MODERN MARKETS INITIATIVE

Stability in Turbulent Times: A Quantitative Analysis of the Liquidity and Narrowed Bid-Ask Spreads Provided by Automated Trading

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MMI provides facts and data regarding the evolution of the electronic markets over the past decades and benefit of market automation in saving investors' money with lower trading costs and narrower bid-ask spreads.

About the Authors

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This report builds on previous research and a 2022 MMI Report by MMI Fellows **Katherine Hong**, **Anush Musthyala**, and **Sreeya Narra**, as well as a 2021 MMI Report by MMI Fellows **Kevin Kang**, **Gourprabh**, **Noah Segal**, **Tianyi Zhang**, and **Xiaoying Tang**, who contributed their research and data analysis on pension funds, 529 plans, and 401k's, from other MMI reports.

Modern Markets Initiative ("MMI"), is a 501c4 nonprofit organization that produces studies, data, and materials on the beneficial role of technological innovation in the capital markets, including the positive role of automated traders. MMI supports well-regulated markets, responsible innovation, and having a strong cop on the beat, and strongly opposes any illegal trading activity, including front-running, illegal spoofing, or other illegal market manipulation.

Introduction

A review of the U.S. equity market structure reveals that the equities markets are the best ever for retail investors as far as low cost trading, liquidity, and efficient price discovery. Despite the upheaval and uncertainty of the global economy of the past three years since the onset of the pandemic, the plumbing of the U.S. equity market has proven resilient and functioned as intended. A European war, inflation, rising interest rates, predictions of recession, natural disasters and, even this Spring, the collapse of Silicon Valley Bank have pounced on the market with wild swings of punishing volatility. Yet, despite the market stress and pressures, US markets operated without flaw or failure, allowing investors to buy or sell stocks, even on trading days of historic volatility.

The mechanical "plumbing" of the US equities markets, the electronic infrastructure that allows our markets to open and close and smoothly operate throughout the trading day, has functioned as intended. Automated trading firms, today a mainstay of the markets, have provided dependable liquidity for market making, and retail and institutional investors have been able to get in or out of market positions when and where they wanted to rebalance portfolios.

There is growing consensus that automated traders - also referred to as "HFT" or high frequency traders - have played a vital function in providing dependable liquidity to investors large and small, in providing efficient price discovery, and in reducing the cost of trading for investors through technology and competition to narrow the bid-ask spread, and other costs of trading.

Among the most recent findings on the benefit of HFT to the markets for liquidity provision and reduced trading costs:

HFT firms are better at handling an uptick in volatility than banks and contribute the "dominant" share of new information into the over $7 billion exchange rates market. *"It turns out that HFTs' price-changing limit and cancel orders contribute nearly half of overall price discovery. On average or during normal market times, we find HFTs provide better order-book liquidity than dealers." – UK's Financial Conduct Authority in January 2023*[1] (analyzing role of HFT in forex market)

"Asset managers that use independent market makers as direct liquidity partners report lower execution costs and fewer issues accessing continuous liquidity during periods of intense volatility." – December 2022 Acuiti study commissioned by market maker Susquehanna (noting 71% of asset managers now using independent market makers saying they began doing so in the last three years).[2]

HFT provides "positive spillovers to the overall market since they reduce transaction costs not only for those who invest in this technology but for all market participants by enhancing the quality of the securities markets."[3] *– September 2022 Deutsche Boerse Paper*

At present, more than half of all Americans are invested in the markets – either directly or indirectly, through a 401k, IRA, 529 college savings plan, pension fund, individual stock portfolio, ABLE fund, or other savings vehicles. It is vital that these investors have transparency on the cost of trading, how bid-ask spreads have evolved over the past decade, and to be able to make informed decisions on their order routing decisions. The data from this study highlights and documents the key benefits retail investors of HFT or "automated traders" have had over the past decades in driving down the cost of trading. HFT

1 HFTs and Dealer Banks: Liquidity and Price Discovery in FX Trading
FCA study, Wenqian Huang, Peter O'Neill and Shihao Yu (January 2023) at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2236201

2 Turbulent Times: How Volatility is Changing Asset Managers Approach to Execution" (December 2022) https://www.acuiti.io/sig-acuiti-turbulent-times-report/

3 Clapham, B., Haferkorn, M. & Zimmermann, K. The Impact of High-Frequency Trading on Modern Securities Markets. Bus Inf Syst Eng 65, 7–24 (September 2022). https://doi.org/10.1007/s12599-022-00768-6 (this research paper analyzed HFT's market impacts through the perspective of a technical failure at Deutsche Börse's Xetra electronic-trading venue and determined "substantial" impacts on liquidity and price volatility when high-frequency trading is interrupted. The paper noted that HFT provides a "positive economic spillovers to the overall market since they reduce transaction costs not only for those who invest in this technology but for all market participants by enhancing the quality of securities markets.")

has reduced bid-ask spreads by more than half over the past decades, contributing to investors cumulatively having 30% more in lifetime savings. As this report details through examples and case studies, pension funds, 501ks, 529 plans, and ABLE plans have benefited from reduced cost of trading which has yielded increased savings over time.

Highlights: Investor Savings from HFT Market Automation

A review of bid-ask spreads over the past three decades reveals that cumulatively there has never been a more cost-effective or efficient time to be a retail investor than today. The following summarizes highlights of reduced bid-ask spreads, and the corresponding projected level of savings to investors as far as dollars saved and years of work saved to reach the same retirement goals, as a result of HFT market automation.

Benefits of Automated Trading	50% Reduced trading costs to investors over past decade	30% More savings in Americans' retirement accounts over lifetime

Narrowed Bid-Ask Spreads: A review of historic bid-ask data indicates that average bid-ask spreads have declined by at least 50 basis points over the past three decades since the pre-HFT automated trading era. This is supported by academic literature:

1. Between the period of the 1990s (average 60 basis point spread) and 2022 (average 1-2 basis point spread), the reduction in bid-ask spreads is over 50 basis points.[4]
2. An industry participant (Vanguard) wrote in a comment letter that it was a conservative estimate that bid-ask spreads and transaction costs had been reduced by at least 50 basis points in the decades before 2010 as a result of automation of the markets.[5]

More recently, data has shown bid-ask spreads shrinking by more than 50% over a decade in the mid-2000s and mid-2010s.[6] Much of the price improvement occurred during the rapid adoption of automated trading technology, which continued to incrementally decline as automated trading technology became widely deployed and the industry standard for electronic market making.

The result of the narrowed bid-ask spreads is that Americans have more savings in their retirement accounts over a lifetime.[7] Electronification initiatives, including HFT automated traders, have played a vital role in driving down the cost of trading for investors, facilitating the creation of an environment for zero-fee trading for retail investors, and proliferation of ETFs, which has helped democratize access to trading for investors big and small.[8]

4 Charles M. Jones, "A Century of Stock Market Liquidity and Trading Costs," Graduate School of Business Columbia University, May 22,2002, https://www0.gsb.columbia.edu/mygsb/faculty/research/pubfiles/4048/A%20century%20of%20Market%20Liquidity%20and%20Trading%20Costs.pdf

5 George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," (April 21, 2010). https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

6 Albert J. Menkveld, "The Economics of High-Frequency Trading: Taking Stock," Annual Review of Financial Economics, Volume 8, Forthcoming, "In the decade of migration to electronic trading and HFT arrival, transaction cost decreased by over 50% for both retail and institutional investors," June 1, 2016, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2787542

7 George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," "...we conservatively estimate that transaction costs have declined 50 bps, or 100 bps round trip... Today's investor with a 30 year time horizon would see a $10,000 investment in such a fund grow to approximately $132,000 in 30 years, compared to approximately $100,000 with the hypothetical return of 8% associated with the higher transaction costs. Thus, any analysis of "high frequency trading" must recognize the corresponding benefits that long-term investors have experienced through tighter spreads and increased liquidity, "April 21, 2010, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

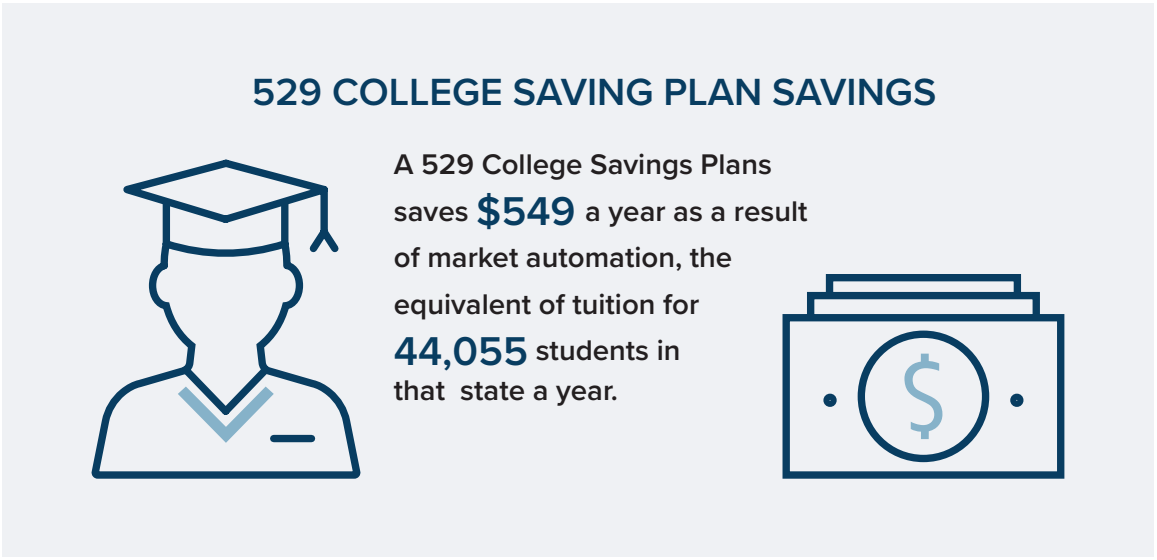
8 D. Hal Scott, "Why U.S. Investors are Better Off Today," Washington Times, "Vanguard estimates that the shift from the old market structure to today's automated market structure has reduced trading costs by 35-60 percent, resulting in a 32% greater yield for long-term investors," January 21, 2016

Key Take-Aways:

Individual Investor with $10,000: A Vanguard Analysis: Assuming an investor starts with $10,000 in their account and invests in a 401k mutual fund for 30 years, that individual would have $65,000 over 30 years, rather than $49,000, after adjusting for inflation. This is a direct result of electronification initiatives including HFT automated trading which have reduced transaction costs, according to a 2010 Vanguard analysis in a comment letter to the SEC. A financial model of this calculation, which assumes the Vanguard estimated a 50 basis point reduced cost of trading as a result of automation of the markets, is here.[9]

Individual Investor with $100,000: Assuming an average 401(k) balance of $100,000, in a portfolio mixed with equities and bonds, that investor would have $157,000 more in lifetime 30-year savings as a result of HFT automated trading technology. A financial model of this calculation, which assumes the Vanguard estimated 50 basis point reduction in trading costs compared to the pre-electronic era, is available here.[10] In other words, without the inclusion of automated trading technology in modern markets, a middle class worker making $70,000 a year would have to work an additional two and a half years to make up the difference in retirement savings.

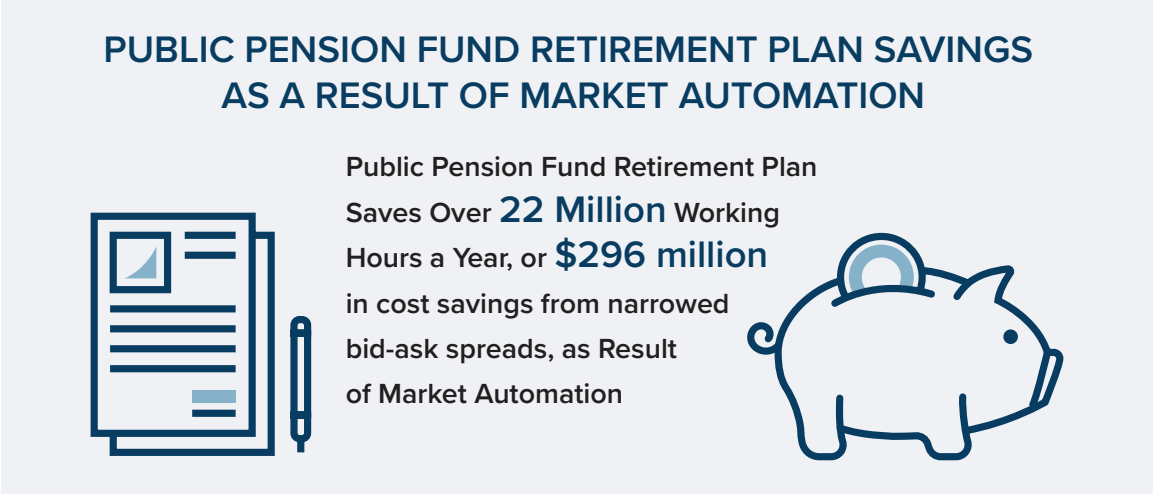
529 College Savings Plans: Equivalent of 44,000 Student Tuition saved from Market Automation: The inclusion of HFT automated trading technology has saved 529 plans millions of dollars per year compared to pre-electronic trading days. As this report details, California 529 plans save an average of $76 million a year – or tuition for 6,100 students – as a result of today's efficient modern markets. Further, Virginia 529 college savings plan saves $549 million a year, which is the equivalent of the tuition for 44,055 students a year as a direct result of modern markets including automated trading technology.



