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LAUREN COHEN

CHRISTOPHER MALLOY

WILL POWLEY

Artificial Intelligence and the Machine Learning Revolution in Finance: Cogent Labs and the Google Cloud Platform (GCP)

David Malkin, known as the "AI Architect" at Cogent Labs, a machine learning software firm based in Tokyo, sat pondering the best path to growth for the company. On Malkin's desk sat a report on the spectacular success of deep learning algorithms at Google's DeepMind Technologies.

Malkin knew that artificial intelligence had great potential to revolutionize several aspects of the financial services industry, but he also knew that artificial intelligence's greatest achievements to date were in extremely narrow functions; and that unleashing artificial intelligence in complex, ever-changing markets could also be a recipe for disaster. Malkin further knew that large, sophisticated financial service clients owned a vast array of proprietary datasets that were impossible to replicate. Meanwhile the major "cloud" providers like Google, Amazon, and Microsoft had large-scale computing infrastructures and multi-billion-dollar research and development budgets with which they could (and did) generate innovative artificial intelligence software of their own.

Malkin wondered how a small software firm like Cogent Labs without its own proprietary datasets, or a large-scale computing infrastructure, or a multi-billion R&D budget could fit in? Would Cogent Labs' current approach of developing their own proprietary machine learning applications to run on the cloud and sell directly to financial services firms in Tokyo prove to be a sustainable model? Or would Cogent Labs ultimately need to partner/merge with one of the major cloud providers in order to provide the expertise necessary to customize their offerings for financial services clients? The team at Google Cloud Platform (GCP) had approached them to use their service, as had Amazon Web Services (AWS), but Microsoft and others had competing offerings as well. And if they picked an exclusive partner, which cloud provider would it be?

Or, was the future even more uncertain; would software firms like Cogent eventually need to create and own new datasets of their own, and build their own infrastructures to host their own new data, in order to avoid being disintermediated in the future if (and when) machine learning expertise became truly commoditized?

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Overview of Artificial Intelligence

History of Artificial Intelligence

In 1959, Arthur Samuel defined machine learning as a "field of study that gives computers the ability to learn without being explicitly programmed."[1] Artificial intelligence used a variety of statistical techniques to perform tasks such as clustering, prediction, image recognition, speech recognition, among other functions. Artificial intelligence was computationally and data intensive.

Modern Applications of Artificial Intelligence

Artificial intelligence was first developed in the 1950's. By the mid-1980's, neural networks became widely used and relied on specialized hardware.[2] By the late 1980's, the hardware needed for artificial intelligence was found to be expensive and the data limited.[3] As a result, artificial intelligence initially underperformed expectations and investment dollars in the late 1980's and 1990's dried up.[4] In the following decades, the growth of personal computers together with the growth of the world wide web led to a sharp decrease in the price of computing and an explosion in the volume of data. Artificial intelligence became increasingly effective across a variety of use-cases and artificial intelligence experienced a resurgence.

By the late 2010's, artificial intelligence had become a value-added component to enterprise and consumer software.[5] Artificial intelligence was ubiquitous in daily life. Artificial intelligence was used in mobile phones for mapping and navigation software, in ride-sharing applications to assist with dynamic pricing, in aviation to assist pilots in flying planes, in operating systems to help learn user preferences, at financial institutions to detect fraud.[6] Thus AI was often seen as a means of technology differentiation rather than a market, as every industry could potentially benefit from what artificial intelligence had to offer. Companies in any given industry could establish a competitive advantage using AI as a tool and the opportunity was large for those who chose to leverage AI.

Many large vendors were trying to establish a position by defining a platform, e.g., IBM Watson's API platform. Industry experts predicted that several markets would emerge in and around monetization of AI and machine learning algorithms. As of 2017, artificial intelligence was a source of technology differentiation, and companies across many industries who had invested in artificial intelligence saw tangible financial results.[7]

There was also a market for open-source artificial intelligence. As of 2017, there were a number of large companies including Google, Facebook, Open AI, and others that open-sourced their artificial intelligence product offerings.

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[1] Samuel Arthur, "Some Studies in Machine Learning Using the Game of Checkers". *IBM Journal of Research and Development*. Vol. 11, Issue. 6, 1967.

[2] Daniel Crevier, *AI: The Tumultuous Search for Artificial Intelligence* (New York: BasicBooks, 1993).

[3] Daniel Crevier, *AI: The Tumultuous Search for Artificial Intelligence* (New York: BasicBooks, 1993), p. 209–210.

[4] Daniel Crevier, *AI: The Tumultuous Search for Artificial Intelligence* (New York: BasicBooks, 1993), p. 117.

[5] Steve Koenig, "AI and Machine Learning: Industry Perspectives,"Wedbush Equity Research (December 2016), 11.

[6] Tractica "Artificial Intelligence Use Cases" https://www.tractica.com/research/artificial-intelligence-use-cases/, accessed March 2018

[7] Steve Koenig, "AI and Machine Learning: Industry Perspectives,"Wedbush Equity Research (December 2016), 11.

