**Broadridge**®

# What are the Applications for Artificial Intelligence in Securities Finance and Collateral Management

A short excerpt of this paper originally appeared in Securities Finance Monitor.

# INTRODUCTION

Following numerous hype cycles, artificial intelligence (AI) is now gaining widespread adoption, with the potential to radically transform many areas of the financial services industry. In 2017, consultancy Opimas expects financial firms to spend more than US$1.5 billion on AI-related technologies. By 2021, this will rise to US$2.8 billion, representing an increase of 75%. Opimas also estimates a 28% improvement in financial institutions' cost-to-income ratio by 2025 as they automate routine processes currently performed by employees.

AI could represent a disruptive technology that reduces the barriers to entry that protect larger incumbents through lean, tech driven business models that reduce the need for expensive staffing. This could see financial institutions disrupted by either existing tech giants or new entrants that possess advantages through improved trading strategies and client servicing, driven by emerging technologies.

Many of the large tech firms such as IBM and Google are now making their AI platforms such as Watson and DeepMind available as open source products. This democratises the ability to build solutions using the massive computing power and AI engines offered by these firms. It will result in an explosion of new AI based solutions in the coming years. For these reasons, senior executives need to closely monitor developments in AI. They should view AI both as a transformative tool to improve return on equity, and as a future threat to their firm's business model.

Another key factor is that AI thrives on large amounts of data. In our industry, securities finance trade reporting under SFTR and derivatives transaction reporting under EMIR/Dodd Frank will result in large quantities of structured and tagged data. According to ESMA, this information will be made publicly available on the Tues following a Fri cut off. ESMA will also require trade repositories to publish data for the past 52 weeks.

Furthermore, the International Swaps and Derivatives Association (ISDA) is now promoting what it calls a 'common domain model'. The derivatives market has undergone multiple rapid sprints in recent years to comply with regulation. This result is tactical solutions and a lack of standardization. ISDA is now looking to address this through a more strategic, efficient and standardized approach to data management.

This could provide an opportunity to apply cognitive computing algorithms against SFTR and EMIR data. However, this will depend on whether the depth and timeliness of data publicly available allows interpretation of market trends in a way that can guide future decision making. Due to the large volumes of very granular data being collected, some work may still be required to standardise this to a degree it can provide value.

---

This paper covers the following topics:

---

What are the latest advances in AI?

---

Why this time is different than previous technological breakthroughs

---

Potential applications for AI in securities finance and collateral management

---

Will AI replace humans and what are the limitations of AI?

---

Key considerations when deploying AI to solve real world business problems.

---

# WHAT ARE THE LATEST KEY ADVANCES IN AI?

In the past few years, there have been major leaps forward in the ability of machines to perform certain tasks better than humans.

This includes:

- Google Deep mind beats the world's top human Go player – a task thought previously impossible due to the game's complexity.

- JPMorgan Chase introduces a system using its Gaia machine learning and big data platform to review commercial loan contracts. Work that used to take loan officers 360,000 hours can now be done in a few seconds.

- IBM's Watson supercomputer begins to run an actively managed ETF using AI – the Equbot with Watson AI Total US ETF.

- Asset servicing firm CACEIS announces it is using machine learning to ease the pressure on its securities lending desk and boost returns for clients by applying artificial intelligence techniques to price loans of corporate bonds.

- Broadridge develops a solution that collates information about Securities Finance Supply and Demand from a range of data sources. This includes securities available for borrow/loan or needed for settlement, short-selling, or any other purpose. It allows the mining of data content from e-mails with offers, needs, or locate/hold requests.

- The world's largest hedge fund, Bridgewater, hires the head of IBM's artificial intelligence unit Watson.

- Speech recognition error rates fall from 8.5% to 4.9% in the space of one year. Speech recognition is now three times as fast as keying in text on a cell phone.

- Image recognition error rates drop from over 30% in 2010 to around 4% in 2016.

- Quants at Goldman Sachs claim to have reverse engineered and rebuilt some of the risk premia components of hedge fund strategies. This includes arbitraging M&A activities and making bond and currency market bets. The firm is now selling these strategies at a fraction of the cost of traditional hedge funds through its Alternative Risk Premia and Hedge Fund Beta funds.

- UBS introduces an automated AI solution for managing clients' post trade allocation requests. The system reads client emails to determine how they want to allocate large block trades between funds and then executes the trades.

- The Facebook Artificial Intelligence Research (FAIR) group, working with the Georgia Institute of Technology, publishes code that allows chat bots to negotiate. The bots even developed "the ability to lie to gain the upper hand in negotiations and feigned interest in a valueless issue, so that they could later 'compromise' by conceding it."

Driving recent advances are six converging developments:

1. Larger data sets. IBM estimates around 90% of the data in the world today has been created in the past 2 years. Machine learning now involves feeding huge numbers of examples – with some very large systems trained by using 36 million examples or more. Machine Learning for images often utilises billions of examples for training.

2. Cheaper processing power and storage that facilitates faster learning. Faster processing power means training a system that may have taken a century or more with 1990s computers now takes a few days.

