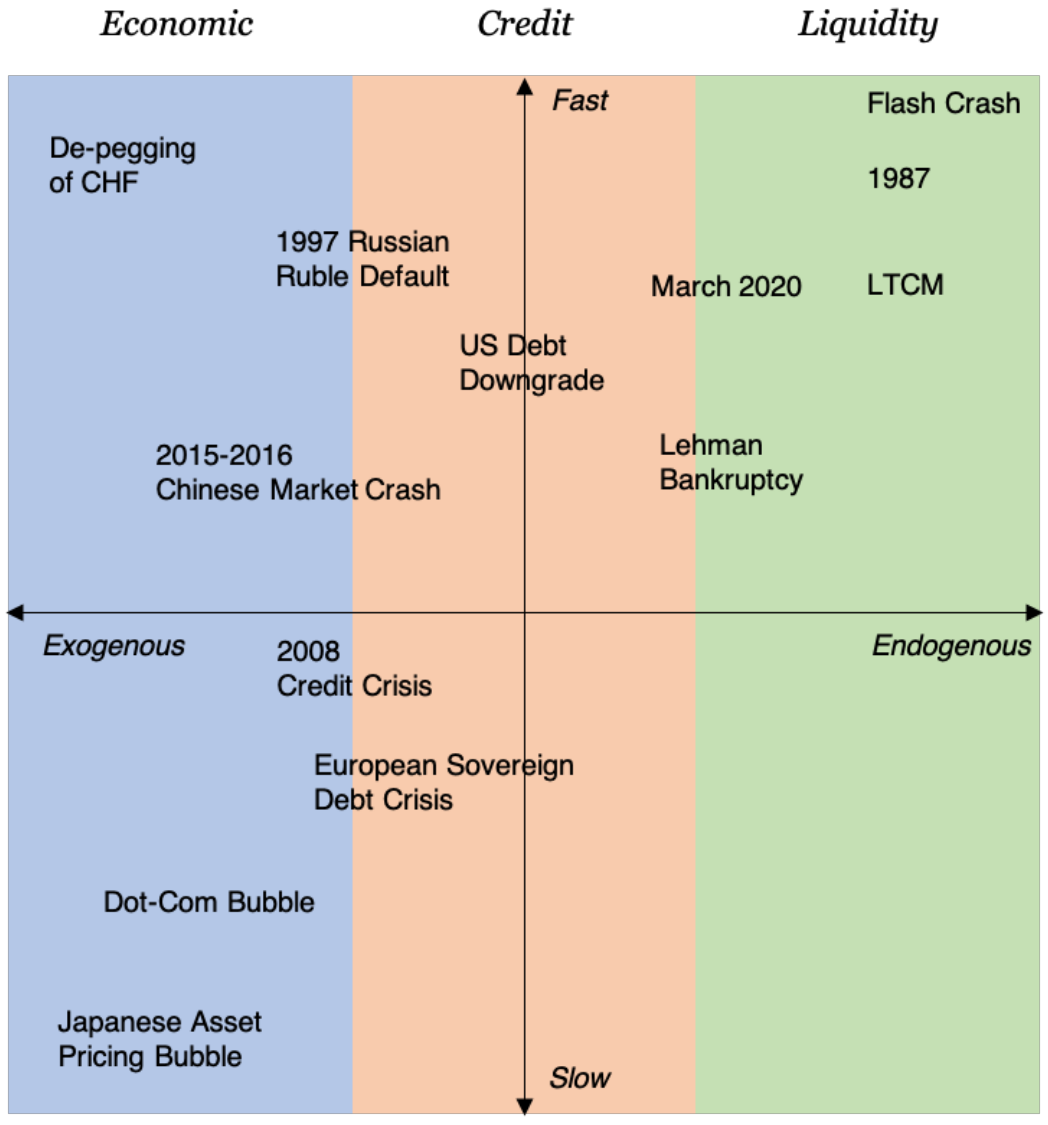
For example, given the current Market Incentive Loop, we might consider[11]:

- A long position in momentum and mega-cap equities paired with a deep out-of-the-money equity index put.
- Long strong balance sheet stocks and short parent equity index (potentially especially effective in small-caps which are particularly susceptible to credit risk).
- Long equities with treasury future overlay paired with defensive trend following.
- Active volatility strategies that seek to exploit mispricing created by structural volatility sellers.

The balance of *positive carry, anti-carry* trades allows us to potentially exploit current market dynamics without leaving us naked to the risk of an unwind of these forces.

Further, a diversified portfolio of risk aversion hedges (e.g. long equity puts or calls on VIX futures), directional hedges (e.g. trend following), and proxy hedges (e.g. equity quality, equity low volatility, or U.S. Treasury futures) allows us to address the inherent trade-offs that exist in risk management. A mantra repeated here at Newfound is that “risk cannot be destroyed, only transformed.” We find that not only do

Figure 19: Exogenous and Endogenous Market Events



different techniques apply in different market environments, but they do so with different degrees, reliabilities, and costs (Figure 20). At-the-money put options, for example, may have a high degree of protection and strong reliability in that protection, but may be prohibitively costly. Trend following, on the other hand, may be able to reduce that cost, but comes with lower reliability and will not kick in during the initial throes of a market decline.

