MODERN MARKETS INITIATIVE

March 24, 2023

By electronic mail to rule-comments@sec.gov

Vanessa Countryman
Secretary
U.S. Securities and Exchange Commission
100 F Street, N.E.
Washington, D.C. 20549-0609

Re: **Disclosure of Order Execution Information (Release No. 34-96493; File No. S7-29-22); Regulation NMS: Minimum Pricing Increments, Access Fees, and Transparency of Better Priced Orders (Release No. 34-96494; File No. S7-30-22); Order Competition Rule (Release No. 34-96495; File No. S7-31-22)**

Dear Ms. Countryman:

Modern Markets Initiative ("MMI"), the education and advocacy organization devoted to the role of technological innovation in creating the world's best markets, appreciates the opportunity to provide written comments to the U.S. Securities and Exchange Commission (the "SEC" or "Commission") in connection with (1) "Disclosure of Order Execution Information" Release No. 34-96493; File No. S7-29-22)("Section 605 Proposal"); (2) "Minimum Pricing Increments, Access Fees, and Transparency of Better Priced Orders" (Release No. 34-96494; File No. S7-30-22)("the Tick Size Proposal"); and (3) "Order Competition Rule" (Release No. 34-96495; File No. S7-31-22)(or "the Order Competition Proposal").

MMI members collectively employ more than 2000 people in over 50 markets globally, and account for approximately 20 percent of daily trading volume in the U.S. equity markets. MMI's members deploy automated trading technology systems to enhance efficiency of trading for retail and institutional investors.

I. Introduction: Best Markets Ever For Investors

The U.S. equity markets are the envy of the world for retail investors, with the most liquid markets and lowest-cost trading. Roughly half of all Americans invest directly or indirectly in these markets through a 401k, 529, or pension. It is therefore vital that the SEC proceed with changes to markets carefully, so as not to disrupt what works so well.

As detailed in MMI's 2022 study, "A Report on Market Automation and Dependable Liquidity in Times of Uncertainty: Investor Savings" (attached hereto), there has never been a more cost-effective time to be a retail investor than today. As a result of market automation, the cost of

trading has more than halved over the past decades through reduced bid-ask spreads, resulting in 30% more lifetime savings in investor bank accounts over 30 years. The ultimate beneficiaries of the narrowed bid-ask spreads include the 50% of Americans invested in the U.S. equity markets - either directly or indirectly through a pension, 401k, ABLE plan, or other investment vehicle. Whereas in the 1990s, the average spread was 60 basis points, this has dropped to an average bid-ask spread of 1-2 basis points by 2023. Costs decreased significantly during the rapid adoption of automated trading technology in the early 2000s and 2010s, but have continued to decline as automated trading technology became widely deployed and the industry standard for electronic market making.

Although the U.S. markets are the best ever in history for investors in terms of cost and dependable liquidity, there is always room to consider incremental improvements. MMI supports an open dialogue, including roundtables, discussions, and information exchange, between the Commission and industry, to maximize efficiencies in the cost of trading and liquidity provision and mitigate potential unintended consequences.

II. Sequential Approach to Consideration and Implementation

Given the positive state of the current equity markets and the lack of consensus around the need for the full set of concurrent proposals, MMI cannot support the Commission's framework as proposed. Each of the proposals will individually result in material changes to markets; taken together as a "Big Bang" change, it is almost impossible to predict all of the interactions (indeed, the proposals do not present analysis on the collective impact of the four proposals together). Such a large, unpredictable implementation opens the door to unnecessary systemic risk for markets and, potentially, harm to investors.

At the same time, MMI does support data driven efforts to improve market structure where new regulation is tailored to address demonstrable market needs. Portions of the Commission's proposed framework fit within this rubric and should be considered as part of an incremental approach to updating equity market structure. This incremental approach should proceed as follows: (1) adopt Section 605 Proposal as a first step; (2) implement a limited version of the Tick Size Proposal as a second step with a built-in *dynamic review mechanism;* and (3) consider moving forward with a revised version of the Order Competition Proposal only if deemed advisable following data analysis on the interplay and market impact of the other proposals and altered to account for industry feedback on its design. MMI is not submitting comments for the SEC's Best Execution Proposal, but believes it should be considered sequentially, after the Section 605 and Tick Size Proposals.

Consistent with the above, MMI urges the Commission to examine, approve and implement each proposal sequentially and only if justified at the time of consideration based on analysis of market needs. Each proposal on its own, if implemented, may completely change the need for, as well as the cost-benefit analysis of, the others. Ideally, as one proposal is approved and implemented, market impacts would be evaluated empirically before other proposals proceed.

Under an incremental approach, the Commission and public would also benefit from additional time for review and discussion. For example, during the period in which Section 605 and modified Tick Size Proposals are being phased in, the Commission could concurrently host roundtables and other public engagement and evaluate the extent to which further changes are necessary to achieve stated goals, taking into account data on market quality after proposals are implemented.

III. First Step: Section 605 Reform

As a first step, the SEC should proceed with the Section 605 Proposal, for which there is broad support. The amendments are a common-sense enhancement to transparency for investors, resulting in their greater ability to optimize order routing. More granular execution quality metrics and more practical formats will enable investors to compare "apples to apples" in making routing decisions in an increasingly fragmented marketplace.

The transparency afforded by the Section 605 amendments may change the behavior of investors, with further information about price improvement, speed of execution, lowest commission, and other data to inform routing decisions.

Finally, we hope that the changes to Rule 605 reporting will be completed and in place *before* the implementation of any of the other changes, so that the metrics reported can be used to gauge the effectiveness of changes to tick sizes, etc.

IV. Second Step: Tick Size Proposal - With *Dynamic Review Mechanism*

Second, the Commission should move forward with a limited and modified version of the Tick Size Proposal, incorporating a dynamic review mechanism to evaluate for adjustments as needed. Although there is growing consensus for some adjustment to tick sizes to address tick-constrained stocks, it is difficult *and unnecessary* to try to forecast precisely how such changes will impact the markets in practice and adopt across-the-board changes without first real world analysis of outcomes. A limited roll-out and evidence-based review mechanism will be necessary to safely manage the change.

At a high level, MMI recommends:

1. **Limited Initial Roll-Out.** The Commission should start by adopting and implementing a limited version of the Tick Size Proposal that only applies tick changes to those stocks that are demonstrated to be tick constrained. Based on analysis of the impact that tick changes have to these stocks, the Commission could consider extending tick size changes to additional stocks.

2. **Proceed Incrementally With an Initial Single Change to Tick Size Increment First.** To minimize risk of disruption, the Commission could begin in a gradual fashion by implementing an initial tick size increment (such as for tick constrained stocks) and

gather data on market impact, before deciding whether to move ahead with further changes.

3. **Build Adaptability and Feedback Loops Into the Plan.** The plan – and all market participants who implement it – should assume that incremental changes may be ongoing after the first iteration. In this way, the Commission can avoid the complexity of trying to predict the compound effects of multiple changes to tick size increments if evidence from initial changes supports refinements to the size of increment and/or extension to additional stocks.

4. **Publish the Tick Size for Every Stock Regularly.** The plan should require the primary/listing exchanges to publish ticker lists to their public websites, accessible to all participants and vendors, with the minimum pricing increment of every stock; and to publish the same data via the SIP every day. Market participants would be able to access this data freely and adjust their systems to any changes. This creates a flexible, dynamic framework that allows for iteration. The question of *how to set the tick size for each stock* should be considered separately from the operational implementation.

5. **Controlled Rollout.** Best practices dictate focusing on a specific subset prior to a broadscale rollout. Tick size changes should be made to a relatively small number of stocks on any given day. The SEC should not attempt a large change all at once, given the difficulty of confidently predicting all of the consequences.

6. **Employ a Dynamic Review Mechanism to Test Spreads in Practice, Establish Common Metrics and Parameters (Spread Leeway), and Allow for Further Adjustments.** Unforeseen market circumstances may arise necessitating further review, and conditions can change dramatically in a matter of months. The Tick Size Proposal should include a Dynamic Review Mechanism, with common, agreed-upon metrics for adjusting tick sizes in the future. A Dynamic Review may indicate that based on changes to market dynamics or other reasons, no further increments may be needed, or conversely, that it should be extended to additional stocks.

7. **Flexibility.** The iterative plan should include a provision for moving a stock *back to a larger tick size* if the reviews show that a change was ineffective or "went too far."

8. **Provide the Public With Data on Reg NMS Bid-Ask Spread History, for Noncommercial Use, for Purposes of Commenting on Proposal.** The Commission should make available to the public for comment the historic bid-ask data on which the Tick Size Proposal was drafted. MMI notes the importance of having access to a data set on Reg NMS bid-ask spread history (for the noncommercial use of replying to these proposals). Although current bid-ask spread data is derivable from public data, historic data going back several years on spreads of Reg NMS stocks is not presently available for free to the public. This historic data would be useful in

conducting analysis over a historic three month period on spread leeway, as well as to provide input on the frequency with which spreads may change for a given NMS stock, to evaluate whether the Tick Size Proposal's quarterly reporting are frequent enough in balancing the need for precision versus the pragmatics of compliance.