9 Albert J. Menkveld, "The Economics of High-Frequency Trading: Taking Stock," Annual Review of Financial Economics, Volume 8, Forthcoming, "In the decade of migration to electronic trading and HFT arrival, transaction cost decreased by over 50% for both retail and institutional investors," June 1, 2016, Original Vanguard Study; see also Katherine Kong, "Individual Investors Savings Calculation," April 2022
George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," "...we conservatively estimate that transaction costs have declined 50 bps, or 100 bps round trip... Today's investor with a 30 year time horizon would see a $10,000 investment in such a fund grow to approximately $132,000 in 30 years, compared to approximately $100,000 with the hypothetical return of 8% associated with the higher transaction costs. Thus, any analysis of "high frequency trading" must recognize the corresponding benefits that long-term investors Wv-j89_Vs3EC6tI0/edit?rtpof=true&sd=have experienced through tighter spreads and increased liquidity, "April 21, 2010, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

10 Katherine Kong, "Individual Investors Savings Calculation," April 2022
George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," "...we conservatively estimate that transaction costs have declined 50 bps, or 100 bps round trip... Today's investor with a 30 year time horizon would see a $10,000 investment in such a fund grow to approximately $132,000 in 30 years, compared to approximately $100,000 with the hypothetical return of 8% associated with the higher transaction costs. Thus, any analysis of "high frequency trading" must recognize the corresponding benefits that long-term investors have experienced through tighter spreads and increased liquidity, "April 21, 2010, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

Public Pension Fund Retirement Plan Saves Over 22 Million Working Hours a Year as a Result of Market Automation: Modern market technology, including HFT automated trading technology, is projected to have saved a mid-size pension fund each year over $70 million in transaction costs, or equal to a savings of about 22,797,000 hours extra that teachers would have to work extra to make up the difference in cost of trading.[11]



Democratization of ETFs as a Result of Market Automation: The emergence of narrowed bid-ask spreads has spurred the growth of ETFs, allowing them to continuously rebalance at a fraction of the cost while enabling investors to enjoy the diversification of an ETF without the risk exposure of a single stock. The bid-ask spread of SPY, as an example of one large ETF, has come down from 14 basis points in the early 2000s to just 1 basis point in 2021. This is in addition to the reduction of bid-ask spreads in the continuous rebalancing of the ETF itself.

11 ZipRecruiter, "Teacher Salary in New Jersey," "As of Mar 3, 2021, the average annual pay for a Teacher in New Jersey is $27,045 a year (or $13/hour," https://www.ziprecruiter.com/Salaries/Teacher-Salary--in-New-Jersey

Key HFT Automated Trading Benefit: Narrower Spreads

CONCEPT OF THE SPREAD: A key variable for saving community stakeholders in their trading costs relates to the concept of the cost of "spreads." A widening – or increase – of a spread would increase the cost of trading for all market participants. A narrowing – or decrease – of a spread reduces the cost of trading for market participants. The financial markets are made up of negotiations between buyers and sellers. Like all negotiations, most end up in compromise.

Figure 1

Bid-Ask Spread: A Dramatic Reduction in Spreads and in the Cost of Trading

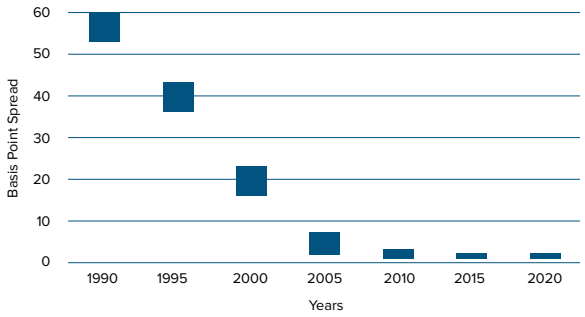


FIGURE 1: Bid-Ask Spreads 1990–2020

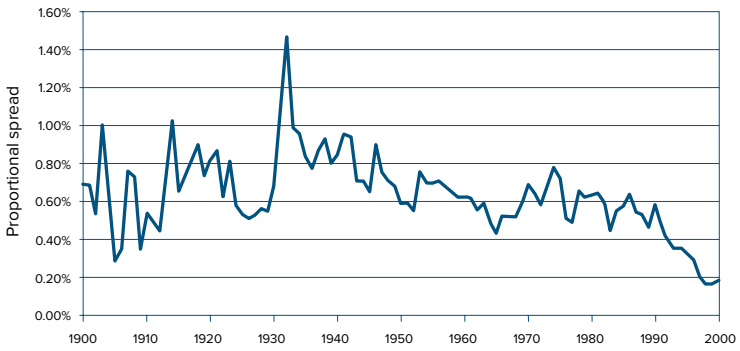
The distance between what someone wants and what someone is willing to pay during a particular negotiation is "the spread." For both parties, the narrower the spread, the less either party has to concede and thus, the better the price from their perspective. Fierce competition between market makers, and the electronification of the markets, has led to a dramatic reduction in spreads and in the cost of trading.[12]

TAKEAWAY #1

Automated Trading Narrows Spreads = Lower Trading Costs: Historically, the electronification of the markets has led to lower bid-ask spreads, and pressure on regulators to implement policies, including narrower tick sizes, to adjust to changing technology, innovation, and competition. The below graph shows bid-ask spreads decreasing from about 50 basis points in 1990 to about 20 basis points by 2000:

FIGURE 2: Bid-Ask Spreads On Dow Stocks

Narrowing Bid-Ask Spreads in Dow Jones Industrial Average Stocks



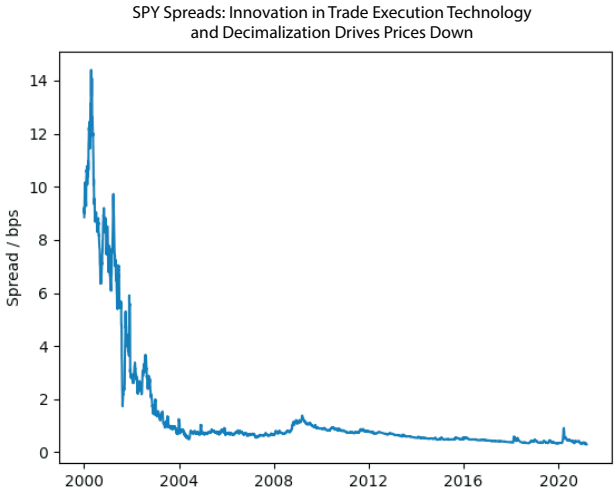
Further, the graph below depicts ongoing price improvement, with bid-ask spreads shrinking from 2.25 cents in 2003 for an average S&P stock (or about 25 basis points) to 1.25 cents for an S&P stock in 2009 (or 14 basis points)[13]

12 Kevin Kang, "Floating column chart (bid ask spreads)," April 2020
Further resources on bid-ask spreads: https://www.investopedia.com/articles/investing/082213/how-calculate-bidask-spread.asp.

13 Note: The average price of S&P stock in 895.84 in 2003, and 2.25 /895.84 = 0.0025, or 25 basis points; verses assuming an S+P price of 1004.20 in August 2009, and 1.25/1004 =0.0012, or 12 basis points; the 14 basis point aligns for ETF spread in 2003.

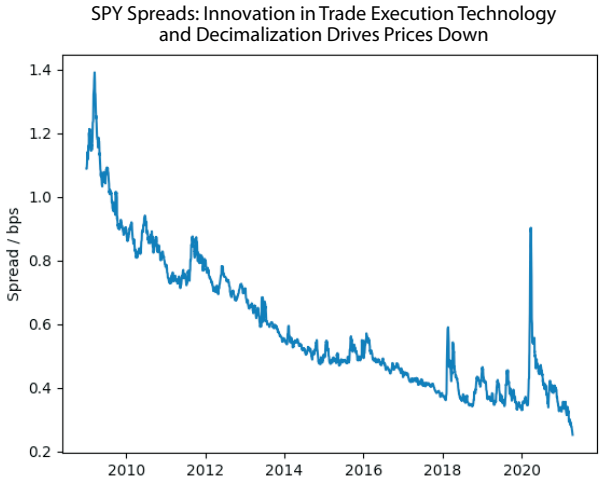
From 2000, where bid-ask spreads had historically ranged around 20 basis points, additional innovation in trade execution technology, as well as decimalization in 2001 in response to that innovation, further drove down prices in the following years.

FIGURE 3: SPY Spreads 2000-2020



Source: Large Market Maker

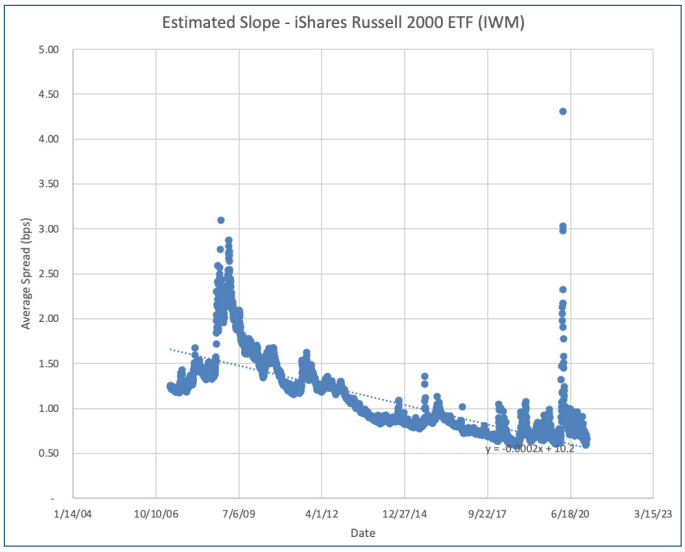
More recently, over the past decade, bid-ask spreads in SPY have declined by more than 50% (excluding up-ticks in bid-ask spread during periods of volatility in 2008 and 2020). The following graph shows a downward slope in bid-ask spreads from about 1 basis point in 2010 downward to .3 basis points in 2021, a reduction by more than half in bid-ask spreads over that period:



Source: Large Market Maker

FIGURE 4: Russell 2000 ETF Bid-Ask Spread Over Past Decade

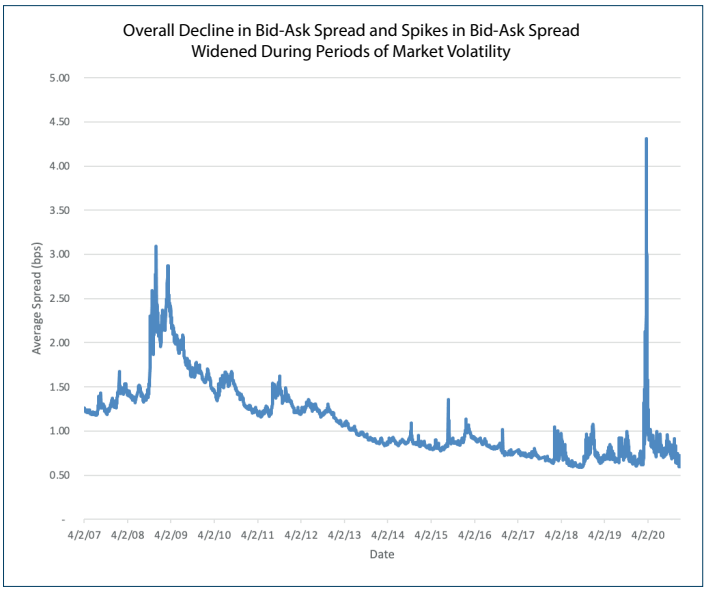
An analysis of bid-ask spreads on the Russell 2000 ETF indicates that the bid-ask spread has been reduced by more than 50% over the past decade. The following analysis shows that bid-ask spreads were about 1.6 basis points in 2007 declining to .6 basis points in 2020. The data points describe the daily bid-ask spreads, and the slope line below was calculated utilizing a regression line of how far the data points on the bid-ask spread are apart from each other to average to a common slope indicating the overall trend line in bid-ask spreads.



Source: BlackRock

Further, the following analysis of the same data illustrates the bid-ask spreads without the trend line calculation. This analysis reflects the overall decline by more than 50 percent in bid-ask spread over the past decade, as well as illustrating the spikes in bid-ask spread which widened during periods of market volatility in 2008 and 2020.

