MONITORING AI PROGRESS FOR CORPORATE GOVERNANCE

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Abstract

Artificial Intelligence technologies are predicted to contribute up to $16 trillion to the global economy by 2030. This rapid increase in AI development will have tremendous significance for all the major players for effective corporate governance and national leadership: boards of directors, owners, regulators, legislators, and the national public interest. While AI is believed to increase both the productivity and competitive advantage, it will lead to rapid transformation in the work force and evolve with a high degree of uncertainty. To facilitate the survival of public and other corporations and entities, all these major players should closely monitor the progress and pay attention to major trends in AI. The main research question of this paper is what are the key threats, challenges, and opportunities of AI. Major threats are the replacement of human activity with AI activity, which may not be able to be controlled by humans. Such control is a major challenge concerning AI as is the control and opportunity of human-AI partnerships. Digital dashboards and quantum computers are also part of all these challenges and opportunities. Accordingly, the paper studies the following AI topics currently being explored in the AI literature: key questions and issues for AI, monitoring trends in AI development, digital board audits for AI action plans, AI robotic process automation, and quantum computers with AI implications, AI progress assessment and conclusions.

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1. INTRODUCTION

The year 2017 was named the year of Artificial Intelligence (AI) by the World Economic Forum. Global quarterly spending for AI increased from $79 million in the first quarter of 2012 to $1.73 billion in the first quarter of 2017. AI technologies are predicted to contribute up to $16 trillion to the global economy by 2030 (Castelluccio, 2017a). In a 2017 M.I.T.-Boston Consulting Group survey of 3,000 corporate executives, 80% believe that AI leads to both an increase in productivity and competitive advantage. AI experts liken the development of AI to the World Wide Web development where just a few large companies could initially afford to use it whereas today scarcely a firm, or person, is unconnected to the web. They predict that the same thing will happen with AI that will become as common as the internet is now (Ovaska-Few, 2017).

For example, IBM's AI Watson is now available on the cloud. Watson continuously learns, gaining in value and technology over time, from previous interactions. With the help of Watson, companies are harnessing the power of cognitive computing to transform industries and help professionals do their jobs better and solve important challenges. To advance Watson, IBM has three dedicated business units (IBM News Room, 2017):

1. *Watson*: established for the development of cloud-delivered cognitive computing technologies, which represent the commercialization of AI across a variety of industries.

2. *Watson Health*: dedicated to improving the ability of doctors, researchers, insurers, and other related health organizations to surface new insights from data in order to deliver personalized healthcare.

3. *Watson Internet of Things (IoT):* focused on making sense of data embedded in - more than 9 billion connected devices operating in the world today, which generate 2.5 quintillion bytes of new data daily.

This tremendous surge in AI and other emerging digital technologies will have huge impacts on corporate governance theory and the survival of the corporation. Agency theory has been the dominant perspective of corporate governance, but the question of corporate purpose has been divided into two theories. The first theory is that corporations have a responsibility to maximize shareholder value and the second theory is that corporations have the responsibility to balance the interests of all stakeholders. Since these two theories go in different directions, the central focus of corporate governance has become blurred.

However, in 2015, a third alternative was proposed by the European Parliament's Committee on Legal Affairs: "Shareholders do not own corporations. Contrary to popular understanding, public companies have legal personhood and are not owned by their investors. The position of shareholders is similar to that of bondholders, creditors, and employees, all of whom have contractual relationships with companies but do not own them" (Tunjic, 2017). Thus, this third alternative is not based upon corporations revolving around the interests of shareholders or stakeholders, but, conversely, where shareholders and stakeholders move around the corporation, which has interests in various capitals: human, intellectual, environmental, social, production, and financial. The corporation must store and convert each of these capitals to maintain and enhance itself and focus on long-term value creation, not short-term financial engineering to make the numbers for executive compensation (Nocera, 2017). Theoretically, this cycle of capital creation can continue into perpetuity, provided the corporation does not exploit the sources of capital, such as share buybacks or dividends, instead of capital expenditures, especially for artificial intelligence technology, or do something stupid or suicidal, like ignoring technology threats and opportunities (Tunjic, 2017).

In 2017, a broader perspective for both corporations and corporate governance was elaborated in a new book, *Stop the Rot*, by Bob Garrat, a company director, consultant, and academic working on corporate governance, board and director evaluation and performance, organizational learning and change, and strategic thinking. He has stated that the major purpose of corporate governance is to drive an organization forward while having prudent control. Consequently, he has advocated that four major players are needed for effective corporate governance and national leadership: boards of directors, owners, regulators, and legislators, all reviewed by a fifth player, a national public oversight mechanism. He further has argued that effective corporate governance has been clearly spelled out in the U.K. Companies Act 2006 with its seven general duties of directors:
1) to act within their powers (their constitution);
2) to promote the success of their company;
3) to exercise independent judgment;
4) to exercise reasonable care, skill, and diligence;
5) to avoid conflicts of interest;
6) not to accept benefits from third parties;
7) to declare interests in proposed transactions.