On the next page we provide a hypothetical example of how we might build a portfolio that maintains greater diversification across hedge strategies while proactively acknowledging the new market regime dynamics laid out within this piece. Specifically, we consider the different return regimes of equity markets and the strategies that may be most effective in each. (See Appendix B for hypothetical and backtested performance.)

We broadly categorize three regimes: prolonged declines, rapid melt-downs, and melt-ups. Without a particular view as to which of these regimes we are most likely to see going forward, we would aim to diversify our portfolio exposure evenly across strategies designed for each.

For prolonged drawdowns, we might adopt an ensemble trend-following approach. Such an approach may be effective against slow-burning contagions, accounting for the fractal nature of both economies and markets and may be better suited for the "second leg down." For rapid melt-downs, we might couple long-only exposure to strong balance sheet companies with a ladder of out-of-the-money put options[11]. For melt-ups, we could pair momentum equity with out-of-the-money call options. Finally, we can wrap the entire portfolio in a tactical U.S. Treasury futures strategy designed to offer diversification, carry, and potential flight-to-safety benefits.

The Daedalean portfolio hypothesized above strives to find a static balance of positive carry, anti-carry trades and strategies across the three identified regimes. But it is by no means the only way such a portfolio might be constructed. Indeed, a static approach potentially ignores important sources of information edge, particularly in light of the highly procyclical Market Incentive Loop.

For example, as we explored in our commentary *Heads I Win, Tails I Hedge*, volatility and liquidity signals can serve as important inputs to constructing an active volatility strategy. By measuring these inputs, we can potentially help reduce the constant cost of equity put protection, instead pressing our bets when signals indicate heightened risk aversion and liquidity concerns.

Figure 20: The Hedge Tradeoff

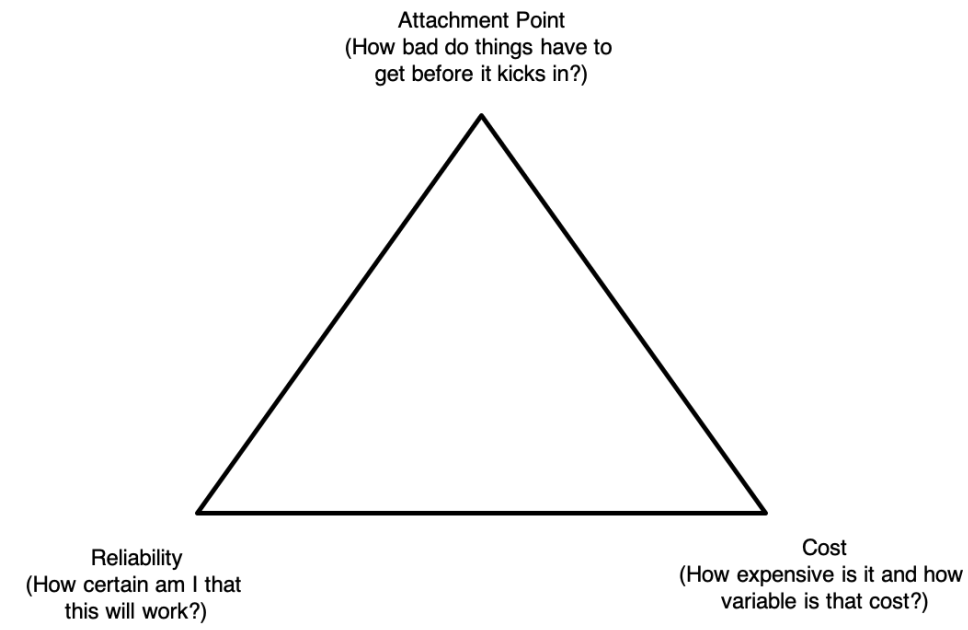


Figure 21: Hedge Classifications

Proxy Hedges

Strategies without explicit defensive mechanism.

- Defensive equity
- Commodity and FX Trend

Rates Duration

Strategies exhibiting bond-like behavior.

- U.S. Treasury futures
- Rates trend

Directional Hedging

Strategies that are designed to do well during prolonged directional changes.