FIGURE 5: Bid-Ask Spreads On iShares Russell



Source: BlackRock

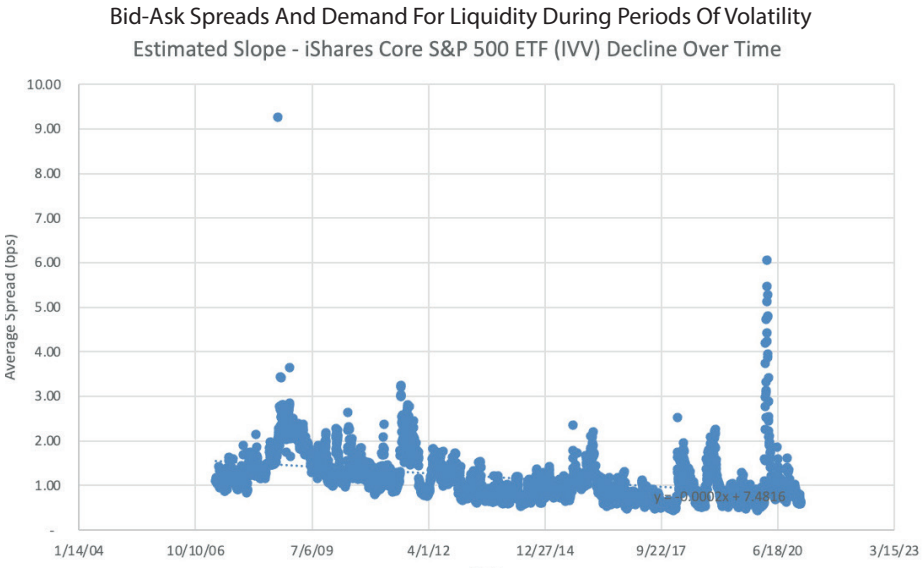
Notably, the above Russell 2000 ETF is a general proxy for small cap markets. The Russell 2000 Index is a small-cap stock market index that makes up the smallest 2,000 stocks in the Russell 3000 Index. It is generally reflective of the bid-ask spreads on equities that are considered “small cap”, or companies ranked 1000 to 3000 in size, generally with an average market cap of $3 billion over time. [14]

14 https://www.suredividend.com/russell-2000-stocks/

Bid-Ask Spread of IVV ETF

The following is an analysis of bid-ask spreads of iShares Core S&P 500 ETF (IVV), the top 500 largest companies that have higher volumes of trading on the stocks, generally.

FIGURE 6: Bid-Ask Spread Of IVV ETF

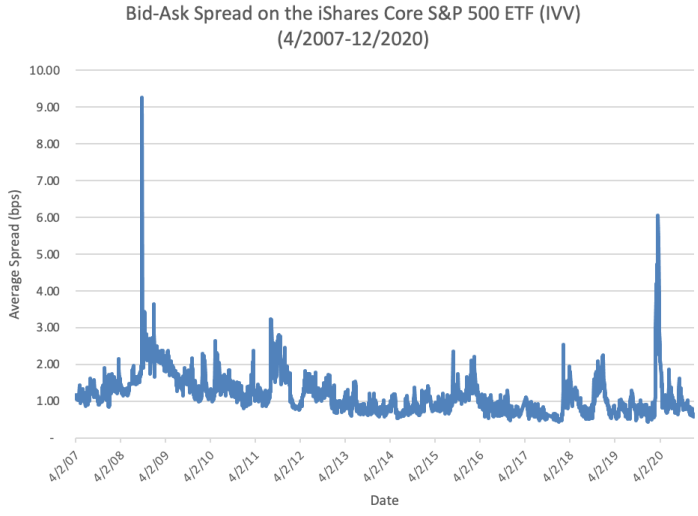


Source: BlackRock

Notably, the above slope-line of IVV ETF indicates a reduction in bid-ask spreads from about 1.5 in August 2007 to .6 by December 2020. This illustrates a more than 50% reduction in bid-ask spreads over the past decade.

The graph below depicts the bid-ask spread of IVV without the slope line, illustrating the spikes of bid-ask spreads in a period of volatility in 2008 and 2020.

FIGURE 7: Bid-Ask Spread On iShares Core S&P 500

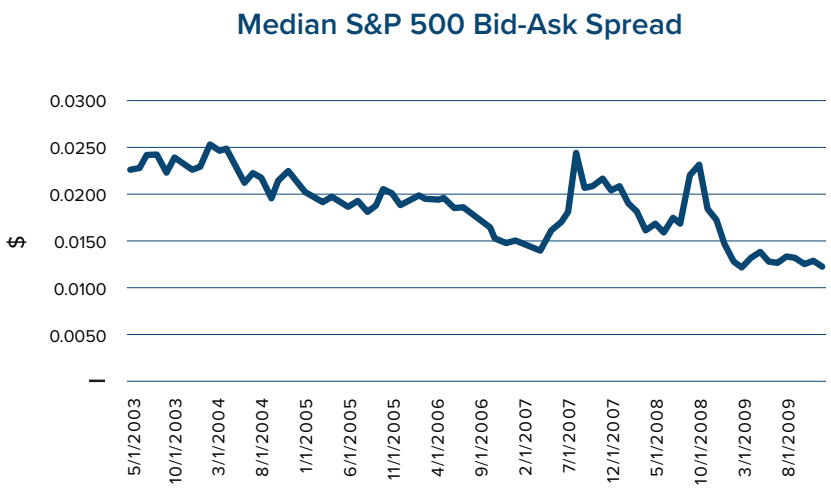


Source: BlackRock

TAKEAWAY #2

A Decrease In Spreads Yields Savings for Every Investor, Including Individual 401k Investors, 529 Savers, and Public Pension Funds: Market automation, including automated trading, has led to savings that can be factored in when looking at the returns of pension funds, 401(k)s, individual investors, with the incremental small dollar savings compounding to larger savings over time. The below chart further shows the decline in spreads between 2003 and 2009, with the following chart in dollar value rather than basis percentage:

FIGURE 8: Median S&P 500 Bid-Ask Spread



For the period between 2003 and 2008, the above chart illustrates – in penny increments rather than basis point value – an overall decline from about 2.5 cents per stock traded around 2003 to 1.25 cents by 2009. (Again, during 2008 one sees a spike in volatility during that period). Although the incremental savings of one to two pennies on a trade might seem small, as the forthcoming sections of this report illustrate, the impact of bid-ask spread on investors in 401(k)s, 529s, pensions, and other savings vehicles is substantial over time.

A Brief History of HFT Automated Trading

Old Model: Floor Based Specialists and Floor Traders

In the floor-based trading era of the 1960s to the early 1990s, stock exchange trading floors were comprised of "floor specialists" as human intermediaries matching buy and sell orders, as well as floor brokers" who stood at the stock exchange trading posts and worked customer orders throughout the day.[15] Historical data indicates that for a $100 trade by a retail investor in the 1960s, with a $6 minimum, the cost of trading including bid-ask spread and minimum brokerage fee equaled about 600 basis points commission.[16] Further, Professor Jones notes in his "Century of Stock Trading" a range of bid-ask spreads declined in 1990 from about 50-60 basis point range to roughly 20 basis points by 2000.[17] Following that, spreads further declined to a range of 1-3 basis points by the 2010s, and are hovering by 2020 at about ½ a basis point for certain large-cap stocks and ETFs.

What happened for bid-ask spreads to rapidly narrow in the 1990s and 2000s onward? Swift adoption of computerized trading systems, HFT/ automated trading technology, and regulatory reform coinciding with market automation. Notably, HFT automated trading firms based in banking hubs all over the world in Chicago, New York, Texas, Amsterdam, Hong Kong, Israel, and Switzerland pioneered the field of utilizing algorithms and automated trading to conduct market making and supply liquidity.[18] These pioneer technologists, coupled with better technological innovations leading toward an eventual all-electronic exchange, as well as regulatory reform to narrow minimum ticks in conjunction with the new technologies, further drove down costs and improved the experience for end-users.

By the late 1990s, the human floor "specialists" on exchanges saw their market dominance challenged by the competition of electronic trading and computers.[19] At the time, the human specialists functioned as intermediaries physically on the exchange floor, matching buy and sell orders with the exchange of physical notes, phone calls, and human contact. The specialists on the New York Stock Exchange (NYSE), which had an 80% market dominance at the time, each had an exclusive market on a portfolio of equities or options, with an obligation to provide liquidity to the market by committing their own capital. By the late 1990s, there were seven specialist firms employing 443 specialists who each managed an exclusive portfolio of five to 10 stocks. The specialist system was designed to avoid large and unreasonable price variations, provide continuous liquidity, and act as a buffer in times of volatility during temporary shifts in supply and demand in stocks.

By the early 2000s, some business models such as the all electronic exchange Nasdaq and all electronic options exchange ISE, were moving toward electronic trading instead of human intermediaries.[20] With the proliferation of computing power and complaints of the human specialists as being "slow intermediaries", taking up to 30 seconds per trade, businesses urged the then-existing "trade through rule" (which had re-

15 Charles M. Jones, "What do we know about high-frequency trading," Columbia Business School, February 25 2013, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2236201.

16 The average 1960s stock price was about $40 and the cost of trading each stock, including the bid-ask spread, was about 33 cents per share, with minimum commissions by brokerages of $6 to trade stocks. In this era of the early 1960s, for retail individual investors making stock trades involving a total amounts of $100 to $400, the minimum commission was especially punishingly high, with a commission for 100 shares at a fixed price at $3 plus 2% of amount traded, with a $6 minimum.
Charles M. Jones, "A Century of Stock Market Liquidity and Trading Costs," Graduate School of Business Columbia University, "At the end of 1962, the average NYSE share price was $40. Trading 100 shares of such a stock would result in a one-way commission of $39, or 0.975% of the money involved. This is a substantial fraction. It is also important to note that, prior to 1968, the NYSE commission schedule was always linear: a trade of 3,000 shares incurred a commission 30 times as large as a trade of 100 shares. Thus, one can think of commissions as a proportional tax on transactions, where the tax rate depends on the share price. Since the proportional commission depends only on the share price, it is possible to estimate the weighted average commission rate during the fixed commission regime by looking only at the cross-sectional distribution of share prices and the total volume of trade. Other than ignoring odd lot transactions, which are a negligible part of total volume over most of the sample, one does not need information on the distribution of order sizes. This is fortunate, since such data are not readily available prior to the advent of intraday data. CRSP volume data begins in July 1962, and from that date forward, it is possible to calculate the weighted average commission rate in this way. For example, in the second half of 1962, the dollar volume- weighted average one-way commission rate on NYSE common stocks is 0.82%," May 22 2002

17 Charles M. Jones, Figure 1 in "A Century of Stock Market Liquidity and Trading Costs," Graduate School of Business Columbia University, May 22 2002

18 The early pioneers of HFT include firms Optiver Timber Hill (founded in 1982, later acquired by Two Sigma in 2017); (founded 1986), Susquehanna (1987), IMC (1989), DRW (1992), Quantlab, Tower, Jane Street (1999), Jump Trading (1999), among 20 other firms; RGM (2001); Sun Trading (2002); Allston (20002); HRT (2002); Flow (2004), Virtu (2008).
"Top 50 HFT firms and their history," Grainstone Lee, https://blog.grainstonelee.com/insight/top-50-hft-firms-and-their-history

19 "The role of specialists at the NYSE," (Feb.15, 2001), CNN Money referring to material from NYSE.com at https://money.cnn.com/2001/02/15/deals/bear_stearns/specialists.htm

20 In 1998, the SEC further opened the door to automation of the market by authorizing electronic exchanges.
SEC, " Regulation of Exchanges and Alternative Trading Systems,"https://www.sec.gov/rules/final/34-40760.txt;
CNNfn, "SEC Oks new trade rules," CNNMoney, "In a bow to the technological boom sweeping the marketplace, the U.S. Securities and Exchange Commission Wednesday approved new rules that will allow electronic trading systems to register as full-fledged exchanges," https://money.cnn.com/1998/12/02/economy/sec/

quired that each exchange respect the price of the other market) and trade at the best price or send the order to another exchange. The Nasdaq model at the time used an electronic model to place orders, involving multiple dealers competing for orders, and proponents argued that electronic orders expedited the time for processing orders.[21]

Decimalization. In 2001, in response to faster technology and competition in the markets, the Securities and Exchange Commission (SEC) changed the minimum tick size between the "bid" and the "ask," shrinking the minimum from 1/16 of a dollar tick sizes, or 6.25 cents, to a single cent, $0.01 per share. Depending on the size of the stock, this shrunk the bid-ask spread as a percentage of the value of the stock substantially. The move to a penny spread minimum was called "decimalization," and put further pressure on the floor-based human specialists to compete with electronic traders who were using coding and computers to execute trades. The minimum penny cent spreads made it harder for specialists to make a profit off market making.