These seven general duties of directors can be used to guide the monitoring and development of AI by directors for their companies.

To weather the storm of the rapid evolution of AI, all the major players for effective corporate governance and national leadership, including boards of directors, owners, regulators, legislators, and the national public interest, are strongly encouraged to assess the threats, challenges, and opportunities of AI development. Accordingly, the main research question of this paper is what are the key threats, challenges, and opportunities of AI, especially with the perspective of the public corporation as separate legal personhood, as advocated by the European Parliament's Committee on Legal Affairs in 2015 and Bob Garrat in his 2017 book. This paper is divided into the following AI topics currently being explored in the AI literature: key questions and issues for AI, monitoring trends in AI development, digital board audits for AI action plans, AI robotic process automation, and quantum computers with AI implications, AI progress assessment, and conclusions.

2. KEY QUESTIONS AND ISSUES FOR AI

There are key questions and issues about AI and its impact on the economy and corporations that Boards of Directors and corporate executives need to analyze and try to answer, such as (Lohr, 2017): *What can it do? Where is it headed? How fast will it spread?*

Three new research reports suggested the following answers: *AI is doing less right now than you think, but it will eventually do more in more places than you think and will evolve faster than powerful technologies did in the past.* The McKinsey Global Institute published a report in November 2017 about automation and jobs and emphasized the uncertainty about AI and its impact on labor markets. A key finding was that up to one-third of the U.S. work force will have to find new occupations by 2030, ranging from a low estimate of 16 million to a high estimate of 54 million, depending upon the pace of technology adoption. This higher 54 million projection suggested a more rapid transformation than in prior change waves in the work force when employment migrated from farms to factories and later from manufacturing to services. A McKinsey researcher said: "we need a major change in how we provide midcareer retraining and how we help displaced workers find new employment", which ties into Garrat's argument that national leadership and public oversight are needed to deal with technology changes for effective corporate governance.

A second 2017 report by Massachusetts Institute of Technology (M.I.T.) and University of

Chicago economists suggested an answer as to why the current AI technology has so far had little impact on productivity with two common themes:

1. Technology itself is only one ingredient in determining the trajectory of AI and its influence. Economics, government policy, and social attitudes will play major roles as well.

2. Historical patterns of adoption of major technologies, from electricity to computers, are likely to hold true for AI. But if the pattern is similar, the pace will be much faster, and the social consequences could be far more wrenching than in past transitions.

These two AI themes are consistent with Garrat's advocacy for the need of the five major players for effective corporate governance and national leadership, boards of directors, owners, regulators, legislators, and a national public oversight mechanism.

The third 2017 research report emphasized the need to monitor changes and trends in the development of AI technology. An AI Index was created in 2014 by researchers at Stanford University, M.I.T., and other organizations. This AI Index tracks AI developments by measuring characteristics, like technical progress, investment, research citations, and university enrollments in AI and other emerging technologies. The goal of this project is to collect, curate and continually update data to better inform business people, scientists, policymakers, and the public (Lohr, 2017), similar to Garrat's five major players for effective corporate governance, especially for the threats, challenges, and opportunities of AI.

In addition, Patelli (2019) raised the ethical concerns of AI evolution and discussed the potential impact on management accounting and other professions. He argued that "AI has three characteristics that exacerbate its potentially unethical implications: the lack of controllability of the underlying decision criteria; the lack of accountability for unintended consequences; and the lack of significant explicit costs, causing some to underestimate AI's ethical impact". These characteristics pose the potential risks of practicing against the ethical principles of any profession. Hence, it is important for management accountants and other professionals to recognize potential biases and adapt their competencies in order to overcome any ethical challenges.

3. MONITORING TRENDS IN AI DEVELOPMENT

The field of AI is evolving rapidly. Without relevant data for reasoning about the state of AI technology, analysis and decision-making related to AI are essentially "flying blind." Accordingly, an AI Index was created in 2014 to address this data issue by tracking activity and progress in AI. The AI Index project aggregates data from the internet, contributes original data, and extracts new metrics from combinations of data series. See the website aiindex.org.

The 2018 and 2017 AI Annual Reports separate data into four primary parts:
1. Volume of Activity.
2. Technical Performance.
3. Derivative Measures.
4. Towards Human-Level Performance.

The Volume of Activity metrics captures the "how much" aspects of the AI field, such as attendance at AI conferences and Venture Capitalists' (VC) investments into startups developing AI systems. The Technical Performance metrics capture "how good" aspects, such as how well computers can understand images and prove mathematical theorems. The Derivative Measures metrics investigate the relationship between trends and introduce an exploratory measure, the AI Vibrancy Index, which combines trends across academia and industry to quantify the liveliness of AI as a separate field. The Towards Human-Level Performance metrics outline a short list of notable areas where AI systems have made significant progress towards matching or exceeding human performance.