Industry Trends

The global artificial intelligence market grew from total global AI funding of $281M in 2011 to $2,388M in 2015 (see **Exhibit 1**).[8] There was widespread disagreement of the market size for artificial intelligence. One leading market research firm covering the artificial intelligence industry estimated that the total value of artificial intelligence revenue by 2024 would be $10B (see **Exhibit 2**).[9] Another leading market research firm covering the artificial intelligence industry estimated that the total value of the artificial intelligence market of $59B by 2025.[10] Artificial intelligence had a global footprint with nearly every major technology company across the world adopting some type of artificial intelligence strategy. **Exhibit 2** showed the expected artificial intelligence revenue by region in 2015–2024.[11]

Artificial Intelligence in Finance

While artificial intelligence had a slew of promising applications in finance, it also had a tumultuous past. Since inception, AI had experienced various "hype cycles" followed by periods of disillusionment.[12] In the 1980s, for instance, a number of major financial institutions attempted to build artificially intelligent systems that could process reams of financial data and assist with financial decisions.[13] These systems were centered on decision-making logic but were, by and large, less useful than anticipated. More recently with the explosion of data and the decreasing cost of computing, artificial intelligence solutions were proving more effective.[14]

As artificial intelligence showed increasing signs of promise, financial institutions attempted additional applications for the software including automated analysis of online behavior. This required processing large amounts of financial data and creating new products that could be personalized to meet and anticipate each user's unique and changing needs. This made it practical for each user to have his/her own digital personal financial assistant. [15]

Additionally, artificial intelligence was already being employed to detect fraud at banks, and to automate a variety of compliance tasks. These applications served to lower compliance costs for financial organizations of all types. And of course, the final frontier—which was still a question mark—was the idea that AI could ultimately be used to profitably trade in the financial markets, and eventually replace the activities of professional fund managers and buy-side investment advisors altogether. Indeed, many large quantitative hedge funds had already hired AI and machine learning experts to design trading strategies across various asset classes; to date very little large-sample, out-of-sample (peer-reviewed) evidence existed to demonstrate that these AI-enabled strategies out-

[8] Steve Koenig, "AI and Machine Learning: Industry Perspectives," Wedbush, accessed May 23, 2017.

[9] Tractica Artificial Intelligence Revenue by Region, World Markets: 2015-2014, accessed May 23, 2017.

[10] Statista. "Revenues from the Artificial Intelligence Market Worldwide, from 2016 to 2025 (in million U.S. dollars)." https://www.statista.com/statistics/607716/worldwide-artificial-intelligence-market-revenues, accessed March 2018.

[11] Tractica Artificial Intelligence Revenue by Region, World Markets: 2015-2014, accessed May 23, 2017.

[12] Gartner. "Gartner Hype Cycle." https://www.gartner.com/technology/research/methodologies/hype-cycle.jsp, accessed February 2018.

[13] QuinStreet Enterprise. "Expert System." https://www.webopedia.com/TERM/E/expert_system.html, accessed February 2018

[14] Dan Schulzer, "CTO Corner: Artificial Intelligence Use in Financial Services," CTO Corner, Financial Services Roundtable. http://www.fsroundtable.org/cto-corner-artificial-intelligence-use-in-financial-services/ , accessed February 2018.

[15] Ibid.

performed human-driven investment approaches in practice, but the mere fact that investment firms were shifting their hiring patterns towards AI experts suggested that these firms at least believed this scenario was possible.

Cogent Labs

Background of the Firm

Cogent Labs was founded in Tokyo by Jun Iinuma and Eric Whiteway in October 2014, and started operating in April 2015 after they capitalised the company and hired their first engineer. Iinuma had been employee number 13 in Salesforce Japan, and was one of the key members to help the company grow in Japan. Whiteway had been a Managing Director at Morgan Stanley for 16 years, heading up the algorithmic trading team in Japan. They quickly brought on Min Song as Director of Technology, who was previously the Principal Engineer at Samsung for 16 years and one of the core members of the Samsung Electronics team responsible for acquiring AI companies worldwide.

By August of 2015, the company had begun to accelerate its growth, and David Malkin was brought on as AI Architect. Malkin had provided consulting services in artificial intelligence, and prior to that Malkin was a quantitative trader at an investment fund, and had earned his PhD at University College London.

At the beginning of 2017, Cogent Labs had secured a significant venture capital investment. The main investors were SBI and Toppan Forms. The investment from SBI was from their FinTech fund, and they were the lead investor. The total investment in the Series A round was approximately $11.5 million USD.

By the middle of 2017, the firm had grown to 30 employees. Cogent's research team included 5 PhDs, but the firm had quickly realized that hiring more cloud engineers was also critical for success, so the firm had expanded in that direction after securing their Series A round of funding. As Malkin noted, "No matter how good your models are, you need to have a good cloud architecture."

Artificial Intelligence at Cogent Labs

Cogent's focus was to be an emerging provider of artificial intelligence software.[16] Cogent sought to bridge the gap between newly published academic research and real-world business solutions by leveraging expertise across many domains, including time series forecasting, information extraction, natural language and speech processing, image classification, and reinforcement learning. Their mission was to create accessible and intuitive AI solutions which solved real problems. Exploring and implementing new academic research was only one piece of the equation—it was critical to understand the actual needs and potential for AI in the consumer and enterprise market, and to develop scalable application infrastructure to transform that research into tools for everyday use.[17]

Cogent's overall AI strategy was that "perception led to understanding, which ultimately led to reasoning." By mid-2017 Cogent was still focusing on the perception side, which meant getting data into databases. The idea was to build "sensing organs" for companies. The goal for 2018 was to better understand this data, and the goal for 2019 was to take action on the data.

[16] David Malkin, interview by author. Tokyo. May 1, 2017.

[17] https://www.linkedin.com/company-beta/17966213/

Cogent's flagship product was an AI-enabled handwriting application called Tegaki, which was generating steady and increasing revenue. The company planned to continue to expand around the Tegaki product, since there were many additional services that could be built around this main product—for example the ability to automatically scan receipts, business cards, and other printed materials.