3. More sophisticated algorithms.

4. Greater use of cloud services. As firms move towards the cloud this will enable greater access to on-demand computing power for AI. It will also allow increased availability and access to data as a source of competitive advantage in trading.

5. Continued pressure on return on equity for financial institutions is driving a search for cost savings, with AI seen as an alternative to outsourcing and offshoring.

6. A vibrant fintech culture driven by both startups and incumbent technology firms.

# WHY DO THESE ADVANCES REPRESENT A STEP CHANGE FROM PREVIOUS AI TECHNOLOGY – WHY IS THIS TIME DIFFERENT?



The advances described above represent a revolutionary rather than evolutionary change in the capabilities of Artificial Intelligence. Rather than humans explicitly programming machines to perform tasks, machines can now learn from examples.

This means that a machine can keep improving on its performance without the need for humans to detail exactly how to accomplish the task. This represents a significant change from past practice.

Machine learning no longer relies on complex code created by developers. Instead, it can improve its knowledge of the world around it based on minimal and non-technical feedback. The main areas of artificial intelligence can be categorised as follows:

• Image recognition
• Natural language processing
• Robotic process automation (RPA)
• Machine learning
• Predictive analytics

# WHAT ARE THE APPLICATIONS FOR AI IN SECURITIES FINANCE AND COLLATERAL MANAGEMENT?

## Natural language processing/machine reading comprehension

The recent advances in natural language processing lend themselves to significant automation of a variety of currently manual tasks:

### 1. Legal Agreement Electronification

The ability to automate the mapping of key terms from ISDA CSA, GMRA and GMSLA is an area where AI can offer significant cost savings. AI can now process both structured and unstructured data. This enables it to interpret the content held within legal agreements and convert this unstructured data into structured data more quickly and accurately than a human.

### 2. Regulatory analysis

The ability of AI to use natural language processing to analyse the unstructured data contained in the mass of new regulation facing the industry is one area that could provide huge benefits.

IBM estimates that financial services firms spend $99 billion every year addressing compliance, which by 2020 will rely on 300 million pages of regulation. As a result, IBM is currently discussing the ability of its Watson supercomputer to help financial institutions deal with this burden.

### 3. Reconciliations and disputes

Management of reconciliations and disputes is another area where natural language processing can provide cost savings. Industry utilities for reconciliations presumably have collected large datasets around how disputes have been reconciled in the past. Machine learning from these examples could enable significant automation around the process with major cost reductions and increased speed in resolving disputes.

BNY Mellon recently reported success with a robotic process automation solution for reconciling trades. The system was able to reconcile a failed trade in a quarter of a second vs 5-10 minutes for a human reconciliation. The machines can also work overnight. However, the bank still requires control teams to check the work for errors.

### 4. Client and Counterparty Communications

Natural language processing also has applications for automating simple communications with clients and counterparts. This enables the processing of text contained in an email from a client or counterpart to determine intent. From there the AI solution automatically provides a standard response for more mundane tasks. Broadridge has recently developed a solution that takes in client e-mails, converts them into structured data using natural language processing, feeds them into a machine learning model to categorise emails and then acts on them. This allows the escalation of more complex queries to humans, freeing up time to focus on more difficult requests.

UBS recently discussed an AI driven client management tool it had developed that uses data on what clients are doing and how they are doing it. This then helps to drive decision making about how to spend time with clients in a more intelligent way.

However, this very much depends on client preferences. Some customers are happy with a light touch, low cost, machine driven relationship with their service providers. Others will always want a more personal relationship. Certain situations require a level of empathy that machines cannot currently, and may never replace. It will therefore be many years before we see humans meeting at the bar area with their robot relationship manager at industry conferences.

### 5. More voice based control and use of virtual assistants

It is entirely possible that in future we could see the application in business for voice based virtual assistants such as Alexa or Siri. For example, a collateral manager could start her day by asking "Alexa, how much additional collateral do I need to source to balance my portfolio today?". From there, the booking of collateral movements and other tasks could also be controlled by voice.

A recent study by McKinsey has suggested that we could see the emergence of what it calls cognitive agents. These assistants offer a virtual workforce to support human employees and customers.

# MACHINE LEARNING AND PREDICTIVE ANALYTICS

Machine learning is the ability of computers to learn without being explicitly programmed. Predictive analytics are used to make predictions about unknown future events.

Recent advances have combined these disciplines with the ability of machines to process vast amounts of big data. This then allows them to identify trends and correlations that humans are unable to see. In theory, this should result in more accurate predictions of future events that can augment human decision making and help front office staff to become more productive.

This can be applied to financial markets, including securities finance and collateral management in the following ways:

## Trading strategy, transaction pricing and risk management

The ability to guide trading strategy is one of the more difficult areas of AI. We are still some way from using this technology to make more reliable and accurate forecasts of future events. There is also considerable debate around whether a machine is able to outperform a human trader or investment manager over time.

It is important to note that existing strategies such as high frequency algorithmic trading are not the same as the replication of an analyst. However, some inroads are being made in this area.

One recent development leverages evolutionary computation. This involves creating a large group of digital stock traders and then testing their performance against past stock performance data. The top performers are selected and their genes utilised to create the next generation of superior traders.

This process is repeated over many thousands of generations, until the system produces an AI trader that can operate independently.

