**Testimony to the House Committee on Financial Services Task Force on Artificial Intelligence**

**Hearing: "Robots on Wall Street: The Impact of AI on Capital Markets and Jobs in the Financial Services Industry"**

**December 6, 2019**

**Submitted by Rebecca Fender, CFA**

**Senior Director, Future of Finance at CFA Institute**

Chairman Foster, Ranking Member Loudermilk, and Members of the task force, thank you for inviting me to testify today. My name is Rebecca Fender, and I am the Senior Director of the Future of Finance, which is the thought leadership platform for CFA Institute.

CFA Institute is the largest non-profit association of investment professionals in the world with 170,000 CFA charterholders in 76 countries. CFA Institute is best known for its Chartered Financial Analyst designation (the CFA charter) – a rigorous three-part graduate-level exam. To earn the designation, charterholders must also have four years of investment industry work experience. CFA Institute is a non-partisan organization and seeks to be a leading voice on global issues of transparency, market efficiency, and investor protection.

The following testimony comes from two of our recent publications and relates to the anticipated impact of technology and artificial intelligence on the investment industry in the coming years.

- Section I comes from the May 2019 paper *Investment Professional of the Future*.[1]
- Section II comes from the paper *AI Pioneers in Investment Management*,[2] by Larry Cao, CFA, Senior Director, Industry Research, based on interviews with investment industry practitioners around the world and from different areas of investments, mostly in April and May 2019.

**Section I: Investment Professional of the Future**

As the investment industry undergoes accelerating change, the investment professional of the future must adapt and embrace new challenges and opportunities for career success. This report considers how investment industry roles, skills, and careers are evolving to shape the attributes of the investment professional of the future. We look out over the next 5–10 years and define investment professionals as those who are influential in investment allocation decisions in such areas as investment strategy, portfolio construction, and trading—areas that encompass portfolio managers and research analyst roles.

Inputs to the report include 3,800+ respondents to a global survey of CFA Institute members and candidates, 130+ respondents to a global survey of industry leaders on trends regarding the world of work in investment management, and 100+ participants in industry roundtables and individual interviews, including investment professionals, human resources and learning and development professionals, university program faculty, and executive recruiters.

[1]CFA Institute, *Investment Professional of the Future* (Charlottesville, VA: CFA Institute, 2019). https://futureprofessional.cfainstitute.org/.

[2]CFA Institute, *AI Pioneers in Investment Management* (Charlottesville, VA: CFA Institute, 2019). www.cfainstitute.org/en/research/industry-research/ai-pioneers-in-investment-management.

***Highlights***

- **Adaptability is essential:** 89% of industry leaders agree that "Individuals' roles will be transformed multiple times during their careers; adaptability and lifelong learning will be the most essential skills."
- **Change is anticipated:** 43% of investment professionals think the role they perform today will be substantially different in 5–10 years' time.
- **AI+HI becomes the norm:** Significant professional roles at the investment firms of the future will include investment roles, technology roles, and innovation roles. We use the shorthand "AI+HI" to denote the interaction of artificial intelligence (AI) and human intelligence (HI). For certain interactions, the combined model adds more value than either component alone because it leverages the benefits of both, instead of technology obscuring the favorable human elements. We cite ethical orientation, transparency, communication, empathy, tacit knowledge, and trust interaction as the key human elements that technology cannot (yet) reproduce.
- **T-shaped skills are valued:** T-shaped professionals have both domain-specific specialist knowledge (the vertical bar of the "T") and wider professional connections, understanding, and organizational perspective (the horizontal bar of the "T"). The keys to their success are readiness to adapt to changing environments and the ability to go beyond their own field and work across disciplines. These skills are acquired from combining traditional learning with experience learning (i.e., learning by doing). Innate to effectiveness in a T-shape is being at ease with technology. Industry leaders rank the importance of skill categories for successful investment professionals in the next 5–10 years as follows: T-shaped skills (49% rank these first), leadership skills (21%), soft skills (16%), and technical skills (14%). The mix of the skills needed varies over career paths.
- **The ability to work with technology is a differentiator:** The type of "skill" required for investment teams will remain predominantly investment skills. Professionals on investment teams who understand the basics of AI, data science, and technology, however, can be expected to be far more effective than someone with similar investment skills but no exposure to such technologies. This does not mean that the majority of CFA charterholders will need to become programmers or statisticians. Quite the contrary, they will need to sharpen their investment skills even more as routine tasks will increasingly be performed by machines. Just 6% of members and candidates say they are proficient in data analysis coding (Python, R, MATLAB, etc.), but 58% have interest in gaining this skill. Similarly, data visualization and data interpretation are areas that more than half expressed interest in. Experience and judgment around data interpretation will become especially important for those with analytical skills.

## A. How Much Existing Investment Professional Roles Will Change

In this time of significant change in the industry, we asked CFA Institute members and candidates how much they think the role they currently hold will change in the next 5–10 years. The results are summarized in **Exhibit 1**. Overall, 43% of respondents say they expect their role to be significantly different. In addition, 5% of respondents say their role is unlikely to exist in 5–10 years. The ones with the greatest anticipated change, however, are not core investment roles but rather those doing IT in finance (80% say their role will substantially change or cease to exist). The three roles most likely to cease to exist are sales agents and traders (both 11%) and performance analysts (19%). Among the latter

group, much time is currently spent gathering data from unintegrated sources, so it is true that upcoming significant changes could relieve performance analysts of some of the tedious parts of their role, freeing up time for more judgment and analysis.

**Exhibit 1**

| **Leaving aside any personal circumstances or your expected career progression, how different, if at all, do you think the role of a(n) [CURRENT OCCUPATION] will be in 5–10 years' time?** | I expect it to be substantially different | I do not think the role I perform today will exist in 5-10 years. |
|---|---|---|
| **Total** | **43%** | **5%** |
| Information Technology | **77%** | **3%** |
| Trader | **51%** | **11%** |
| Financial Adviser/Planner/Wealth Manager | **54%** | **4%** |
| Accountant or Auditor | **49%** | **9%** |
| Risk Analyst/Manager | **54%** | **3%** |
| Performance Analyst | **31%** | **19%** |
| Research Analyst, Investment Analyst, or Quantitative Analyst | **45%** | **4%** |
| Credit Analyst | **44%** | **3%** |
| Investment Consultant | **45%** | **1%** |
| Relationship Manager/Account Manager | **40%** | **6%** |
| Portfolio Manager | **39%** | **3%** |
| Investment Strategist | **36%** | **5%** |
| Chief Executive Officer (CEO) | **30%** | **0%** |
| Chief Investment Officer (CIO) | **24%** | **1%** |