3.1. Volume of Activity

This metric includes the number of Computer Science papers published in academia, which were tagged by the keywords, Artificial Intelligence. The number of such AI papers produced each year has increased by more than 9x from 1996 through 2015. Due to data collection limitations, another metric collected just the number of students enrolled in introductory Artificial Intelligence courses and Machine Learning (ML) courses, a subfield of AI, at Stanford University although many universities have offered AI courses since the 1990s. Introductory AI class enrollments have increased 11x since 1996 and enrollments in ML classes have increased 7x over the same period. Another metric measures the number of active venture-backed US private companies developing AI systems. The number of such VC-backed US startups has increased 14x from 2000 through 2015 while actual funding for such startups has increased 6x over the same period.

Another volume metric measures the growth of the share of US jobs requiring AI skills. The share of such US jobs has grown 4.5x from 2013 through 2017 while similar Canadian and UK jobs have grown 12x and 8x, respectively, over this time period. Concerning these job openings, the following skills breakdowns were collected: 11x for machine learning, 7x for deep learning, 5x for natural language processing, 3x for computer vision, and 2x for speech recognition. Another metric measures the number of shipments of industrial robot units. From 2000 to 2015, shipments to international countries grew from 100,000 to 250,000 units or 2.5x while shipments to North America grew from only 10,000 to 20,000 or 2x. Concerning public interest with media coverage, the percent of articles referencing AI grew from 12% to 30%, or 2.5x, from 2013 through 2017.

3.2. Technical Performance

This metric includes the performance of AI systems on the object detection task in the Large-Scale Visual Recognition Challenge (LSSVRC) Competition. From 2010 through 2017, the accuracy rates of the best AI system have increased from 71.5% to 97.5%, exceeding human performance, which has remained constant at 95% accuracy. However, from 2015 through 2017, while human performance on giving open-ended answers to questions about images has

remained constant at 82%, the lower performance of the best AI system has improved from 55% to only 68%. Another metric assesses natural language understanding by the performance of AI systems on parsing the syntactic structure of sentences. From 1995 through 2015, constituency-parsing scores of AI systems improved approximately from 85% to 93% on sentences of less than 40 words and on sentences of all lengths.

Another metric assesses question answering for AI systems on a task to find the answer to a question within a document. From 2015 through 2017, human performance was constant at 82% accuracy while the best AI system almost caught up, improving from 60% to 79%. Another metric assesses speech recognition on a task to recognize speech from phone call audio. From 2010 through 2017, human performance remained constant at 95% while the best AI system caught up to this 95% human performance accuracy after starting at 84% accuracy. Another metric measures theorem proving with the average tractability of a large set of theorems proving problems for Automated Theorem Provers. Tractability measures the fraction of state-of-the-art Automated Theorem Provers that can solve a problem. From 2011 through 2016, the average tractability improved from 58% to 82%. Another metric measures the percentage of problems solved by competitive SAT solvers on industry-applicable problems. From 2007 through 2014, the best AI system improved from 50% to 82% of the problems solved.

3.3. Derivative Measures

These metrics assess how the data gathered by the AI Index can be used for further analysis and to encourage the development of both refined and new metrics. Dynamic trends across academia and industry are analyzed, and metrics are aggregated into a combined AI Vibrancy Index. A few representative measurements from the prior two data sets were selected: AI paper publishing, combined enrollment in introductory AI and ML courses at Stanford, and VC investments into AI-related startups. Since these quantities cannot be compared or aggregated directly, each measurement was normalized starting in the year 2000 in order to analyze the relationship between these trends. Thus, metrics are compared with growth rates instead of absolute values over time. Academic activity initially drove steady progress, growing about 5x from 2000 to 2013 versus only 2x for VC investment. However, VC investment became the driver of the steep increase in total activity from 2013 to 2016, going from 2x to 6x while the academic activity measures just increased from 6x to about 8x.

The AI Vibrancy Index aggregates these measurements from academia and industry (publishing, enrollment, and VC investment) to quantify the liveliness of AI as a field. To compute this AI Vibrancy Index, the normalized publishing, enrollment, and investment metrics are averaged over the time period from 2000 through 2015. This Index grew from 1x in 2000 to 6.5x in 2015. Such an Index is just a starting point to encourage the development of further derived, relevant measures.

3.4. Towards Human-Level Performance

Obviously, computers are vastly superior to humans in certain tasks, like arithmetic calculations and other mechanical applications. However, the competence of AI systems becomes more difficult to assess when dealing with more challenging tasks, like answering questions, playing games, and making medical diagnoses. In addition, while AI systems may perform better on certain tasks, such performance may degrade dramatically if the task is modified even slightly. While there are credible claims that AI systems have reached or exceeded human-level performance, such achievements may say nothing about the ability of AI systems to generalize. Since games provide a relatively simple and controlled experimental environment, they are often used for AI research.

Such games can be assessed with milestones that represent progress toward, or even surpassing, human performance. For example, a checkers AI system beat the human world champion in 1995. Other examples of superior AI system performances were IBM's Deep Blue which beat the world chess champion, Gary Kasparov, in 1997 and IBM's Watson which won first prize in a Jeopardy Competition in 2011. The AlphaGo AI system developed by Google's DeepMind team beat top-ranked players in 2016 and 2017. Also, in 2017, IBM's Watson, trained on a data set of 129,450 clinical images of 2,032 different diseases, classified skin cancer at a level of competence comparable to 21 board-certified dermatologists.