RESPONSES TO QUESTIONS PRESENTED:

(Q2) Are the proposed minimum pricing increments appropriate for NMS stocks? If not, why not, and what minimum pricing increments would be appropriate?

Setting exact parameters across a wide range of securities is a complex task. MMI members believe it will be difficult to achieve a perfect outcome on the first iteration and that any plan of this scale should set out clear criteria for success as well as build in a mechanism for ongoing adjustments.

One criterion to measure success is "spread leeway," following on prior analysis by RGM Advisors, LLC.[1] This metric effectively quantifies the extent to which bid-ask spreads are constrained by the minimum tick size. Spread leeway is equal to the average quoted spread divided by the minimum tick size. Prior studies have suggested a spread leeway of 3-9 as optimal for tick sizes to be neither too small, nor too large. A small spread leeway (2 or less) indicates that the current tick increment is too large, and that bid-ask spreads are constrained by the minimum tick increment, making it harder for traders to post better quotes. Conversely, a large spread leeway (over 8 or 9) indicates that the current tick increment is too small, which could introduce "flickering" quotes and higher message rates as traders fine-tune prices.

If tick size is too small, it may lead to reduced visible liquidity, encourage undercutting behavior, and increase market data for events without a commensurate benefit for that cost.

By contrast, if a tick size is too large (e.g., larger than the bid-ask spread), then stocks are tick constrained, which incentivizes more trading off-exchange and harms price discovery.

(Q3) Should all NMS stocks have the same minimum pricing increment instead of the proposed variable minimum pricing increments determined by the proposed Time Weighted Average Quoted Spreads? If so, why? What should be the minimum pricing increment?

MMI supports the concept of an "intelligent" tick size as opposed to a "one size fits all" approach. MMI supports a framework that may evolve over time based on empirical data, including but not limited to optimal spread leeway.

The benefits of intelligent tick size, if calibrated correctly, include:

- Increased efficiency in price discovery for investors;

[1] https://www.sec.gov/comments/4-657/4657-40.pdf

- Efficiency in price discovery for "tick constrained" stocks; and
- Savings for investors and end users due to a narrower bid-ask spread.

(Q4) Are the proposed average quoted spread thresholds for each proposed minimum pricing increment appropriate? Why or why not?

Please refer to the above comments on spread leeway.

(Q6) Would the proposed minimum pricing increments cause flickering quotes? Please explain.

There is a potential for tick sizes that are too narrow to cause flickering quotes. Data would indicate where the tick size is too small - e.g., a spread leeway higher than 8/9 - this problem may present. During iterative reviews, the SEC and industry participants should evaluate this.

(Q10) Should the minimum pricing increment be modified on a quarterly basis? If not, how often should the minimum pricing increments be potentially modified, e.g., on a monthly basis, on a bi-annual basis, on an annual basis?

Overall, MMI members are neutral on the proposed quarterly basis modification, although a semi-annual basis may provide algorithmic models more time to adjust and decrease potential disruption. The frequency of updates should be reviewed after an initial period. The evaluation period preceding the change should be at least one quarter to avoid capturing instances of market volatility, or events such as stock splits that may indirectly drive trading interest that cause the behavior and characteristics of a stock to depart dramatically from its history.

(Q27) Should the primary listing exchange be required to provide an indicator of the applicable minimum pricing increments to competing consolidators, self- aggregators, and the appropriate exclusive SIP? Why or why not?

MMI supports requiring the primary listing exchange to provide an indicator of the applicable minimum pricing increments to competing consolidators, self-aggregators and the appropriate exclusive SIP. The Tick Size Proposal will be easier for industry to implement if tick size and lot size are publicly available on the SIP.

To be effective, this should be done in a well-organized, timely fashion: published on the SIP every morning as well as by the listing exchanges, on a public website, in a machine-readable format, so that any participant in the markets may automatically retrieve these files free of charge. Changes should be notified a standard, reasonable number of days in advance, so that all participants can download the files, adjust systems, and carry out quality control.

(Q30) Are the proposed levels of the access fee caps appropriate? Why or why not? If not, what factors should be considered in determining the appropriate level of the access fee caps?

MMI believes the access fees should be scaled based on 30% of the minimum pricing increment.

V. Order Competition Proposal

MMI recommends the Commission postpone consideration of the Order Competition Rule until after the Section 605 and Tick Size Proposals are implemented.

While MMI members may stand to benefit from increased trading on lit exchanges, members were unable to reach consensus about the Order Competition Proposal and indicated that, at minimum, the Proposal, if advanced and re-proposed, would be improved by being less prescriptive and allowing for more market innovation.

Potential benefits and drawbacks discussed included:

Potential Benefits:

- Allows a broader group of market participants to access retail order flow that is currently routed to a select group of wholesalers; in other words, introduces competition and affords retail investors a wider and more diversified supply of liquidity;
- Encourages the return of retail investors and liquidity from off-exchange dealing to transparent, public exchanges;
- May decrease costs for investors through greater price improvement on some retail orders;
- Reduces the concentration risk of the status quo, where the vast majority of all U.S. equities retail orders are executed by a handful of large market participants.

Potential Drawbacks:

- Discourages innovation by over-constraining retail brokers' routing choices; in other words, the plan may suppress an even better solution brought about by competition and market innovation;
- May lead to diminished liquidity in thinly-traded stocks by disrupting the current ecosystem, where wholesalers provide liquidity to stocks across the liquidity spectrum;
- May increase costs for investors through the potential return of trading commissions, in the absence of payment for order flow;
- Introduces a large risk of information leakage and potential trade-through issues because of the prescriptive duration of 100 to 300 milliseconds (compared to existing 1 millisecond auctions);
- Increases exchange market data volume, with an associated operational risks and costs borne by all market participants;

- Requires the definition of additional types of CAT reportable events and increases such reportable events, driving up CAT costs and performance challenges;
- Broker dealers may be challenged to deal with the operational complexity of routing to multiple auction systems, which may lead them to outsource to a select group of wholesalers, consolidators, or other intermediaries; not only could this add cost, but may also increase the concentration of flow in wholesalers' hands.

Even within the MMI membership, there are a variety of perspectives about the potential benefits and drawbacks of the Order Competition Proposal. Given this lack of clear vision on how best to achieve order-by-order competition, MMI advises the SEC to pause consideration of the Proposal until after implementation of Section 605 and Tick Size proposals to grant further time for economic analysis and review, and to move forward with this concept based on a demonstrated need and after re-proposing to incorporate industry feedback on the structure of this type of auction mechanism.

RESPONSES TO QUESTIONS PRESENTED:

(Q2) Proposed Rule 615(c)(2) would prohibit display of auction responses. In the case of an execution in a qualified auction, a transaction report maintaining the anonymity of the parties would be displayed in consolidated market data. Does the proposed prohibition sufficiently mitigate the possibility of information leakage for participants in a qualified auction? Are there different or additional requirements that would better mitigate the possibility of information leakage?

Anonymity of the parties is insufficient to stop information leakage if orders are posted for 100 to 300 milliseconds. This timeframe - compared to existing auctions with a 1 millisecond duration - is an eternity in modern markets trading and introduces the moral hazard of third parties potentially trading ahead of investors.

VI. CONCLUSION

The U.S. equities markets are the envy of the world. The past three years have tested them like never before, and they have continued to deliver stable functionality to all investors. As such, any proposal to change, even if to improve, what is already working well should be evaluated carefully. An incremental approach would be prudent to allow the impact of each proposal to be assessed individually and mitigate the risk of harm. MMI would be pleased to be a resource to the Commission should it desire to convene roundtables or other public discussions on any of the proposals.

Thank you for your consideration.

Very truly yours,

Kirsten Wegner
Chief Executive Officer
Modern Markets Initiative

CC: The Honorable Gary Gensler, Chair
The Honorable Hester M. Peirce, Commissioner,
The Honorable Caroline A. Crenshaw, Commissioner
The Honorable Mark T. Uyeda, Commissioner
The Honorable Jamie Lizárraga, Commissioner

MODERN MARKETS INITIATIVE

A Report on Market Automation and Dependable Liquidity in Times of Uncertainty: Investor Savings from Narrowed Bid Ask Spreads, Markets Functioning as Intended

Kirsten Wegner, Katherine Hong, Anush Musthyala and Sreeya Narra

July 2022

V.1

Contents

IN THIS STUDY

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

About the Authors

Kirsten Wegner, CEO of Modern Markets Initiative, is a thought leader on innovation in the markets and the use of technology to deliver retail investors the best prices.

Katherine Hong is a Research Fellow at the Modern Markets Initiative. Her work at MMI is focused on presenting rigorous definitions and computations in the report. Katherine is a student at New York University Courant Institute, where her studies include machine learning in time series, algorithmic trading, and numerical methods. Katherine's work experience includes being a machine learning summer associate at JP Morgan Asset Management, quantitative summer analyst at EvarInvest Asset Management, and research assistant at the Princeton Center of Statistics and Machine Learning.

Anush Musthyala is a Research Fellow at the Modern Markets Initiative. His work with MMI is focused on research and analysis regarding market automation and narrowed bid-ask spreads with an emphasis on the future of the workforce and algorithmic trading. Anush is a student at New York University, where his interests include quantitative finance, mentorship, photography, and travel. Anush's previous work experiences include working as a research fellow at the NYU Center for Data Science and as an IT consultant at Soroban Capital Partners LP.