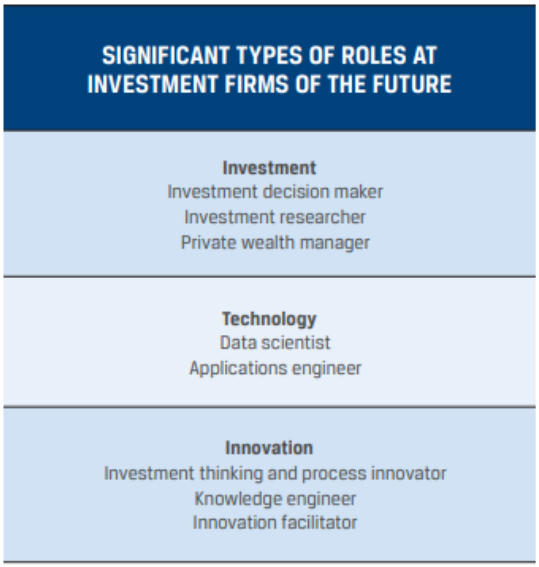
SOURCE: CFA INSTITUTE MEMBERS AND CANDIDATES SURVEY

## B. The Most Valuable Roles in the Future and How They Relate to Technology

There is consensus among the practitioners we interviewed and our survey respondents that technology will be the dominant driver for change in investment management and an increasingly essential element of work for almost all investment professionals. Barbara Petitt, CFA, head of curriculum and learning experience for CFA Institute, said, "As technology becomes the lingua franca, investment professionals must become literate in a language that is not their own and be able to ask the right questions. Asking the right questions is and remains a key competency for our profession."

As the industry moves to an AI+HI model, investment teams of the future will fulfill three main functions (investment, technology, and innovation) in eight types of

**Exhibit 2**



roles, as shown in **Exhibit 2**, at the investment firms of the future.[3]

Investment decision-making roles are typically undertaken by chief investment officers and portfolio managers, depending on the size and structure of the firm. Investment research is predominantly provided by research analysts. Private wealth managers are generalists who also serve a relationship function with their clients. These roles exist today, but as seen in **Exhibit 1**, many investment professionals expect them to change significantly. Among wealth managers, 54% expect the role to be substantially different, compared with 45% of research analysts and 39% of portfolio managers.

Data scientist roles are increasingly present at investment organizations. These professionals are the architects and the applications engineers are the builders; they work together to develop and implement the technology components of the investment process.

Innovators focus on improving the existing investment process. A key role innovators play in the face of technology disruption is to facilitate the collaboration between investment and technology teams. One will find investment thinking and process innovators both among senior researchers in the industry and at leading research universities. Knowledge engineers are subject matter experts who identify key industry trends and emerging investment expertise. They focus on gathering insights from the innovators and sharing it with the rest of the investment professionals. Innovation facilitators play a similar role to private wealth managers except that they operate in the innovation space.

### C. How Individuals Will Increasingly Differentiate Themselves by Their Ability to Work with Technology

Collaboration to apply technology, as discussed earlier, involves human intelligence in training, explaining, and sustaining roles (ensuring the technology works safely and ethically). It involves the machine in amplifying, interacting, and replicating roles (reproducing human skills). The roles are complementary in all cases—their effectiveness is present only when there is some AI+HI combination.

Investment professionals of the future will increasingly differentiate themselves by their ability to work with technology to enhance their quality of work generally and performance levels more specifically. The need and ability to work with technology translates into different requirements for the three functions of investment, technology, and innovation highlighted above.

The type of skill required for investment teams, which includes the majority of CFA charterholders, will remain predominantly investment skills. Professionals on investment teams who understand the basics of AI, data science, and technology can be expected to be far more effective than someone with similar investment skills but no exposure to such technologies. We must emphasize that we do not think this means that the majority of CFA charterholders will need to become programmers or statisticians. We also doubt that investment professionals in general are committed to such a development. Quite the contrary, we think professionals need to continue to sharpen their investment skills because routine tasks will increasingly be performed by machines. Experience and judgment will become more important in the more-complicated tasks that often carry greater impact and higher risk.

[3]This discussion benefited from the future professional roles section in Richard Susskind and Daniel Susskind, *The Future of the Professions: How Technology Will Transform the Work of Human Experts* (Oxford, United Kingdom: Oxford University Press, 2015).

The big data opportunity in portfolio management is additive in nature. Unstructured data analysis today is the equivalent of going where people have not been before (i.e., uncovering previously hidden information). In addition to annual reports and conference call transcripts, the explosion of data in today's world has put a vast amount of new information at the disposal of investment professionals, including such alternative data as social media, satellite images, customer and cargo traffic information captured with sensors, and web scraping. In this way, analysts can gain knowledge without physically being present. In other words, information is stored and transmitted in the form of images and written and spoken languages. AI and big data technologies will enable analysts to have access to a vast amount of public information, much of which was not available to investors before. This shift is often referred to as going beyond the "data tap" (i.e., Form 10-K data being periodically dripped out) to the "data lake" (i.e., constant access to constantly growing publicly and privately accessible data). The challenge now is for the analyst to create value by making sense of this massively expanded data and integrating them into portfolio construction. It speaks to the human roles in training, explaining, and sustaining and machine roles in amplifying, interacting, and replicating.

The most important skillset on a growth trajectory for innovation professionals is T-shaped skills. Innovation professionals are subject matter experts, but the key to success will be their readiness to adapt to changing environments and their ability to go beyond their own field and work across disciplines. We would argue innovation professionals in investment firms need to be grounded in both investment and technology, so they can communicate effectively with technology and investment professionals, respectively.

In practice, we expect investment teams and technology teams to collaborate closely in shared team space. We believe this is the most effective institutional approach to foster T-shaped skills across teams and for organizations to get the most out of professionals with T-shaped skills.

### D. How Firms Can Navigate and Harness Technology

We have categorized the effects of technology into three levels, shown in **Exhibit 3**.