- Trend following
- Put replication
- Equity replacement

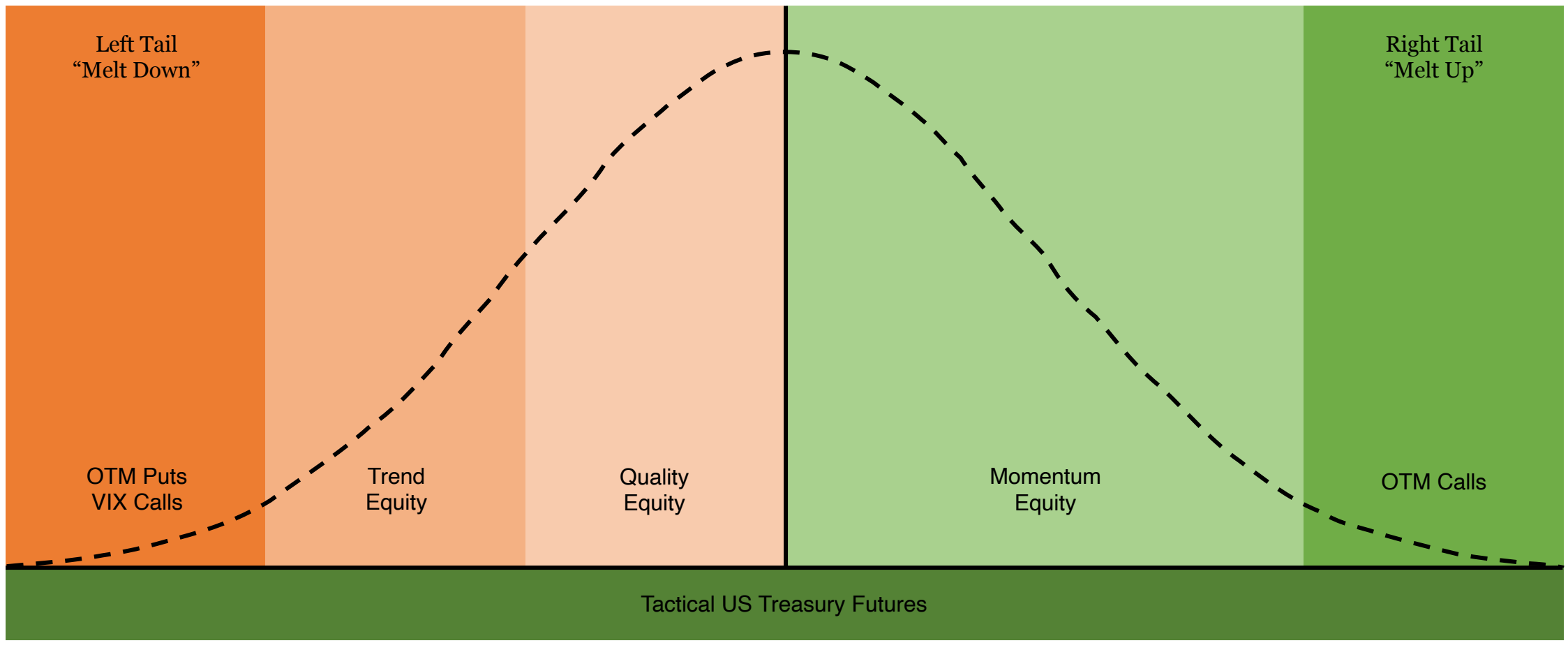
Risk Aversion Hedging

Hedges that have high correlation to fast and sharp sell-offs and increases in market risk aversion.