Sreeya Narra is a Research Fellow at the Modern Markets Initiative. Her work at MMI is focused on research and analysis regarding market automation, narrowed bid-ask spreads, with an emphasis on market savings calculations for the Able plan. Sreeya is currently a student at New York University, where her interests include economics and computer science. Sreeya developed a deep passion for finance from her previous work as a Wealth Management Intern at Kotak Mahindra Bank and enjoys partaking in equity research as a member of NYU's Smart Women Securities. In her free time, she enjoys developing new software applications and participates in start-up sprints.

This report builds on previous research and 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

This 2022 report comes at one of the most pivotal times in the markets since the Great Financial Crisis of 2008 - with extreme market volatility, perhaps the most uncertain geopolitical environment since World War II, ongoing pandemic variants in year two of the Covid pandemic, supply chain problems in construction materials, computer chips, and even baby formula, and the highest inflation rate since the 1980s. It is notable that despite the fluctuations in the markets, the equities markets are functioning as intended - with investors able to get in or out of their positions efficiently, and rebalance and reallocate capital as needed. The electronic intermediaries known as "automated traders" provide continuous liquidity, using algorithms to match bids and asks to glue together liquidity in the markets for investors, both for individual retail investors as well as larger institutional investors.

Against this backdrop of recent volatility and and negative economic signals, this report looks at trends in the cost of trading over the past three decades and illustrates that the cost of trading has dramatically declined from the pre-automated trading area to the current automated trading environment. The report calculates the projected savings of market automation to retail investors in categories including pension funds, 529 plans, individual 401(k) savers, ABLE plan participants, among others.

At present, about half of all Americans are invested in the stock market, either directly or indirectly, through these funds. This report looks at the state of the US equities markets as it relates to the benefit of automated trading technology in ensuring investors have 30% more in lifetime savings, as compared to a pre-electronic trading era before market automation (roughly before 2000). Whereas 30 years ago an investor might pay $6 to trade $100 in stock, now as a result of market automation, the cost to trade the same amount of stock is closer to a penny. It has never been a better time in the history of the capital markets to be a retail investor, as far as low-cost trading and long-term investing returns.

Technological innovation in the capital markets, including market automation paired together with regulatory reform reducing minimum tick sizes, has driven down the cost of trading substantially over the past three decades. Since the 1990s, electronification initiatives including automated trading technology, improved exchange technology, decimalization, Reg NMS (protecting linked markets), among other technological and regulatory developments, have made the overall trading ecosystem of the U.S. capital markets more accessible and improved the end-user experience for the investor. Since 2001 decimalization, further market efficiencies including automated trading have further provided liquidity, dampening volatility and narrowing spreads even further over the past two decades. The net result of these cumulative "electronification initiatives" has been more money in the pockets of investors in investment plans, pension funds, 401(k)s and less fees going to intermediaries.

The electronification of the markets has leveled the technology playing field between Wall Street and Main Street, providing far more equitable access to the markets for retail investors at a time when savings and investment have never been more important to many. As of 2022, a survey conducted by TIAA indicates heightened focus on investing, with a majority of Americans indicating a heightened focus on financial wellness since the pandemic.[1]

The heightened focus on investing is further demonstrated by historically high levels of retail investor

1 TIAA 2022 Financial Wellness Survey (2022).

participation in 2020-2022, with more than half of Americans invested in the stock market,[2] and the volume of retail investor participation at a historic high of 20% - 25% of daily trading volume.[3] Given the large participation of retail investors in the capital markets, it is vital to encourage financial literacy, risk management and transparency in the capital markets, including making information public on bid-ask spreads and the technology underlying liquidity provision in order to instill confidence in the integrity of the capital markets and to provide further information on the decline in the cost of trading over the past decades and role of technology in delivering these savings. While these savings are not a line-item in investors' monthly brokerage statements, they are nevertheless very real and accretive to long-term investing success.

Many Americans are afforded the opportunity to participate in a variety of investment vehicles in order to help successfully meet life's financial milestones. This report reviews and analyzes publicly available data on the cost savings passed on to retail investors in 529 college savings plans, 401(k) plans, pension plans, and other savings vehicles, as a result of narrowed bid-ask spreads over the past three decades. Small incremental costs of trading add up significantly over time, this study breaks down the benefit of modern trading technology and accompanying regulatory changes in delivering narrowed bid-ask spreads –and accompanying savings – to retail investors over time.

Whether an individual retail investor is trading through a smartphone, PC or tablet, it has never been easier or more low-cost to be an investor than in today's modern markets. With the current uncertainty regarding inflation in particular, it is important that investors have confidence in the markets and participate in long-term investing to offset the negative impact of inflation on deteriorating value of cash savings.

Highlights: Investor Savings from 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 over the past three decades, and 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 market automation.

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

2 Kim Parker and Richard Fry, "More than half of U.S. households have some investment in the stock market," Pew Research Center, " As of 2020, about 52% of American families are invested in the stock market through individual savings accounts, 401(k)s, pension funds, 529 plans, and ABLE plans," March 25 2020, https://www.pewresearch.org/fact-tank/2020/03/25/more-than-half-of-u-s-households-have-some-investment-in-the-stock-market/ https://www.reuters.com/markets/wealth/retail-inflows-nearly-all-time-high-despite-market-turbulence-2022-05-25/

3 Caitlin McCabe "It Isn't Just AMC. Retail Traders Increase Pull on the Stock Market" Wall Street Journal (June 18, 2021)

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-automated trading era . This is supported by academic literature:

1. Between the time period of 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 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, that has helped democratize access to trading for investors big and small.[8]

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 401(k) mutual fund for 30 years, that individual would have $68,000 over 30 years, rather than $52,000, after adjusting for inflation. This is a direct result of electronification initiatives including 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 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 **$165,000 more in lifetime 30-year savings** as a result of automated trading technology. A financial model of this calculation, which assumes the Vanguard estimated 50 basis point reduction in trading costs compared to pre-electronic era, is available here.[10] In other words, without modern markets including automated trading technology, a middle class worker making $70,000 a year would have to work an additional two years to make up the difference in retirement savings.

---

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

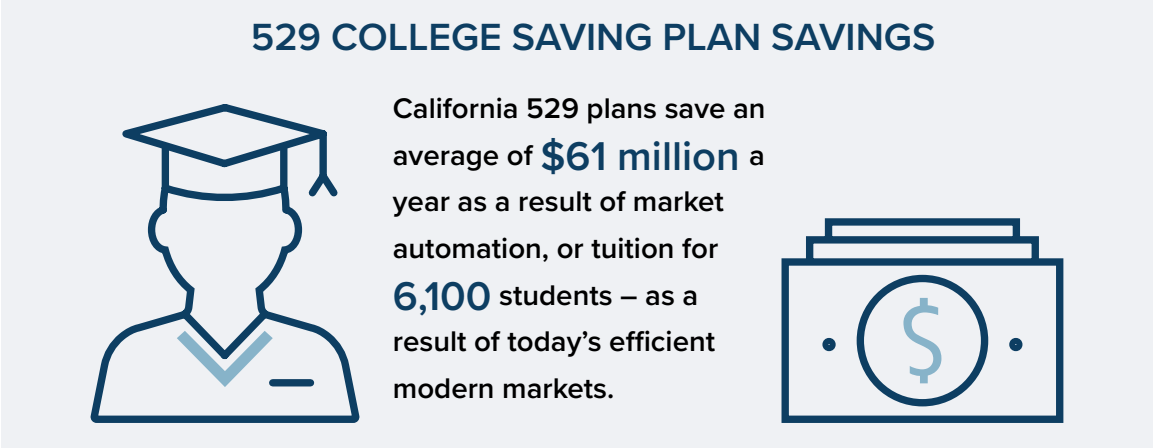
7 George Sauter, "Vanguard Comment letter on SEC Concept Release on Equity Market Structure," "...we conservatively estimate that transaction costs have declined 50 bps, or 100 bps round trip... Today's investor with a 30 year time horizon would see a $10,000 investment in such a fund grow to approximately $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

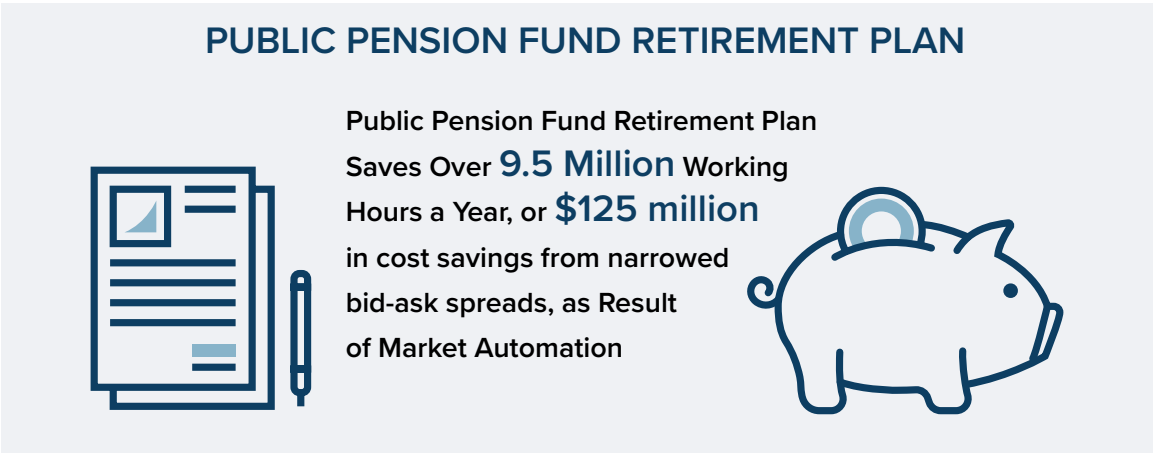
9 Albert J. Menkveld, "The Economics of High-Frequency Trading: Taking Stock," Annual Review of Financial Economics, Volume 8, Forthcoming, "In the decade of migration to electronic trading and HFT arrival, transaction cost decreased by over 50% for both retail and institutional investors," June 1, 2016, 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 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

529 College Savings Plans - Equivalent of 6,100 Student Tuitions saved from Market Automation: Modern market technology including 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 $61 million a year – or tuition for 6,100 students – as a result of today's efficient modern markets..