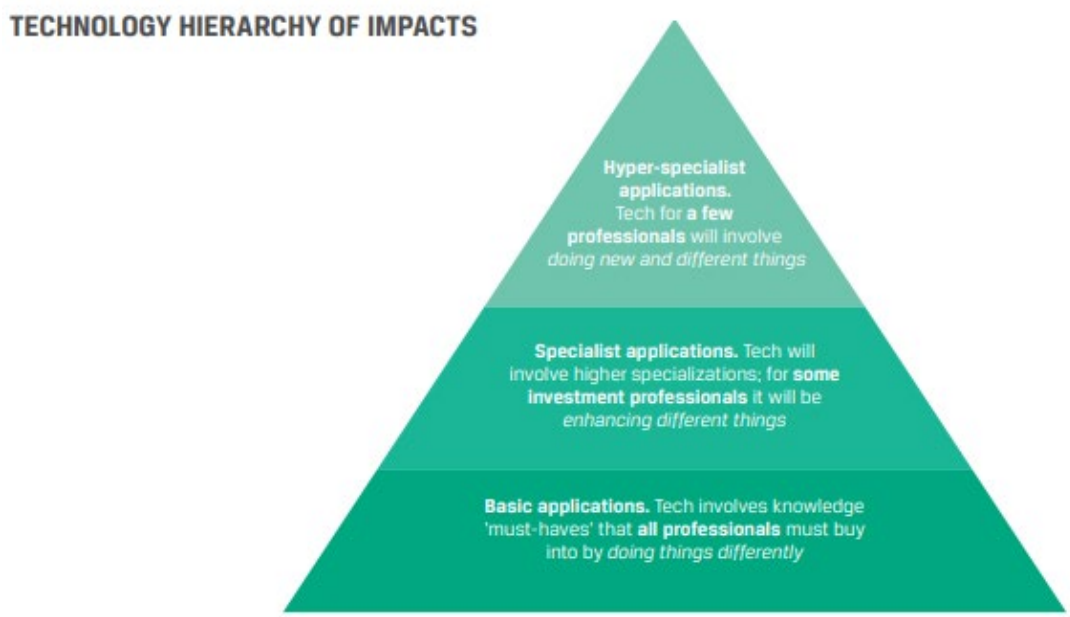
1. The basic applications in technology require all professionals to do things differently, ensuring technology improves task execution in amplifying, interacting, and replicating (replacing tasks and sometimes displacing human roles).
2. The specialist applications in technology will be in enhancing different things where investment teams and technology teams collaborate closely in shared team space and to foster T-shaped team skills.
3. The hyper-specialist applications in technology are derived from data science evolution and its spin-offs in new and different things like training, explaining, and sustaining (ensuring safe and accurate tech deployment). While many of these individuals will not be investment trained, the best will be.

*What is different?* There is a wholesale shift occurring in people plus technology models for the industry. That shift will evolve and accelerate.

*What is the same?* Professionals have always had to respond to new technologies. Recall the impact the desktop computer had on the investment industry.

*What advice can we offer to the investment professional of the future?* Build tech-savvy skills (i.e., understanding and using technology effectively) and make sure it serves you, not the other way around.

**Exhibit 3**




**Section II: AI Pioneers in Investment Management**

Will robots replace human investment managers? As the investment industry stands on the cusp of arguably its greatest technological transformation, we set out to understand the current state of adoption of artificial intelligence (AI) and big data applications in investment management and to exemplify where and how such technologies can be put to use.

***Highlights***

- We identify three types of AI and big data applications in investment management: (1) using natural language processing (NLP), computer vision, and voice recognition to efficiently process text, image, and audio data; (2) using machine learning (ML), including deep learning, techniques to improve the effectiveness of algorithms used in investment processes; (3) using AI techniques to process big data, including alternative and unstructured data, for investment insights.
- According to a CFA Institute survey, relatively few investment professionals are currently using AI/big data techniques in their investment processes. Most portfolio managers continue to rely on Excel and desktop market data tools; only 10% of portfolio manager respondents have used AI/ML techniques in the past 12 months.
- We identify five major hurdles to successful adoption of AI and big data in investment processes: cost, talent, technology, leadership vision, and time. Investment firms will need to substantially overcome the five hurdles to reach the top of the FinTech pyramid.

- Powerful FinTech will be the result of collaboration between *Fin* (financial institutions) and *Tech* (technology companies). Successful firms will be centered on T-shaped teams that combine investment expertise, innovation, and technology application across investment strategies or processes.

***Key Takeaways***

- The decision to use AI and big data techniques should be benchmarked against the performance of traditional techniques. Firms should determine whether the potential additional alpha capture is worth the additional cost and complexity of applying AI and big data.
- A machine is only as intelligent as the data it learns from. The more comprehensive the training data, the more generalized the machine will process new events, thereby mitigating common pitfalls like overfitting.
- ML techniques are more suited to systematic strategies (including rules-based, quantitative strategies), and unstructured and alternative data are typically used more by discretionary (active) managers.
- Niche, sector-specific data sets are of more relevance to a fundamental analyst or portfolio manager searching for alpha than a systematic manager.
- The effective use of such data sets could provide one of the biggest opportunities for a besieged active management sector.
- AI and big data are no panacea; they cannot solve every investment problem. For example, only a small proportion of big data can generate meaningful signals; reliably extracting signal from noise is difficult.

## A. Applying AI and Big Data in Investments: Challenges and Opportunities

In the words of numerous industry heavyweights, AI is the new electricity. The *Economist* magazine championed the slogan, "Data is the new oil."[4] We discuss in this section how some firms are taking advantage of frontier powers in investment management.

### AI: NLP, computer vision, and voice recognition

Researchers have made tremendous strides in building the ultimate "seeing, hearing, and understanding" machine in recent years.[5] In the case of natural language processing (NLP), computer vision, and voice recognition programs, AI is used to capture text, audio, and imagery from a variety of public sources and internal/vendor databases. Examples include transcribing analyst conference calls and extracting data from issuer filings for valuation models. In most cases, the program automates what is traditionally a manual and repetitive task performed by an analyst. We expect to see these types of applications being used more and more in the industry; they broaden the investment professionals' reach and improve efficiency by combing through multiple data sources and combining them into one platform.

Such programs also increase human capacity by freeing time otherwise spent on manual work. Junior analysts used to spend much of their research time finding and entering information. These routine and

[4]See www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data.
[5]See Larry Cao, "Artificial Intelligence, Machine Learning, and Deep Learning: A Primer," *Enterprising Investor* blog (13 February 2018): https://blogs.cfainstitute.org/investor/2018/02/13/artificial-intelligence-machine-learning-and-deep-learning-in-investment-management-a-primer/.

repetitive activities will likely become the first to be taken over by AI programs, which have a natural advantage in this type of work.

**AI: Machine learning (ML) and deep learning (DL)**

More sophisticated programs will further process the information harvested from various sources to generate signals to inform the investment decision-making process. This often requires sophisticated AI techniques, such as ML and DL.

Machine learning is a general term for computing methods and algorithms that allow machines to uncover patterns without explicit programming instructions.[6] ML programs inform themselves how to interpret inputs and predict outputs.[7] Deep learning is a type of ML that is based on artificial neural networks (a type of learning modeled on the human brain).