A key focus was to continue to build around the idea of general perception. As Malkin noted, "Companies like Salesforce were building AI models that dealt with data once it was already in their database. However, in this first stage we think there is still a huge opening for using AI to simply ingest new data. We want to go from the unstructured to the structured, not just handwriting but actually video and speech."

And finally, Cogent was building out a time-series platform for financial services clients, which to date were primarily large Japanese financial institutions. The goal for this product line was to create customized models for clients very quickly using their platform.

As Malkin described, "while these various product lines may appear a bit different, they are still essentially beachheads into various companies. Our strategy is: cost cutting first and then value-add later. We do not think that any AI software company sees their products as the primary goal—it is mainly about getting into the market and being positioned to leverage AI fully down the line."

In terms of where Cogent fit into the overall AI landscape (as depicted in **Exhibit 3)**, Cogent saw itself as part of the "Horizontal Applications" segment. In fact, Cogent was the 3rd most funded startup in the world in 2017 in that category.

Applications of AI and Machine Learning

Malkin saw the landscape of opportunities for Cogent to be quite broad, with several possible applications in the finance sector. **Figure 1** presented a taxonomy of some of the possibilities:

Figure 1

	General	Finance-Specific
Customer-Facing	A	B
Internal	C	D
Investment/Trading		E1, E2

Source: Created by casewriter, drawn from interview with David Malkin.

According to Malkin, the following examples illustrated how specific products or applications could be located within this taxonomy:

A — Any kind of AI-enabled "chat-bot" or automated sales agent.

B — "Robo-advisors" for finance-specific roles, such as wealth management for lower incomecustomers, or a smart wallet to help one spend money more efficiently and wisely.

C — Customer support, cyber security, data inputting (e.g., Tegaki).

D — Insurance underwriting, insurance claims resolution, fraud detection, compliance support.

And within the trading and investment section there were at least two subdivisions:

E1 — AI systems that helped an investor or a financial services firm gather more and newer information—e.g., satellite images, Twitter sentiment, textual understanding of broker reports, etc.

E2 — Specific algorithmic trading strategies. These would consist of models that took some parameters from different data series, and aimed to predict the returns on the overall

E1 and E2 were different in that E1 might consist of simply adding this new data or new AI-enabled analysis into a man-made investment strategy or model, while E2 added the extra step of having the AI help create and execute the trading strategy itself.

The Cloud Computing Landscape

Given the vast computing resources needed to successfully design and implement machine learning and AI-enabled software applications, the entire ecosystem depended critically on the "cloud." Indeed, the rapid development of the cloud was at the heart of the artificial intelligence explosion in financial services. Beginning with Amazon Web Services in March 2006, the major technology companies had developed large computing infrastructures that they rented to computing customers of all stripes. As of June 2017, the three largest providers of cloud computing in the United States were Amazon, Microsoft and Google. According to Gartner, Amazon Web Services was the market leader with an end-of-2016 revenue run rate of more than $14 billion.[18] Microsoft was a large and diversified technology company that was focused on delivering its software capabilities via cloud services. Microsoft entered the cloud market with the launch of Azure Virtual Machines in June 2012 and launched with general availability in April 2013.[19] Google was an internet-centric provider of technology and services. Google had a cloud computing offering since 2008, but did not fully enter the cloud computing market until Google Compute Engine was launched in June 2012 and launched with general availability in December 2013.[20]

Amazon Web Services was, according to Gartner, seen to be the most mature, enterprise-ready provider, with the capability of governing a large number of users and assets. Amazon Web Services was able to support secure, vital business production applications. Amazon Web Services also had a network of more than 2,000 consulting partners capable of assisting clients with technically complex and business critical projects.[21]

Microsoft was second in market share and Gartner estimated its end-of-2016 revenue run rate as approximately $3 billion.[22] Microsoft's cloud offering, Microsoft Azure, was a capable and broad platform, and Microsoft had the ability to bundle Azure with other Microsoft products and services in order to drive adoption. Microsoft was frequently chosen as a strategic cloud provider by customers that were committed to Microsoft technologies, or that liked Microsoft's overall cloud strategy, which

[18] Lydia Leong, Raj Bala, Craig Lowery and Dennis Smith, "Magic Quadrant for Cloud Infrastructure as a Service, Worldwide," Gartner, accessed June 23, 2017.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Ibid.

spanned the full range of cloud computing services and also offered customers the opportunity to host their data locally, in the customer's data center.

Google Cloud Platform (GCP)

Background and History

Google was a relative late-comer to the cloud computing space, but had quickly grown its Google Cloud Platform (GCP). Google's strategy for cloud computing was based in part on commercializing the internal innovative technology capabilities that Google had developed to run its consumer business at scale. In the last few years, Google also invested heavily in new enterprise capabilities that appealed to well established Fortune 500 companies. As a result, Gartner stated that "GCP has a rich set of well-architected, innovative capabilities, and is suitable for a broad range of use cases that run well in a virtualized environment", critical for institutions of any size.[23] Meanwhile, Google's cloud offering remains attractive to cloud-native companies and those that wanted to "run like Google."