3.5. What is missing?

The AI Index 2018 and 2017 reports conclude with a What's Missing section. Many important technical areas remain to be analyzed. There are no clear benchmarks or effective reporting metrics in some areas, such as dialogue systems, planning, and continuous control in robotics. Other areas await progress to analyze and collect data, such as commonsense reasoning, recommender systems, and standardized testing. This AI Index report is very US-centric, despite a significant amount of AI activity and progress throughout the world. For example, the level of investment and activity in China today is significant but outside the scope of this report.

To date, there are no relevant metrics about AI's impact in key industries, such as healthcare, finance, automotive, and education. The closest information is a general AI adoption survey by industry and function from 2,135 respondents by McKinsey & Company in 2018 (Shoham et al., 2018). Garrat's five major players, directors, owners, regulators, legislators, and a national public oversight mechanism, are all relevant in assessing the impact of AI. For example, both governments and corporations have made substantial investments in AI research and development, but there is no formal reporting of such data for the development of AI metrics. Also, there is much more AI investment than just VC startup financing. Additional understanding of all the disparate domains is needed to help develop additional AI metrics and indexes. Garrat's national public oversight mechanism could be tasked with

developing AI metrics and indexes for key AI areas, such as safety, predictability, fairness of algorithms, privacy, ethical implications of increased automation, and retraining of displaced workers.

3.6. Top 10 strategic tech trends

For the last several years, the global analysts at Gartner, Inc. have released their top 10 strategic technology trends for the upcoming year. They define strategic technology trends as those that have substantial disruptive potential along with the kind of attention that is encouraging widespread adoption. Underlying these trends are emerging calls for digital ethics and privacy guarantees and the prospect of quantum computing that will move machine intelligence into hyper-drive. A Gartner global head of research commented: "Nearly two-thirds of CEOs and CFOs anticipate business model change, frequently due to digital transformation and investors are rewarding organizations that wrap every product and service with digital capabilities. Company executives are interested in what you do with data through advanced analytics and artificial intelligence. Leaders apply technology and information in unique and creative ways to outperform their peers." Thus, there is the need to monitor ongoing technology trends, such as the following (Castelluccio, 2018):

1. *Autonomous things.* These are things that use AI to perform human tasks, such as vehicles, robotics, drones, appliances, and agents. A Gartner executive predicted: "As autonomous things proliferate, we expect a shift from stand-alone intelligent things to a swarm of collaborative intelligent things, with multiple devices working together, either independently of people or with human input."

2. *Augmented analytics.* It represents a third major wave for data and analytics capabilities as data scientists use automated algorithms to explore more hypotheses. Helping them will be natural language queries, algorithms that find relevant patterns, features, and models that can be auto-selected and auto-generated code.

3. *AI-driven development.* There will be embedded AI-enabled tools to assist professional developers to create AI-powered solutions. These tools are encouraging the use of virtual software developers and citizen application developers.

4. *Digital twins.* A digital twin (computer model) of a real-world object, like a power plant, can be invaluable as a way to monitor in real-time and even remotely initiate maintenance for the actual plant. The current use of twinning usually involves computer models of IoT (Internet of things) devices.

5. *Empowered edge.* Edge computing is a way to move the information processing and content collection away from the center of the cloud out closer to the data sources (the edges) where IoT devices reside. A steady increase in the embedding of a sensor, storage, compute and advanced AI capabilities in edge devices is expected.

6. *Immersive experience.* Virtual reality (VR), augmented reality (AR), and mixed reality (MR) will continue to change how users interact with the world and by 2022, 70% of enterprises will be experimenting with immersive technologies for consumer and enterprise use and 25% will have deployed to production.

7. *Blockchain.* Blockchain is a type of distributed ledger, an expanding chronologically ordered list of cryptographically signed, irrevocable transactional records shared by all participants in a network. Businesses should begin evaluating the technology, as blockchain will create $3.1 trillion in business value by 2030.

8. *Smart spaces.* Smart spaces are the places where human and computer intelligence meshes in an environment that is not shared but rather enjoined by both. A smart space is a physical or digital environment in which humans and technology-enabled systems interact in increasingly open, connected, coordinated and intelligent ecosystems.

9. *Digital ethics and privacy.* Enterprises that do not pay attention are at risk of consumer backlash. Conversations regarding privacy must be grounded in ethics and trust and should move from "Are we compliant" toward "Are we doing the right thing."

10. *Quantum computing.* Businesses need to increase their understanding of potential applications for quantum computing as well as the threat it poses to standard security measures like encryption. For example, a classic computer could read every book in a library in a linear fashion. A quantum computer would read all the books simultaneously. Quantum computing in the form of a commercially available, affordable, and reliable service would transform some industries.