Other developments include start-up Kensho, who's investors including Goldman Sachs. Kensho claims to offer a solution that can scan documents on a wide range of topics from economic reports to politics. According to Kensho, it then uses this data to provide answers to "more than 65 million question combinations on where markets are headed." Examples of queries include "Which cement stocks go up the most when a Category 3 hurricane hits Florida?" or "Which sectors and industries perform best three months before and after a rate hike?"

Of course, one should treat these types of correlations with caution as they do not necessarily infer a stable cause and effect relationship. For example, there is a very close correlation between the per capita consumption of margarine with divorce rates in Maine (see http://www.tylervigen.com/spurious-correlations for this and other spurious correlations).

However, when used to augment human judgement, this could provide a powerful tool that assists human decision making on investment priorities.

## Machine learning and predictive analytics in securities finance

AI driven tools are now appearing in Securities Finance. Caceis recently announced it is using AI technology to price lending fees for client assets. Caceis reports that this is generating higher returns and enabling it to compete with larger competitors.

To quote the report in Global Investor ISF magazine:

*"We receive thousands of emails every day quoting many underlying holdings. To quote a competitive price, it is necessary to check over 20 features for each asset," explains Manson (of Caceis). "We aim to think smart rather than just increase manpower for such tasks. Automation and straight-through processing can only take you so far, but true machine learning is providing a revolutionary solution."*

*"In technical terms, we completely modelled a corporate bond within our systems, using more than 36 variables to classify the bond by 3 features: the level, the sensitivity to the utilisation rate, and the convexity. Polynomial regressions and trees are the main analyses used to perfect the model, which was performed on our extensive lendable assets directory to create a vast reference database."*

https://globalinvestorgroup.com/articles/3688556/caceis-brings-machine-learning-to-sec-lending

Caceis also discussed its use of AI for lending buffer management and a natural language processing tool for processing details of client emails and automating the initiation of the negotiation process.

## Sftr as a game changer

In the Securities Finance business, firms could also deploy AI against the data gathered from SFTR. By feeding in examples of trends it could then become possible to second guess moves by counterparties, clients and regulators and CCPs.
For example, regulators may react to certain trends in the SFTR data that signal a build-up of risk by raising haircut floors or increasing capital requirements.

If market participants can use AI to better predict when this type of activity will occur, along with other key events such as bond market squeezes, then this can inform strategic decision making.

Likewise, it could be possible to feed in historic data around trades to identify trading strategies that resulted in positive P&L. From there the firm could employ AI to suggest more effective trading strategies to human traders as a way to enhance human performance through better data.

Furthermore, firms can deploy AI to analyse trends in relationships with counterparties. An example would be using large datasets to predict what their collateral behaviour or borrow requirements will be to a reasonable degree of accuracy. This allows the firm to then adapt its inventory and liquidity profiles accordingly.

This type of information would typically be held internally in the mind of the collateral manager or trader, or more recently, captured by collateral optimisation algorithms. Collateral managers therefore use a range of disparate tools and analytics to inform complex human decision making. AI offers the ability to augment their understanding of trading and collateral activity by analysing much larger datasets to assist human decision making in this area.

This type of 'predicting the future' activity is the holy grail of AI. More forward thinking financial institutions are therefore seeking to address this opportunity by investing heavily in AI to leverage the large datasets they themselves currently own. How this story plays out will be one of the most interesting developments in the 21st century global business landscape.

Predictive analytics using large data sets will no doubt provide a useful tool to augment human decision making in increasingly complex financial markets. However, it is debatable whether predictive analytics using past data are able to effectively predict the future any more than humans can.

## Best execution

According to consultancy Finadium, AI could also play a role in determining best execution in the securities finance markets. This could assist with Mifid II compliance and other rules around best execution.

## Collateral optimisation, stress testing and liquidity forecasting

As mentioned earlier, collateral optimisation and liquidity management is one area where AI has the potential to support decision making. There are a large number of parameters influencing optimisation decisions (for example; collateral costs, operational and settlement costs, counterparty efficiency etc.). Feeding historic data around performance of optimisation runs and then using AI to suggest more optimal collateral allocations in the future could provide major cost benefits.

There are similar applications for AI around collateral stress testing and liquidity forecasting. Due to the mission critical nature of collateral management, it is likely that AI will enhance the role of the collateral/liquidity manager rather than replace it.

## Counterparty credit risk

The ability to assess whether a counterpart is likely to default is another key use case for AI. This could leverage huge amounts of data from multiple sources from news and analyst reports to social media sentiment around the company on platforms such as Facebook and Twitter to look for indicators of default.

The trend towards Peer to Peer/All to All networks in securities finance could also leverage AI to increase disintermediation. There are continuing questions about whether buy side firms are geared up to monitor counterparty credit risk effectively when engaging in Peer to Peer transactions.

It is worth noting that a number of new products are coming onto market employing artificial intelligence that may solve the credit risk problem and make it easier for the buy side to assess counterparty risk. However, it is still early days and conservative buy side firms and regulators may baulk at using an opaque black box style solution for something as critical as assessing counterparty risk.