DL algorithms are often applied to improve the results of NLP, computer vision, and voice recognition programs. They can also help extract useful information from large piles of data. For example, these algorithms can infer certain key words from conference call transcripts or identify sentiment from unstructured data, such as social media. Such information can then be translated into trading signals or, more simply, alerts for human analysts and portfolio managers to process.

ML and DL programs are also popular with quantitative (systematic) managers who often find it helpful to apply these techniques in order to improve the effectiveness of their quantitative processes. There are several cases in the report that illustrate this point.

Traditional statistics and econometrics are based on techniques first developed a couple of centuries ago, and their applications in finance often involve linear regression models. These linear models are effective in many situations. However, at least some of the complexities in the real world may be better captured using ML techniques because of their ability to handle contextual and nonlinear relationships, which can often arise in finance. For example, ML techniques may be more effective than linear regressions in the presence of multicollinearity (where explanatory variables are correlated).[8] In these cases, ML and DL techniques provide investment managers with additional toolkits that can give them an edge.[9]

**Big data: Alternative data and unstructured data**

Data scientists define big data with four Vs: volume, variety, veracity, and velocity.[10] The terms often used in the investment circles are “alternative data” or “unstructured data.”

Alternative data refers to data from sources that are not currently used or not yet mainstream. In comparison to structured data, which is data that are digitized and stored in relational databases,

---

[6]K.C. Rasekhschaffe and R.C. Jones, “Machine Learning for Stock Selection,” *Financial Analysts Journal*, vol. 75, no. 3 (Third Quarter 2019).
[7]Cao, “Artificial Intelligence, Machine Learning, and Deep Learning” (2018).
[8]See Rasekhschaffe and Jones (2019).
[9]For suggested further reading on machine learning, including types of ML algorithms and their applications, see the CFA Institute Refresher Reading on "Machine Learning" (2020 Curriculum), available to CFA Institute members and charterholders at www.cfainstitute.org/en/membership/professional-development/refresher-readings/2020/machine-learning.
[10]See www.ibmbigdatahub.com/infographic/four-vs-big-data.

unstructured data refers to data that are often in text, image, or voice formats and are not readily processable. Alternative data and unstructured data are related and yet not quite the same. Alternative data is often unstructured when first discovered, and unstructured data is usually not used by mainstream investors, making it alternative.

Examples of alternative data/unstructured data often used in the investment world today include satellite images, earnings conference call recordings and transcripts, social media postings, consumer credit and debit card data, and e-commerce transactions.

Finding the new data source that generates alpha has become the next arms race among some analysts and investment managers, much like how managers have traditionally competed to find the unturned stone in the public markets. In a way, extracting signals from big data is simply an extension of what analysts used to do—visiting stores to check out customer traffic, for example. Now some of them use satellite images or sensor information of the parking lot to infer the same information. The new techniques offer efficiency gains; an analyst can cover a lot more stores in much less time using satellite imagery or sensor data.

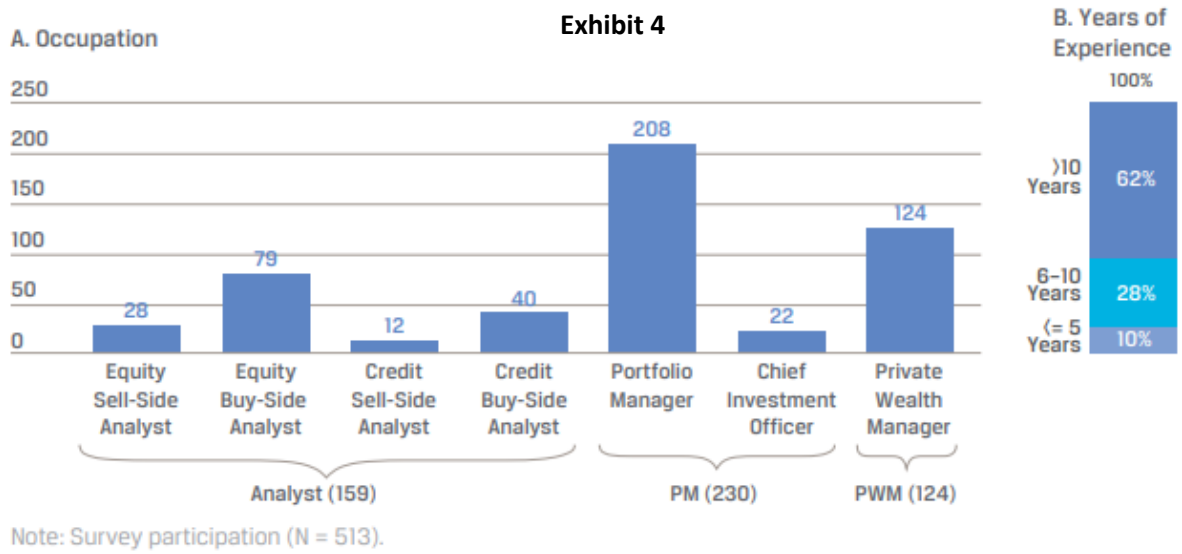
Alternative data tends to be niche and is more popular with fundamental managers running discretionary portfolios who use these data as one input in the investment decision-making process. Some of the cases included in this report provide real-world examples of how alternative and unstructured data are being used.

**B. Where Does the Industry Stand in terms of Applying AI and Big Data?**

CFA Institute conducted a survey to understand the state of adoption of different technologies in the workflows of analysts, portfolio managers, and private wealth managers. This section provides some of the pertinent findings to illustrate the industry landscape regarding AI technologies and to set in context the specific case studies that follow.

The survey was sent to a randomized sample of CFA Institute charterholder members in March 2019, and there were a total of 734 respondents (52% from the Americas, 18% from Asia Pacific, 30% from

**Exhibit 4**




Note: Survey participation (N = 513).