In 2017, Google Cloud Platform was one of the fastest-growing lines of revenue across Alphabet.[24] That growth was driven in part by a change in the way companies were working with Google Cloud. For example, Google Cloud expanded its business through new state of the art data centers allowing more information to be stored on the cloud. Google was also investing heavily into the Google Cloud team. The large number of new hires in the second quarter of 2017 brought into the Cloud team, along with significant capital expenditures related to Google Cloud, positioned the Google Cloud Platform for growth. Google Cloud's efforts were beginning to pay off, as Google Cloud scored three times as many large deals for its cloud service in the second quarter of 2017 as it did in the second quarter of 2016.[25]

Google Cloud's marketing leaned into Google's position as a leader in machine learning, and Google had a number of subsidiaries that specialized in this domain. One such subsidiary was Google DeepMind. Google DeepMind collaborated with leading data companies to use its advanced machine learning techniques to build innovative general learning models. While the data was highly proprietary, the general learning models were not. One well-known example of this was the game "Go." In 2017, Google DeepMind participated in a large competition between its software and the world's best Go player. This competition, which was streamed on YouTube, attracted substantial media attention and garnered more than 2 million views.[26] This media attention helped Google increase the awareness of its strength in machine learning, which also helped Google Cloud Platform grow its business and reach new clients. Google Cloud Platform's marketing also relied on the support of the firm's partners.

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[23] Ibid.

[24] Ruth Porat, Chief Financial Officer of Alphabet Inc., remarks made in Q1 2017 Earnings Call, Mountain View, California, April 23, 2017. From transcript provided by Seeking Alpha, https://seekingalpha.com/article/4066436-alphabet-goog-q1-2017-results-earnings-call-transcript, accessed 10/2017.

[25] Blair Hanley Frank, "Google Cloud growth is outpacing the company's ad business," InfoWorld, April 28, 2017, https://www.infoworld.com/article/3193154/cloud-computing/google-cloud-growth-is-outpacing-the-companys-ad-business.html, accessed October 2017.

[26] "Match 1—Google DeepMind Challenge Match: Lee Sedol vs AlphaGO," March 9, 2016, https://www.youtube.com/watch?v=vFr3K2DORc8.

GCP and the Financial Services Sector

Google grouped its financial services clients into four categories: 1) large, traditional financial services firms; 2) hedge funds and quantitative investment firms; 3) fintech firms and other finance-related startups; and 4) a group of companies that Google termed "partner" firms. The first group consisted of large sell-side firms (e.g., HSBC), as well as other established buy-side and retail investment firms such as Fidelity Investments. These firms had large compliance costs and regulatory burdens, and Google viewed these firms as excellent candidates for the compliance optimization and cost-saving solutions that AI could provide. The second category consisted largely of technologically savvy hedge funds and "quant" investment firms (such as Citadel and TwoSigma) that viewed technology as a source of competitive advantage. The third category of customers consisted of start-up firms that were already "cloud native" and hence immersed in working on the cloud already. Finally, there were partner firms such as Cogent Labs. Google realized that in order for them to successfully populate and grow their AI cloud-based ecosystem, they needed to lure not only buyers, but also providers. This group included data providers, as well as software providers such as Cogent.

According to Ulku Rowe, Technical Director of Financial Services, with Google's Office of the CTO, Google Cloud Platform had a number of competitive advantages that were particularly attractive for financial firms. The first advantage lay in the domain of security and compliance. As a result of Alphabet's dominant search engine (Google), Alphabet had developed substantial know-how with respect to securing its data. Alphabet achieved this through secure transits, tracking hardware, custom-made servers, and state of the art physical security systems. In general, Google Cloud Platform placed great emphasis on compliance, and met rigorous privacy and compliance standards that tested for data safety, privacy, and security. Google Cloud used a number of third-party auditors to verify and certify its security protocols. For instance, Google offered Cloud Platform customers EU model contract clauses as a method to meet the adequacy and security requirements of the EU Data Protection Directive. And the "European Union's data protection authorities have concluded that Google's model contract clauses met EU regulatory expectations, confirming that Google Cloud services provided sufficient commitments to frame international data flows from Europe to the rest of the world."[27]

Another competitive advantage of Google Cloud Platform was its commitment to open-source. For example, TensorFlow was the backbone of much of GCP's machine learning toolkit, and this was an open source software library for machine intelligence. It was "originally developed by researchers and engineers working on the Google Brain Team within Google's Machine Intelligence research organization for the purposes of conducting machine learning and deep neural networks research, but the system is general enough to be applicable in a wide variety of other domains as well."[28] Since Tensor-flow is an open source library, it can be run anywhere including client's own on-prem hardware or even competing clouds. However, Google believed that customers will get the best performance running TensorFlow models on the Google Cloud Platform. Google Cloud also sought to lower its clients' switching costs by providing technical teams who aided in transitioning clients between cloud providers. Google also did not require any form of exclusivity, and supported customers that wanted to use multiple cloud providers to meet their needs.

A final key selling point for GCP was Google's tradition of innovation and reputation for engineering excellence. Google's parent company, Alphabet, held a large and diverse group of innovative subsidiaries that used machine learning and highly proprietary datasets to solve some of

[27] "Google Cloud Platform Security," https://cloud.google.com/security/compliance.

[28] Corrie Elston, interview by author, Cambridge, MA, June 7, 2017.

the world's most important problems: everything from radically increasing life extension to curing cancer to solving traffic. While Alphabet's subsidiaries considered their datasets to be highly proprietary and therefore confidential, Alphabet's subsidiaries readily published the code for such work in the world's top journals. And many of GCP's financial service customers often already had their *own* very valuable, highly proprietary data. Therefore, Google Cloud's offering of a large computing infrastructure along with innovative machine learning code written by some of the world's most talented computer science experts was very attractive to many financial service clients. (**Exhibit 4** laid out a sampling of the tools and services that Google Cloud offered these clients.)

According to Corrie Elston, Solutions Architect at Google and formerly at Goldman Sachs for ten years, "These financial services companies have a trove of valuable, proprietary data that can be paired together with our innovative artificial intelligence software like Google DeepMind in order to build the most sophisticated models around." These models could be used for compliance tasks and cost-saving initiatives, but also to better understand company fundamentals, company linkages, and sector-wide patterns; and ultimately to predict the direction and magnitude of future asset returns. For example, **Exhibit 5** depicted the use-case for "know your customer" policies, which were a cost-center for many financial services clients and which could be optimized and streamlined by using Google's Cloud Vision API and Cloud Natural Language API.