4. DIGITAL BOARD AUDITS FOR AI ACTION PLANS

An international corporate governance consultant, Martin Hilb, has developed a digital board audit for boards of directors that can be useful in monitoring and assessing AI progress, especially the related threats, challenges, and opportunities represented by AI, in order to develop AI action plans (Hilb, 2017). The definition of a digital board audit is based on two major objectives:

1) a periodic, objective, and systematic digital diagnosis of the strengths and weaknesses of the corporate governance policies and practices of a company;

2) a joint digital development, implementation, and re-evaluation of the actions for the improvement of the corporate governance policies and practices based on the results of the digital diagnosis.

The recommended digital board audit has four phases:

1. Periodic diagnosis of board and management teams.

2. Performance targets for board and management teams.

3. Identification of possible resistance in moving from existing to desirable states.

4. Actions to overcome resistance and to realize performance targets.

Digital board audits are then conducted on the basis of the following ten characteristics:

1. *Completeness:* all members of the board of directors, key company executives, and key shareholder representatives, like Garrat's major parties for corporate governance.

2. *Inquiry tool:* the chairperson invites all these members to complete the questionnaire and send it electronically to a neutral organization that is responsible for the analysis and interpretation of the results.

3. *Degree of compulsion:* participation should be voluntary.

4. *Analysis of the survey:* the audit should be managed by an external, neutral organization.

5. *Data evaluation and interpretation:* the external, neutral organization evaluates and presents the results to the board, top management, and key shareholders.

6. *Length of the questionnaire:* it should be two pages maximum, such that it is short enough to encourage completion and long enough to obtain a good overview of all relevant governance aspects.

7. *Degree of standardization:* it should be standardized to facilitate evaluation and comparison with past results and other relevant companies for benchmarking. It contains three short open-ended questions to allow for additional responses.

8. *Survey variables:* the issues in the questionnaire can be adjusted to the needs of the company, such as specific AI challenges.

9. *Periodic review:* the survey should be carried out at regular intervals, e.g. annually.

10. *Competitive context:* the survey can also be used to compare results with comparable companies with relevant benchmarking by an external, neutral organization.

The recommended digital board audit questionnaire has the following eight relevant corporate governance aspects, each with an average of eight specific characteristics, which are assessed both on importance and satisfaction attributes. There are also three open-ended questions at the end of the questionnaire:

1. Guiding principles of the board.
2. Board culture.
3. Board structure.
4. Board composition based upon competence.
5. Board meetings.
6. Board and other senior management.
7. Responsibilities of the board towards stakeholders.
8. Performance evaluation by the board.
9. What is the greatest strength of your board?
10. What is the area most in need of development on your board?
11. How would you propose that the development area be addressed?

These three open-ended questions may uncover various strengths and weaknesses of a company's current AI environment, challenges, and opportunities. The external, neutral entity then analyzes the results, such as: a ranking of importance; a ranking of satisfaction; a ranking of deficits (importance – satisfaction); a draft of an AI action plan.

An AI action plan and results are reviewed and approved, when appropriate, by the following major players, like Garrat's five major parties for effective corporate governance:

1. Self-review by board members.
2. Board review by top management.
3. Board review by shareholders.
4. Board review by researchers and analysts.
5. Board review by the media and the public.

5. AI ROBOTIC PROCESS AUTOMATION

This digital and AI board audit process could be applied to the emerging field of robotic process automation (RPA) which uses evolving AI to manage transaction processing and reporting. For example, accountants no longer would have to match millions of transactions, painstakingly aggregating data or spending hours creating Excel reports that are out of date as soon as they are printed. Freed from such mundane tasks, accountants can focus more on the interesting, meaningful activities of analysis, strategy, and decision-making that contribute to organizational success. RPA facilitates continuous data that delivers real-time, relevant, and reliable financial data every day to help executives with strategy and business decisions in order to compete in an increasingly challenging, global economy (Moffitt, Rozario, & Vasarhelyi, 2018; Tucker, 2017). Such benefits may apply to any business or organizational departments that have similar mundane data tasks, but finance and accounting professionals and departments will be used here as an example.

Key takeaways from the AI-enabled RPA include the following five items (Tucker, 2017):

1. Change is risky but not changing is riskier. Companies that do not adopt new technology with proven efficiency benefits risk being surpassed by those that do adopt it.

2. The first step is to get your finance and accounting teams on board. Manage fear and uncertainty by communicating that the role of robotics is that of a "personal assistant" and will elevate financial analysts and accountants to more knowledge and intelligence-based roles.

3. Robots liberate human potential. When the time-consuming, error-prone, repetitive work is automated by "robo-accountants", human workers are finally free to analyze and strategize.

4. The Robotic Finance and Accounting Departments are hybrid systems. Humans are an integral part when it comes to RPA. Their judgment and nuance are critical, and the most successful approach enables both humans and robots to solve problems by doing what they do best.

5. RPA really is the only way forward. With the increasingly complex, regulatory guidelines and ongoing changes to local statutory reporting, it's essential for financial analysts and accountants to move into complex and critical roles. This is exactly what these robots are designed to allow such managers and employees to do.