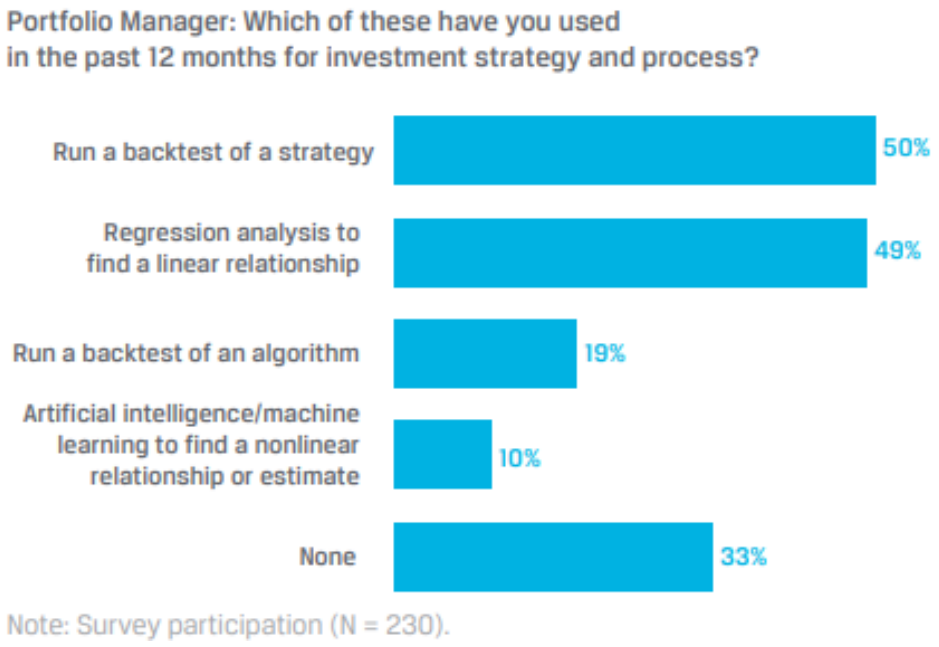
Europe, Middle East and Africa). Respondent occupations spanned equity and credit analysis, portfolio management, chief investment officers, and private wealth management, as shown in **Exhibit 4**.

The professional experience of the respondents ranged from new entrants to those with more than 10 years of experience**.**

The survey results indicate that few investment professionals are currently using programs typically utilized in ML techniques, including coding languages such as Python, R, and MATLAB. Most portfolio managers continue to rely on Excel (indicated by 95% of portfolio manager respondents) and desktop market data tools (three quarters of portfolio manager respondents) for their investment strategy and processes.

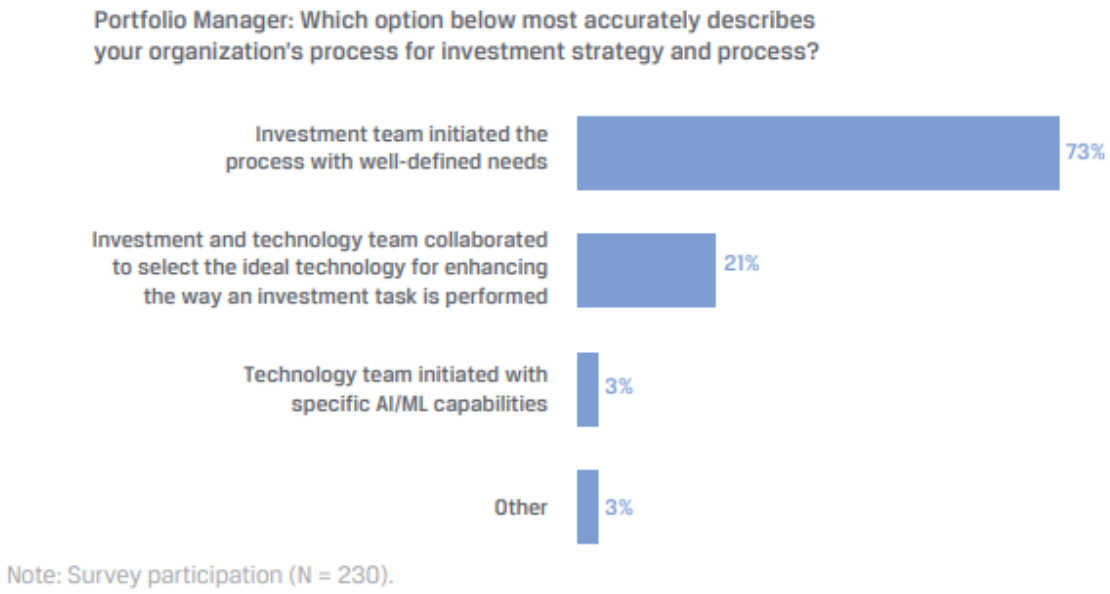
Moreover, as the results in **Exhibit 5** illustrate, only 10% of portfolio manager respondents have used AI/ML techniques in the past 12 months, and the number of respondents using linear regression in investment strategy and process outnumbers those using AI/ML techniques by almost five to one.

**Exhibit 5: Statistical Techniques Used in Investment Strategy and Process**



At the organizational level, the extent of collaboration between investment and technology teams remains relatively low, as shown in **Exhibit 6**. This suggests further integration may be needed to realize process efficiencies as these technologies take hold.