Despite these advantages, the financial services sector was relatively challenging to penetrate for public cloud providers. As Rowe noted, many financial firms were late-entrants in terms of transitioning to the cloud and taking advantage of the AI systems that GCP had built and enabled. Many large players had huge legacy systems, in contrast to other sectors such as media or gaming. Google Cloud also did not have the benefit of a long history of enterprise relationships like some of the other cloud providers like Microsoft or IBM. Many financial services firms also did not have all the in-house human capital with the necessary skillset to take advantage of all the capabilities that GCP offered. This last issue presented an opportunity for Google, of course, and was one of the reasons Google sought to populate their ecosystem with a variety of providers who could help work with these larger institutions to offer them custom, AI-enabled solutions (hosted on GCP) to aid their businesses in various ways. This was consistent with Google's strategy across a wide range of sectors and domains, namely that creating a larger, self-sustaining ecosystem that connected and facilitated different types of providers and consumers was the key to scaling GCP's footprint in the financial services sector. And firms like Cogent, which provided models, algorithms, and machine learning expertise, would always be a vital part of this ecosystem.

How Cogent Labs Used the Cloud

Like many AI-focused firms, Cogent Labs was an active user of the cloud, and utilized a slew of offerings and services from multiple providers such as Google Cloud and Amazon Web Services. According to engineers at Cogent, both GCP and AWS offered useful, and at times complementary services and tools.

Cogent's use of GCP centered around a set of technical advantages, such as: a) GCP's native support of Kubernetes (an open-source system to manage containerized applications), b) GCP's superior logging tool, and c) GCP's cheaper price point for compute instance. Cogent also preferred GCP's "BigQuery", a fully managed, petabyte scale, low-cost enterprise data warehouse for analytics. On the flip side, Cogent was drawn to AWS because, according to Cogent's perception at the time, it had more components, more detail configurations, and was cheaper for GPU (graphics processing unit) and relational database services. In addition, AWS provided a dedicated server, and if one was "on-premises" and wanted to use the cloud, AWS had a direct connect to reduce network latency. It is

important to note that this comparison was based on Cogent's perception for their particular workload. Moreover, in the very competitive Cloud market, technical and cost comparisons continue to evolve at a rapid pace, with cloud providers outpacing each other on a daily basis.

Cogent viewed both providers as important for its current development efforts, and did not see an immediate need to switch to one over the other. "If there is no network connection between your GCP and AWS, keeping your services at both places is fine. However, it is easier to manage and optimize your resources at one place," said Malkin. In addition, the scenario where Cogent would not need to use either GCP or AWS seemed unlikely in the near future:

"Most of our services are in the Kubernetes cluster, which has very good portability that we can move to any other cloud services/on-premise easily. However, we also use components such as storage, message, logging which makes it hard to move away from them because of network latency. Also, I would avoid hosting our own data storage at this point because it's a bigger cost for us. If we can find alternatives for these services or we are big enough to host all by ourselves, moving away from the cloud might be an option at some point."

Cogent's Recent Financial Services Applications

By the end of 2017, Cogent had begun to deploy their machine learning expertise in a variety of areas relevant to the financial services sector. For instance, **Exhibit 6** showed graphs that illustrated Cogent's "Kaidoku" service, which was a "natural language understanding platform." Here the use-case was to better understand the text of product complaints for various financial products. In the graph, each point in the plot corresponded to some text or document that Cogent had mapped into this two dimensional space; points that were closer together were more similar in meaning, so that the user could see text that was similar being clustered together (and by similar they meant not simply in the words it is using, but in the actual meaning of the text). The different colors could be used to identify certain categories. For instance in the bluish plots, each point represented a complaint submitted about a financial product, and the colors represent different product categories the complaints were about (e.g., the light blue of which there is a large cluster in the bottom right are all complaints about student loans).

The green overlays were the results of a keyword search. Next to this graph was the screenshot of Cogent's internal technology demo. In the middle one can see all the information about one of those complaints. On the right, once can see that Cogent selected certain keywords, "citi", "promotion", "gold," meaning that all the green spots had highlighted complaints that contained these words. It turned out that Cogent had identified a large cluster of very similar complaints about a promotion run by Citibank about their product known as the Citigold checking account.

On the trading side, Cogent had also recently entered into an agreement with Daiwa Securities (see **Exhibit 7** for the press release) to deploy a new machine learning-based algorithm designed to better predict stock-level trading activity throughout a given day. Rather than employing a standard trading algorithm or a set of volume predictors that was essentially static within a given day—which was common in the industry—Cogent had developed a volume prediction engine capable of detecting and modeling non-linear changes in volume patterns, which could then be used in real-time to dynamically react to current signals from the market. Cogent had entered into an agreement to provide a real-time feed of predicted volume estimates via API to Daiwa, who would then offer this trading algorithm to their clients (consisting of large institutional investors, many of whom employed quantitative trading strategies).

Concerns Related to Artificial Intelligence and Finance

While there was clearly a large opportunity for artificial intelligence in finance due to the large amount of data available and the quantitative nature of the industry, there was also significant concern that artificial intelligence could be misused. For decades, world-class researchers from leading universities and professional fund managers from leading investment houses had worked to build models to predict asset prices. And despite the talents of these researchers and professional fund managers, not to mention the huge financial rewards present in the industry, the overall evidence on the success of these models, and on the success of professional investment managers to outperform passive benchmarks, was underwhelming. As a result, the principals at both Cogent Labs and Google Cloud were concerned that financial service clients could be deceived by the effectiveness of artificial intelligence in other more narrow applications (e.g., computer vision) and therefore become overly confident in the ability of artificial intelligence to predict and explain asset prices.