# LIMITATIONS AND CHALLENGES AROUND ARTIFICIAL INTELLIGENCE

## Differences between AI and humans

AI solutions are currently able to perform some tasks better than humans. For example, beating the world's best human go player at Go. However, AI currently has a very narrow intelligence compared to the far broader intelligence of humans. AI systems are currently very specialised around a single specific task. The AI solution that beat the world's best go player is unable to pilot a driverless car or even play a game of checkers.

## Creativity, empathy and emotional intelligence

Emotional intelligence, empathy and creativity are other areas where artificial intelligence still lags far behind human performance.

Research is also starting to suggest that human intelligence and brain functioning is closely intertwined with other parts of our biology such as the bacteria in our digestive tract (see https://www.scientificamerican.com/article/the-neuroscience-of-gut/ for more details). This complex and not yet fully understood biological synergy provides a powerful differentiator for human cognition over that of machines, particularly around areas such as emotional intelligence and creativity.

However, AI systems can spot trends that humans are unable to see, due to the sheer volume of data that these solutions can process very rapidly. The advantage of AI is that it can digest a vast number of reports more quickly. This means that traders can use them to screen for patterns that humans are unable to identify and then trade more effectively on these correlations and trends.

Conversely, humans can often find solutions to problems in a more creative way than a machine and AI systems also make different types of errors than humans. When it comes to analysing reports, a human can bring a more sophisticated judgement than AI. In terms of emotional intelligence and the ability to display empathy, humans also possess huge advantages over AI.

For these reasons, it is unlikely that AI will make humans completely obsolete any time soon. AI solutions need to be set up correctly. Humans also need to maintain and govern them appropriately to maximise their output. This means completely unsupervised learning is still some way off.

AI will therefore most likely become another useful tool to augment human trading decisions rather than fully replacing humans in financial institutions.

## AI driven trading strategies become crowded

If everyone deploys the same technology and algorithms, then AI driven strategies cease to become a differentiator and trading strategies become crowded. This sees the ability to focus on how algorithms are deployed, governed and adapted becoming a core competency for successful market participants.

## Lack of auditability and difficulties around error detection

The black box nature of machine learning, where it is very difficult to determine the exact steps an AI system took to reach a certain outcome raises major issues around audit trails. With auditability a key aspect of governance for financial institutions this could become an increasing problem that drives significant regulatory scrutiny of AI in the future. This lack of visibility in terms of process also makes error identification extremely difficult in the event something goes wrong. Furthermore, it introduces operational and reputational risk. The flash crashes that have occurred in past years are good examples of when algorithms have caused serious problems.

## Regulation

The European Banking Authority recently signalled it is considering closer supervision and regulation of fintech firms. The federal reserve has also warned banks against using AI to analyse model risk (the AI algorithm actually being another source of model risk in itself). Other regulators may also share this view as the potential for fintech to transform the structure and stability of financial markets increases.

Furthermore, data privacy will continue to grow in importance as ownership of vast datasets becomes a key source of competitive advantage.

## Systemic threats

Without going into too much detail on this topic as it is beyond the scope of this paper, there is a potential for unintended consequences with AI driven trading strategies. As AI becomes more powerful it becomes harder to control. Regulators and policy makers may not have a good understanding of AI and it could be difficult to regulate unforeseen events before they occur.

For example, programming an AI solution to achieve a particular objective could lead to unexpected and undesirable outcomes. Giving an AI solution a remit to make money from a particular trading strategy could see it interpret the best way to achieve that objective as causing a market crash through distributing fake news and then shorting securities.

Clearly we are some way off from this type of situation. However, as we come closer to creating super intelligent machines with broader intelligence, that are also connected to the internet, it is important to carefully consider these risks.

## Human augmentation rather than human displacement

Because of the factors above, AI will therefore most likely become another useful tool to enhance human trading activities rather than resulting in the complete replacement of humans in financial services.

Some senior roles may be replaced by artificial intelligence and some areas will see reductions in headcount. However, new roles will also emerge. The ability for humans to work across roles such as quants, data scientists, technology and business teams as these functions converge will be particularly valuable in future.

It is also likely that AI will lead to productivity gains that drive economic growth. This will lead to increased economic activity, the emergence of new products and industries and higher trading volumes. This increased activity will create new jobs for humans in areas where they still have advantages over machines.

# KEY CONSIDERATIONS WHEN DEPLOYING AI TO SOLVE REAL WORLD BUSINESS PROBLEMS.

## Big data infrastructure

There are a number of things to consider when thinking about how to deploy AI. As a starting point, firms that can leverage a robust big data infrastructure can provide a foundation for AI to function.

The economist recently proposed that data has now overtaken oil as the world's most valuable resource. The ability to collect, aggregate, standardise and analyse data to guide decision making will become a core competence for financial institutions.

This can be challenging, although the advent of EMIR and SFTR reporting mandates are driving centralisation and standardisation of data models within firms. Firms need to weigh up the cost and effort involved in getting the right data model in place then maintaining and updating that data before they can apply AI against it.

Firms should also consider how AI related technologies fit within their existing technology stack.