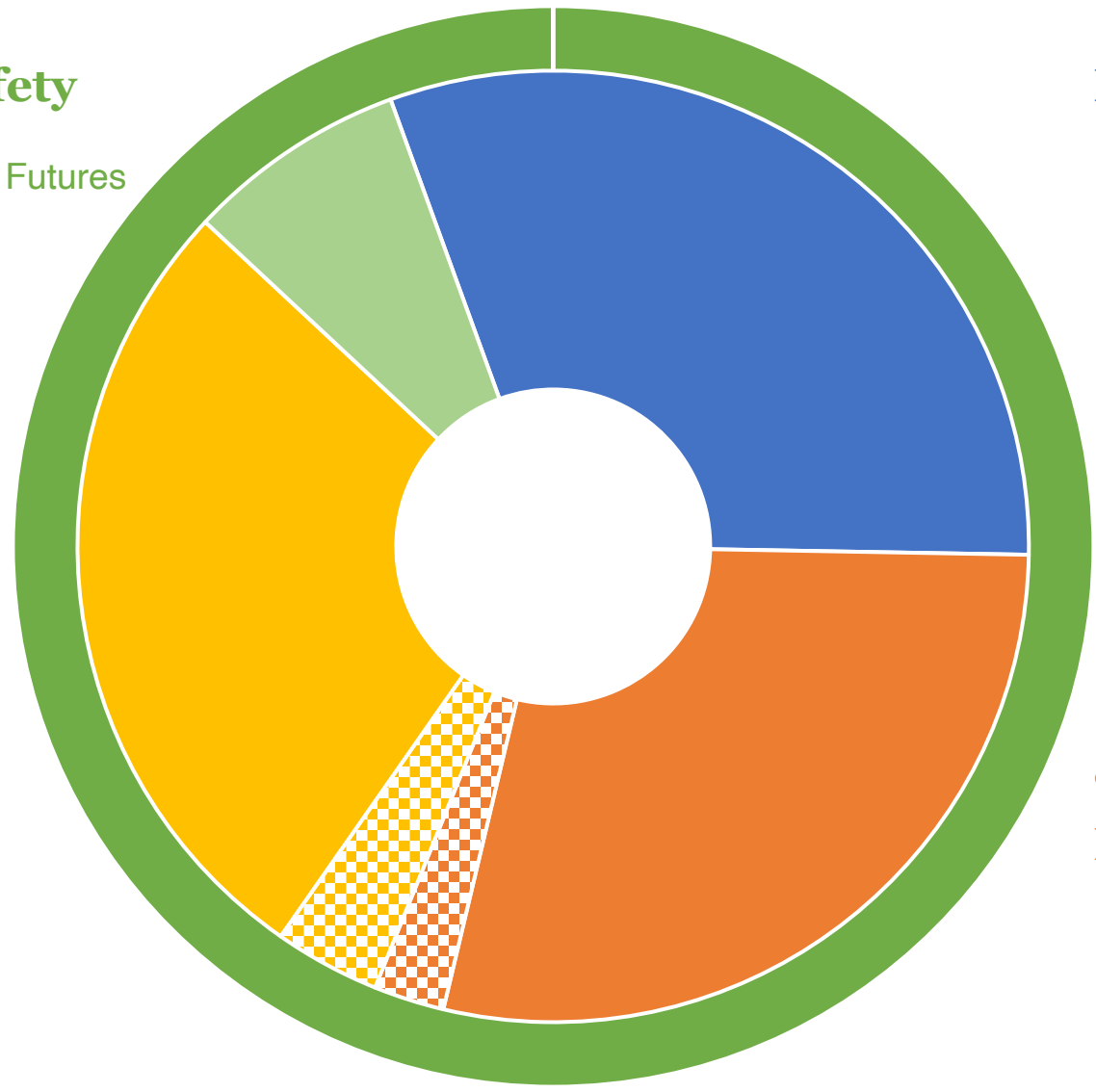
- Long equity put
- Call on VIX

11. In reality, this may be prohibitively expensive (especially in popular tenors). For those with the ability, delta-hedging the options may help offset some of the negative performance drag and vega-weighting may create greater consistency in outcomes than a target notional spend.

EQUITY MARKET RETURN REGIME AND CORRESPONDING STRATEGIES



HYPOTHETICAL DAEDALEAN PORTFOLIO



Carry + Flight-to-Safety
- Collateral
- Tactical US Treasury Futures

Prolonged Decline
- Trend Equity
- Equity Replacement

"Melt Up" Dynamics
- Momentum Equity
- OTM Call Options

"Melt Down" Dynamics
- Quality Equity
- OTM Put Options

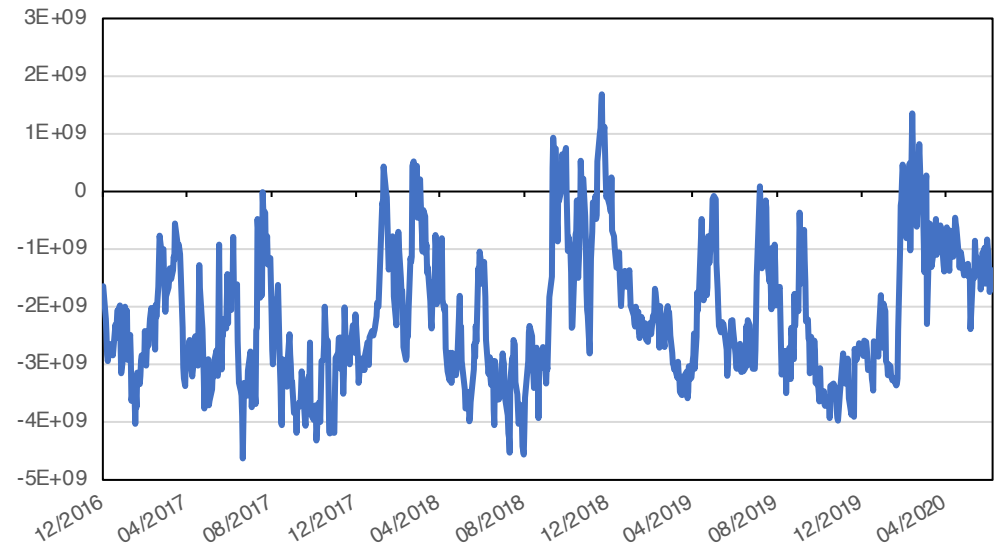
Furthermore, given our perspective that hedging-based liquidity demands are driving liquidity cascades, these approaches may potentially be enhanced through the explicit modeling of dealer and structural hedger positions. Figure 22, for example, seeks to model aggregate dealer hedging flows for every $1 change in the S&P 500. We can see that these hedging pressures are predominately negative, leading to suppressed volatility environments. In some environments – such as Q4 2018 and March 2020 – we can see that they shift significantly positive, leading hedgers to become liquidity takers. This can be combined with measures of CTA positioning and net levered ETP exposure to gain a better picture of liquidity needs.

While Figure 22 models these hedging pressures given point-in-time S&P 500 levels, there is no reason that they cannot be used for forecast hedging needs at different S&P 500 levels, helping allocators identify potential "hotspots" of liquidity slippage where hedgers tilt from aggregate liquidity providers to liquidity takers.

Similarly, we can look towards vehicle return differences as a potential identifier of liquidity mismatches. In Figure 23 we plot the absolute daily return difference between the Vanguard 500 Index Fund and the Vanguard S&P 500 ETF. We would expect arbitrage to keep these returns within tight bounds; however we can see that in late February 2020 daily returns began to deviate meaningfully, potentially indicating liquidity stress.