Front Running Lawsuit and Floor Specialists. By 2003, the tension between the established human intermediary system of the specialists and the newer electronic intermediary model reached a fever pitch at a Congressional hearing in late October.[22] Inquiries had been made regarding five big board specialists (Van Der Moolen, LaBranche, Fleet Specialist, Bear Wagner Specialists, and Spear Leeds & Kellog Specialist) accused of "front running" investors and "interpositioning" or getting between a natural buyer and seller to pocket an improper profit[23]. Findings had been made that among the human specialist firms, Van Der Moolen Specialists USA, was "front running" investors between 2000 and the end of 2002, and illegally "trading ahead" of customers' orders causing or allowing its traders to Van Der Moolen's interest ahead of investors by ignoring one investor order while interacting with another investor, thereby creating illegal profits for itself. The New York Stock Exchange (NYSE) sought $150 million in fines and improvements, as well as reimbursement for investor losses, from five of its specialist firms. The news cycle of the specialist scandal drove broader discussions about equity market structure.

Man vs. Machine. By the fall of 2003, Congress held a hearing on the floor specialists, amid criticism that the human intermediaries were slow with 10 to 30 second lag times in trading, and that the market structure of the past needed to be updated to changing times and technologies.[24] Witnesses noted that humans could only process a trade in 10 seconds, whereas electronic intermediaries could process 300 trades per second.[25] At that hearing, the heads of the Nasdaq, the Philadelphia Stock Exchange, and the Cincinnati Stock Exchange testified in favor of opening up trading to newer electronic trading systems and criticized the "slow, manual markets" of the human specialist system which was protected at the time by the trade-through rule.[26] A Fidelity Investments equity trader quoted in The Wall Street Journal recommended replacing the floor-based specialist system with "an electronic system… in which computers pair buy and sell orders with no human go-between." The advantage of eliminating the go-between was faster processing and narrower spreads.[27]

The human, floor-based specialist system was criticized at the hearing as being against the best interests of investors, outdated, and self-serving. One witness from American Enterprise Institute (AEI) testified that the specialist system *"permits about 400 traders from just seven firms, with inside knowledge, to enhance their own accounts as well, is an anomaly, an antique among the world's major exchanges. Why does it persist? In*

21 Anupriya Gupta, "History of Algorithmic Trading, HFT and News Based Trading, QuantInsti, "By the year 2001, HFT trades had an execution time of several seconds. By 2010 this had shrunk to milliseconds, even microseconds and subsequently nanoseconds in 2012," June 2 2015, https://blog.quantinsti.com/history-algorithmic-trading-hft/

22 "NYSE v NASDAQ," Forbes, " You can feel it in the air on Wall Street. Stock trading is heating up again. But which stock market will be the biggest beneficiary: the New York Stock Exchange or Nasdaq? That question is crucial for Wall Street firms, still putting their trading desks in order after seeing revenue fall off a cliff from 2000 highs. The two markets have vastly different components. Nasdaq-listed trades are entirely automated. NYSE trades are still overseen by specialists. While traders have some say in how, when and at what price the trades are crossed, they can't pick the market. Only the companies can. And the competition for companies is about to get tighter," Aug 18 2003, https://www.forbes.com/2003/08/18/cx_aw_0818mondaymatchup.html?sh=7aa6d1498675

23 Laurie P. Cohen, Susanne Craig, Ianthe Jeanne Dugan and Kate KellyStaff Reporters of "NYSE to Punish Five Specialists in Trading Inquiry: Action on Improper Trades Is Blow to Auction System;SEC Probes Front-Running," The Wall Street Journal (October 16, 2003).

24 "Reviewing U.S. Capital Market Structure: The New York Stock Exchange and Related Issues," House Committee on Financial Services hearing, October 16 2003

25 Meyer Frucher, then-CEO of the Philadelphia Stock Exchange, and David Coliker, then-CEO of the Cincinnati Stock Exchange, emphasized the advantages of electronic trading systems with multiple dealers results in aggressive cost competition. They noted that electronic trading systems permitted 300 trades to be processed per second, as opposed to the manual, floor-based specialist system with a processing time of around 10 seconds.

26 Bob Greifeld, then CEO of NASAQ, testified that the floor-based specialist system of the NYSE stifled investor choice by forcing investors to use "slow, manual markets" and criticized the floor based specialist system as having: higher costs, slower execution of orders, and less transparency than electronic order systems. Further, James Glassman, then a fellow at the American Enterprise Institute, testified in opposition of the floor-based specialist system, urging electronic market making systems instead.

27 John Hechinger, "Fidelity Urges NYSE to Revamp Trading Operations," The Wall Street Journal, October 14 2003.

fact, the obvious reason the system continues is that it is immensely profitable for the specialists themselves." James Glassman, a fellow at the American Enterprise Institute, cited that pre-tax margins of specialist firms are estimated to be 35% to 60%, while the profits for the industry category of security brokers, dealers, and flotation companies are only 9.7%. Glassman described specialists as a "profitable cartel" existing not for the public good, but rather because "specialists are enormously powerful." Further, he cited conflicts of interest in the floor-based specialist system.[28]

At the time of the hearing, NYSE had an 80% market share, and even though NYSE had to sue some of its floor specialists, the exchange argued in favor of the "trade through rule." The rule required the orders to be routed to the exchange with the best price, however with 30 second delays in the execution of trades with specialists, critics argued that best price might be stale by the time it was routed toward the specialist.

Reg NMS and Further Market Fragmentation. By 2005, when Reg NMS was adopted, the SEC staff reported growing consensus emerging in comment letters that the trade-through rule was "seriously outdated and in need of reform" and that there were problems giving equal protection against trade throughs to both automated and manual protections; commenters noted the problems inherent with a 30-second period to respond to attempts to access quotations under the floor-based specialist system; Reg NMS was adopted and Rule 611 eliminated the "trade through rule," creating new trade-through provisions, which only protected automated quotations that could be accessed immediately, would promote "equal regulation and fair competition among markets by eliminating any potential advantage that the old floor-based model may have given manual markets over automated markets."[29]

New Model: HFT Automated Traders and Electronic Intermediaries – Rise of Retail Investors

The initial growth of automated traders largely in the 1990s and early 2000s featured an unlikely group of Wall Street disruptors without conventional backgrounds, such as MBAs. Instead, these automated traders had backgrounds and degrees in engineering, physics, and calculus. The new generation of coders on Wall Street formed startups and grew quickly as they offered cheaper and faster trading.

Among the early firms using automated trading technology were: Amsterdam-based firms, Optiver in 1986 and IMC in 1989; Susquehanna in 1987; DRW in 1992, New York-based Tower in 1998; Citadel in 1990; Texas-based Quantlab in 1999, Jane Street in 1999, Getco in 1999, RGM in 2001, Hudson River Trading in 2002, Sun Trading in 2003, GTS in 2006, Virtu in 2007, among others. At the time, these firms began as small startups taking on larger Wall Street titans such as established specialists that had been around for decades.

Indeed, the technology of automated trading began to be more widely deployed. By the mid-2010s, the use of automated trading technology leveled off to about 50% of daily trading volume. As Larry Tabb and co-authors noted in 2009, "electronic routing and execution has become the mechanism by which our capital markets operate. Algorithms account for more than 25% of all shares traded by the buy-side today – a number steadily rising for several years now."[30] Competition between over a dozen automated trading firms drove down bid-ask spreads to a level of 2 to 3 basis points by the mid-2010s, down from a range closer to 20 basis points at the start of 2000.

The "flash crash" of May 6, 2010, when the stock market lost more than 5% and recovered most of it in less than an hour, raised heightened concerns about trading technology and robots on Wall Street. Of note, the flash crash was later found to be attributable to human error/action.[31] It is arguable that automated trading technology helped dampen volatility by stepping in to provide liquidity, or the volatility could have been a lot worse. The volatility of the "flash crash" further resulted in industry and lawmakers coming together to find innovative ways to curb volatility. As a result, circuit-breakers and limit up, limit down were instituted – such

28 James K. Glassman, a fellow at the American Enterprise Institute,cited the following examples of the power of human, floor-based specialist firms on: (1) two or three representatives of specialist firms such typically sit on the board of the Exchange at any time; (2) the CEOs of various investment banks also had minority ownership in certain specialist firms, and also sat on the board of exchanges (citing the then-CEO of Bear Sterns, which has a minority interest in a specialist firm Bear Wagner, and was also vice chairman of the NYSE board; also citing the then-CEO of Goldman Sachs Group, Inc., which at the time owned a fourth of the specialist firm Spear, Leads & Kellog, also sat on the NYSE board.)

29 "Memorandum for Rule 611 of Regulation NMS," https://www.sec.gov/spotlight/emsac/memo-rule-611-regulation-nms.pdf

30 Larry Tabb et al., "High Frequency Trading Technology: A TABB Anthology," Tabb Group, August 10 2009, https://research.tabbgroup.com/report/v07-021-high-frequency-trading-technology-tabb-anthology.

31 An individual Navinder Sarao, later known as the "Hound of Hounslow," took actions from his bedroom computer including illegal "spoofing."
Andy Verity & Eleanor Lawrie, "Hound of Hounslow: Who is Navinder Sarao, the 'flash crash trader'?" BBC Business, January 28 2020, https://www.bbc.com/news/explainers-51265169
Portia Crowe, "The trader blamed for the 'flash crash' tried to blow the whistle on other traders -- more than 100 times," Business Insider, May 15 2015, https://www.businessinsider.com.au/navinder-singh-sarao-blew-the-whistle-on-other-traders-2015-5

that trading in stocks could be halted for five minutes when they move more than a certain amount. Since then, during periods of volatility, these circuit breakers have been implemented and worked well; examples of the use of circuit-breakers included the August 25, 2015 volatility and more recently Q1 2020 covid volatility, when circuit breakers were implemented successfully to curb volatility.[32] Further, during the height of the 2020 Covid market volatility, all automated trading firms operated remotely and without any notable shortages of liquidity.

Over the past decade, there has been much discourse over the benefits and risks of HFT market automation, with many hearings and comment letters from participants. Notably, industry participant Vanguard, wrote letters in support of automated trading technology to the SEC, in support of the faster trading technology that was automated, noting that the electronic intermediaries could knit together liquidity between an increasingly fragmented number of exchanges. In a 2010 comment letter to the SEC, Vanguard noted, "Any analysis of high frequency trading' must recognize the corresponding benefits that long-term investors have experienced through tighter spreads and increased liquidity. Vanguard believes a vast majority of 'high frequency trading' adds value to the marketplace, though increased liquidity, tighter bid-ask spreads."[33] Further commentators noted that the intense competition between automated professional trading firms contributed to narrower bid-ask spreads, narrowing retail trading and institutional trading costs.[34]

Further, at a 2012 Congressional hearing before the Senate Banking Committee, market structure expert Larry Tabb testified that market automation has saved investors money with lower commissions and trading costs:

> *"Smaller individual investors (those placing their own orders into the marketplace via online brokers) have never had a more efficient and inexpensive marketplace. Many studies have stated that not only are equity commission rates very low (under $10) but spreads in the US markets (up until this year), are historically low. Individual investors, as long as they are not buying sizable positions receive quick and inexpensive executions.")*
>
> *Larry Tabb, before Senate hearing in 2012* [35]

Criticism of market automation has centered on the misuse of technology for illegal activity such as front-running, spoofing, or other illegal practices. Many of the criticisms voiced in the 2014 book *Flash Boys* reiterate similar types of spoofing accusations of which floor-based specialists were accused of in 2003, by utilizing new technology of electronic rather than manual trading. The SEC has developed new technologies utilizing its MIDAS system, as well as other forms of AI and market oversight, to be a strong cop on the beat to ensure that any illegal trading activity – whether manual or electronic – is detected and deterred. The important discussions on market integrity and fairness have continued over the past year, including confidence building that the public has confidence in the benefits of automated trading technology in cost savings and efficient markets.

32 Bob Pisani, "What happened during the Aug 24 'flash crash'," CNBC, Sept 25 2015, https://www.cnbc.com/2015/09/25/what-happened-during-the-aug-24-flash-crash.html

33 Note: Reduction of 50 basis point cost of trading as a result of HFT leading up to 2010
"Concept Release on Equity Market Structure," Vanguard, April 21 2020, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

34 Jeff Castura, Robert Litzenberger, Richard Gorelick RGM Advisors, LLC, "Market Efficiency and Microstructure Evolution in U.S. Equity Markets: A High-Frequency Perspective," "The intense competition among automated professional trading firms significantly contributes to narrower bid-ask spreads and consequently lowers retail and institutional trading costs. At the same time, this competition has driven down profit margins for professional traders to small fractions of a penny per share. Fairer prices - Diverse automated professional trading strategies improve price discovery, ensuring prices track fair value and rapidly reflect all relevant market information," April 22 2010, https://www.sec.gov/comments/s7-02-10/s70210-155.pdf

35 Larry Tabb, "Written Testimony to the United States Senate Committee on Banking, Housing, and Urban Affairs Washington, DC," "Smaller individual investors (those placing their own orders into the marketplace via online brokers) have never had a more efficient and inexpensive marketplace. Many studies have stated that not only are equity commission rates very low (under $10) but spreads in the US markets (up until this year), are historically low. Individual investors, as long as they are not buying sizable positions receive quick and inexpensive executions," September 20 2012. https://www.banking.senate.gov/imo/media/doc/TabbTestimony92012.pdf

As of 2023, exchanges have become more like technology companies, using algorithms, coding, and technology as tools for humans to bring new efficiencies to the market. The NYSE, previously floor-based around the turn of the century, has embraced a system of "designated market makers" in which human traders use automated trading technology to satisfy market maker obligations and duties.[36]

Arguably, the spreads could narrow even further, if regulators were to reduce the tick-constrained stocks for certain large cap companies to a fraction of trading increment below a penny, as is currently under consideration in the SEC's Tick Size Proposal.[37]

Future of Automated Trading: Expansion and Further Mainstream Adoption of Technology

As the cost-saving technology underlying automated trading and execution has been adopted by a broader group of market participants, it becomes increasingly difficult to differentiate automated traders – including HFT from other market participants employing HFT-like technology. A proliferation of automated trading systems utilizing high speed trading has become available to retail investors, democratizing fast trading to retail investors where at the click of a button, and in many cases for free, the average investor can buy and sell stocks in a fraction of a second. The technology behind HFT is being deployed for faster and more efficient trading for investors across the board.