## Process mapping

A solid understanding and mapping of processes is critical for AI to work well. Badly engineered processes that are then automated will result in sub optimal outcomes. Inadvertently introducing bias can be a serious issue with AI. Particular care should be taken around areas such as fair and equitable client allocations and best execution.

Once AI has been introduced, it can also begin to change operating models and require new governance structures. It therefore requires ongoing analysis of its impact and continued change management processes.

## Avoiding the hype

It is also important to avoid getting caught up in the hype of AI and to think carefully about how to deploy the technology to solve a real world problem. Simply trying to find a use case for the latest exciting new technology can end up with a solution looking for a problem.

Additionally, many real world problems can be solved using less complex algorithms. It is therefore important to consider whether it is worthwhile using AI to solve a particular business problem.

Employing a sledgehammer to crack a nut in instances where there are limited cost benefits offers poor value. Smart machines need to be properly set up, maintained and continuously governed if they are to be of maximum benefit to the enterprise. These ongoing costs should be factored into any decision to deploy AI.

When thinking about launching a solution, one should also evaluate existing products offered by third party vendors such as Broadridge before considering building a custom AI solution from scratch.

## Start small

Looking at ways to gain quick wins in the deployment of AI technology is another consideration. Starting out by incorporating machine learning into small subcomponents of a larger process or system is a good first step rather than seeking to replace entire sets of systems. Targeting improvements in areas that allow augmentation of human performance rather than the replacement of people can also provide many benefits.

## Create internal centres of excellence

One approach is for firms to create internal centres of excellence. Broadridge has employed this model in its own research into AI. This brings together a mix of business people and technology experts to determine convergence between the business and the technological capabilities of AI.

Cross functional collaboration allows a closer matching of solutions to real world problems. This naturally leads into use case identification and proof of concept work. These groups can then help to promote the application of AI to other areas of the organisation.

## Combine technologies

Following implementation of basic robotic process automation (RPA) techniques, a more advanced solution can combine RPA with machine learning for example. Likewise, a combination of RPA, machine learning and natural language processing can multiply the benefits of these solutions, with a corresponding rise in complexity. Matching the technology to the problem it is solving is key when 'chaining' complementary technologies.

## People and culture

From a resourcing point of view, firms should also begin thinking about how they invest in new skillsets to position for the future. Recruiting staff with prior experience in training machine learning algorithms is one area that will become a core requirement.

The impact on staff of deploying AI and ensuring the firm puts in place the appropriate change management procedures is another important consideration.

Likewise, recruitment policy needs to highlight creative thinking and experimentation, data analysis and interpretation, and strategy development as these will be the human skills required to succeed as the basis of competition evolves.

In future, financial firms may also need to change their cultures to attract the right skillsets. Banks will be competing with Google, Apple and Amazon for data scientists. Senior leaders will therefore need to realign away from a more traditional view of the world towards a mind-set of digital transformation. Keep an eye out for the emergence of ping pong tables and sleep pods on the trading floor.

All of this coincides with a greater expectation from shareholders for financial institutions to innovate around technology. For a good example of a bank that is already cultivating a brand image that looks more like a tech firm, see Morgan Stanley's website https://www.morganstanley.com/

# CONCLUSION

The use of AI tools presents interesting possibilities in securities finance and collateral management. In conjunction with an increasing amount of data available to the industry, there is great potential to create new applications that reduce the time spent on mundane day to day tasks and improve strategic decision making.

In the next few years, market participants will finish implementing the recent round of regulatory initiatives. We will then begin to see more rapid and widespread uptake of AI technologies to achieve competitive advantage. This will also coincide with the maturing of AI tools for a wider range of business applications.

While this will entail changes for human traders, collateral managers and operations personnel, it is important to note that machine learning systems rarely replace a person's entire job or a full end to end process.

The successful AI solutions of the future will combine the strengths of both humans and machines to perform tasks more effectively than either of them could do individually.

# REFERENCES

Arai, N. (2017). *Can a robot pass a university entrance exam?* [Online Video]. 12 April 2017. Available from: https://www.ted.com/talks/noriko_arai_can_a_robot_pass_a_university_entrance_exam. [Accessed: 4 September 2017].

Autor, D. (2016). *Will automation take away all our jobs?* [Online Video]. 13 September 2016. Available from: https://www.ted.com/talks/david_autor_why_are_there_still_so_many_jobs. [Accessed: 20 September 2017].

Bertoni, S. (2014). *Goldman Sachs Leads $15 Million Investment In Tech Start Up Kensho. Forbes* https://www.forbes.com/sites/stevenbertoni/2014/11/24/goldman-sachs-leads-15-million-investment-in-tech-start-up-kensho/#4fc4edb81b48 [Accessed 24th July 2017]

Blackburn, G. 2017. *When AI goes too far.* [ONLINE] Available at: https://www.freshminds.co.uk/whats-fresh/post/2017/04/04/guest-blog-when-ai-goes-too-far. [Accessed 21 September 2017].

Blalock, M (2017) *The next big wave: How financial institutions can stay ahead of the AI revolution.* Intel/Finextra Research https://www.finextra.com/surveys/survey.aspx?surveyguid=71aafe10-0023-41b4-9b57-df25f98b9fb3 [Accessed 20th Aug 2017]

Bostron, N. (2015). *What happens when our computers get smarter than we are?* [Online Video]. 10 March 2015. Available from: https://www.ted.com/talks/nick_bostrom_what_happens_when_our_computers_get_smarter_than_we_are#t-675507. [Accessed: 8 August 2017].