**Exhibit 6: Organizational Responsibilities for Investment Strategy and Process**



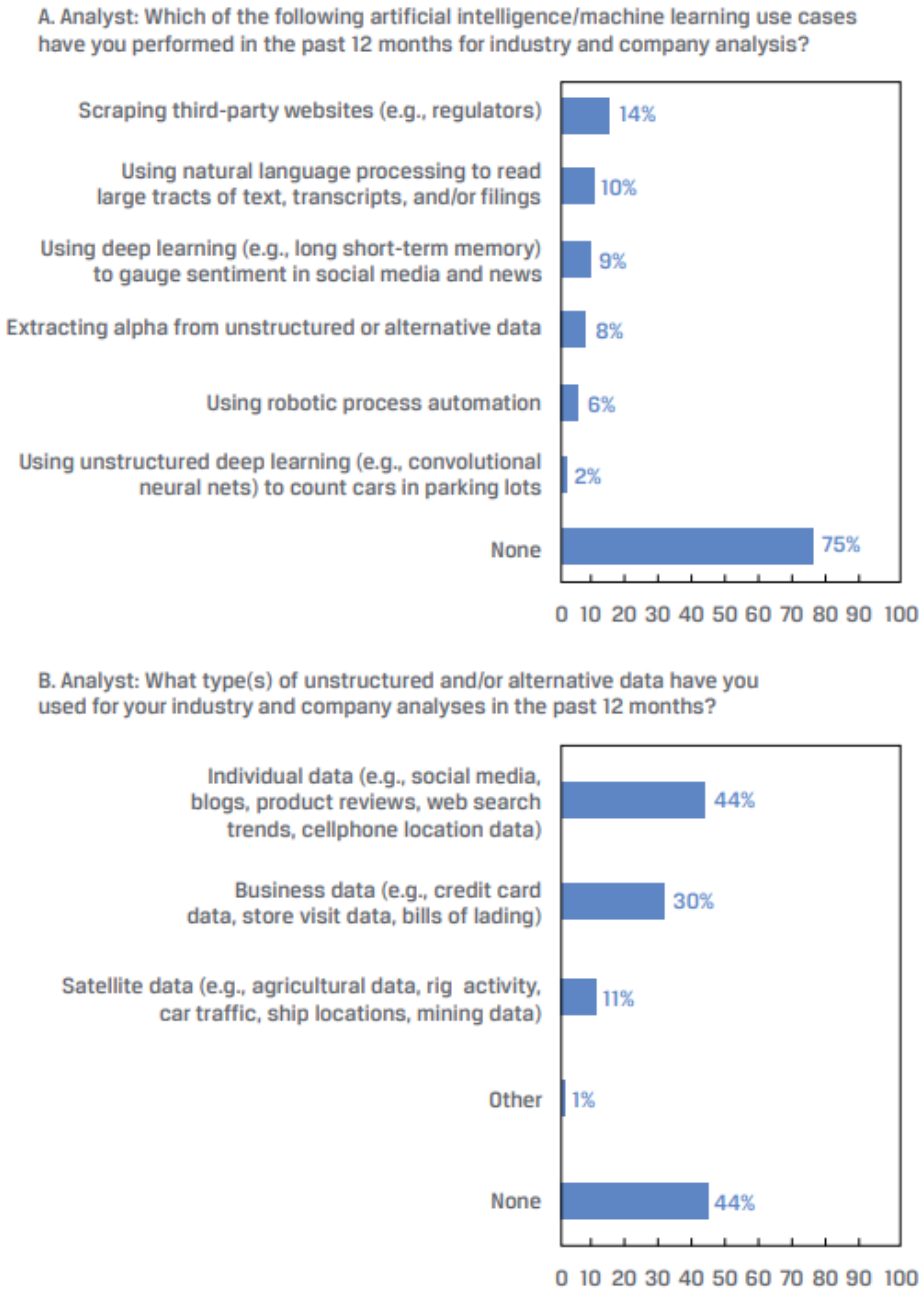

Note: Survey participation (N = 230).

The prevalence of AI/ML techniques in trading strategies is also low, according to the survey: 69% of portfolio manager respondents report not using any AI/ML techniques for creating trading algorithms in the past 12 months. Those professionals who are using these techniques indicate a wide range of use cases, including arriving at buy or sell decisions based on various input variables (15%), building signals (14%), and determining sentiment based on NLP (10%), among several others.

A similar result emerges in Panel A of **Exhibit 7**, which shows that three-quarters of analyst respondents are not using AI/ML techniques for industry and company analysis. Of those who are, the two most popular techniques cited are scraping third-party websites (cited by 14% of respondents) and using NLP (cited by 10% of respondents). In comparison, 40% of respondents cited using linear regression for industry and company analysis (not shown).

Using unstructured and alternative data for industry and company analysis is more popular than using AI/ML techniques among investment professionals. As illustrated in Panel B of **Exhibit 7**, 44% of analyst respondents report using individual data, such as social media, product reviews, and web search trends, in the past 12 months while only 11% have used satellite imagery. One caveat of these results, however, is that they do not allow us to infer how often or how extensively these data sources are being used in industry and company analysis. A significant number of professionals, 44%, report not using these data.

**Exhibit 7: AI/ML Techniques vs. Unstructured/Alternative Data for Industry and Company**

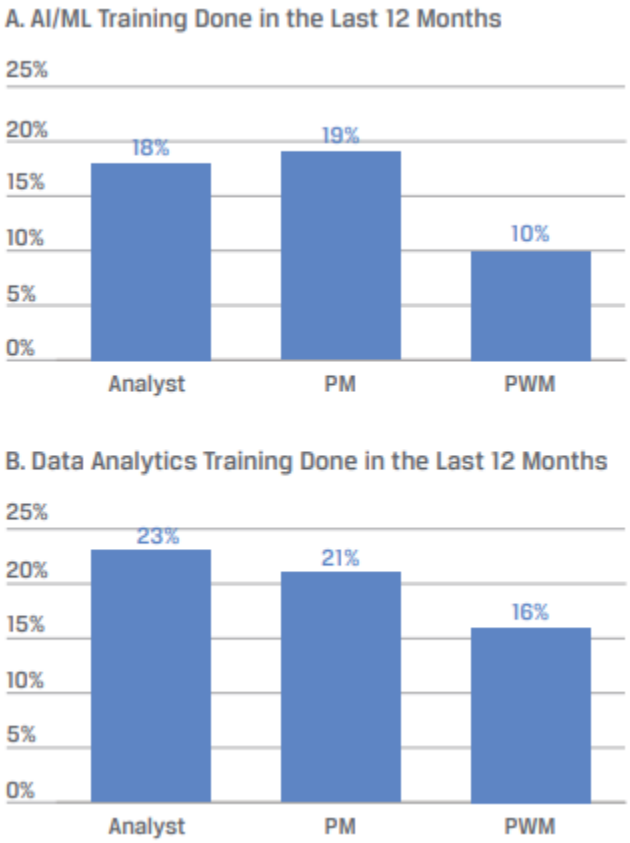



Note: Survey participation (N = 159).

In sum, these results suggest that the investment industry is in the very early stages of adoption of AI techniques and related technologies, and few professionals are currently using AI/big data techniques in their daily investment processes.

However, approximately one fifth of analysts and portfolio managers report participating in AI/big data training, as illustrated in **Exhibit 8**.

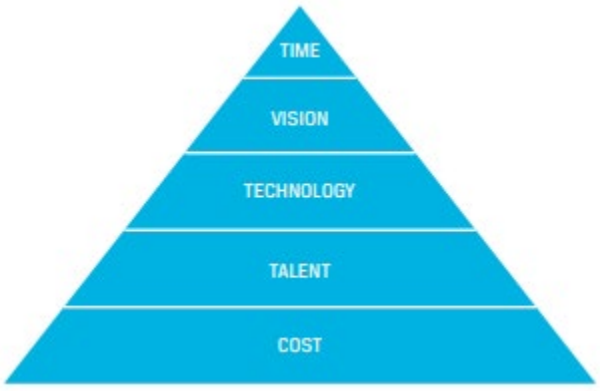
**Exhibit 8: AI/ML vs. Data Analytics Training**




Overall, given the low current utilization of AI and big data techniques coupled with the large number of practitioners undergoing training in these fields, the industry seems poised to undergo significant growth in the coming years.

## C. Challenges in Applying AI and Big Data: The FinTech Pyramid

**Exhibit 9: The FinTech Pyramid**



So, what is holding investment professionals and investment firms back from realizing the full power of AI and big data? We have identified five major hurdles, which are described next in increasing order of difficulty.