Public Pension Fund Retirement Plan Saves Over 9.5 Million Working Hours a Year as Result of Market Automation: Modern market technology, including automated trading technology, is projected to have saved a mid-size pension fund each year over $125 million in transaction costs, or equal to a savings of about 9,560,000 hours extra that teachers would have to work extra to make up the difference in cost of trading.[11] 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 to offset the need for further funding gaps from the state.



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 2000's 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 Automated Trading Benefit: Narrower Spreads

CONCEPT OF THE SPREAD: A key variable for savings community stakeholders in their trading costs related 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 makes the cost of trading less expensive for market participants. The financial markets are made up of negotiations between buyers and sellers. Like all negotiations, most end up in compromise.

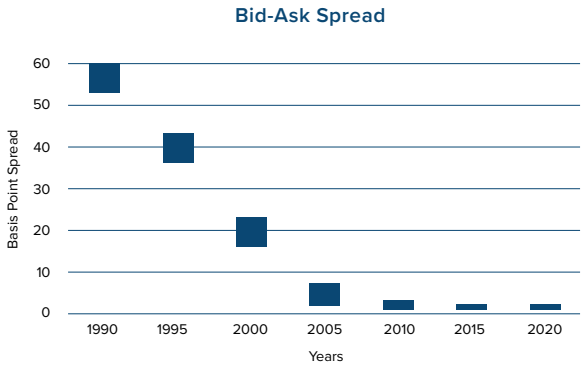


TABLE I: BID-ASK SPREADS 1990–2020

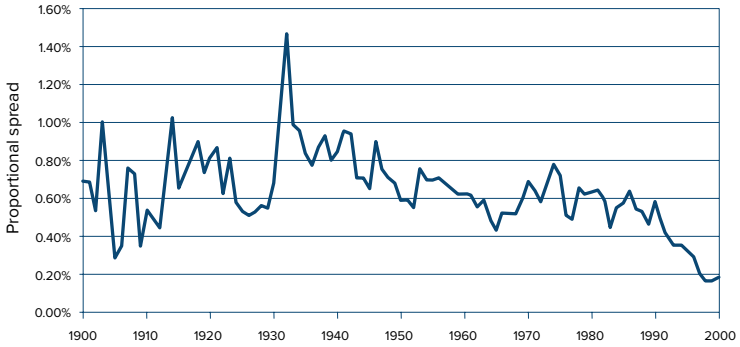
The distance between what someone wants and what someone is willing to pay during a particular negotiation is "the spread." For both parties, the narrower the spread, the less either party has to concede and thus, the better the price from their perspective. Fierce competition between market makers, and 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:

TABLE 2: BID-ASK SPREADS ON DOW STOCKS

Figure 1. Bid-ask spreads on Dow Jones stocks
(all DJ stocks 1900-1928, DJIA stocks 1929-present)



Further, the additional 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] Table: Median bid-ask spreads on S&P 500 stocks, 2003-2009. Source: Knight Securities via Angel, Harris, and Spatt (2010)[14]

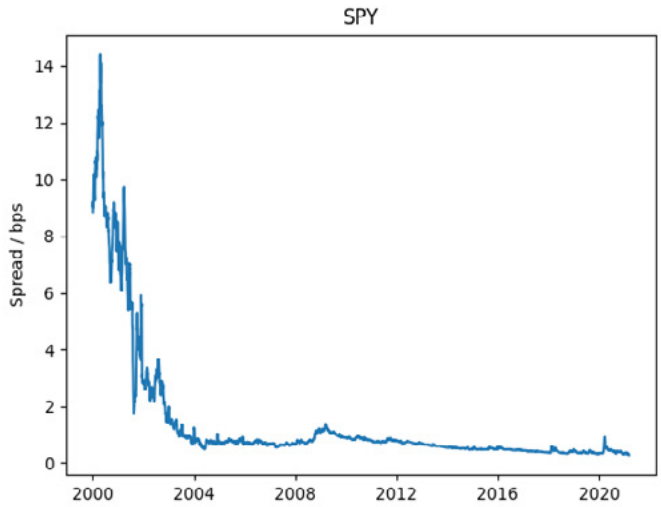
12 Kevin Kang, "Floating column chart (bid ask spreads)," April 2020
Further resources on bid-ask spreads: https://www.investopedia.com/articles/investing/082213/how-calculate-bidask-spread.asp.

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.

14 Charles M. Jones, "What do we know about high-frequency trading," Columbia Business School, February 25 2013, https://ccl.yale.edu/sites/default/files/files/jones_ssrn.pdf

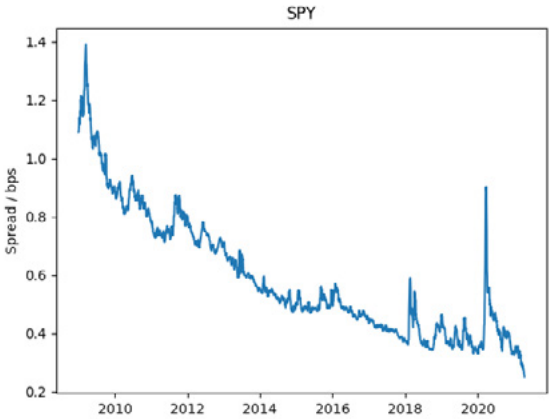
From 2000, where bid-ask spreads had historically ranged around 20 basis points, further innovation in trade execution technology, as well as decimalization in 2001 in response to that innovation, further drove down prices in the following years.

TABLE 3: SPY SPREADS 2000–2020



Source: Large Market Maker

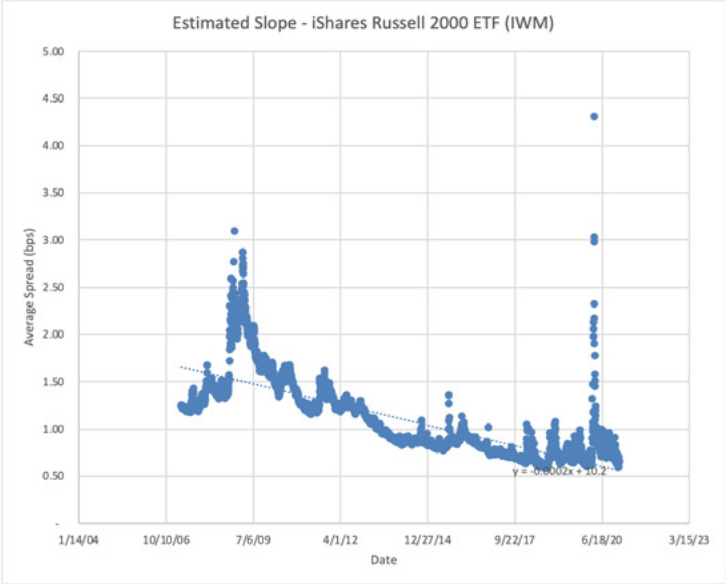
More recently, over the past decade, bid-ask spreads in SPY have declined by more than 50% (excluding up-ticks in bid-ask spread during periods of volatility in 2008 and 2020). The following graph shows a downward slope in bid-ask spreads from about 1 basis point in 2010 downward to .3 basis points in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



Source: Large Market Maker

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

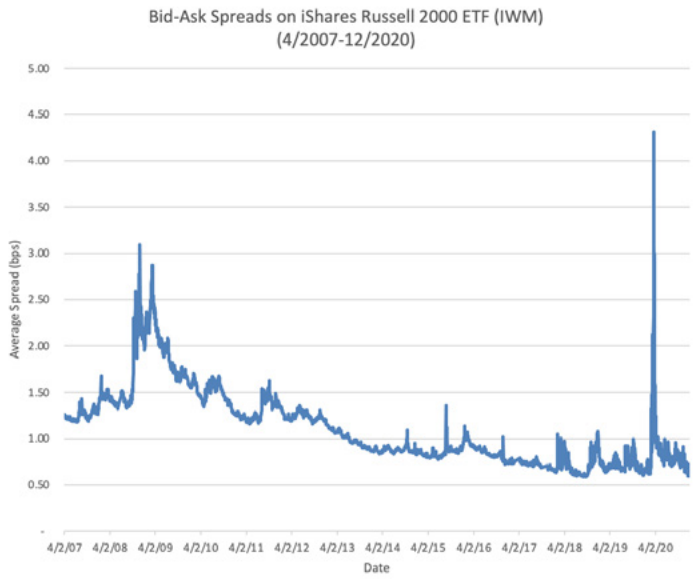
An analysis of bid-ask spreads on the Russell 2000 ETF indicates that the bid-ask spread has been reduced by more than 50% over the past decade. The following analysis shows that bid-ask spreads were about 1.6 basis points in 2007 declining to .6 basis points in 2020. The data points describe the daily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