The expansion of automated trading is anticipated to continue, as the technology underlying high-frequency trading continues to be widely deployed, providing dependable liquidity to the markets and low cost trading. [38] Many types of firms, including firms dealing "on own account" as well as brokerages, hedge funds, or firms dealing as an agent "on behalf of clients", employ automated trading technology of similar risk profiles. A survey showed that over the past year, 44% of investment managers reported plans to mostly build automated trading execution technology in the fixed income markets. [39] Another survey indicated that of buy and sell side managers in the corporate bond space, over 70% reported an increase or substantial increase in electronic trading volumes since three years ago. [40] Additionally, a report released on January 19, 2021 indicated that the algorithmic trading market is anticipated to further grow over the next five years.[41]

As automated trading is more broadly deployed across different types of business entities, it is important to note that automated trading technology is a tool that is being more widely deployed across industries. Automated trading technology will likely continue to expand as a tool for trading new asset classes (e.g., bonds, futures), trading in expanded geographies (e.g., Asia, India, Africa), for different types of investors (e.g., brokers, pension managers, 529 plan advisors, individual investors on Excel spreadsheets), and become further ubiquitous. As the speed of trading reaches the limits of physics, the next range of cost savings is likely to come from additional sources: AI, cloud computing, machine learning, and other innovations.

36 "The NYSE's unique market model combines leading technology with human judgment to prioritize price discovery and stability over speed for our listed companies. Coupled with our electronic markets, we believe nothing can take the place of human insight and accountability. It's the human element at NYSE that results in lower volatility, deeper liquidity and improved prices." https://www.nyse.com/market-model (April 2021)

37 "Minimum Pricing Increments, Access Fees, and Transparency of Better Priced Orders" (Release No. 34-96494; File No. S7-30-22)("the Tick Size Proposal"); https://www.sec.gov/rules/proposed/2022/34-96494.pdf (December 14, 2022)

38 Kirsten Wegner, "5 market structure trends for lawmakers to watch in 2021," The Hill, December 8 2020

39 "ICMA's 3rd study into the state and evolution of the European investment grade corporate bond secondary market," ICMA, March 2020

40 " An Automated Future: The Role of the Fixed Income Trader", page 22, Bloomberg, March 1 2021.

41 "Algorithmic Trading Market Research Report by Trading Type, by Component, by Deployment, by Organisation Size, by End User - Global Forecast to 2025 - Cumulative Impact of COVID-19," Intrado, January 19 2021

The History of Automated Trading

1960–1990

Human “floor specialists” match buy and sell orders on stock exchange trading floors, while “floor brokers” at trading posts work customer orders.

1995

Floor specialists on exchanges see their market dominance challenged by the competition of electronic trading and computers. The cost of trading is $6 for $100 in stocks. On Nasdaq, tick sizes of 1/8 dollar for stocks at or above $10 per share and 1/32 dollar for bid quotations are below $10 per share.

2000–2001

Tick size moves to a penny in a move known as “decimalization.” Nasdaq and ISE move toward electronic trading.

2003

Man vs. Machine. In the fall, Congress holds a hearing on the floor specialists amid criticism that the human intermediaries were slow with 10 to 30 second lag times in trading, and that the market structure of the past needed to be updated to changing times and technologies. A lawsuit against human specialists for front-running added fever pitch tension to the room.

2005

Reg NMS is adopted, and the SEC staff reports a growing consensus that the trade-through rule is outdated and needs reform, and that there are problems giving equal protection against trade throughs to both automated and manual protections.

2009–2020

The longest bull market in US stock market history lasts 11 years.

2010

On May 6, a $4.1 billion trade on the NYSE results in financial markets around the world simultaneously crashing without warning. The “Flash Crash” wipes out an estimated $1 billion in market capitalization before rebounding. The SEC responded in September with rules to expand a circuit breaker rule for cross-market trading halts.

2013

Modern Markets Initiative (MMI) is established, to educate the public on market automation, including the role of high frequency trading in democratizing the markets by reducing the cost of trading for investors and providing dependable liquidity.

2014

About half of investors are invested directly or indirectly in the markets through a direct account, or through a 401k, 529, or pension plan. Congress enacts the Achieving a Better Life Experience (ABLE) Act of 2014 as an option for investors, allowing states to create tax-advantaged savings programs for eligible people with disabilities.

2016

ETF investing expands, made available through market automation and low-cost trading, with SPY crossing $200 billion in assets.

2019

Market automation further contributes to low-cost trading, and major industry players Fidelity Investments, Charles Schwab, E-Trade, TD Ameritrade, and Interactive Brokers among firms moving to zero commission trading.

2020

COVID19 causes major volatility to the stock markets, but markets continue to function as intended, with automated traders providing dependable liquidity. NYSE temporarily shifted to full electronic trading for first time in history, before reopening Trading Floor.

2021

Retail investor share of total trading volume reaches 22%, double the trading volume of 2011, with more women and minorities, and first-time traders participating in the markets.

2022–2023

The equities markets in the US are the best markets ever for retail investors when it comes to low-cost trading and dependable liquidity. While US markets are the gold standard and envy of the world, there is always room for improvement. In Q4 2022, the SEC proposes four rules to change US market structure, relating to Rule 605, tick size and access fees, best execution, and order competition, opening comments to the public.

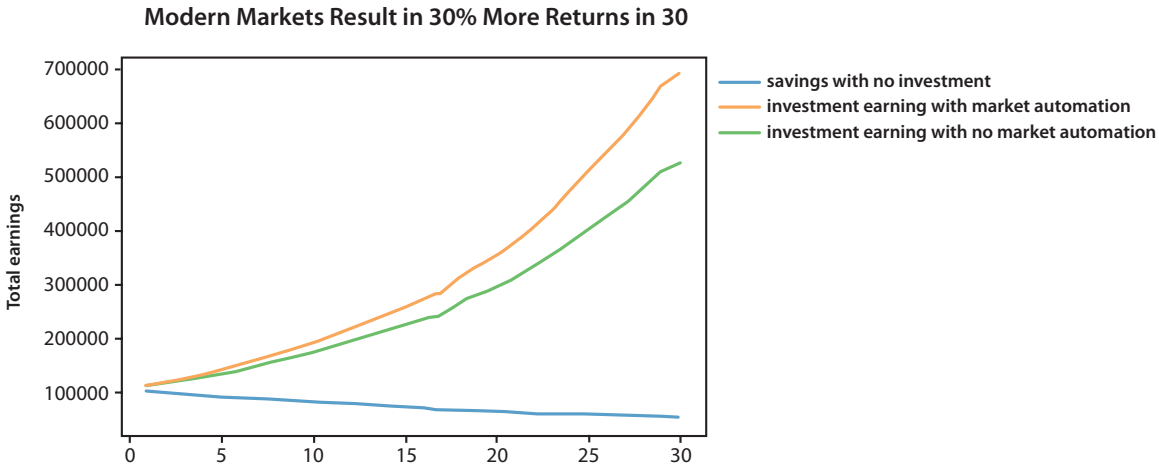
Automated Trading Technology: Savings for Individual Savers: 401(k) Holders, IRA Savers

The level of retail investors has risen over the past decades, with only 30% of Americans owning stock in 1990, and a general upward trend to over 50% of Americans owning stock around 2000 onward.[42] The volume of retail trading, as a percentage of overall market share, has also increased in the past year up to 25% of daily trading volume, up from a typical baseline of 10-15% of total market share in prior years.[43] There is room for optimism that the markets can be further democratized by encouraging underrepresented demographics, especially women and minorities, to invest in the markets and participate in the upside of long-term savings and investment.

Market automation (including automated trading, tech innovation at exchanges, ETFs, and regulatory reform) has had a positive impact on 401(k) and IRA holders across the United States. The rate of return of a 401k mutual fund with market automation is estimated to be 9% on average, while the rate without market automation is 8%. With the return rate difference, individual investors are projected to save $1,674/year (for 10 years) and $5,243/year (for 30 years) in reduced trading costs as a result of automated markets per year, for an average 401(k) portfolio or IRA plan with $100,000 in assets. The estimated savings of market automation over a lifetime of a 401(k) account of this size is a total of an additional $157,311 after 30 years more than the investor would have in his or her account without market automation.

Note that we assumed a consistent 9% or 8% return of the 401(k) mutual fund, but in reality, even when the average annual return remains constant, the return from one year to another can be drastically different. Investors could lose money over the investment or gain more than the expected return, and the earning pattern over the years will not be exponential. We also assumed a constant 0.04% savings account interest rate based on the current rate of banks. However, the savings account interest rate in the past may be different from the rate now. We could not find historical savings account interest rates beyond 2010, so we used a constant rate of 0.04% from today.

FIGURE 9: Retail Investor Savings from Market Automation With Inflation Adjustment



Source: Katherine Hong, MMI Fellow

From our estimate, an investor with $100,000 in principal, as the above graph shows, without market automation (e.g. in a 1990s era pre-tech exchanges, pre-ETFs, and pre-HFT and regs), the total amount would grow to $493,904, whereas with moderns markets of 2021 (including automated trading, technologically innovative exchanges, and innovative ETFs) the total amount would grow to $651,215. This represents an improvement on returns of more than 30% cumulatively - or more than $150,000 over a lifetime 30-year savings. Translated

42 Allison Schrager, "More Americans Own Stock Than Ever," Quartz Media, September 25 2019, https://qz.com/1700958/more-americans-own-stock-than-ever/.

43 Anush Mustyhyala, "529 Plan Savings" (2022).

to an everyday investor making $70,000 a year, this would equate to having to work two and a half years extra to reach the same retirement goal without market automation. Data is available.[44]

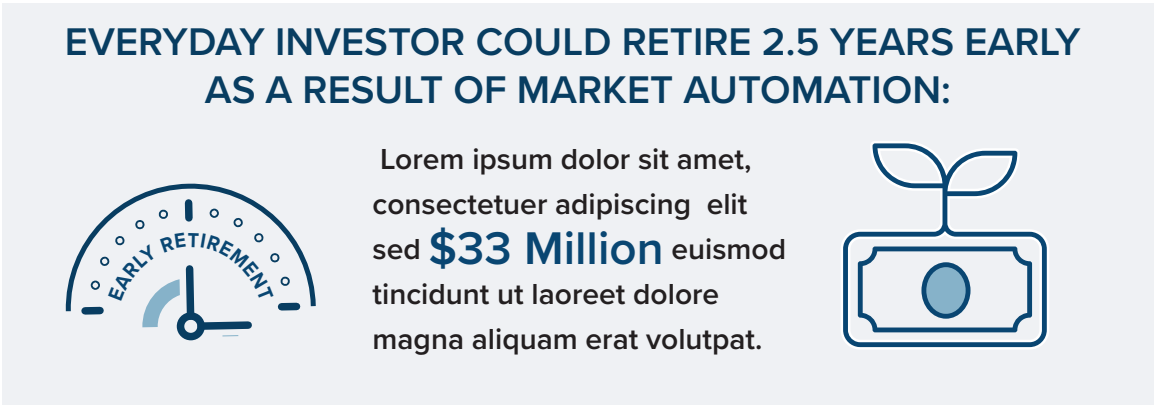
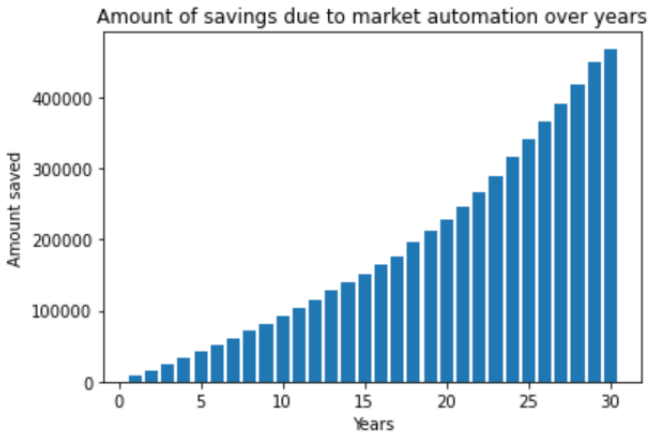


FIGURE 10: SAVINGS FROM MARKET AUTOMATION:



source: Anush Musthyala– MMI Fellow

The above graph highlights the exponential increase in savings as a result of the reduction in bid-ask spreads, building up to over $155,000 in savings over a lifetime.