**Hurdle #1: Cost**

Financial institutions are not strangers to huge IT budgets, but launching AI and big data capability can involve significant upfront cost as well as ongoing maintenance costs.

The high cost can at least in part be attributed to the new data sets that enable these technologies and that have been catching the industry's attention.[11] Identifying, cleansing, and making sense of these data sets is no small feat, which is why one prominent economist believes that small firms will find it increasingly difficult to compete in the age of AI and big data.[12]

**Hurdle #2: Talent**

College graduates with basic programming and statistics training, not to mention those with advanced degrees in AI or related fields, are already very popular with employers in the age of AI. Yet this is only part of the story.

There is a real advantage of working at one of the top technology companies that employs and invests significantly in AI. Google, Microsoft, Baidu, and Alibaba are some of the names that come to mind. Much of the latest and greatest developments in AI are taking place at these companies, and the small number of employees involved in these projects have become a rare breed who have access to knowledge and skills not currently taught yet in the top schools around the world.

What further complicates matters is that it seems very few of the top AI talents are actually looking to work in the investment industry. Maybe AlphaGo and driverless cars are innately more exciting for AI scientists. Either way, obtaining talent appears at least a degree harder than managing the cost.

**Hurdle #3: Technology**

We are at the beginning of the AI revolution, and technology is still fast evolving. This creates significant challenges for those investing in AI applications because the risk of being leapfrogged by a latecomer is significant. Staying current with the latest developments is a real challenge for most investment professionals and organizations, barring a privileged few. Having a sizeable budget and top talent are prerequisites to staying ahead of the pack.

Similarly, in the alternative data space, the exploration of new data sources is in its relative infancy. There are many new data vendors entering the field, and extracting useful signals from the avalanche of data remains challenging.

**Hurdle #4: Vision**

There will likely be sweeping changes in the investment industry driven by advances in AI and big data technologies in the coming decades. These technological changes have to be managed from the top of organizations for them to fully penetrate the business while efficiently deploying resources.

---

[11] See, for example, www.cnbc.com/2017/11/28/making-millions-from-the-data-hidden-in-plain-sight.html.
[12] www.nytimes.com/2018/01/12/business/ai-investing-humans-dominating.html.

As noted in *Investment Firm of the Future*, IT deployment in investment firms has been substantially reactive to date, with firms trying to marshal technology to capture efficiencies in the face of legacy issues.[13] Firms will need to focus on proactively developing the skills and procuring the systems to stay competitive. Strategic vision, leadership commitment, and collective ownership of IT deployment will be essential for firms to succeed in the future.

**Hurdle #5: Time**

Any progress, no matter how small, often takes a significant investment of time, among other things. This is simply a fact of life when you are on the frontier of development.

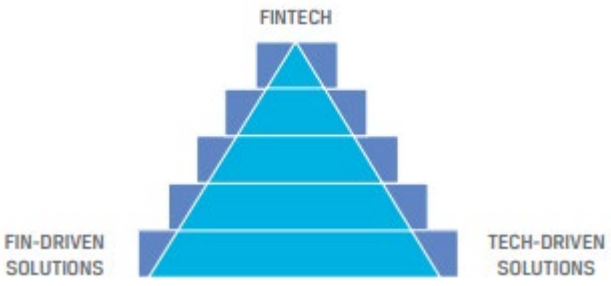
Every firm wants to be the first at turning over a rock and uncovering useful information, but exploring ways to increase alpha and integrating the new approaches into existing investment processes take time. Even in the most advanced markets and at firms where the most sophisticated technologies have been in deployment for many years, most big data projects still require a lot of time and effort to prepare the data and make them fit for purpose. Patience and persistence are necessary, and even then, many projects will not succeed. Time remains one of the toughest challenges to overcome, and success does not happen overnight.

**Current state of play and the road map to the top of the pyramid**

Investment firms will need to substantially overcome the five hurdles (i.e., use the latest AI and big data technologies to solve core investment problems) to reach the top of the pyramid, where *Fin* meets *Tech*. But ascent to the top requires a collaborative approach; overcoming each hurdle requires consideration of both Fin and Tech dimensions.

Conceptually, this is illustrated in **Exhibit 10**. In the Fin corner, investment solutions tend to be driven by quants who come from a finance background. By and large, these types of solutions rely on existing data sets and do not rely heavily on alternative data, saving time and effort in identifying relevance (separating signal from noise) and testing and cleansing data. At the same time, they may not benefit from new information from alternative data and the latest technical breakthroughs in NLP, computer vision, and voice recognition, for example.

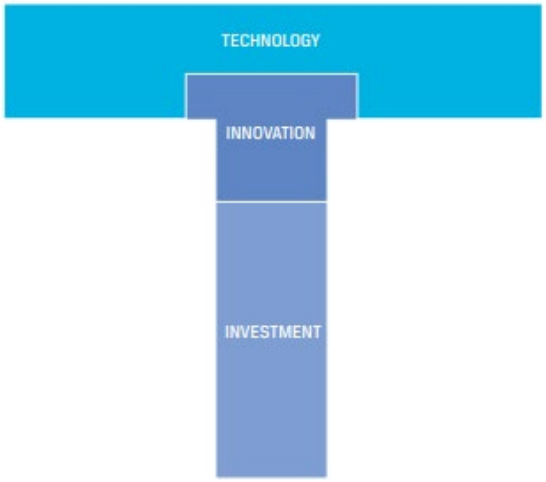
**Exhibit 10: Where Fin Meets Tech**




[13]CFA Institute, *Investment Firm of the Future* (Charlottesville, VA: CFA Institute 2018): 10–11.

Also in the Fin corner are some discretionary managers experimenting with new data sources that they come across. What is often missing is the overall strategy of systematically leveraging new technologies to gather and process new information that will feed into the investment process, creating an edge.

**Exhibit 11: T-Shaped Team**




In the Tech corner, solutions are typically driven by technologists coming from outside the investment world. The architects and their teams tend to have in-depth knowledge of the latest AI and big data technologies and can create the fanciest wizardry that leverages the latest technology. Often, they are not built with a specific business objective or end user profile in mind and cannot be easily incorporated into the investment process of an established investment firm.

Introducing AI and big data into investments may be the single most significant change to the investment process that investment professionals will experience in their careers. Given the complexity illustrated by the FinTech pyramid, it will take many iterations to get everything right and reach the top of the pyramid. The important takeaway is the need to take a collaborative approach and expect to ascend the pyramid step by step. There is no shortcut.