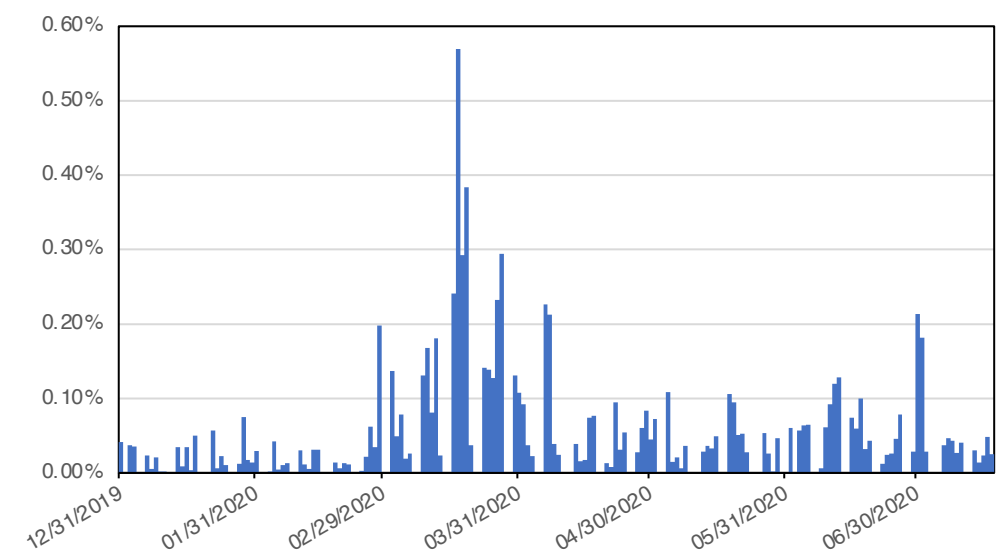
Such signals are not explicitly incorporated in the Daedalean portfolio above, but we believe can potentially enhance the construction of any strategy seeking to exploit the current market incentive structure.

Figure 22: Forecasted Option Dealer Hedging Pressure / $1 Change in SPX



Source: CBOE. Calculations by Newfound Research.

Figure 23: Absolute Daily Return Difference between Vanguard 500 Index Fund (VFINX) and Vanguard S&P 500 ETF (VOO)



Source: Tiingo. Calculations by Newfound Research.

PORTENTS OF AN UNWIND

If we accept the current market incentive structure, a natural question becomes, "what breaks the chain?" Or, if nothing breaks the chain, what is the end game? Aspects of the former are far easier to speculate on than the latter.

For example, regulatory changes with respect to market maker participation could result in structurally enhanced liquidity provision during periods of market stress, tempering cascades. Absent of these positive obligations, large market makers are likely to pull liquidity during margin call events.

Of course, regulations may do little if high frequency traders are capital-constrained during these periods. Consider that Virtu Financial – a large, listed, global liquidity supplier – announced on March 20th, 2020 that they were raising $450 million USD to "augment [their] liquidity provisioning services globally." If regulators were to make "crisis capital" available to large liquidity providers during periods of stress (as they have done with the banking sector in the past), it may significantly alleviate liquidity cascade risks.

Liquidity cascade risks may also subside on their own if large hedging pressures are reduced. For example, were we to witness a significant unwind of volatility selling programs in markets (e.g. covered call strategies), we would likely see a reduction in bi-modal volatility. This may be measurable by tracking open interest over time, and more specifically in the zero-to-two month tenors.

How regulators might step in if they determine that a rise of passive and/or indexing is destabilizing markets is a more difficult question to answer. If the concentration of assets among a few players (e.g. BlackRock, Vanguard and State Street) represents a systemic risk, we could see potential spin-outs, though we do not believe this addresses the core issues discussed herein. One potential answer is more stringent liquidity testing, particularly if coupled with position size or diversification limits. This could implicitly acknowledge the concern that "free-float" market capitalization is not really "free float" when it is in the hands of passive players. Other ideas may include changing tax incentives for active versus passive players. Finally, a restriction of passive and indexed vehicles within retirement plans may help curb the marginal flow of assets.

The biggest problem, however, lies in developing a test to identify active versus passive. While active mutual funds versus indexed ETFs may represent a clear delineation, it ignores closet index funds, passive and index-linked separately managed accounts, and the growing interest in "direct indexing." These are non-trivial hurdles that we believe will make it very difficult for regulators to intervene.

At the extremes of passive investing saturation, we might expect meaningful, and even permanent, price distortions in individual securities, making it difficult for active investors to profit from traditional price convergence. However, in these cases, opportunities may exist for patient investors who can profit either from significantly enhanced yields (either dividend or buyback) or mergers and acquisition activity.

Another key component of the Loop is the role of monetary policy, where we must ask, "at what frequency does unprecedented monetary policy stop being unprecedented," and "is there a limit to the Fed's balance sheet?" In the last two crises (2008 and March 2020), we witnessed semi-coordinated monetary (and fiscal) policy actions taken around the globe. Would the effectiveness of unconventional monetary policies be diminished in the case of a U.S.-only crisis?