TABLE 5: BID-ASK SPREADS ON iSHARES RUSSELL



Source: **BlackRock**

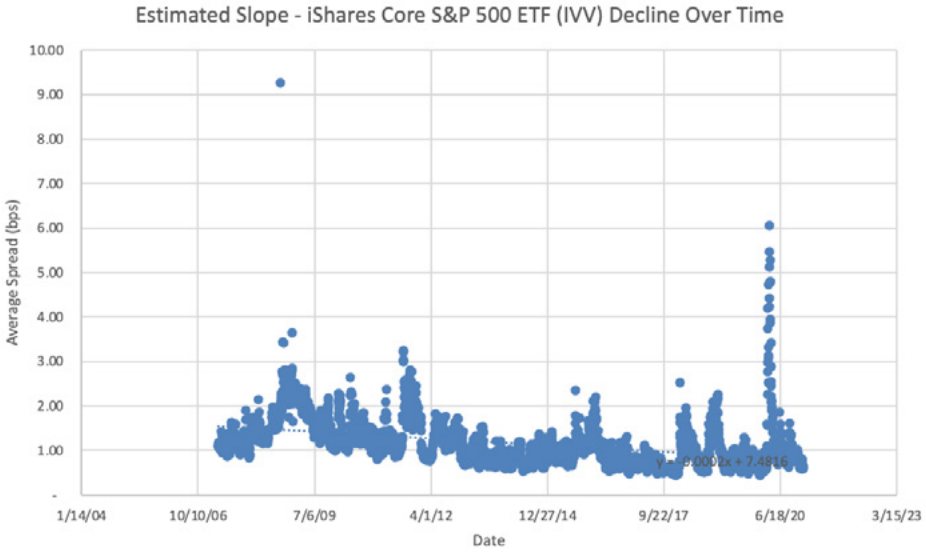
Notably, the above Russell 2000 ETF is a general proxy for small cap markets. The Russell 2000 Index is a small-cap stock market index that makes up the smallest 2,000 stocks in the Russell 3000 Index. It is generally reflective of the bid-ask spreads on equities that are considered “small cap”, or companies ranked 1000 to 3000 in size, generally with an average market cap of $3 billion over time. [15]

15 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.

TABLE 6: Bid-Ask Spread of IVV ETF

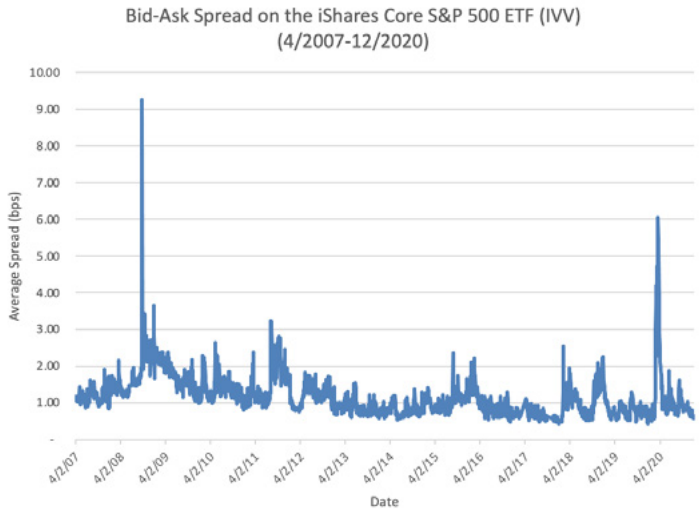


Source: BlackRock

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 illustrates the bid-ask spread of IVV without the slope line, illustrating the spikes of bid-ask spreads in period of volatility in 2008 and 2020.

TABLE 7: BID-ASK SPREAD ON iSHARES CORE S+P 500



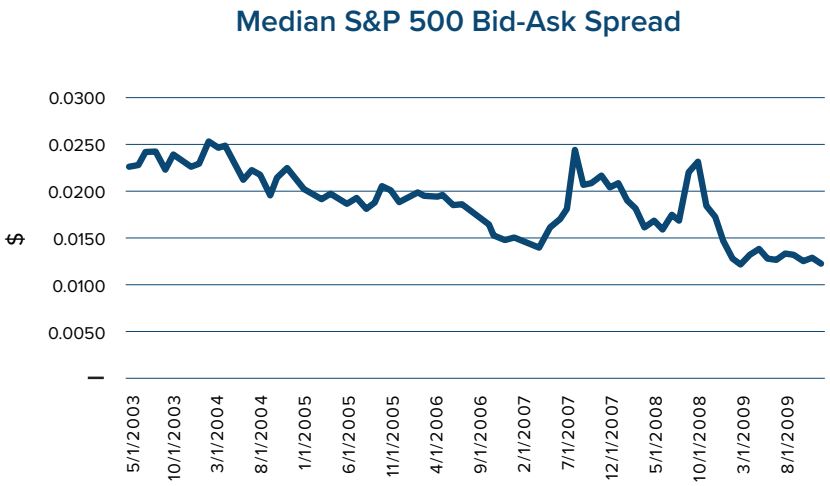
Source: **BlackRock**

TAKEAWAY #2

A Decrease In Spreads Yields Savings for Every Investor, Including Individual 401(k) 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 adding up and 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:

TABLE 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 Automated Trading

Old Model: Floor Based Specialists and Floor Traders

In the floor-based trading era of the 1960's to the early 1990's, 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. [16] Historical data indicates that for a $100 trade by a retail investor in the 1960's, with a $6 minimum, the cost of trading including bid-ask spread and minimum brokerage fee equaled about 600 basis points commission.[17] Further, Professor Jones notes in his "Century of Stock Trading" a range of bid-ask spreads declining in 1990 from about a 50-60 basis point range to roughly 20 basis points by 2000.[18] 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 narrow so rapidly in the 1990s and 2000s onward? Rapid adoption of computerization of trading systems, automated trading technology, and regulatory reform coinciding with market automation. Notably, 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.[19] These pioneer technologists, coupled with better technological innovations leading toward eventual all-electronic exchanges, 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 1990's, the human floor "specialists" on exchanges saw their market dominance challenged by the competition of electronic trading and computers.[20] 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 1990's, 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 2000's, 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. 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 required 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

16 Charles M. Jones, "What do we know about high-frequency trading," Columbia Business School, February 25 2013, https://ccl.yale.edu/sites/default/files/files/jones_ssrn.pdf

17 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

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

19 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

20 "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

competing for orders, and proponents argued that electronic orders expedited 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 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 fever pitch at a Congressional hearing in late October.[22] Inquires 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]. It was discovered that among the human specialist firms, Van Der Moolen Specialists USA, was "front running" investors between 2000 and end of 2002, and illegally "trading ahead" of customers' orders causing or allowing its traders to put 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 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*

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.

flotation companies is 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 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: Automated Traders and Electronic Intermediaries – Rise of Retail Investors The initial growth of automated traders largely in the 1990's and early 2000's featured an unlikely group of Wall Street disruptors without conventional backgrounds, such as MBA's. 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-2010's, 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 mid-2010's, 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 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 use of circuit-breakers included August 25, 2015 volatility and more recently Q1 2020 Covid volatility, when cir-

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

cuit 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 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 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, but 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 building the public's confidence in the benefits of automated trading technology in cost savings and efficient markets.

As of 2021, 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]

What is the net impact of all this automation and deployment of technology, as far as savings to retail investors? One must look no further than a snapshot at bid-ask spreads of a selection of stocks on a recent Q1 2021 date – March 12, 2021, to see the price improvement since the last selection from over a decade before.

These are just a few snapshots to illustrate the reduced spread of stocks – it is arguable that the spreads

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

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)

could go down even further, were regulators to reduce the tick size for large cap companies below a dollar to something even more of a fraction.

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. [37] 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. [38] 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 in the last three years. [39] Additionally, a report released on January 19, 2021 indicated that the algorithmic trading market is anticipated to further grow over the next five years.[40]

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. It is likely that automated trading technology will continue to expand as a tool to trading of 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.