Brown, M. (2016). *Luminance Automates Mergers With Robot Lawyer A.I. Inverse Skunkworks* https://www.inverse.com/article/20952-luminance-automates-mergers-with-robot-lawyer-a-i [Accessed 20th Aug 2017]

Brynjolfsson, E. & McAfee, A (2017) *The business of artificial intelligence. Harvard Business Review.* https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence [Accessed 4th Aug 2017].

Burgess, M (2017) *Google I/O 2017: all the highlights from the tech giant's developer conference.* Wired Magazine http://www.wired.co.uk/article/google-io-2017-highlights [Accessed 24th July 2017]

Chandarana, D. 2017. *How cognitive technologies are transforming capital markets.* [ONLINE] Available at: http://www.mckinsey.com/industries/financial-services/our-insights/cognitive-technologies-in-capital-markets. [Accessed 6 September 2017].

Christian, B. (2017) *Millennials are driving the future fintech trends – and big banks will fail if they don't keep up.* [ONLINE] Wired Magazine. http://www.wired.co.uk/article/wired-money-2017-fireside-chats [Accessed 5th Aug 2017]

Clark, L. (2017) *Facebook teaches bots how to negotiate. They learn to lie instead.* Wired Magazine http://www.wired.co.uk/article/facebook-teaches-bots-how-to-negotiate-and-lie [Accessed 24th July 2017]

Crosman, P. 2017. *Bring on the bots.* [ONLINE] Available at: https://www.americanbanker.com/news/bring-on-the-bots. [Accessed 8 January 2017].

Crosman, P. 2016. *How BNY Mellon Became a Pioneer in Bots.* [ONLINE] Available at: https://www.americanbanker.com/news/how-bny-mellon-became-a-pioneer-in-bots. [Accessed 8 August 2017].

Curran, E & Xiaoqing, P (2017) *AI Will Add $15.7 Trillion to the Global Economy.* Bloomberg https://www.bloomberg.com/news/articles/2017-06-28/ai-seen-adding-15-7-trillion-as-game-changer-for-global-economy [Accessed 24th July 2017]

Deangelis, S. (2017). *Artificial Intelligence: How Algorithms Make Systems Smart.* https://www.wired.com/insights/2014/09/artificial-intelligence-algorithms-2/ [Accessed 10th Aug 2017]

De Chazournes, J. and Ray A. (2017). *Next Generation of Post-Trade Technology: Evolution to Revolution.* Celent. https://www.celent.com/insights/227055362 [Accessed 20th Sep 2017]

Desjardins, J. (2016). *Chart: The Largest Companies by Market Cap Over 15 Years. Visual Capitalist* http://www.visualcapitalist.com/chart-largest-companies-market-cap-15-years/ [Accessed 5th Aug 2017]

Economist. 2017. *Why China's AI push is worrying.* [ONLINE] Available at: https://www.economist.com/news/leaders/21725561-state-controlled-corporations-are-developing-powerful-artificial-intelligence-why-chinas-ai-push. [Accessed 8 August 2017].

Economist, (2017). *The world's most valuable resource is no longer oil, but data.* Economist https://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource [Accessed 20th Sep 2017]

Financial Times (2017) *JP Morgan develops robot to execute trades. Financial Times.* https://www.ft.com/content/16b8ffb6-7161-11e7-aca6-c6bd07df1a3c?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3BFYWV%2FRkoSaK2GVfyQMKzTw%3D%3D [Accessed 5th Aug 2017]

Finextra, (2017) *Deutsche Bank boss says 'big number' will be replaced by robots.* Finextra https://www.finextra.com/newsarticle/31034/deutsche-bank-boss-says-big-number-will-be-replaced-by-robots?utm_medium=dailynewsletter&utm_source=2017-9-7 [Accessed on 7th Sep 2017]

Galleon, D .and Gohd, C. (2017). *IBM Just Achieved a Deep Learning Breakthrough.* [ONLINE] Available at: https://futurism.com/ibm-just-achieved-a-deep-learning-breakthrough/. [Accessed 5 September 2017].

Galeon, D and Houser, K. 2017. *DeepMind is Teaching AIs How to Manage Real-World Tasks Through Gaming.* [ONLINE] Available at: https://futurism.com/deepmind-is-teaching-ais-how-to-manage-real-world-tasks-through-gaming/. [Accessed 15 August 2017].

Galper, J. (2017). *The overlapping of quant and tech teams in capital markets.* Finadium Research http://finadium.com/the-overlapping-of-quant-and-tech-teams-in-capital-markets-premium/ [Accessed 4th Sep 2017]

Gawade, S. (2017). *The rise of the Robots – People Report.* BNY Mellon. https://www.bnymellon.com/us/en/who-we-are/people-report/innovate/the-rise-of-robots.jsp [Accessed 20th Aug 2017]

Gruber, T. (2017) *How AI can enhance our memory, work and social lives.* Ted Talks https://www.ted.com/talks/tom_gruber_how_ai_can_enhance_our_memory_work_and_social_lives [Accessed on 12th Aug 2017]

Hanson, R. (2017). *What would happen if we upload our brains to computers?* [Online Video]. 12 April 2017. Available from: https://www.ted.com/talks/robin_hanson_what_would_happen_if_we_upload_our_brains_to_computers. [Accessed: 20 July 2017].