Fortunately, at least from the perspective of U.S. investors, increased globalization as well as the status of the U.S. dollar as the premier reserve currency makes such a case more difficult. For the time being, economies and markets are inextricably linked, and so it likely holds that U.S. monetary and macroprudential policy is really the world's monetary and macroprudential policy. Arguably, this gives U.S. policy makers significant leeway. Increasingly nationalist economic policies, the waning influence of oil, and a reduction of U.S. military presence around the globe, however, may all serve as contributors to dethroning the eminence of the U.S. dollar.

What happens when the world no longer bends to U.S. monetary policy but breaks? Contemplating this end game is much more difficult. After all, assessing risk in a nonlinear environment is difficult, particularly when that nonlinearity appears outside of known confidence intervals. De-stabilized markets, an economic recession, de-valuation of the U.S. dollar, and significant inflationary pressures all immediately jump to mind as possibilities but are by no means a comprehensive enumeration.

THE BALANCE OF OPPOSITES

The Market Incentive Loop that accelerated with experimental monetary policy in 2008 came full circle in March 2020, and the Federal Reserve did not blink. Implementing unconventional monetary policy at unprecedented speed allowed for the rapid stabilization of markets, but also served to reinforce the Loop itself. A Loop that we believe can lead to a widening gyre of melt-up and melt-down dynamics.

Markets are inherently reflexive structures. If quantitative easing incentivizes an increase in corporate debt issuance (due both to lower borrowing rates and increasing investor confidence), do both securities and the economy at large become increasingly sensitive to central bank policy?

We are reminded of the *cobra effect:*

> *"The British government was concerned about the number of venomous cobras in Delhi. The government therefore offered a bounty for every dead cobra. Initially this was a successful strategy as large numbers of snakes were killed for the reward. Eventually, however, enterprising people began to breed cobras for the income. When the government became aware of this, the reward program was scrapped, causing the cobra breeders to set the worthless snakes free; the wild cobra population further increased."*[12]

Investors looking to develop a multi-decade, set-and-forget portfolio can likely look past the Loop and instead focus on developing a balance of exposures diversified across economic regimes (e.g. positive and negative economic and growth shocks). It may be prudent to also complement this portfolio with hedges that can offer convex payoffs to those extreme tail risks the investor is most sensitive to (e.g. U.S. monetary debasement for U.S. investors).

For investors without the luxury of time, the Loop may dominate their reality. Liquidity is the keystone and we believe that managing risk through the Loop requires finding balance in opposites: positive carry, anti-carry trades. The duality of this structure pairs offense with defense, seeking enhanced returns to help offset the cost of convex hedges that may allow investors to become liquidity providers during periods of market stress.

Investors focused solely upon the rapid impacts of liquidity cascades will be blind to the risks of slow-burning, exogenous economic events. A true balance of opposites, therefore, requires not only matching offense with a convex defense, but striking balance in risk management across the many potential endogenous and exogenous market events that lead to truly disruptive losses.

We believe successful investing internalizes our core philosophy that *risk cannot be destroyed, only transformed*. While the expectation of return requires bearing some risk, through a balance of positive carry, anti-carry trades we believe we can aim to navigate the current Market Incentive Loop with greater stability.

12. https://en.wikipedia.org/wiki/Cobra_effect

APPENDIX A: Options and Dealer Hedging Pressures

Consider the following example: an institution sells an out-of-the-money call option on an equity index (e.g. the S&P 500) to try to generate yield. The index is trading at $100 and the option is struck at $105. The option is set to expire 2 months from now and currently has an implied volatility of 20%. For simplicity, we'll presume prevailing interest rates are 0%.

On the other side of this trade is an options dealer, who is now long this call option. The goal of the dealer is not to make a directional bet, but to profit from making markets and capturing the bid/ask spread. Therefore, once long this call option, the dealer will want to hedge their exposure to changes in the option's value. A primary driver of the **option's value** is the current level of the underlying index: as the index goes down in value, the option is worth less, and as the index goes up, the option is worth more.

The sensitivity the option value has to changes in the underlying index level is measured by the option greek **delta**, which we can think of being somewhat akin to a stock's beta. When the option has high delta, its value will be very sensitive to underlying changes in the index level, and when delta is very low, it will be insensitive. We can see, below, that when the index price is far below the strike (i.e. the option is very out-of-the-money), delta approaches zero and when the index level is far above the strike (i.e. the option is very in-the-money), the delta approaches 1.

In the world of Black-Scholes option pricing, delta tells us the number of *shares* of the underlying index we would need to own to replicate the payoff of the option. As the option moves further in-the-money, we need to buy more shares; as the option moves further out-of-the-money, we need to reduce the number of shares.

In order to hedge this sensitivity, the dealer will need to *short* an equivalent number of shares of the index. The key point here is that the dealer's hedge is not static: it is dynamic. As the index goes up, the option's delta goes up, and the dealer needs to short more shares. As the index goes down, the option's delta goes down, and the dealer needs to short less (and therefore buys to cover).