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, on a general upward trend to over 50% of Americans owning stock around 2000 onward.[41] 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.[42] 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 401(k) 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 $1,940/year (for 10 years) and $5,523/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

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

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

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

40 "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

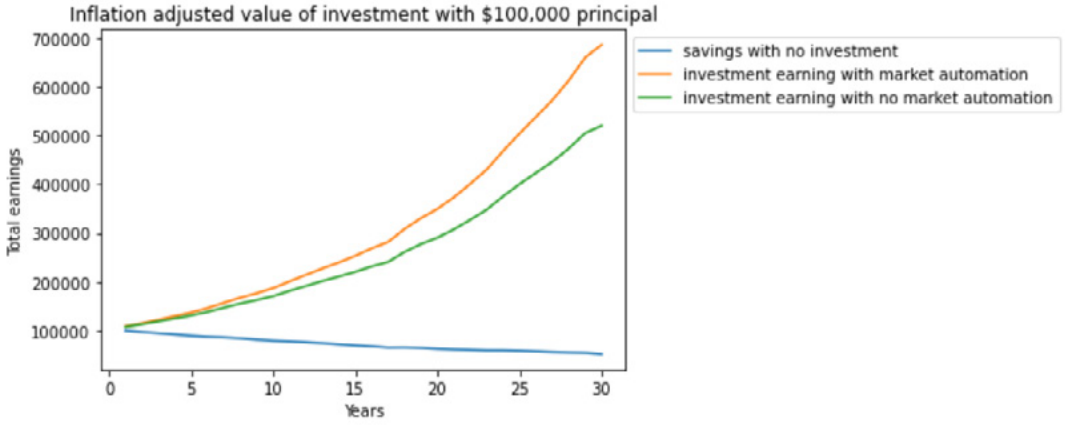
41 Allison Schrager, "More Americans Own Stock Than Ever," Quartz Media, September 25 2019, https://qz.com/1700958/more-americans-own-stock-than-ever/.

42 Anush Musthyala, "529 Plan Savings" (2022).

over a lifetime of a 401(k) account of this size is a total of an additional **$165,683 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.

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



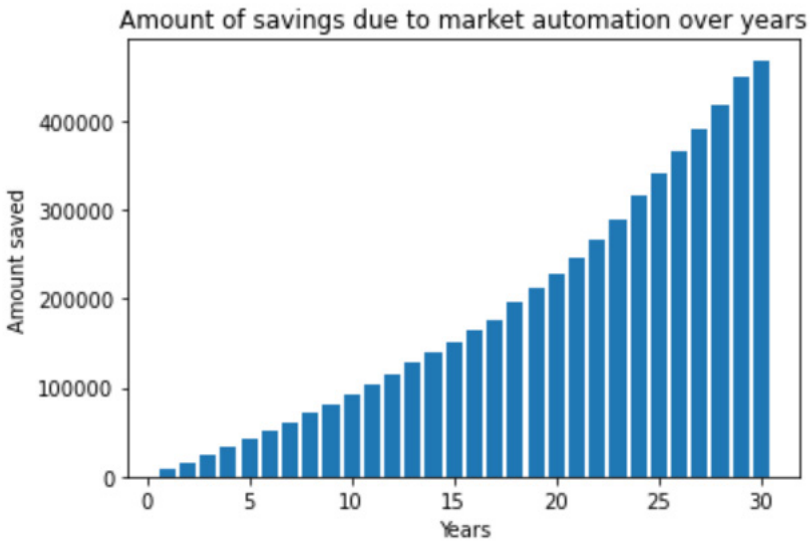
Source: Katherine Hong, MMI Fellow

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 $520,188, whereas with moderns markets of 2021 (including automated trading, technologically innovative exchanges, and innovative ETFs) the total amount would grow to $685,871. This represents an improvement on returns of more than 30% cumulatively - or more than $165,000 over a lifetime 30 year savings. Translated 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.[43]

43 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

TABLE 10: SAVINGS FROM MARKET AUTOMATION:



Source: Katherine Hong, 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 $165,000 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.[44]

As of September 2020, 401(k) plans held an estimated $6.5 trillion AUM in the United States and represented more than 20% of the $33.1 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[45].

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[46].

According to the Investment Company Institute (ICI):

- Average 401(k) account balances varied by participant age and tenure.
- Account balances were higher the longer 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.

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

45 "Frequently Asked Questions About 401(k) Plan Research," Investment Company Institute, July 24 2019, https://www.ici.org/policy/retirement/plan/401(k)/faqs_401(k)n

46 Frequently Asked Questions About 401(k) Plan Research," Investment Company Institute, July 24 2019, https://www.ici.org/policy/retirement/plan/401(k)/faqs_401(k)n

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, debt), such that:

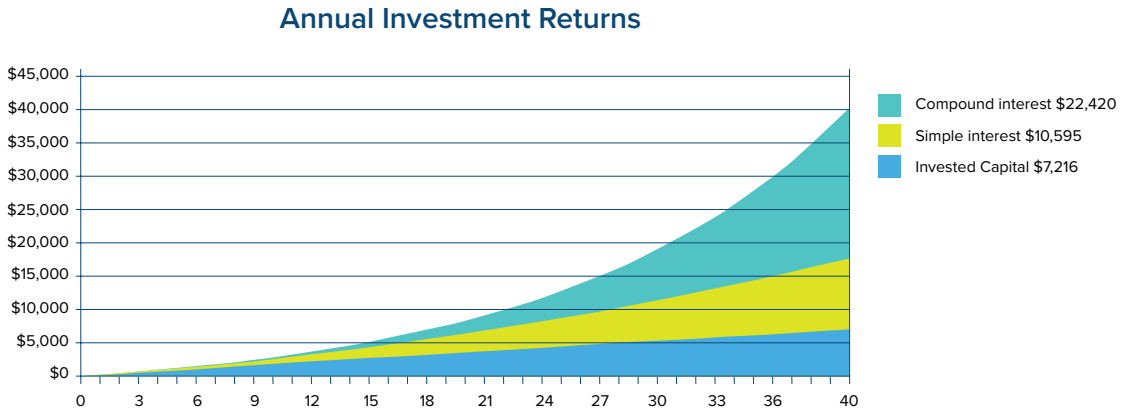
- $60,000 equities (including mutual funds and employer stock) x 0.67 turnover x 100 basis points in widened bid-ask spread without automated trading = $402
- $40,000 in fixed income/bonds/debt x 0.67 turnover x 100 basis points in widened bid-ask spread = $268
- If 100% in equities (including mutual funds and employer stock) x 0.67 turnover x 100 basis points in widened bid-ask spread without automated trading = $670.00[47]

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[48], the following calculation shows that over 40 years, paying in $670.00 a year, at 7% annual growth (the average for pension funds) that this 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.

TABLE 11: ANNUAL INVESTMENT RETURNS



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

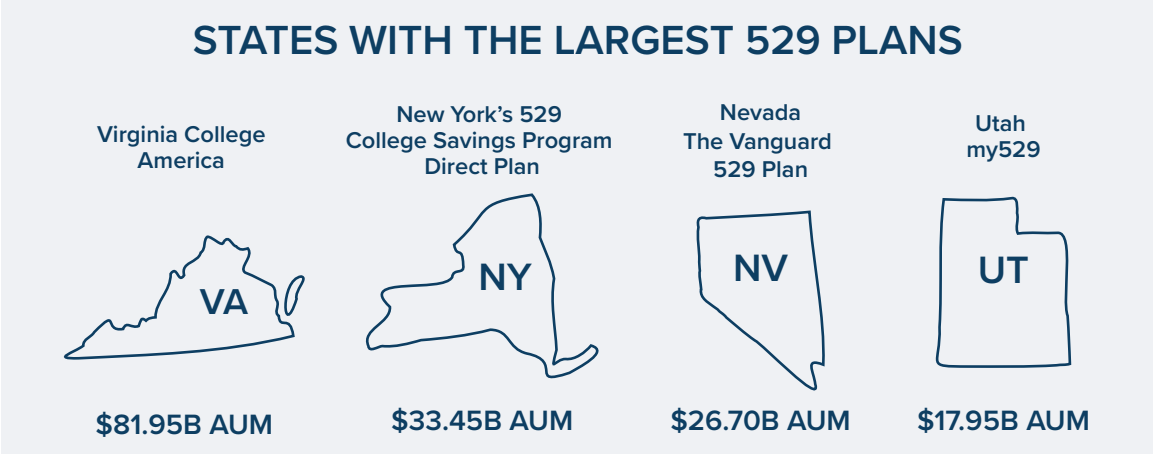
48 https://www.aarp.org/money/investing/investment_return_calculator/

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 $131 million (Virginia College America) for a plan portfolio with a size of $81.95 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.[49]

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.[50]

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



For a 529 Plan Portfolio with $12 billion ($11.36-California ScholarShare College Savings Plan) in assets under management, the projected cost savings of market automation is $61 million in annual cost savings.[51] This number assumes that the 529 plan with assets under management of $11.36 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:

- $3.04 billion stocks x 0.67 x 100 basis points savings = $30.5 million
- $3.04 billion in fixed income/ debt x 0.67 x 100 basis points savings= $30.5 million

Under these assumptions, the total cost of trading by 529 plan portfolio in this example with $11.36 billion AUM would be $61 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 instate tuition for approximately 6108 students per year. Note the average tuition of a public state college is $9,970 for in-state residents[52].

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

---

49 National Association of State Treasurers, February 2021
Anush Musthyala, "529 Plan Savings" (2022).

50 "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

51 Anush Musthyala, "529 Plan Savings" (2022).
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.

52 The average tuition is $9,970 for state residents at public colleges
https://www.valuepenguin.com/student-loans/average-cost-of-college#:~:text=The%20average%20cost%20of%20public%20colleges%20in%20the,%243%2C500%20more%20than%20South%20Dakota%27s%20out-of-state%20tuition%2C%20%2412%2C480.