Harris, S. (2016). *Can we build AI without losing control over it?* [Online Video]. 14 June 2016. Available from: https://www.ted.com/talks/sam_harris_can_we_build_ai_without_losing_control_over_it. [Accessed: 24 August 2017].

Hosanagar, K. and Saxena, A. (2017) *The First Wave of Corporate AI Is Doomed to Fail. Harvard Business Review.* https://hbr.org/2017/04/the-first-wave-of-corporate-ai-is-doomed-to-fail [Accessed 10th July 2017]

IBM, (2017) *Rethinking risk management in the age of cognitive computing –* Risk Magazine https://www.risk.net/technology/5303091/rethinking-risk-management-in-the-age-of-cognitive-computing [Accessed on 20th July 2017]
Kasparov, G. (2017). *Don't fear intelligent machines. Work with them.* [Online Video]. 11 April 2017. Available from: https://www.ted.com/talks/garry_kasparov_don_t_fear_intelligent_machines_work_with_them. [Accessed: 27 July 2017].

Kilburn, F. (2017) *Quants look to image recognition to process alternative data.* Risk Magazine https://www.risk.net/asset-management/5305971/quants-look-to-image-recognition-to-process-alternative-data [Accessed on 20th July 2017]

Lant, K. 2017. *Generative Design Could Radically Transform the Look of Our World.* [ONLINE] Available at: https://futurism.com/generative-design-could-radically-transform-the-look-of-our-world/. [Accessed 30 August 2017].

Laurent, L. 2017. *The Limits of Artificial Intelligence.* [ONLINE] Available at: https://www.bloomberg.com/news/articles/2017-06-13/the-limits-of-artificial-intelligence. [Accessed 23 August 2017].

Leroy, S. 2017. *Will AI Replace the Traditional Trader by 2020?.* [ONLINE] Available at: http://www.tabbforum.com/opinions/will-ai-replace-the-traditional-trader-by-2020?. [Accessed 4 September 2017].

Libert, B. and Beck, M. (2017). *AI May Soon Replace Even the Most Elite Consultants.* Harvard Business Review. https://hbr.org/2017/07/ai-may-soon-replace-even-the-most-elite-consultants [Accessed 7th Aug 2017]

Martone, R. 2017. *The Neuroscience of the Gut.* [ONLINE] Available at: https://www.scientificamerican.com/article/the-neuroscience-of-gut/. [Accessed 16 August 2017].

McKinsey Global Institute. 2017. *ARTIFICIAL INTELLIGENCE - THE NEXT DIGITAL FRONTIER?.* [ONLINE] Available at: http://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/how-artificial-intelligence-can-deliver-real-value-to-companies. [Accessed 24 September 2017].

O'Neil, C. (2017). *The era of blind faith in big data must end.* [Online Video]. 12 April 2017. Available from: https://www.ted.com/talks/cathy_o_neil_the_era_of_blind_faith_in_big_data_must_end. [Accessed: 4 September 2017].

Pierron, A. (2017) *Artificial Intelligence in Capital Markets: The Next Operational Revolution.* Opimas http://www.opimas.com/research/210/detail/ [Accessed 20th Aug 2017]

Savi, R. (2015). *Finding big alpha in big data.* Blackrock https://www.blackrock.com/institutions/en-axj/insights/finding-big-alpha-in-big-data. [Accessed 24th July 2017]

Schmidhuber et al (2017). *How AI is transforming the future of fintech.* Wired Magazine. http://www.wired.co.uk/article/how-ai-is-transforming-the-future-of-fintech [Accessed 10th Aug 2017]

Shah, C. (2017) *Buy-Side IT Spending Trends: Cloud as an Enabler for Digital Transformation.* Sapient Global Markets http://tabbforum.com/opinions/buy-side-it-spending-trends-cloud-as-an-enabler-for-digital-transformation? [Accessed 5th Aug 2017]

Son, H. (2017) *JPMorgan Marshals an Army of Developers to Automate High Finance.* Bloomberg https://www.bloomberg.com/news/articles/2017-02-28/jpmorgan-marshals-an-army-of-developers-to-automate-high-finance [Accessed on 20th July 2017]

Stacey, K & Nicolaou, A (2017) *Stitched up by robots - the threat to emerging economies.* Financial Times https://www.ft.com/content/9f146ab6-621c-11e7-91a7-502f7ee26895 [Accessed on 18th July 2017]

Stinchfield, R. (2017). *AI is learning the art of the deal – who will keep watch over bots as they learn to trade?* Finadium Research http://finadium.com/ai-is-learning-the-art-of-the-deal-who-will-keep-watch-over-bots-as-they-learn-to-trade/ [Accessed 5th Aug 2017]

Stinchfield, R. (2017). *Fintech Focus Integrating Innovation in Capital Markets.* Finadium Research http://finadium.com/fintech-focus-integrating-innovation-in-capital-markets/ [Accessed 5th June 2017]

Stinchfield, R. 2017. *Can Artificial Intelligence in credit risk be the next big leap forward?* Fintech startup James offers a case study. [ONLINE] Available at: http://finadium.com/can-artificial-intelligence-in-credit-risk-be-the-next-big-leap-forward-fintech-startup-james-offers-a-case-study/. [Accessed 22 August 2017].