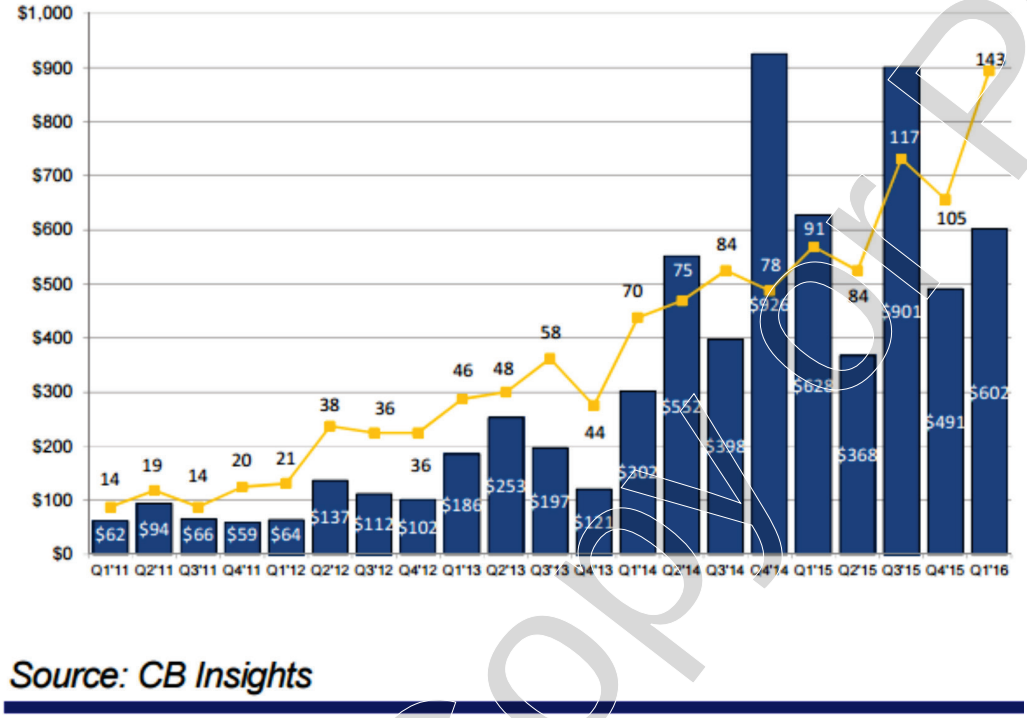
At the same time, Elston explained, "While there is no question that there is an opportunity for financial service firms to misuse artificial intelligence, many financial service firms have a plethora of quantitative talent available to carefully leverage their proprietary data and our innovative tools to identify anomalies and correct mispricings."

Ulku Rowe added, "At Google, we are very excited about what AI can do for financial services. By building better financial models, we can lower the cost of participation and create safer financial markets**.** We can democratize finance and provide universal financial inclusion. That's not that far away given the computational capabilities, access to intelligent data sets and the power of AI."

Conclusion

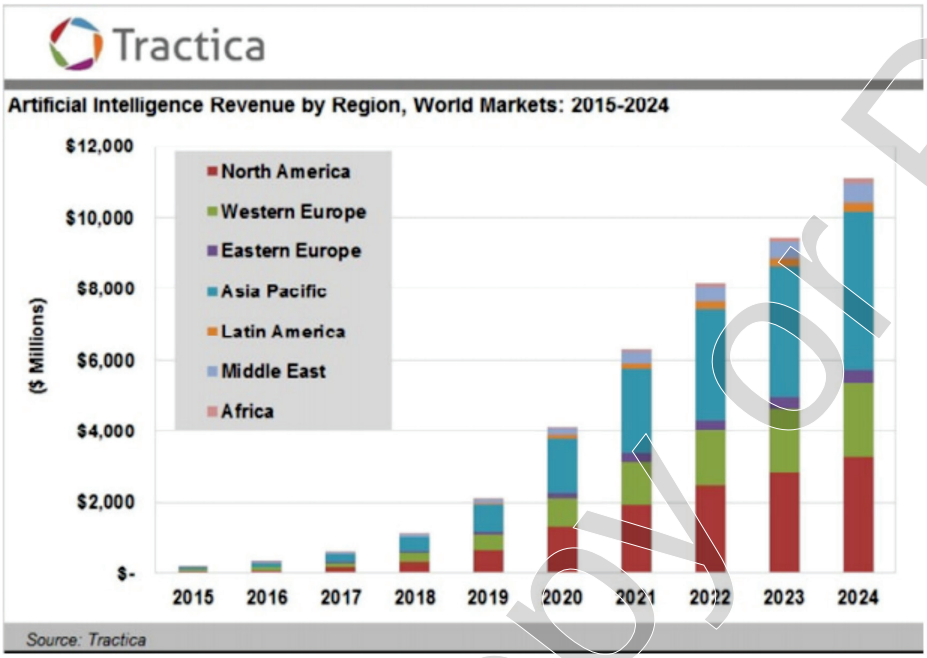
As Malkin thought about the opportunities and challenges that lay ahead, he was excited about the potential for artificial intelligence in the financial services industry and across several verticals. Malkin, however, knew that the road would not be easy for Cogent Labs. Cogent Labs was wedged between major financial institutions with billions of dollars in resources and relationships nonpareil, and the world's largest technology companies with giant computing infrastructures, massive research and development budgets, and hundreds of billions of dollars in cash. While Malkin was optimistic, he knew that Cogent Labs needed to find both a hook and a barrier—a way to bring the proprietary financial service data and the cloud computing resources together to help better serve Cogent Lab's financial service clients, while at the same protecting their own intellectual property and ability to scale in the future.