To strengthen corporate governance and for managing this evolving RPA, boards of directors and corporate executives could use the following five tips, which are based on well-established project or process improvement steps (Moffitt, Rozario, & Vasarhelyi, 2018; Tucker, 2017; Parcells, 2016):

1. Analyze your current state with an end-to-end view of the desired outcomes. This will reveal where robots help, and which tasks must still be performed by financial analysts and accountants. Ask your staff for help with identifying the most painful, inefficient, and risky finance and accounting processes.

2. Design your future state. Play the "What If" game and design your ideal plan for the future. Then

start with the low-hanging fruit and areas with excess risk exposure.

3. Optimize and automate processes. First, improve and standardize your processes. Then determine which processes the robots can and should perform. In addition, an important driver for successful RPA implementation is to understand the process from beginning to end in order to break it down into small modules that can be interpreted by RPA software programs.

4. Review outcomes and controls. On a quarterly or annual basis, review the outcome of your robotic finance and accounting departments. What is working and what is not?

5. Continuously improve. Combining the knowledge gleaned from the review stage, rinse and repeat. Return to the first step and focus on new risks and more challenging automation projects.

A robotic finance or accounting department would be populated by robots that are not mechanical creatures but software robots who reside virtually on servers and in the cloud. They work behind the scenes in two ways: 1) task-oriented and 2) streamlining and automating processes. Thus, they can improve the following five functions of these departments: 1) data import; 2) data processing and verification; 3) exception management; 4) reporting and analysis; 5) auditing.

Also, Patelli (2019) emphasized the importance of infusing the AI process with strong ethics and values. In addition to adapting knowledge and skills, human workers should be guided and educated to involve ethics in the implementation of AI solutions. He pointed out that "only a combination of advanced skills and strong ethical principles can help management accountants tackle the great ethical challenges posed by the evolution of nonneutral AI".

In summary, by automating time-consuming, error-prone, repetitive work, AI robots create more possibilities for human workers to do what human brains do best: creating, connecting, and analyzing. Instead of mourning the loss of mind-numbing data processing tasks, the opportunity to advance human potential and organization success is here with AI robot-human partnerships. When financial data is available in minutes and smart humans finally have the time to analyze it, organizations can respond more quickly to the marketplace, capitalize on innovation opportunities, ensure continuous integrity, and uphold the confidence of stakeholders and consumers (Tucker, 2017; Parcells, 2016). Such positive results will benefit all five of Garrat's corporate governance parties: boards of directors, owners, regulators, legislators, and a national public oversight mechanism.

6. QUANTUM COMPUTERS WITH AI IMPLICATIONS

Quantum mechanics laws are behind the next revolution in computing. A reliable, large-scale quantum computer could transform industries from AI to chemistry, accelerating machine learning and engineering new materials, chemicals, and drugs. An expert, said: "It isn't just a faster computer of the kind that we're used to. It's a fundamentally new way of harnessing nature to do computations." Classical computers, like a laptop or iPhone, store and process information using binary bits, which have a value of either 1 or 0. Quantum bits, or

qubits, use superposition to exist in both states at once – effectively one and zero at the same time. A classical computer's binary bits are like coins that display heads or tails whereas a quantum computer's qubits are like coins spinning through the air in a coin toss, showing both sides at once (Nicas, 2017).

This dynamism allows qubits to encode and process more information than binary bits, such that today's most powerful laptops are closer to abacuses than to quantum computers. The computing power of a data center several city blocks long could theoretically be achieved by a quantum chip the size of a period at the end of a sentence. Unlike classical computers that test all possible solutions to a problem, quantum computers use algorithms to cancel out paths leading to wrong answers, leaving only paths to the right answer. Thus, they work for specific, unthinkably complex problems, like simulating new molecules to engineer lighter airplane parts, more effective drugs, and better batteries. However, they are unsuited for everyday tasks, like surfing the internet or updating your Facebook status.

One potential, almost universal, the impact would be the threat to cybersecurity as current public-key cryptography is used to protect health records, online transactions, and vast amounts of other sensitive data. An enormous number – several hundred digits long – acts as a lock on encrypted data while the number's two prime factors are the key. It would take a classical computer several years to find those two prime factors. Quantum computers could, in theory, do this almost instantly. The race to build quantum computers is driven by the potential to upend industries. Experts believe their biggest near-term promise is to supercharge AI, machine learning, and related businesses. A Google AI expert expects all machine learning to be running on quantum computers within the decade, and the commercial race for quantum computers is increasing. In May 2017, IBM unveiled a chip with 16 qubits and Google now has a 22-qubit chip and is racing to finish a 49-qubit chip, where quantum computers leverage very complex natural laws, rather than analyzing the world with ones and zeros (Nicas, 2017).

Another Google AI expert predicts that humans and machines will merge within 20 years with a chip in your brain as medical robots will go inside your brain and connect or neocortex to the smart cloud by 2029 (Greene, 2017). Quantum computing projects are also underway at Microsoft and Intel as well as several Chinese companies. In August 2016, China launched the first quantum communications satellite, designed to establish ultra-secure quantum communications by transmitting uncrackable, cryptographic keys from space to the ground (Wong, 2016).