Automated Trading Technology Savings: Public Pension Plans

Public Pension Plans

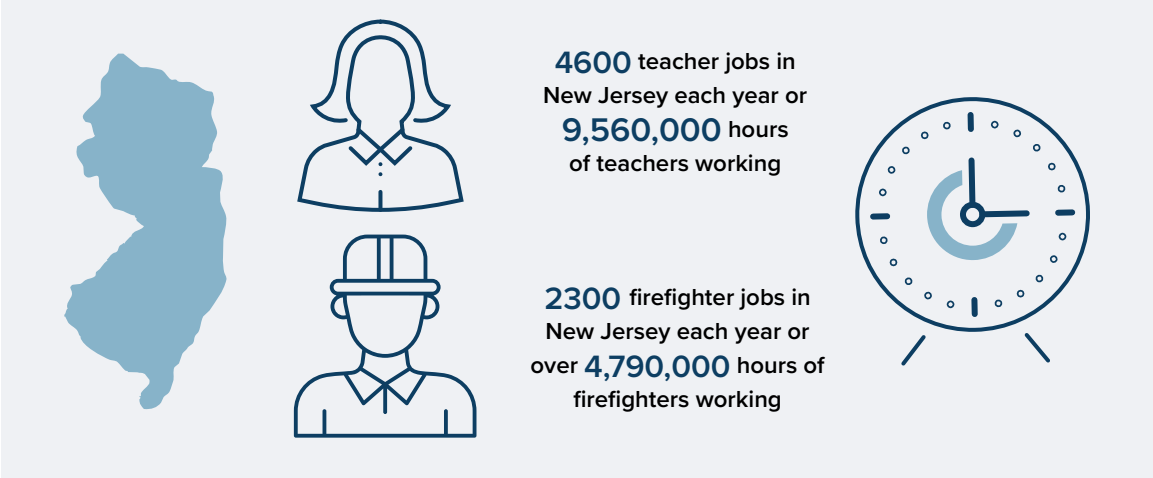
Market automation (including automated trading, tech innovation at exchanges, ETFs, and accompanying regulatory reform to modernize regulation in response to innovation) has yielded cost savings to public pension funds through lower transaction costs. For example, for a pension fund with $87 billion 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 point each way purchase and sale) = $93.46 million
- $11.63 billion in fixed income /debt x 0.26 turnover x 100 basis points savings (total round-trip, includes 50 basis point each way purchase and sale) = $136.14 million
- $212.89 million in derivatives x 0.26 turnover x 100 basis point (total round-trip, includes 50 basis point each way purchase and sale= $2.02 million[53]

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 to 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:



54 55

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[56].
- Total market automation savings = total AUM × turnover rate × market automation savings in bps

53 Anush Musthyala, "Calculation of Bid-Ask Spread Savings for New Jersey Pension Plan" (2022)

54 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

55 As of February 26, 2021, the average Fire Fighter salary in New Jersey is $53953 a year https://www.salary.com/research/salary/benchmark/fire-fighter-salary/nj

56 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

- 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 investments 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 12: PENSION FUND INVESTMENTS

INVESTMENT PERFORMANCE – PUBLIC EMPLOYEES' RETIREMENT FUND (PERF)

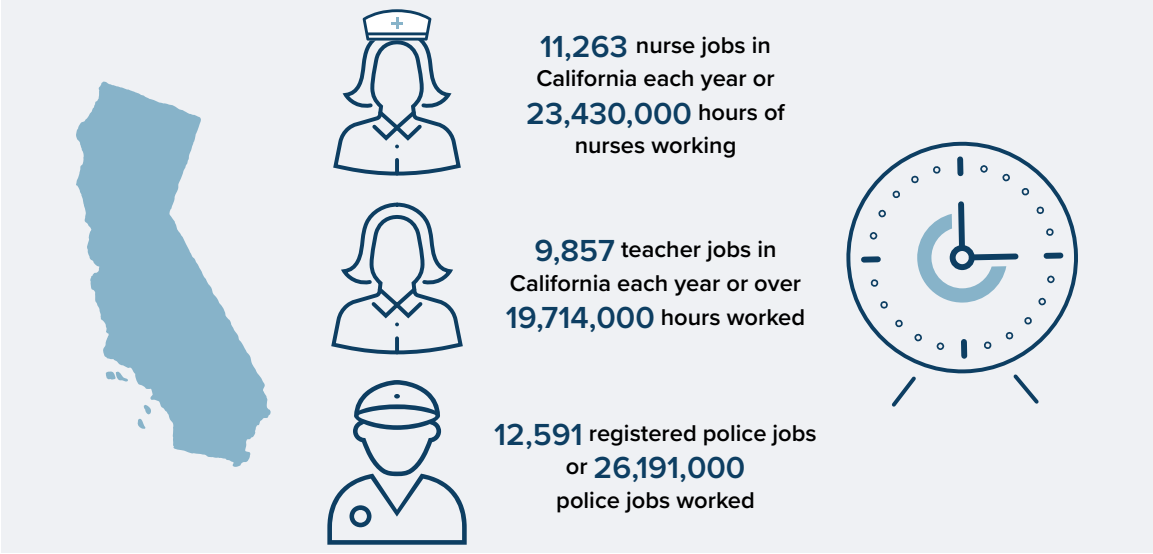
Summary of Investments – PERF – As of June 30, 2021 (Dollars in Thousands)

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:

(24.4 billion + 163.5 billion + 125.8 billion) * 0.26 * 100bps = 815.6 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 $815.6 million projected a year, as a result of market automation, which equals about:



57 58 59

57 As of February 28, 2021, the approximate number of registered nurses is 453,158
https://www.rn.ca.gov/consumers/stats.shtml; As of March 29, 2021 the average annual pay for a registered nurse is $72,410 a year ($34.81/hr)
https://www.salary.com/research/salary/alternate/registered-nurse-rn-level-1-salary/ca

58 As of January 13, 2021 there are 307,000 teachers in California with an average salary of $82,746 a year ($41.37/hr)
https://www.ed-data.org/article/Teachers-in-California
https://www.cde.ca.gov/fg/fr/sa/cefavgsalaries.asp

59 As of 2019, there are 121,000 registered police in California
https://www.ppic.org/publication/law-enforcement-staffing-in-california/.
As of March 29, 2021 the average annual pay for a police officer is $64,776 a year ($31.14/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.[60] 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.

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

The calculations are as follows:

TABLE 14: SATEMENT OF ACTIVITIES

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%

- 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

Notably, this model utilizes a low turnover rate of 0.15 for the model, which may not be representative of other ABLE plans but is utilized for this calculation. [61]

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

61 See Sreeya Narra, MMI Fellow, "ABLE Fund Calculation on Bid-Ask Spreads". See also Able Plan annual report for asset allocation reference at https://www.ableunited.com/wp-content/uploads/2021-ABLE-United-Digital-Annual-Report.pdf

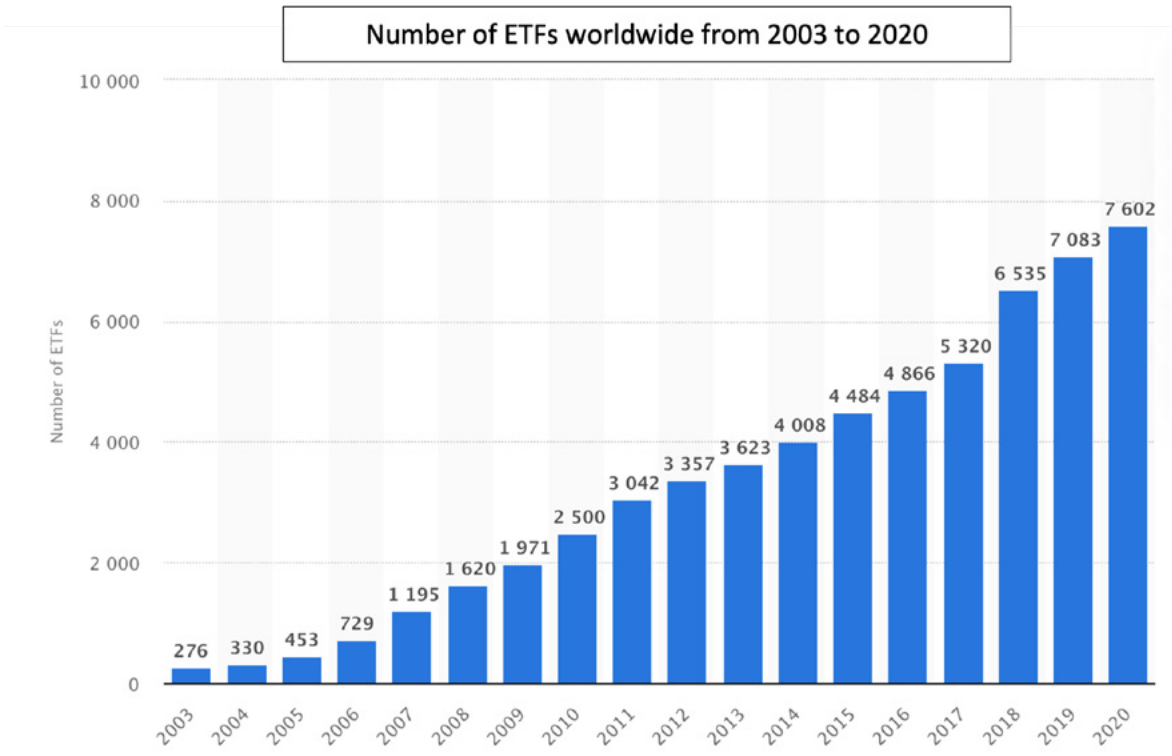
Evolution of ETFs, Index Funds, Low-Cost Products to Diversify Risk