Exhibit 1 Total Global AI Funding and Number of Deals



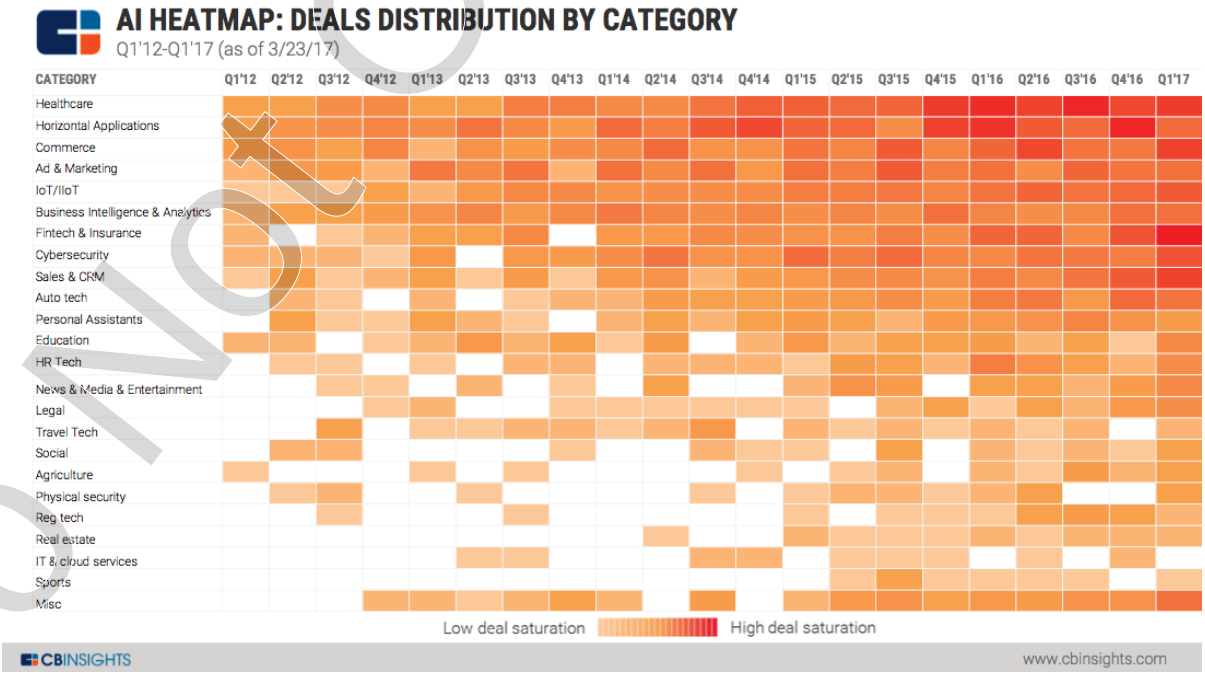
Source: Steve Koenig, *AI and Machine Learning: Industry Perspectives*, Wedbush Equity Research (December 2016), page 10.

Exhibit 2 Artificial Intelligence Revenue by Region, World Markets: 2015–2024



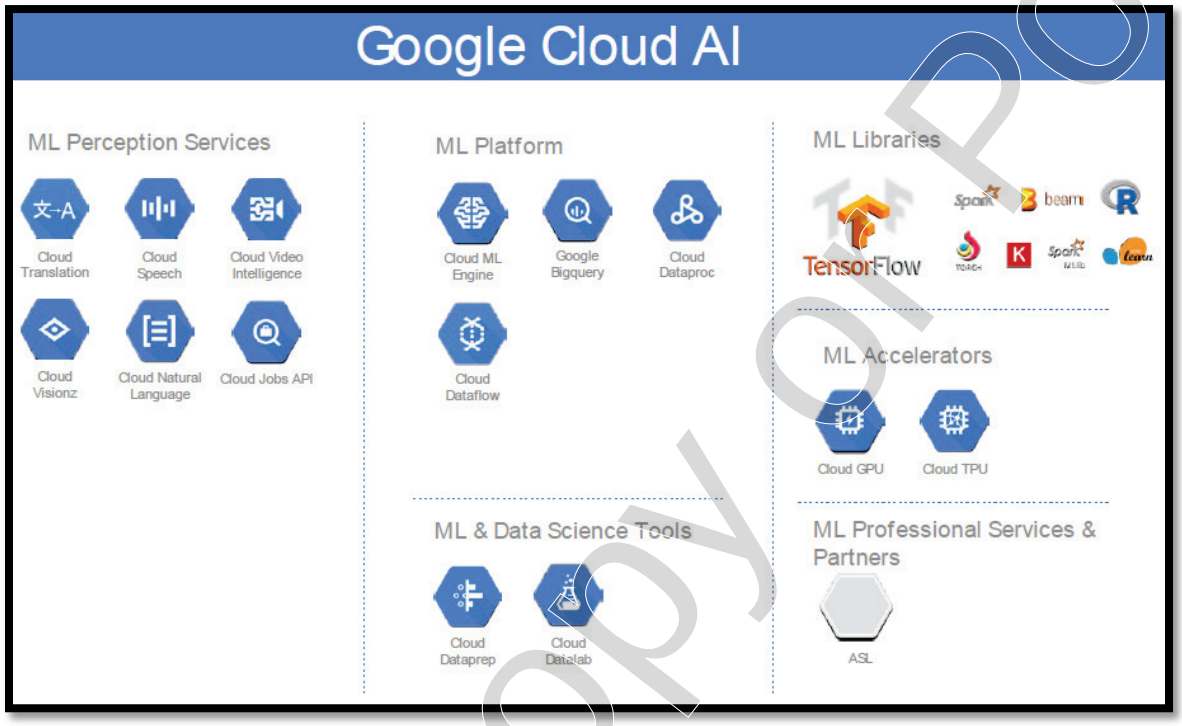
Source: Steve Koenig, *AI and Machine Learning: Industry Perspectives*, Wedbush Equity Research (December 2016), page 10.