7. AI PROGRESS ASSESSMENT

The executive editor of the M.I.T. Technology Review recently assessed why AI has yet to reshape most businesses (Bergstein, 2019). Despite projections of AI sweeping the world, people in a wide range of industries say the technology is tricky to deploy and costly with initial payoffs often modest. In contrast to the AI advances in high-tech companies, like

Google, Microsoft, and IBM, AI generally has made only incremental changes in businesses that are not inherently digital. Most companies are not generating substantially more output from their employees. AI productivity gains are generated by the biggest and richest companies, which can afford to spend heavily on the talent and technology infrastructure necessary to make AI work well. Almost everyone has to be attuned to how AI works and where its blind spots are, especially the people who will be expected to trust its judgments. In addition to money, AI progress requires patience, meticulousness, and key human skills that are too often in short supply.

For example, a data scientist commented that the transition of a company to machine learning will be about 100x harder that a transition to mobile. Among the biggest obstacles is getting disparate record-keeping systems to talk to each other. One health organization took a year and a half to deploy a conversational software agent, due to the information technology (IT) problems involved in linking the software to patient medical records, insurance-billing data, and other hospital and physician systems. Some large retailers save supply-chain records and consumer transactions in separate systems, neither of which is connected to broader data storehouses. Thus, the most common AI uses so far have involved business processes that are siloed with abundant data, such as computer security and fraud detection at banks. A chief digital officer observed that 10% of the work is AI while 90% of the work is actually data extraction, cleansing, normalizing, and wrangling. Other challenges slowing down AI adoption included transforming field data into formats a computer could parse and designing software that would feed relevant information into users' electronic screens. Domain experts or key AI users have to be involved in building AI applications that is a real challenge since these people are the critical managers and employees of a company (Bergstein, 2019).

Automation is also splitting the American labor force into two worlds. Small islands of highly educated professionals are making good wages at major corporations, like Intel and Boeing. However, there is a sea of less-educated employees making low wages at businesses, like hotels, restaurants, and nursing homes, which stay viable by keeping wages low and their tasks are tough to automate. Because automation pushes workers to the less productive parts of the economy, despite the spread of IT, robots, and AI breakthroughs, overall productivity growth has remained sluggish in the United States (Porter, 2019). A 2018 research study found that over the last 40 years, jobs have fallen in every single industry that introduced technologies to enhance productivity. The only reason employment did not fall across the entire U.S. economy is that other industries with less productivity growth picked up the slack. The challenge is not the quantity of jobs but the quality of jobs available to low and medium skill workers (Autor & Salomons, 2018).

However, AI has moved from the theoretical realm toward the global marketplace. A United Nations World Intellectual Property Organization (WIPO) released its first publication in the WIPO Technology Trends series on January 31, 2019. It considered more than 340,000 AI-related patent applications since the 1950s over the last 70 years. 50 percent of all AI patents have been published in just the last five years. The top five companies for AI patent applications are IBM (8,290 at the end of 2016), Microsoft (5,930), Toshiba (5,223), Samsung (5,102), and NEC Group (4,406). Considering the trends in AI techniques, machine learning far outpaces all others with 89% of filings mentioning this AI technique and 40% of all AI-related patents. Within the general category of machine learning, deep neural learning is the fastest-growing AI technique with a 175% increase between 2013 and 2016. AI, machine learning, deep neural learning, natural language processing, and computer vision, coupled with the advances of quantum computing and cloud-based AI, have all been called key components of a Fourth Industrial Revolution (Castelluccio, 2019).

In 2018, Deloitte surveyed 1,100 information technology and line-of-business executives from US-based companies to obtain a cross-industry view of how their organizations are adopting and benefiting from cognitive computing/AI. Respondents rated the top AI benefits for their companies as follows:

- Enhance current products;
- Optimize internal operations;
- Make better decisions;
- Optimize external operations;
- Free workers to be more creative;
- Create new products;

Respondents also reported the top AI use cases for their companies as follows:

- Information technology automation;
- Quality control/detecting defects;
- Cybersecurity;
- Predictive analysis;
- Customer service (including virtual assistants);
- Risk management.

Deloitte concluded that its survey results clearly show that growing numbers of companies are becoming more sophisticated in their usage of AI technologies. It urged companies to start selecting the business use cases that can deliver measurable value through AI-powered capabilities. It advocated that by using cloud services as a gateway, it is never been easier to explore and access AI's potential with minimal up-front investment and a reduced need for in-house expertise (Deloitte Insights, 2019).

8. CONCLUSION

The major research question of this paper is what are the key threats, challenges, and opportunities of AI. Major threats are the replacement of human activity with AI activity, which may not be able to be controlled by humans. Such control is a major challenge concerning AI as is the control and opportunity of human-AI partnerships. Digital dashboards and quantum computers are also part of all these challenges and opportunities. Monitoring the top ten strategic tech trends each year also helps analyze these AI issues. For example, ongoing trends are autonomous things, augmented analytics, AI-driven development, digital twins, empowered edge, immersive experience, blockchain, smart spaces, digital ethics and privacy, and quantum computing.