About the 401(k) Industry

The 401(k) industry is primarily a savings vehicle for middle class Americans. Data shows that 401(k) savings plans primarily benefit middle class families, with 80% of participants in 401(k) plans making less than $100,000 per year, and 43% of participants making less than $50,000 per year[45]

As of September 2020, 401(k) plans held an estimated $7.3 trillion AUM in the United States and represented more than 20% of the $37.2 trillion in United States retirement assets. This is an increase from 2010, when 401(k) assets were valued at $3.1 trillion AUM and represented 17% of the United States retirement market[46].

Notably, of the 401(k) plans, about 65% of the assets were held in mutual funds. The remaining were held in company stock (stock of the employer), individual stocks and bonds, guaranteed investment contracts (GICs), bank collective trusts, life insurance separate accounts, and other pooled investment products[47].

44 Katherine Kong, "Individual Investors Savings Calculation," April 2022
George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," "...we conservatively estimate that transaction costs have declined 50 bps, or 100 bps round trip... Today's investor with a 30 year time horizon would see a $10,000 investment in such a fund grow to approximately $132,000 in 30 years, compared to approximately $100,000 with the hypothetical return of 8% associated with the higher transaction costs. Thus, any analysis of "high frequency trading" must recognize the corresponding benefits that long-term investors have experienced through tighter spreads and increased liquidity, "April 21, 2010, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf

45 American Retirement Association, November 12 2020, https://www.usaretirement.org/retirement-issues

46 "Frequently Asked Questions About 401(k) Plan Research," Investment Company Institute, July 24 2019, https://www.ici.org/faqs/faq/401k/faqs_401k

47 Frequently Asked Questions About 401(k) Plan Research," Investment Company Institute, July 24 2019, https://www.ici.org/policy/retirement/plan/401k/faqs_401kn

According to the Investment Company Institute (ICI):

- Average 401(k) account balances varied by participant age and tenure.
- Account balances were higher the longer the 401(k) plan participants worked for current employers and the older the participant.
- Participants in their forties with more than two to five years of tenure had an average 401(k) plan account balance of about $38,000.
- Participants in their sixties with more than 30 years of tenure have an average account balance of $287,000.
- The median 401(k) plan participant was 45 years old at year-end 2016, and the median job tenure was seven years.

Calculation of Savings for 401(k) Investor with $100,000 In Account

The following is an example of what the projected cost savings are for an individual 401(k) Plan Portfolio of $100,000, relative to the bid-ask spreads in a pre-market automation era. This model assumes that the 401(k) account is comprised of 60% equities, including mutual funds and employer stock, and 40% in fixed income (including bonds and debt), such that:

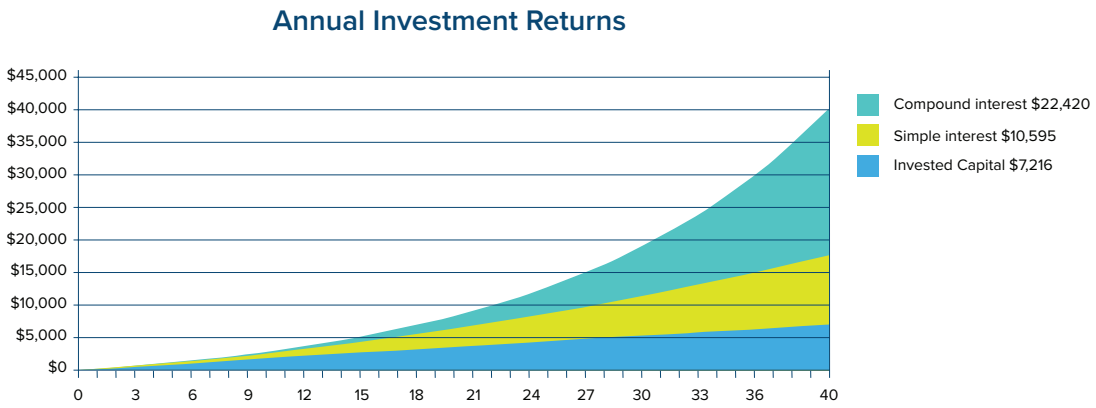
- $60,000 equities (including mutual funds and employer stock) x 0.67 turnover x 100 basis points in widened bid-ask spread without automated trading = $402
- $40,000 in fixed income/bonds/debt x 0.67 turnover x 100 basis points in widened bid-ask spread = $268
- If 100% in equities (including mutual funds and employer stock) x 0.67 turnover x 100 basis points in widened bid-ask spread without automated trading = $670.00[48]

For example, under this type of widened bid-ask spread without market automation (including automated trading, tech innovation at exchanges, ETFs, and regulatory reform), for every $100,000 of assets in a 401(k) plan, the saver would pay an additional $670.00 in the cost of trading of widened bid-ask spreads in a given year.

Utilizing the AARP's Compound interest calculator[49], the following calculation shows that over 40 years, paying in $670.00 a year, at 7% annual growth (the average for pension funds) would yield a total value of $77,860 after 40 years.

In other words, for a teacher who makes $83,059 a year that would equate to 11 months of working.

FIGURE 11: ANNUAL INVESTMENT RETURNS



48 Katherine Kong, "Individual Investors Savings Calculation," April 2022

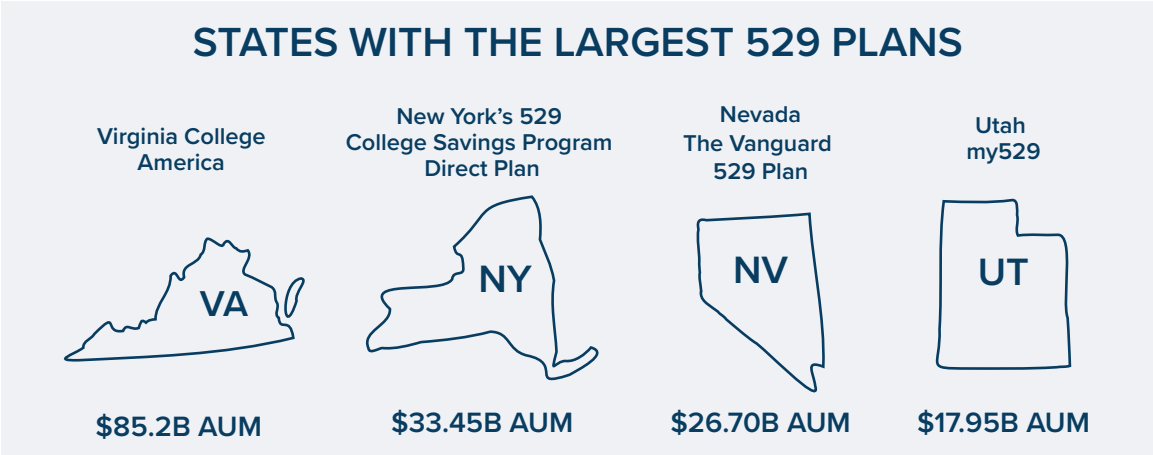
49 https://www.aarp.org/money/investing/investment_return_calculator/

Automated Trading Technology Savings: 529 College Savings Plans

Market automation (including automated trading, tech innovation at exchanges, ETFs, and regulatory reform) has positively impacted 529 College Savings Plan Portfolios across the country, with projected cost savings of $570 million (Virginia College America) for a plan portfolio with a size of $85.2 billion range. 529 plans are a widely used tool for families to save for their children's education costs, with over 44% of parents utilizing 529 plans to help save for college.[50]

As of December 31, 2020, over 14.83 million families utilized 529 tax-advantaged savings plans for educational expenses. The total assets under management in 529 plans reached $425.2 billion, according to a 2020 report from the College Savings Plans Network.[51]

Many states offer a 529 College Savings plan. Among the largest state 529 plans are:



For a 529 Plan Portfolio with $85 billion ($85.2-California ScholarShare College Savings Plan) in assets under management, the projected cost savings of market automation is in annual cost savings.[52] This number assumes that the 529 plan with assets under management of $85.2 billion is invested 40% in stocks, 40% in debt, and 20% in derivatives or cash equivalents, with a turnover rate of 0.67, the average turnover rate for a mutual fund investment. The calculations are as follows:

- $22.833 billion stocks x 0.67 x 100 basis points savings = $228.34 million
- $22.833 billion in fixed income/ debt x 0.67 x 100 basis points savings= $228.34million
- $11.416 billion in derivatives x 0.67 x 100 basis points savings = 114.17 million

Under these assumptions, the total cost of trading by 529 plan portfolio in this example with $85.2 billion AUM would be $570 million saved because of market automation (collectively, including automated trading, tech innovation at exchanges, ETFs, and accompanying regulatory reform). In sum, the impact of the benefit of market automation on such a 529 plan would be equivalent to the cost of in-state tuition for approximately 57,000 students per year. Note the average tuition of a public state college is $9,970 for in-state residents[53].

This would mean that the cost savings of $18 million has saved the equivalent of full in-state tuition for more than 6,000 students in a given year for a single state plan.

50 National Association of State Treasurers, February 2021
Anush Mustyhyala, "529 Plan Savings" (2023).

51 "Total Assets in 529 Plans Nationally," College Savings, June 30 2020, https://www.collegesavings.org/wp-content/uploads/2020/09/CSPN-2020-MYD-Infographic.pdf

52 Anush Mustyhyala, "529 Plan Savings" (2023).
Note: 2020 data verses 2012 – past decade; based on the price improvement between 2002 and 2012 – when HFT revolutionized bid-ask spreads; gave us the spreads on the paper, did give us the average 2002- 2020; Vanguard paper estimates a 100 basis point round trip reduction in cost, or 50 basis points reduced, https://www.sec.gov/comments/s7-02-10/s70210-122.pdf (data that supports the conclusion that bid-ask spreads have narrowed by at least 50 basis points since 2002.

53 The average tuition is $9,970 for state residents at public colleges
https://www.collegedata.com/en/pay-your-way/college-sticker-shock/how-much-does-college-cost/whats-the-price-tag-for-a-college-education/

Automated Trading Technology Savings: Public Pension Plans

Public Pension Plans

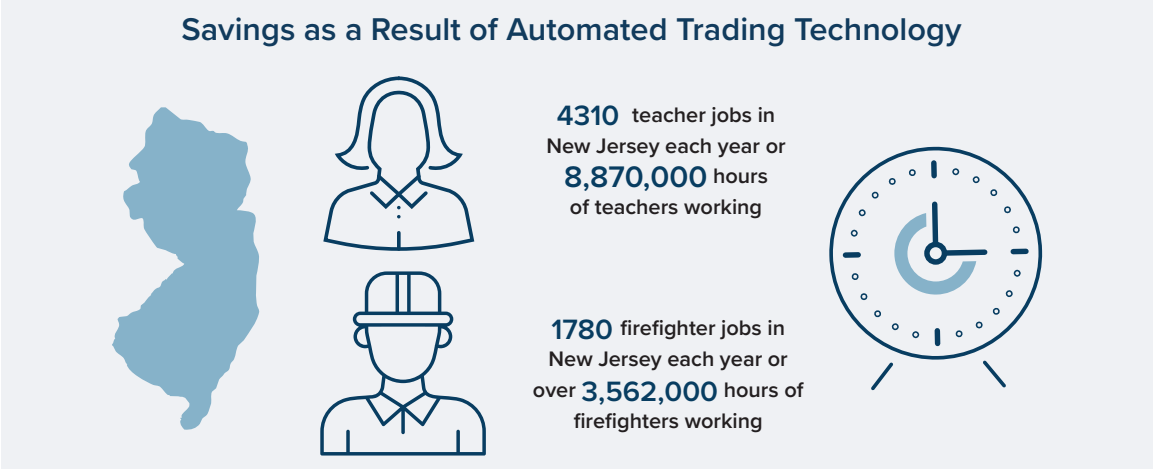
Market automation (including automated trading, tech innovation at exchanges, ETFs, and accompanying regulatory reform to modernize regulation in response to innovation) has yielded cost savings to public pension funds through lower transaction costs. For example, for a pension fund with $87 billion of assets under management, it is projected that the cost savings as a result of lowered transaction costs in a given year is $296 million.