Stinchfield, R. (2017). *Big Data, little lies, big problems – how Big Data can manipulate algorithmic trading.* Finadium Research http://finadium.com/big-data-little-lies-big-problems-how-big-data-can-manipulate-algorithmic-trading/ [Accessed 20th Sep 2017]

Stinchfield, R. (2017). *Finadium Research Report - Artificial Intelligence in Capital Markets: What Matters and What Doesn't.* Finadium Research http://finadium.com/finadium-ai-in-capital-markets-what-matters-and-what-doesnt/ [Accessed 5th Aug 2017]

Stinchfield, R. (2017) *IBM and Promontory bring Watson AI to regulatory technology.* [online] Finadium Research, http://finadium.com/ibm-and-promontory-bring-watson-ai-to-regulatory-technology/ [Accessed on 12th Aug 2017]

The Guardian. (2017). *How Artificial Intelligence will change the world: a live event - Science Weekly podcast.* Science Weekly. [ONLINE]. 27 April 2017. Available from: https://www.theguardian.com/science/audio/2017/apr/27/how-artificial-intelligence-will-change-the-world-a-live-event-science-weekly-podcast [Accessed: 24 July 2017].

Temperton, J. (2017) *AI is hurtling forwards like a rocket but no one is behind the controls.* Wired Magazine http://www.wired.co.uk/article/jaan-tallinn-artificial-intelligence-risk-safety [Accessed 24th July 2017]

Tufeki, Z. (2016). *Machine intelligence makes human morals more important.* [Online Video]. 15 June 2016. Available from: https://www.ted.com/talks/zeynep_tufekci_machine_intelligence_makes_human_morals_more_important. [Accessed: 1 August 2017].

Vigen, T. (2015). *Spurious Correlations* http://www.tylervigen.com/spurious-correlations [Accessed 5th Aug 2017]

Waral et al (2016). *Artificial Intelligence: Disruption Era Begins.* Tabb Forum http://tabbforum.com/opinions/artificial-intelligence-disruption-era-begins [Accessed 7th Aug 2017]

Whit, A. et al (2016) *Gartner Predicts 2017: Artificial Intelligence.* [ONLINE] Gartner. https://www.gartner.com/doc/3519744/predicts--artificial-intelligence (Accessed 4th Sep 2017).

Wigglesworth, R (2016) *Search for a super-algo.* Financial Times, https://www.ft.com/content/5eb91614-bee5-11e5-846f-79b0e3d20eaf [Accessed on 12th Aug 2017]

Williams-Crut, O. 2017. *UBS investment bank exec: 'Digesting and analysing data is the future'.* [ONLINE] Available at: http://uk.businessinsider.com/ubs-investment-bank-coo-beatriz-martn-jimnez-fintech-robots-automation-2017-7. [Accessed 8 August 2017].

Woodall, L. (2017) *Banks warned off machine learning for model risk.* Risk Magazine. http://www.risk.net/risk-management/5317461/regulators-wary-of-machine-learning-in-model-risk? [Accessed 17th Aug 2017].

Wordsworth, R (2017) *How AI is transforming the future of fintech.* Wired Magazine http://www.wired.co.uk/article/how-ai-is-transforming-the-future-of-fintech [Accessed 24th July 2017]

Woolley, P. & and Vayanos, D. (2017) *Action must be taken to stop quants exploiting weakness.* Financial Times https://www.ft.com/content/76c6e87c-60a0-11e7-8814-0ac7eb84e5f1 [Accessed 24th July 2017]

Xiaoqing, P et al. 2017. *China's Got a Huge Artificial Intelligence Plan.* [ONLINE] Available at: https://www.bloomberg.com/news/articles/2017-07-21/china-artificial-intelligence-plan-seeks-59-billion-industry. [Accessed 26 July 2017].

## Author Information

Martin Seagroatt is Marketing Director, Securities Finance and Collateral management at Broadridge Financial Solutions, Inc.

Previously he was marketing director at 4sight Financial Software. In June 2016 4sight was acquired by Broadridge and the 4sight Securities Finance and Collateral Management System rebranded as the Broadridge Securities Financing and Collateral Management Solution.

In his 11 years at 4sight, he specialized in securities lending, repo and OTC/listed derivatives collateral management solutions. Prior to that Martin worked as a business expert in technology systems for risk management in the energy industry.

## About Broadridge

Broadridge, a global fintech leader with over $8 billion* in market capitalization, provides communications, technology, data and analytics. We help drive business transformation for our clients with solutions for enriching client engagement, navigating risk, optimizing efficiency and generating revenue growth.

**Communications**
**Technology**
**Data and Analytics**

**broadridge.com**

**Broadridge**®