### D. Making It Happen: T-Shaped Teams

The FinTech pyramid highlights the strategic imperatives of applying AI and big data in investments. The T-shaped team concept we introduce in this section provides an operational and organizational approach to making it happen.

We discussed in *Investment Professional of the Future*[14] the increasing importance for individual investment professionals to acquire T-shaped skills. T-shaped professionals have both domain-specific specialist knowledge and wider professional connections, understanding, and organizational perspective. In addition, T-shaped teams have a broad and deep collective intelligence and benefit from a collaborative culture and cognitive diversity.

In the context of AI and big data in investments, we can apply the concept of T-shaped teams. The combination of skills and collective intelligence gathered through investment expertise and technology application across investment strategies or processes is an example of a T-shaped team in this area. We also emphasize a third aspect of T-shaped teams in this context—namely, the role of innovators in connecting investment and technology teams, requiring such professionals to be particularly strong in T-shaped skills. The small T in the overall T-shape shown in **Exhibit 11** illustrates this aspect.

Under this framework, roles in the investment function are not substantially different from what we observe in the industry today, but that may not be true for the technology function. The technology

[14]CFA Institute, *Investment Professional of the Future* (Charlottesville, VA: CFA Institute, 2019). www.cfainstitute.org/en/research/survey-reports/investment-professional-of-the-future

function in future investment teams will likely require different skill sets than those required today. In particular, data scientists, in addition to computer engineers, will become important.

The third function, innovation, is of critical importance, because its main function is to facilitate collaboration between the investment and technology functions, something that the industry has not had a strong track record to date. Innovators may have the title of researcher, strategist, product manager, or business developer. The lack of appreciation for this function is evidenced by the fact that professionals serving the roles often sit in different departments at different firms. Some sit in the investment or technology departments but must have a keen understanding of their counterparts' business to be effective collaborators. Strategists and product managers, for example, may take on the role because they have a better understanding of the big picture than the specialists from the investment and technology functions.

As noted in "FinTech and the Future of Financial Services," powerful FinTech will be the result of collaboration between powerful Fin (ancial institutions) and powerful Tech (nology companies).[15] The argument is true not only from a strategic perspective but also from an operational and organizational perspective.

In the early stage of collaboration, T-shaped teams are typically small in scale and often exist only on an informal, project-specific basis. As operations mature, T-shaped teams become more commonplace and are more permanent features of the organizational structure. The complexity of the issues at hand requires organizational commitment, which can be best identified by the number (and effectiveness) of the T-shaped teams an organization supports.

### E. AI in Practice: Examples from Our Case studies

Below are a few examples from our case studies of how AI is processing these large and complex data sets:

- First, Goldman Sachs' sell-side research team is better able to analyze national concrete companies supplying the construction industry by using geospatial data of 9,000 U.S. quarries that each act as local businesses.
- Second, the data science team at American Century Investments studied psychology textbooks to determine patterns of deception in children and criminals. They then applied machine learning to these patterns so they can recognize them in earnings calls to find where information might be purposely omitted and to determine where spin, obfuscation, and blame are being used and communicated.
- Finally, Bloomberg has had a sentiment analysis product available since 2009, which analyzes the potential effect of news stories on valuations. They process 2 million documents a day through their machine learning platform. This was alternative data used only by hedge funds at first but now many of their clients use it.

[15]Larry Cao, "FinTech and the Future of Financial Services," in *Fintech 2017: China, Asia, and Beyond* (Charlottesville, VA: CFA Institute 2017). Available in Chinese at www1.hkej.com/dailynews/investment/article/1313726/.

## F. Implications for Regulators

Just as the investment industry is beginning to employ greater technology, regulators can look at new data in the world of "regtech." We see several potential regulatory concerns and challenges related to AI.

1. One is the ability of SEC monitoring and enforcement to keep up with insider information and Reg FD data that makes its way undetected through the vast AI "vacuum." The speed and volume of data collected present a new surveillance challenge for both compliance departments and regulators.
2. Regulators will need to have the tools and resources to recognize when investment products are marketed using faulty or inaccurate data that subject investors to higher risks. Application of these tools will help regulators apply and enforce existing regulations calling for full and fair disclosure of investment strategies and methodologies.
3. Regulators should consider how firm cultures adapt to increasingly tech-informed investing. Most successful AI pioneer firms seek broad input when designing new products and processes, and having diverse perspectives can reduce the risk of building biases into models.

## G. Outlook and Word of Caution

We believe in the power of the "AI + HI" model—that is, most tasks are and will remain best handled using both AI and human intelligence, and the collective power of the two is superior to either element on its own.[16] The path of adoption begins with routine, rudimentary tasks such as capturing information from texts and images, producing reports, and populating spreadsheet models, where AI has some advantage over human beings in the breadth of information they can process at high speeds. Analysts are then free for higher-value tasks that require more experience and judgment.

It is not a race between humans and machines. The competition ultimately is among "AI + HI" teams, and the stronger teams that effectively harness and combine both elements will outlast the weaker ones. The successful investment teams of the future will excel in collective intelligence through cognitive diversity (artificial and human) and T-shaped skills.

Despite the important role they will play in the investment industry, AI and big data are no panacea. In some situations, additional information (big data) can add alpha, and in others, enhanced algorithms (ML) may detect previously undiscovered patterns. Still, AI and big data certainly won't provide all the answers investors need or want.

One of the challenges ML techniques face, for example, is that they work better in the test environment (i.e., based on the training data set) and may not always respond appropriately to new situations in the real world. This is the problem of overfitting—where algorithms perform well in sample but poorly out of sample. AI may work for AlphaGo, where all the rules are set. The ever-changing investment world, however, presents more difficulties. In addition, at least some of the ML programs for business are more like a black box; users do not have access to the logic behind ML actions. As a result, some of the features captured by the programs have no causal relationship with the variables the models try to predict.

[16]See Larry Cao, *Fintech 2018: The Asia Pacific Edition* (Charlottesville, VA: CFA Institute, 2018) and CFA Institute, *Investment Professional of the Future* (Charlottesville, VA: CFA Institute, 2019).

As technology and understanding progress, these challenges may be overcome, but as of now, we should put the power of AI and big data in perspective when embarking on a journey to explore the unknown.

Based on our research, including interviews and conversations with academics and practitioners in both investments and technology, we can conclude that

1. AI and big data have the potential to bring about the most significant change to the investment management industry that current professionals will experience in their careers.
2. Successful investment firms of the future will start to strategically plan their integration of AI and big data techniques into their investment processes now.
3. Successful investment professionals will understand and exploit the opportunities brought about by these new technologies and applications, enabled by collaborative organizational cultures, cognitive diversity, and T-shaped teams.