New Jersey Division of Pension and Benefits ($99.37 Billion AUM) = $125 Million Projected Annual Savings from Automated Trading

The calculations are as follows:

- $35.94 billion domestic equity x 0.26 turnover x 100 basis points savings (total round-trip, includes 50 basis points each way purchase and sale) = $93.46 million
- $11.63 billion in fixed income /debt x .26 turnover x 100 basis points savings (total round-trip, includes 50 basis points each way purchase and sale) = $136.14 million
- $212.89 million in derivatives x 0.26 turnover x 100 basis points (total round-trip, includes 50 basis points each way purchase and sale= $2.02 million[54]

As a result of market automation, saving pension funds millions a year, the pension funds are able to deploy those funds directly to the plan participants and offset the need for further funding gaps from the state. For example, for the New Jersey pension savings of $125 million projected a year, this equals about:



55 56

CalPERS ($392.5 Billion AUM) = $1.95 Billion Projected Annual Savings from Automated Trading

The assumptions are as follows:

- We assume that the 401(k) asset-weighted average portfolio turnover rate is 26% according to an Investment Company Institute report in 2021[57].

54 Anush Musthyala, "Calculation of Bid-Ask Spread Savings for New Jersey Pension Plan" (2023)

55 As of Mar 3, 2021, the average annual pay for a Teacher in New Jersey is $28 a year (or $14/hour) https://www.ziprecruiter.com/Salaries/Teacher-Salary--in-New-Jersey

56 As of February 26, 2021, the average Fire Fighter salary in New Jersey is $53,953 a year https://www.salary.com/research/salary/benchmark/fire-fighter-salary/nj

57 Investment Company Institute, June 2021, The Economics of Providing 401(k) Plans: Services, Fees, and Expenses, 2020. https://www.ici.org/system/files/2021-06/per27-06.pdf

- Total market automation savings = total AUM × turnover rate × market automation savings in bps
- CalPERS invests in five main categories of assets: short-term investments, public equity, fixed income, real assets, private equity, and debt. Out of the five categories, public equity, fixed income, and short-term investment returns are impacted by market automation. Since real assets and private equity are not traded on exchanges, they are not impacted by market automation. The table below lists CalPERS assets under management by category.

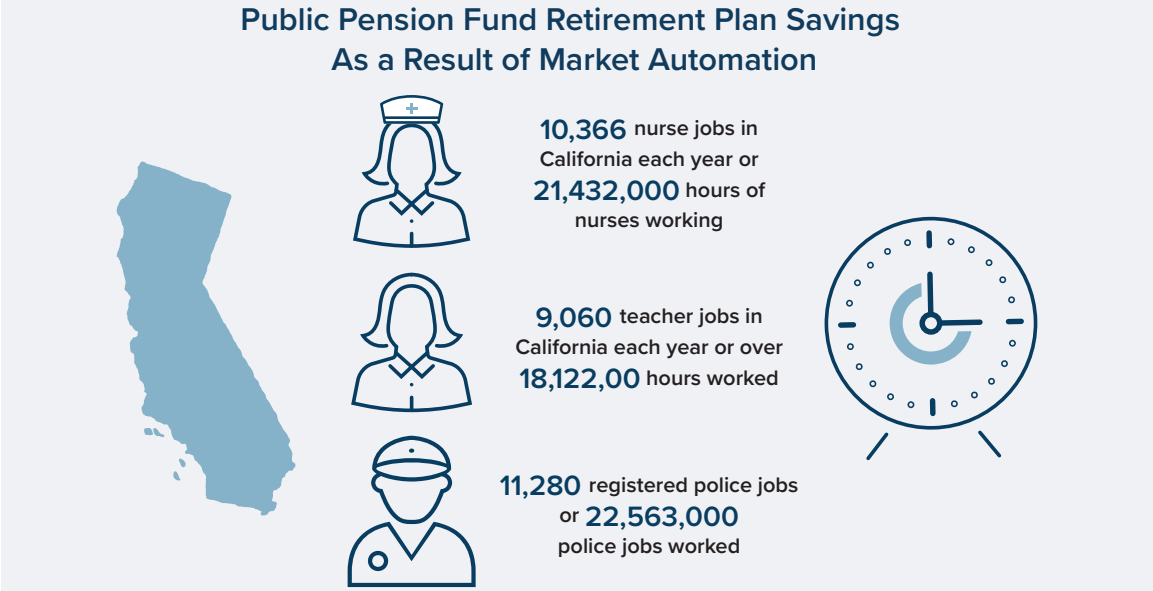
TABLE 1: PENSION FUND INVESTMENTS

Modeled Underlying Asset Allocation for Pension Fund Investments
Summary of Investments – PERF – As of June 30, 2021 (Dollars in Thousands)

Category	Book Value	Fair value	% of Investments at Fair Value
Short-Term Investments	$24,358,295	$24,311,494	5%
Public Equity	163,470,743	238,939,352	49%
Fixed Income	125,834,120	129,929,381	27%
Real Assets	31,222,280	47.207,101	10%
Private Equity/Debt	39,256,295	44,830,727	9%
TOTAL INVESTMENT VALUE	**$384,141,733**	**$485,218,055**	**100%**

The calculations are as follows:
(16.4 billion + 158.964 billion + 123.877 billion) * .26 * 100 bps = 778 million

As a result of market automation, CalPERS is able to deploy its funds more efficiently and maximize returns, without the drag on investment of wider spreads and increased trading costs that were present in a pre-automated trading era of the 1990s for example. For example, for the CalPERS pension savings of $778 million projected a year, as a result of market automation, which equals about:



58 59 60

58 As of February 1, 2023, the approximate number of registered nurses is 510, 265 https://www.rn.ca.gov/consumers/stats.shtml; As of February 27, 2023 the average annual pay for a registered nurse is $75,050 a year ($36.30/hr)https://www.salary.com/research/salary/alternate/registered-nurse-rn-level-1-salary/ca

59 As of January 13, 2021 there are 307,000 teachers in California. As of September 21, 2022 the average salary is $85,856 a year ($42.93/hr) https://www.ed-data.org/article/Teachers-in-California https://www.cde.ca.gov/fg/fr/sa/cefavgsalaries.asp

60 As of 2021, there are 117,600 registered police in California https://www.ppic.org/publication/law-enforcement-staffing-in-california/#:~:text=Almost%20half%20of%20California's%20law,about%2041%2C600%20were%20civilian%20staff. As of February 27, 2023 the average annual pay for a police officer is $68,956 a year ($34.48/hr) https://www.salary.com/research/salary/benchmark/police-patrol-officer-salary/ca

The cost savings allows pension funds instead to invest directly to the plan participants and to offset the need for further funding gaps from the state.

Automated Trading Technology Savings: ABLE Plans

The past decade has seen the rise of ABLE plans to allow investors to save for the care of disabled dependents through tax-advantaged accounts. With more than $878 million in assets under management spread across more than 100,874 accounts nationwide, 43 States and the District of Columbia currently offer Plans to their residents.[61] Among the most recent trends and developments in the ABLE market are:

- Multi-state collaborative structures are accumulating assets and accounts faster than smaller individual States could have achieved on their own.
- While legislative and operational factors have limited the size and scope of ABLE Plans, the industry has experienced significant growth, reflecting the commitment of States to offer this product and the demand for it from participants.
- Simplicity, low cost, and flexibility are key features that have enhanced the appeal of ABLE Plans to account holders.
- The following are calculations of the benefit of market automation to ABLE plans.

62

ABLE United 2021 - Florida ($48 Million AUM) = $7.2 Million Projected Annual Savings from Automated Trading

The calculations are as follows:

TABLE 2: STATEMENT OF ACTIVITIES

Modeled Statement of Activities for Florida ABLE Plan

STATEMENT OF ACTIVITIES			
YEAR ENDED JUNE 30	2021	2020	CHANGE
Additions	$29,103,176	$16,079,894	80.99%
Deductions	($7,547,539)	($5,639,223)	33.84%
Increase in net position	$21,555,637	$10,440,671	106.46%
Net position, beginning	$29,433,478	$18,992,807	54.97%
Net position, ending	$50,989,115	$29,433,478	73.24%

61 Paul Curley, CFA, "2Q 2021 529 and ABLE Market Sizing Highlights" (August 6, 2021)

62 Hourly Cost Of Home Health Care Average $25/Hour. $7.2 Million Divided By $25 Equals 288,000 Hours Of Home Health Care

- Minimum of securities bought or sold (for 2021): $7,547,539
- NAV: $50,989,115
- Portfolio Turnover ratio: 7,547,539 /50,989,115 = 0.148 = 0.15
- **Market Savings Calculation: $48,109,713*0.15*1.0 = $7,216,456.95 = $7.2 million**

It is worth noting that the turnover value is quite indicating that the plan is risk averse despite being a tax-free account.

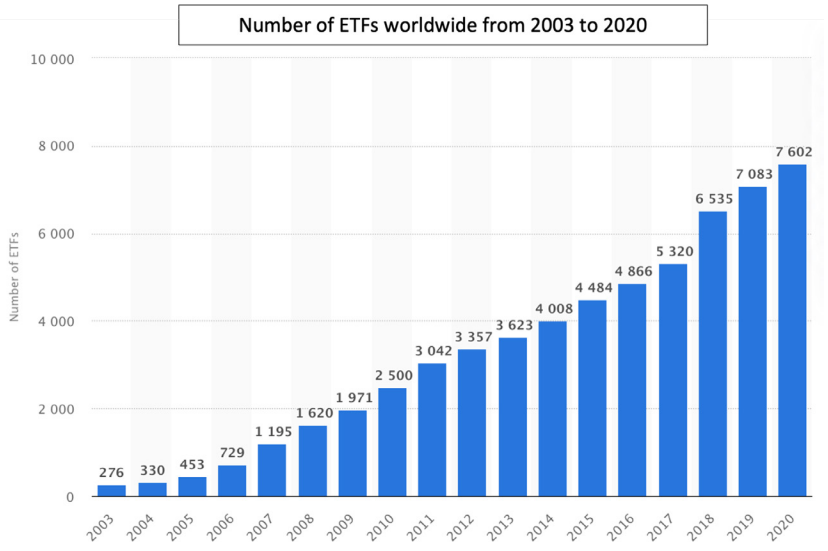
Evolution of ETFs, Index Funds, Low-Cost Products to Diversify Risk

The ETF industry has grown over the past decades, leveraging market efficiencies and technological innovation. It is anticipated that assets in ETFs are poised to hit $50 trillion in the United States by 2030, up from $5.3 trillion in assets in the United States at the end of 2020.[63] Automated trading technology is key to market efficiency underlying ETFs, as ETFs are rebalanced continuously with low cost and deep liquidity. [64]

In a 2013 interview, the head of Credit Suisse noted the connection between ETFs and automated trading:

The following graph shows the tremendous growth and popularity of ETFs as a low-cost investment tool for retail and institutional investors over the past decades:

FIGURE 15: ETF GROWTH



Source: Statista[65]

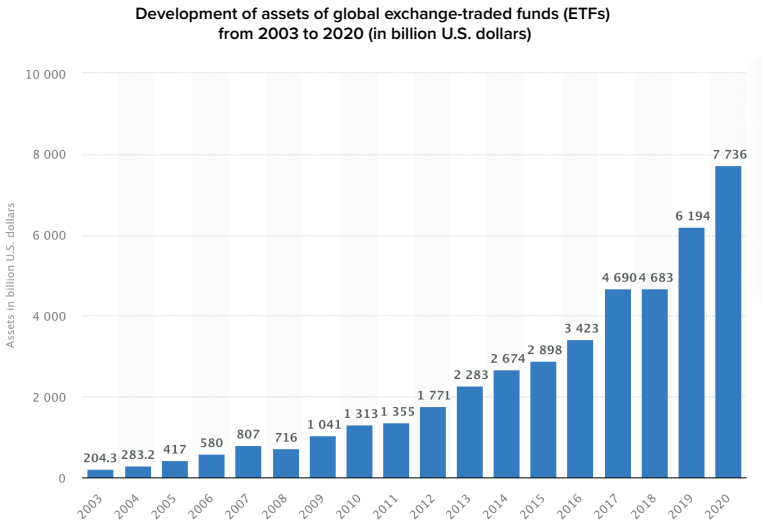
The above graph shows the ETF industry's tremendous growth, with a proliferation of initially 273 different ETF products at the outset of 2003, up to more than 7,600 different ETF products offered by 2020. This reflects the tremendous demand for ETFs among retail and institutional investors as a source of investment products. ETFs have been lauded by proponents as a way to diversify risk among a basket of stocks or industries, and a way to reduce cost of investment through passive investment rather than actively managed stock portfolios.