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.[62] Automated trading technology is key to market efficiency underlying ETFs, as ETFs are rebalanced continuously with low cost and deep liquidity. [63]

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:

TABLE 15: ETF GROWTH



Source: Statista[64]

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. [65]

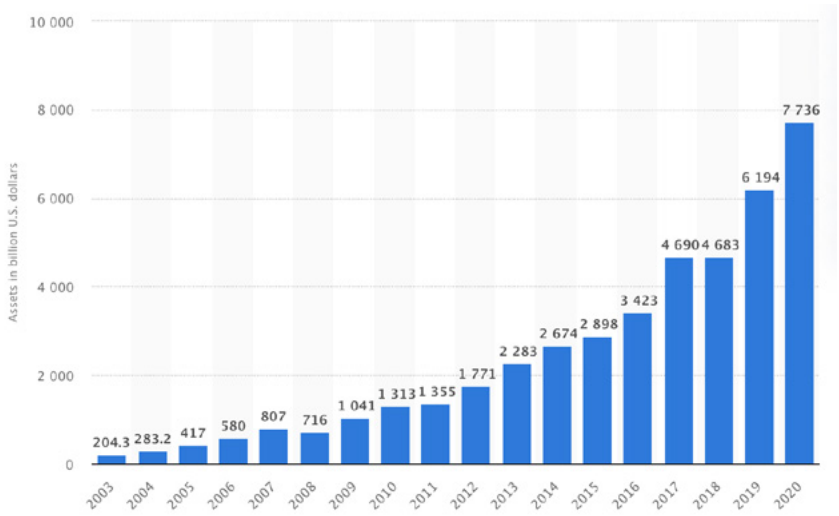
62 Carmen Reinicke, "The ETF market will hit $50 trillion by 2030, Bank of America says," Markets Insider, December 13 2019, https://markets.businessinsider.com/news/stocks/etf-market-grow-50-trillion-assets-2030-bank-america-passive-2019-12-1028763048

63 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

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

65 Benefits and considerations of ETFs" Charles Schwab (June 2022), at https://www.schwab.com/etfs/benefits

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



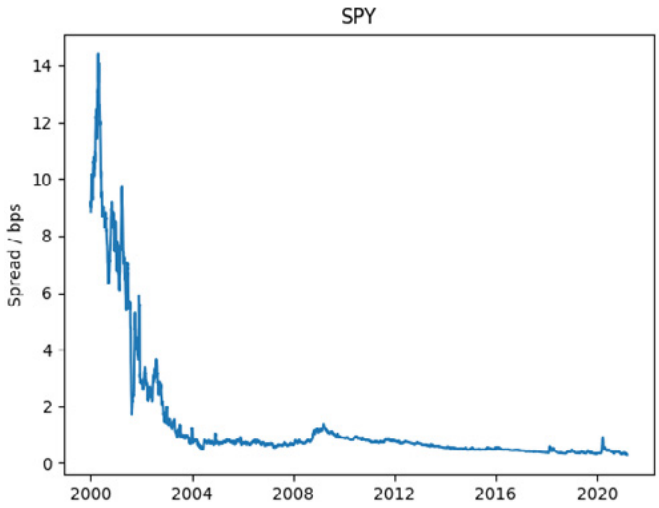
Source: Bloomberg; Deutsche Bank; Thomson Reuters; ETFG [66]

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

Notably, market automation and lower cost of trading has 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 the course of 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”:

TABLE 17: SPY BID-ASK SPREAD



Source: Large Market Maker

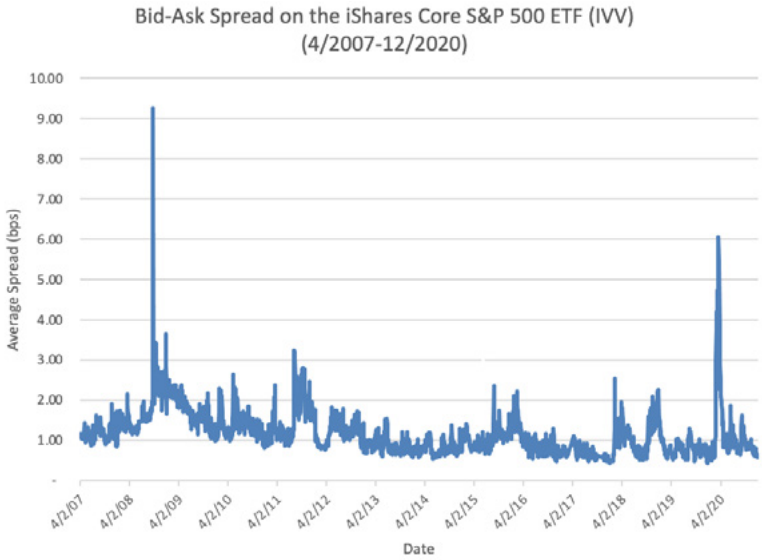
66 https://www.statista.com/statistics/224579/worldwide-etf-assets-under-management-since-1997/

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 leveling off at roughly 1 basis point since 2012. Since the inception of automated trading and automated trading technology in 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 consistent narrow bid-ask spread between 2007 and 2020 in nonvolatile period on the iShares ETFs in the 1 to 2.5 basis point range:

TABLE 18: BID-ASK SPREAD ON ISHARES CORE S+P 500

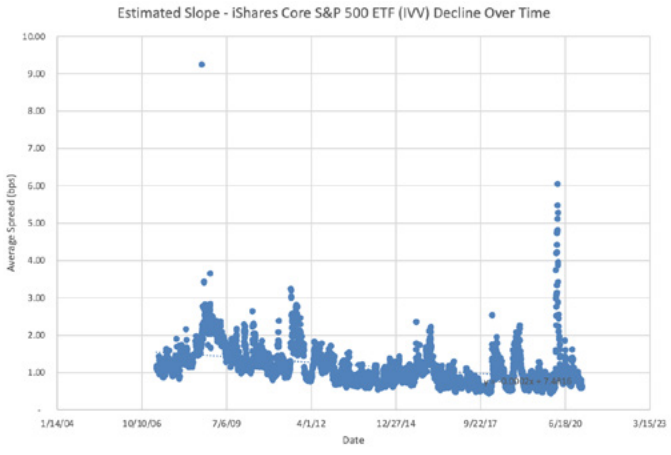


Source: Blackrock

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:

TABLE 19: ETF BID-ASK 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 of 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 are 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 utilized:

- 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: 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.

In this formula, the Average net assets is 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.

68 Charles M. Jones, "What do we know about high-frequency trading," Columbia Business School, February 25 2013, https://ccl.yale.edu/sites/default/files/files/jones_ssrn.pdf

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

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

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:

Figure 10

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 0.78 to 0.32 in industry, weighted asset classes, but the simple average portfolio turnover rate remains at 0.67. 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 actual turnover rate 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

In uncertain geopolitical times, it is an economic imperative that both retail and institutional investors have confidence that the technology behind the capital markets is working, whether the markets are heading up or down, and that investors are able to get in and out of positions efficiently. As detailed in this report, retail investors, pension funds, 529 participants, and investors large and small benefit from market automation through narrowed bid-ask spreads, as well as dependable liquidity. Market downturns put particular pressure on buyside investors and to paraphrase an old adage, a penny saved is more than a penny earned; as a result of market automation, months or even years are shaved off what plan participants would need to work to reach the same retirement goals, and savers for college have more in their accounts to pay for education, than in pre-automated trading technology days. Further, pension funds shave off incremental basis points to help meet year-end target growth and move closer to attaining or surpassing goals.

Looking ahead, as the markets further automate and electronic trading technology is more widely deployed across market participants, it is important that:

- Whether the markets go up or down, that there is liquidity in the markets that investors can get in or out of positions, and that the markets continue to function as intended;
- Investors continue to benefit from lower trading costs and narrowed-bid ask spreads
- Robust, pro-investor competition exists in the markets to avoid unfair market consolidation and encourage new entrants to the markets with innovative fintech businesses;
- Regulatory policies are data-driven and consider the interests of the wide cross section of industry participants
- Regulators have the resources to continue to be effective cops on the beat at the SEC, FINRA and CFTC to ensure that any market manipulation such as front-running, spoofing, or other bad acts, are detected and deterred.

With an unknown time horizon for ongoing uncertainty – geopolitical, inflation, supply chain, and COVID-related – it must be recognized that a dominant attribute of today's modern markets is that the mechanics of the market function and operate efficiently and that retail investors have dependable liquidity and maximized cost savings, as well as well-funded regulators to ensure investor protections and safety and soundness of the markets.