Exhibit 3 Artificial Intelligence Industry, Broken Down by VC Investment into Various Categories



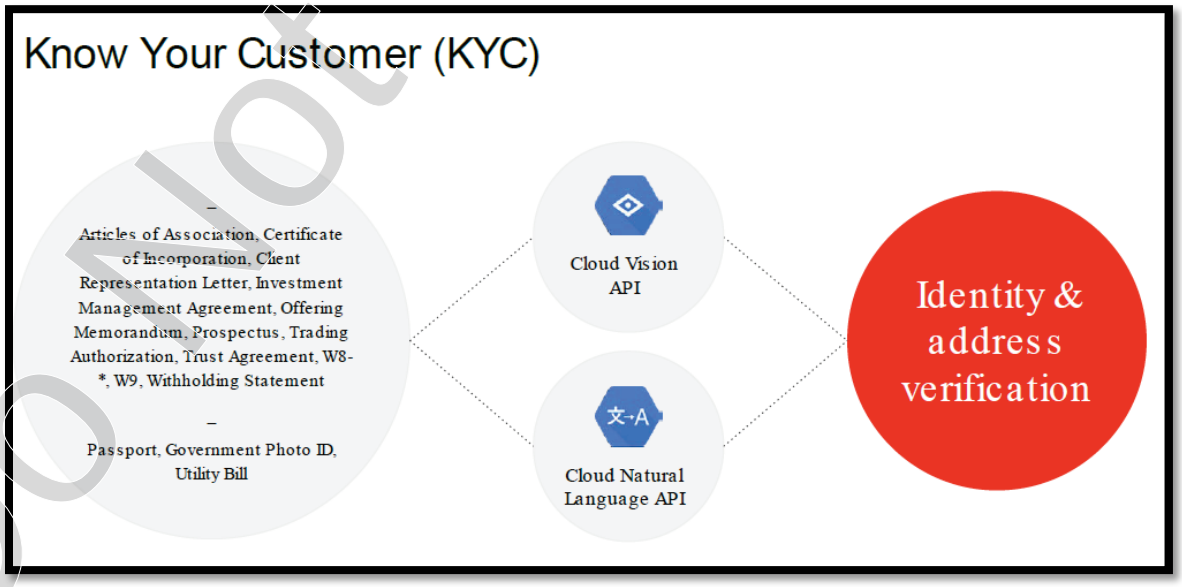
Source: *Artificial Intelligence Trends to Watch in 2018*, CB Insights (2018), https://www.cbinsights.com/research/report/artificial-intelligence-trends-2018/, page 3.

Exhibit 4 Google Cloud Artificial Intelligence Tools and Services



Source: Google.

Exhibit 5 Google Cloud Finance Application: Know Your Customer (KYC) Verification Policies



Source: Google.

Exhibit 6 Cogent Labs' Kaidoku "Natural Language Understanding" Product

Source: Cogent Labs.

Exhibit 7 Press Release Regarding Cogent Labs and Daiwa Securities Agreement

November 2nd, 2017

Daiwa Securities Co. Ltd.
Cogent Labs

Artificial Intelligence (AI) Prediction of Trading Volume on the Tokyo Stock Exchange for Algorithmic Trading

Daiwa Securities Co. Ltd. (Daiwa) has entered into an agreement with Cogent Labs (Cogent) for use of novel artificial intelligence (AI) technology in Daiwa's algorithmic trading platform. The technology was co-developed by Cogent in collaboration with Daiwa Securities, and gives Daiwa's trading algorithms access to real-time predictive capabilities utilizing deep learning.

Daiwa Securities has been actively engaged in a firm-wide effort to develop and deploy AI technologies in order to better assist our clients in their investment decision-making processes. Our collaboration with Cogent focuses on detecting and predicting intra-day volume patterns in real-time for stocks listed on the Tokyo Stock Exchange (TSE) using state-of-the art deep learning techniques.

Liquidity is one of the most critical factors used by institutional clients to evaluate the performance of broker trading algorithms, and use of volume-weighted metrics such as the volume weighted average price (VWAP) and participation weighted price (PWP) are widely accepted as standards for benchmarking execution performance. The ability to achieve higher real-time predictive accuracy to anticipate and detect sudden, non-linear changes in volume and price is critical to achieving stable, as well as superior execution performance. Through the use of AI, we were able to develop a model that achieved as high as 39% reduction in out-of-sample prediction error on 76% of our universe against a current industry-benchmark statistical volume prediction model*.

Daiwa is committed delivering superior products and services to our clients through the use of AI and other machine-learning capabilities. We plan to begin offering AI-empowered trading algorithms in Japan within the first half of fiscal 2018.

* The models were trained on 6 months of data and validation results were calculated on 10 days of data immediately following the training period. Overall average improvement was 7-10% over all test days and all stocks. The evaluation results are not a guarantee of future performance.

Source: Cogent Labs.