63 Carmen Reinicke, "The ETF market will hit $50 trillion by 2030, Bank of America says," Markets Insider, December 13 2019, https://markets.businessinsider.com/news/stocks/etf-market-grow-50-trillion-assets-2030-bank-america-passive-2019-12-1028763048?op=1

64 Drew Voros, "High Frequency Trading Key to ETFs," ETF.com, September 25 2013, https://www.etf.com/sections/features/19955-high-frequency-trading-key-to-etfs.html?nopaging=1

65 https://www.statista.com/statistics/278249/global-number-of-etfs/

FIGURE 16: Development of assets of global exchange-traded funds (ETFs) from 2003 to 2020 (in billion U.S. dollars)



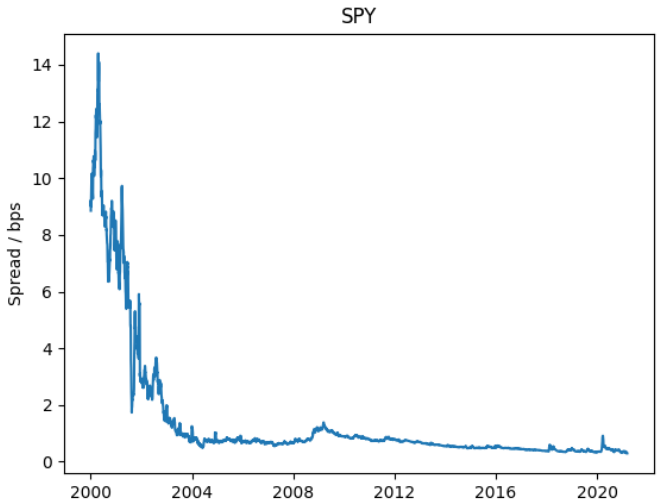
Source: Bloomberg; Deutsche Bank; Thomson Reuters; ETFG [66]

The above graph shows the expansion of the assets in management in the ETF industry, rising from 204 billion in 2003, to 7.7 trillion in 2020. This rapid expansion in assets under management is a reflection of the growing demand for this low-cost investment product for retail and institutional investors.

Notably, market automation and lower cost of trading have coincided with the move toward ETFs, index funds, and other asset classes that must continuously be rebalanced. ETFs must rebalance, or re-adjust their basket of holdings over a year to bring their underlying components in conformance with benchmark indices, potentially rebalancing billions of dollars of investment holdings, with narrow bid-ask spreads important in those indexing events[67].

The following is a graph that shows a dramatic decline in the bid-ask spread of a popular ETF known as the "SPY":

FIGURE 17: SPY BID-ASK SPREAD



Source: Large Market Maker

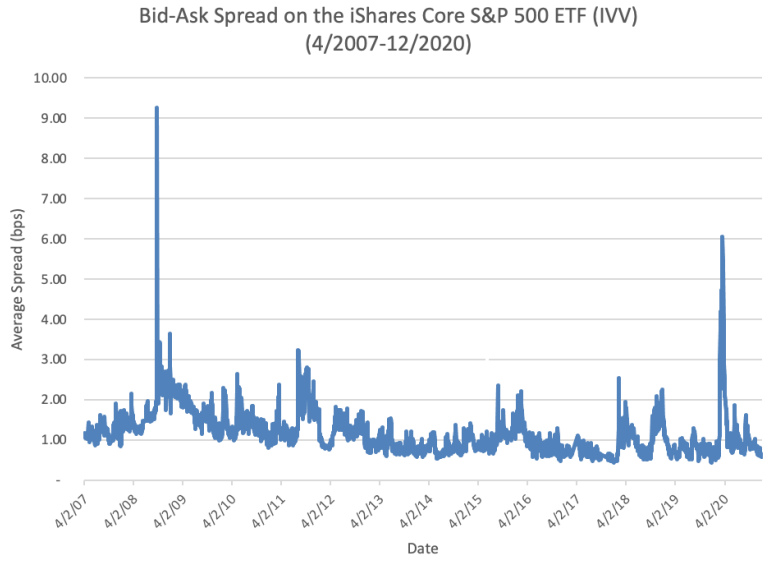
66 https://www.statista.com/statistics/224579/worldwide-etf-assets-under-management-since-1997/#:~:text=In%202020%2C%20the%20assets%20managed,approximately%207.74%20trillion%20U.S.%20dollars.

67 https://www.etftrends.com/smart-beta-channel/etf-portfolio-rebalancing-reflects-importance-of-indexing/

As shown in this graph, the bid-ask spread has declined from over 14 basis points in 2001, to level off at roughly 1 basis point since 2012. Since the inception of automated trading and automated trading technology in the early 2000s, bid-ask spreads have narrowed as competition between electronic market makers increased, and the former floor-based human specialists were displaced. For an investor in $10,000 of SPY ETF in 2001, applying a 14 basis point bid-ask spread, the investor would have paid an additional $14.00 in spread, compared to $1 in spread in modern markets. Note: High-volume securities such as index exchange-traded funds (ETFs) are usually highly liquid with narrow spreads. This may be the cause of why the bid-ask spread is smaller compared to other stocks with lower volumes, which would have wider spreads.

The following additional graph shows a consistent narrow bid-ask spread between 2007 and 2020 in a non-volatile period on the iShares ETFs in the 1 to 2.5 basis point range:

FIGURE 18: BID-ASK SPREAD ON ISHARES CORE S&P 500

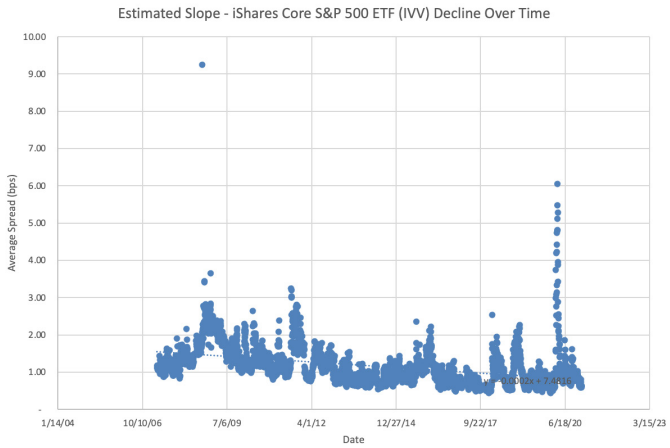


Source: Blackrock

The above graph on bid-ask spread on iShares ETF (which represents a portfolio of larger publicly traded companies) demonstrates that during periods of volatility including market disruption in 2008 and Covid volatility in Q1 2020, there was a widening of bid-ask spreads to the 9 and 6 basis point level, respectively.

Further, collecting data from various ETF spread sources, the below graph shows a downward slope overall in bid-ask spreads on ETFs over the past decades:

FIGURE 19: ETF BID-ASK SPREADS SPREADS



Source: Modern Markets Initiative

Methodology

The following are key metrics that a Portfolio would need to identify the cost savings of market automation:

100 Basis Point Reduced Bid-Ask Spread Calculations. On the calculations, the savings from market automation is calculated using the round-trip cost of rebalancing a stock for the sale, and repurchase, of an asset class, with savings being 100 basis points, the sum of two 50 basis point savings on the sale and purchase of a security. This number is arrived at from research by Professor Charles Jones, who writes that the cost of trading has come down from 50-60 basis points pre-market automation in the 1990s,[68] to a current level of about 1 basis point.

Turnover. When calculating how much a Portfolio would benefit from reduced bid-ask spreads, the Portfolio would need to utilize the "turnover" of the value of the portfolio (also called the "notional value", rather than the total assets in the portfolio. This is essentially the frequency with which a fund is rebalanced, or the value is turned over.

Example: Portfolio has $2 billion in stock assets value, and has a turnover rate of 67%, meaning that each of those assets is bought and sold 0.67 times a year (e.g. for managing risk, buying options, other risk management; this is the average for mutual funds); the savings of market automation would be on the $1.34 billion in stock assets (the "turnover" or "notional value") rather than the total $2 billion under management. This is arrived at by multiplying $2 billion times 0.67 turnover rate for the value that would be subject to the savings from market automation.

Asset-weighted average turnover rates have varied for mutual funds over the past few decades between 22% and highs of 70%. For example, for mutual funds, in the 2000s, turnover was 70%. As of 2010, actively managed mutual funds had an asset-weighted average turnover rate of 41%. The more recent turnover rate average is 26%.[69]

For purposes of this Report's calculations, research was conducted on average turnover rates in various investment vehicles, as well as historically available data. The following assumptions are used for utilizing:

- Individual 401(k) Plans – turnover of 100%
- 529 College Savings Plans – turnover of 67%
- Public Pension Funds – turnover of 26%
- University Endowments – turnover of 32%

Notably, investors utilizing ETFs or other pooled investment vehicles must factor in a higher rate of turnover, as those products are continuously rebalanced.

Turnover Formula - Where turnover is not based on assumptions of averages of asset classes, but rather on actual historic turnover, the following formulas were used for calculations.

$$\text{Portfolio Turnover Ratio} = \frac{\text{Minimum of Securities Bought or Sold}}{\text{Average Net Assets}} \times 100$$

Source: Source: Corporate Finance Institute[70]

In this formula, the Minimum of securities bought or sold references the total dollar amount of new securities purchased or the total amount of securities sold (whichever is less) over a one-year term.

68 Charles M. Jones, "What do we know about high-frequency trading," Columbia Business School, February 25 2013, at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2236201.

69 https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/portfolio-turnover-ratio/

70 https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/portfolio-turnover-ratio/

In this formula, the Average net assets are equal to the average monthly dollar amount of net assets in the fund.

Where data is publicly available, this report takes into account data available on minimum securities bought or sold and average net assets to arrive at a turnover rate. Where data is not available, the report relies on stated industry averages for different asset classes.

Notably, historically it is difficult to make assumptions utilizing a single turnover rate as the rates have historically varied over the years. The following is data from the Corporate Finance Institute, on fluctuating levels of turnover in past years in equities market mutual funds:

TABLE 3

Average Portfolio Turnover Rates for Equity Mutual Funds

Percentage of assets

Year	Industry asset-weighted average portfolio turnover rate	401(k) asset-weighed average portfolio turnover rate	Simple average portfolio turnover rate
2000	78	70	103
2005	51	43	84
2010	50	41	97
2015	34	26	66
2016	34	27	68
2017	30	24	61
2018	32	26	65
2019	28	22	59
2020	32	26	67

Note: The turnover rate is the lesser of a fund's purchases or sales of portfolio securities for the year divided by the fund's average total net assets for the year.
Source: Investment Company Institute

Source: Corporate Finance Institute, Figure 10 [71]

Notably, turnover rates have generally declined from .78 to .32 in industry, weighted asset classes, but the simple average portfolio turnover rate remains at .67. In this study, we use the asset class weighted turnover rate.

Asset Classes. Certain asset classes have different types of average turnover rates or range assumptions, where data on the actual turnover rates is not available, and average turnover for different asset classes is used instead for calculations. For purposes of this report's calculations, the following assumptions are used:

- Individual 401(k) Plans – distribution of 60% equities, 40% bonds
- 529 Plans – distribution of 40% equities, 40% bonds, and 20% derivatives
- Public Pension Funds – distribution of 40% equities, 40% bonds, and 20% derivatives
- University Endowments (large) – distribution of 30% equities, 30% bonds and derivatives, and 40% other – e.g. private equity, VC, real estate

Notably, the types of asset allocations vary between individual Portfolios, and the numbers utilized are intended to be directionally correct, utilizing hypothetical allocations and assumptions.

71 https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/portfolio-turnover-ratio/

Conclusion

The efficiency and effectiveness of the modern markets in the United States is in large part due to innovation. Just some 30 years ago, computers were far from commonplace and networks connections and speed were but a minuscule fraction of what they are today. “Open outcry” trading still ruled the day with orders being taken over the telephone with steep transaction fees. But with the advent of the 21st Century – innovation took hold on Wall Street, led by technologists who created what we know today as automated trading – the backbone of the capital markets.

As this report documents, the results have been a staggering success for retail and institutional investors. Faster trade execution, far more precise pricing, more money saved for retirement faster, a diversified product set, and new opportunities for hedging. In essence, high frequency trading reinvented equities investing this century, to the benefit of all investors, regardless of order size.

HFT market making firms benefit investors -large and small - through provision of liquidity including in times of volatility, and in reducing the cost of trading through narrowed bid-ask spreads. Investors benefit from the cumulative savings over a lifetime of narrowed bid ask spreads with increased lifetime savings, and improved lifetime returns whether for a 529 plan participant, 401(k)s, pension funds, ABLE fund, or otherwise. As a result of HFT market automation, savers have shaved off additional years they would need to work to reach the same retirement goals. Savers for college have more in their accounts to pay for education. Everyday investors benefit from the cumulative savings of narrowed bid-ask spreads from HFT firms.

Over the turbulent times of the past three years, the US equities markets have been tested with historic volatility like never before. Despite the turbulence, the equities markets have functioned as intended, with the markets remaining open for price discovery, with dependable liquidity from HFT automated trading firms, and with retail investors able to get in and out of their positions.

Looking ahead, there is room for more thoughtful and empirical-based review of equity market structure to make further enhancements to the markets. Although the US equities markets are the envy of the world, there is always room for improvement. Among the items that may be considered for potential improvements are increased transparency initiatives so investors can make informed order routing decisions, as well as review of tick size on, for example, tick constrained stocks. Such enhancements to market structure are best conducted through thoughtful discussions in roundtables, public-private information sharing, and other open exchange between regulators and industry to optimize empirical data and analysis.