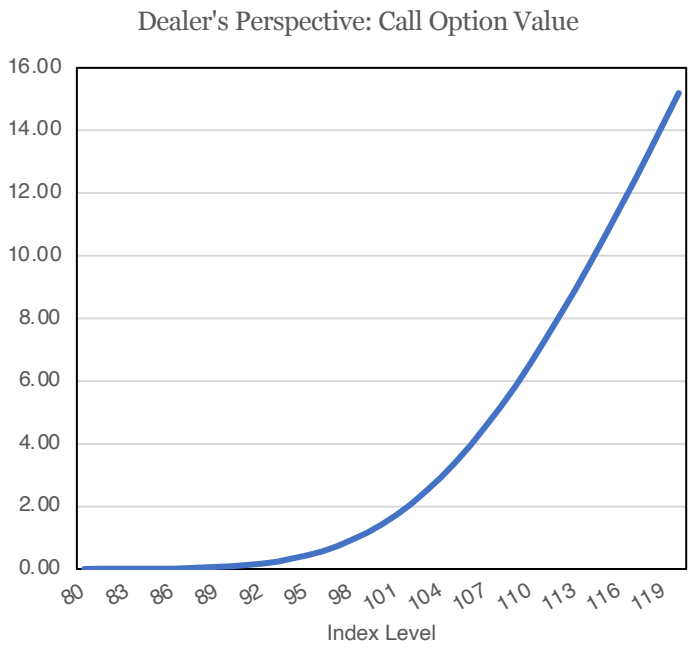
We can see that delta is not a linear function, and its own rate of change is measured by **gamma**. If delta represents the number of shares needed, gamma represents the increase (decrease) in those shares for a $1 increase (decrease) in the index level. When gamma is high, it means dealers will be actively updating their hedges as the underlying index changes value. When gamma is low, it means hedges need not change much.

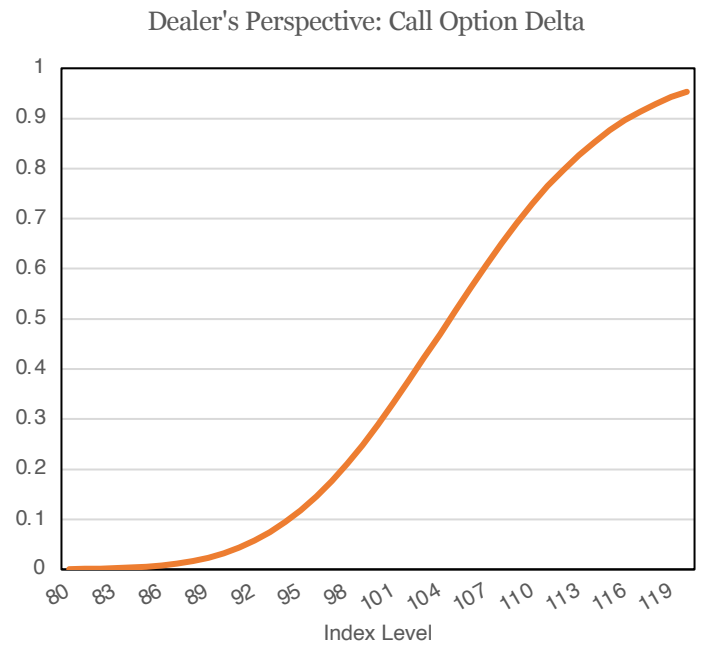
In the graph below, we can see that at an index level of $100, the option's gamma is approximately 0.04. This means for a $1 increase (decrease) in index level, the option's delta will increase (decrease) by 0.04 shares. Dealers who are trying to hedge will therefore have to short an extra 0.04 shares as the index level goes up and buy back 0.04 shares as the index level goes down. By multiplying this share change by share value, we can get an estimate of actual dollar buying/selling pressure that will be initiated by dealers (0.04 x $100 = $4).

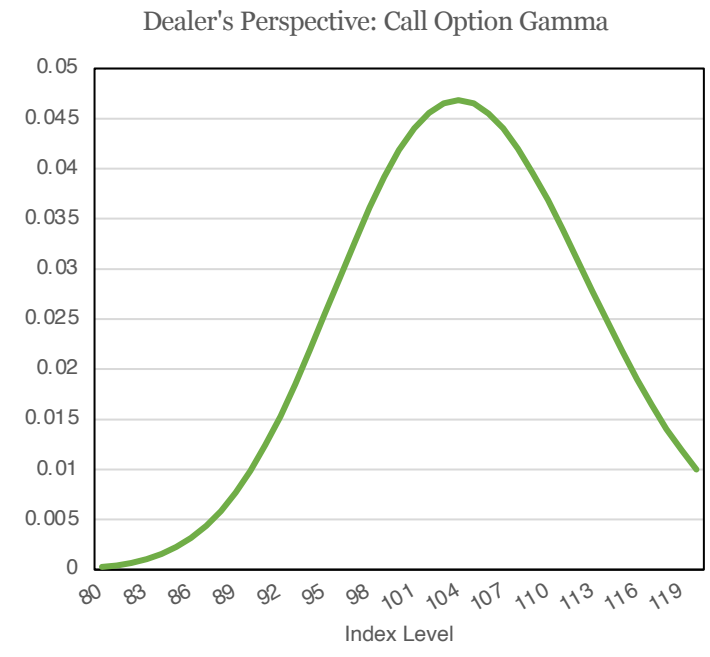
Note that as the index level falls, both gamma and delta go towards zero. The calls are simply too far out-of-the-money for their value to change much, and so dealer hedging activity diminishes.