The rapid increase in the development of AI has tremendous significance for Garrat's major players needed for effective corporate governance and national leadership: boards of directors, owners, regulators, legislators, and the national public interest. Boards of directors, corporate executives, and all these other major players are encouraged to assess the threats, challenges, and opportunities of AI, especially with the perspective of the public corporation as separate legal personhood, as advocated by the European Parliament's Committee on Legal Affairs in 2015. To facilitate the survival of public and other corporations and entities, all these major players should monitor the progress and pay attention to major AI developments. Accordingly, this paper discussed the following major AI topics currently being explored in the AI literature: key questions and issues for AI, monitoring trends in AI development, digital board audits for AI action plans, AI robotic process automation, quantum computers with AI implications, and AI progress assessment.

Also, for effective corporate governance in this emerging AI area, the National Association of Corporate Directors has an ongoing effort to help corporate board members understand how the latest technology innovations and megatrends affect their industries. This effort included four key questions that directors could use to press their management team for briefings on their strategic plans for such technology advances, like AI (Essenmacher, 2017):

1. Have we considered how these forces can provide a strategic advantage to us, either by creating new revenue streams or new efficiencies?

2. Have we considered the risks to our business, including how we could be disintermediated or how a particular disruptive force might create competition, including from unlikely or unforeseen sources?

3. How are we thinking about innovation? Are we good at fostering it in-house or should we look to outside partnerships to supercharge our efficiencies, products, and capabilities?

4. What are we doing internally, including a review of compensation and incentive plans, to ensure new ideas get an open and fair hearing and are not killed off internally by managers who may not want to upset the status quo?

The main limitation of this study and generally the research in the AI field is the lack of a systematic approach to keep up with the rapidly changing technology, especially for AI development and monitoring, digital audits, robotic process automation, and quantum computers. Future perspectives for research include key technology updates for organizational and corporate governance impacts.

An especially challenging issue for executives and boards of directors is "the deadly soul of a new machine." This was the title of a *New York Times* article on December 7, 2018 by Timothy Egan. He wrote about the Indonesian Lion Air flight, which crashed 13 minutes after takeoff on October 29, 2018 and killed all 189 people on board. A later March 10, 2019 Ethiopian Airlines flight crash with the Boeing 737 MAX killed all 157 people. This new Boeing 737 MAX airplane had been in service just since October 2018 and had flown 800 hours prior to this 2018 crash. The Lion Air pilots requested a return to the airport two minutes after takeoff as the advanced electronic brain in this airplane was forcing the jetliner down. The human pilots tried to return the plane to manual control and override the electronic brain in order to correct this downward plunge, but the automatic pilot took control back from them and crashed the plane. The Boeing 737 Max airplane has now been out of service since March 2019 and more problems have recently been found with it (Kreiter, 2020). Egan's question is: "At what point is control lost and the creations take over?" He answered: "How about now?" As Stephen Hawking cautioned: "AI could develop a will of its own that is in conflict with ours" (Devaney, 2016).

Egan commented that all these artificial intelligence innovations are designed to make life easier and safer or at least more profitable for their corporate owners. He cited another example where a driverless car killed a woman in a Tempe, Arizona crosswalk and noted that other driverless cars have been slower to react than humans. In nearby Chandler, Arizona, there have been 21 attacks by residents who have been slashing tires and throwing rocks at self-driving vans owned by a driverless-car company spun out of Google (Romero, 2018).

A report by the U.S. Federal Aviation Administration in 2013 found that 60 percent of flight accidents over the recent decade were linked to confusion between pilots and automated systems. What is the role of corporate executives and boards of directors in dealing with these technology advances? Satya Nadella, the Microsoft CEO, provided guidance at the company's 2018 annual shareholder meeting as he said: "Big Tech should be asking not what computers can do, but what they should do." Egan agreed and commented that Facebook has never asked such a question, only focusing upon its own company growth, and has become a "monster of misinformation." He summarized: "We are at the cusp of an age of technological totalitarianism and need to ask for more screening, more ethical considerations, more projections of what can go wrong, as we surrender judgment, reason, and oversight to our soulless creations." Concerning Flight 610, he summarized: "It's equally haunting to grasp the full meaning of what happened: the system overrode the humans and killed everyone. Our invention. Our folly" (Egan, 2018).

Concerning future research, one extension is to examine the social impact of technology advances and the role of corporate executives and boards of directors. Should not corporate executives and boards of directors consider technology's impact on society in an evolving, intrinsic value focus, rather than just the narrow profitability impact on their own companies? (Grove & Lockhart, 2019). Field studies of companies dealing with this question and the related issues could be done. Another extension is to employ Google's AI approach to assess digital ethics issues, which is a two-part mission: 1) solve intelligence and 2) use it to solve everything else. There are two prerequisites: 1) the work AI produces can never be used for espionage or defense purposes and 2) there must be an ethics board established to oversee the research as it approaches achieving AI (Castelluccio, 2017b).

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