At the aggregate level, we have ignored the presence of put options, which are generally purchased by investors and therefore *sold* by dealers. As the index level drops towards the strike of the puts, their delta begins to pick up. However, because the dealer is now *short* the put (whereas they were long the call), they must take the exact opposite hedging action: holding a net short position in the underlying index, shorting more shares as the index goes down, and buying shares back as the index goes up.

By estimating overall dealer positioning, we can gain insight into their expected hedging pressures as markets change.







APPENDIX B – Annual Returns

	S&P 500	Trend Equity	Momentum Equity	OTM SPX Calls	Quality Equity	OTM SPX Puts	Tactical UST Futures	Daedalus Portfolio
2006	15.91%	14.77%	10.58%	2.48%	10.93%	-1.53%	-0.89%	10.60%
2007	5.08%	4.12%	17.63%	-1.21%	6.56%	-0.52%	4.95%	11.29%
2008	-36.81%	-4.48%	-40.98%	-5.03%	-28.14%	4.63%	12.48%	-8.62%
2009	26.37%	16.49%	17.46%	3.27%	26.19%	-2.29%	-2.93%	15.23%
2010	15.06%	11.52%	18.03%	-0.03%	17.30%	-1.50%	7.47%	19.33%
2011	1.89%	-6.66%	5.93%	-1.79%	10.97%	-0.66%	10.50%	10.67%
2012	15.99%	10.85%	14.92%	-1.09%	13.49%	-1.72%	2.19%	10.64%
2013	32.31%	33.45%	34.39%	11.28%	33.10%	-2.98%	-2.97%	34.44%
2014	13.46%	11.41%	14.61%	2.93%	15.92%	-1.76%	4.97%	18.15%
2015	1.25%	-4.40%	8.93%	-3.83%	6.68%	-0.97%	1.18%	-0.62%
2016	12.00%	6.09%	5.00%	1.11%	7.35%	-1.47%	1.13%	6.07%
2017	21.70%	21.21%	37.50%	8.02%	25.87%	-2.55%	0.16%	29.88%
2018	-4.56%	-0.96%	-1.66%	-0.35%	0.83%	0.31%	-0.33%	-0.91%
2019	31.22%	16.42%	26.29%	7.87%	33.97%	-2.48%	3.33%	30.51%
2020*	9.68%	-9.32%	23.11%	8.95%	21.88%	4.29%	4.16%	27.06%
Ann. Return	9.75%	7.74%	11.63%	2.17%	13.13%	-0.81%	3.09%	13.68%
Ann. Volatility	16.96%	10.92%	18.27%	4.89%	15.23%	2.28%	4.53%	11.97%
Worst Year	-36.81%	-9.32%	-40.98%	-5.03%	-28.00%	-2.98%	-2.97%	-8.62%

* Through 8/31/2020

Source: Sharadar, Stevens Analytics, CBOE, Tiingo, MSCI. Calculations by Newfound Research. *Past performance is not an indicator of future results. Performance is backtested and hypothetical. Performance figures are gross of all fees, including, but not limited to, manager fees, transaction costs, and taxes. Performance assumes the reinvestment of all distributions. Returns from 6/17/2005 to 8/31/2020 based upon data availability.*

S&P 500 is the SSgA S&P 500 ETF ("SPY").

Trend Equity is the Newfound U.S. Trend Equity Index (a strategy which allocates between a total U.S. equity market ETF and short-term U.S. Treasuries based upon an ensemble of trend signals).

Momentum Equity is the MSCI USA Momentum Index.

Quality Equity begins with a parent universe of the top 1000 U.S. equities ranked by market capitalization. Stocks are then ranked by Merton's distance-to-default metric. The top 250 securities are purchased and held in equal weight. The portfolio is rebalanced quarterly utilizing a staggered rebalance methodology with three overlapping monthly implementations.

Tactical UST Futures is tactical strategy applied to continuously adjusted front-month futures contract for 10-year U.S. Treasuries ("TY"), rolled when open interest in the second contract exceeds the first. Strategy signals rely upon an ensemble of trend, valuation, and carry signals. Further details available upon request.

OTM SPX Puts buys a 6-month 25-Delta put option on the S&P 500 index ("SPX") and holds it until it is 2 months from expiration, at which point it is sold. The strategy seeks to spend 30 basis points of NAV per month and holds a ladder of 4 positions.

OTM SPX Calls buys a 12-month 20-Delta call option on the S&P 500 index ("SPX") and holds it until it is 6 months from expiration, at which point it is sold. The strategy seeks to spend 20 basis points of NAV per month and holds a ladder of 6 positions.

The Daedalus Portfolio is 30.83% Trend Equity, 28.43% Momentum Equity, 2.4% OTM Calls, 27.23% Quality Equity, 3.6% OTM Puts, 7.5% cash collateral (assuming 0% return), and 100% notional exposure to the Tactical UST Futures strategy.

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