

Accounting and Auditing in the Digital Age

by Charles Hoffman, CPA (Charles.Hoffman@me.com)

Last Revised - June 28, 2017

“The McKinsey Global Institute estimates that, compared with the Industrial Revolution of the late 18th and early 19th centuries, AI’s disruption of society is happening ten times faster and at 300 times the scale. That means roughly 3000 times the impact¹.”

Executive summary:

- The fourth industrial revolution is occurring which is enabling businesses to operate in significantly different ways; enabling technologies include artificial intelligence, internetworked physical devices, cyber-physical systems, nanotechnology, and biotechnology.
- Professional accountants and accounting practices, procedures, and processes will need to adapt. Education and training of professional accountants also needs to adapt.
- Humans augmented by machine capabilities, much like an electronic calculator enabling a human to do math quicker, will empower knowledge workers who know how to leverage the use of those machines.
- Three primary enabling technological innovations are driving this significant change to the current accounting practices, processes, and methods: XBRL-based structured digital financial reports, knowledge-based systems and other application of artificial intelligence, and blockchain-based distributed ledgers
- While it is difficult to precisely predict the productivity gains which will be realized, initial information is showing the productivity gains will be very, very significant.

¹ Georgios Petropoulos, *Do we understand the impact of artificial intelligence on employment?*, <http://bruegel.org/2017/04/do-we-understand-the-impact-of-artificial-intelligence-on-employment/>

The Fourth Industrial Revolution

What is now commonly referred to as the *Fourth Industrial Revolution*^{2,3} is changing how businesses operate and professional accountants and auditors will need to adapt⁴ to remain relevant and thrive. The training and education of professional accountants also needs to adapt to better prepare new graduates and enable retraining of current professional accountants to adjust to new technologies and the new practices, procedures, and processes that technology will enable.

You might have heard other terms to describe the rapid changes that are occurring. Some call it *The Digital Industrial Revolution*⁵. Others refer to the changes as *Industry 4.0*^{6,7}. And others call it the *Artificial Intelligence Revolution*^{8,9}.

The over-arching theme of the change is computers performing more tasks that have historically been performed by humans.

Many say that the **first industrial revolution** resulted from the perfection of the steam engine. The steam engine enabled work to be performed by machines rather than humans, improving productivity tremendously.

The **second industrial revolution** resulted from the harnessing of oil and electricity to create mass production, the assembly line, and the invention of important technologies such as the telephone, the light bulb, the phonograph, and the internal combustion engine. Again, productivity increased significantly.

The **third industrial revolution** resulted from the change from analog electronic and mechanical devices to more effective and efficient digital devices. This era sees the invention of the

² Wikipedia, *Fourth Industrial Revolution*, retrieved May 4, 2017, https://en.wikipedia.org/wiki/Fourth_Industrial_Revolution

³ Forbes, Bernard Marr, *Why Everyone Must Get Ready For The 4th Industrial Revolution* <https://www.forbes.com/sites/bernardmarr/2016/04/05/why-everyone-must-get-ready-for-4th-industrial-revolution>

⁴ Shelly Palmer, *Digital Transformation in Seven Steps*, <https://www.shellypalmer.com/2017/02/digital-transformation-in-7-brain-busting-steps/>

⁵ National Public Radio, TED Radio Hour, *The Industrial Revolution*, retrieved May 4, 2017, <https://www.npr.org/player/embed/524731597/524879464>

⁶ Cornelius Baur and Dominik Wee, McKinsey & Company, *Manufacturing's Next Act*, <http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act>

⁷ PriceWaterhouseCoopers, *Industry 4.0: Building the digital enterprise*, <http://www.pwc.com/gx/en/industries/industry-4.0.html>

⁸ Steven Levy, Wired, *The AI Revolution is On*, https://www.wired.com/2010/12/ff_ai_essay_airevolution/

⁹ Wired, *The President in Conversation With MIT's Joi Ito and WIRED's Scott Dadich, Barack Obama, Neural Nets, Self-driving Cars, and the Future of the World*, <https://www.wired.com/2016/10/president-obama-mit-joi-ito-interview/>

personal computer, the internet, and significant advances in information and communications technology. Another productivity improvement.

The **fourth industrial revolution** builds on the third and includes advances in artificial intelligence; internetworked physical devices (often referred to as the internet of things¹⁰); cyber-physical systems which are mechanisms controlled or monitored by computer-based algorithms; nanotechnology which is the manipulation of matter on an atomic, molecular, and supramolecular scale; and biotechnology which is the use of organisms and living systems to create products. Even more productivity gains will be realized.

What is common to each of the four revolutions is the use of technology and innovation to enable substantial productivity gains. To achieve this, the gap between the problem and the solution must be bridged. Information technology professionals learning accounting and auditing would help bridge the gap. Or, accountants learning a bit about how the technology works so they can have effective conversations with technologists can bridge the gap.

Pressure to Adapt: increasing workloads, errors, ever increasing complexity

It is easy to understand the impact of the first, second, and third industrial revolutions because they are in our past. The fourth though, because while that change is occurring now most of the change is still in our future, it can be really hard to separate the science-fact from the science-fiction¹¹. But not correctly distinguishing the fiction from fact can contribute to leading you down the wrong path. Also, there is risk associated using the strategy of completely ignoring the reality of the changes that are occurring. The past does provides clues as to what might happen in the future.

Oxford University researchers¹² have estimated that 47 percent of U.S. jobs could be displaced by automation within the next two decades. An article, *The Top 5 Jobs Robots Will Take First*,¹³ even has accountants listed in the top five jobs that will be automated. That full list is:

1. Middle management
2. Commodity salespeople

¹⁰ Wikipedia, *Internet of Things*, retrieved May 4, 2017, https://en.wikipedia.org/wiki/Internet_of_things

¹¹ Georgios Petropoulos, *Do we understand the impact of artificial intelligence on employment?*, <http://bruegel.org/2017/04/do-we-understand-the-impact-of-artificial-intelligence-on-employment/>

¹² Carl Benedikt Frey and Michael A. Osborne, *THE FUTURE OF EMPLOYMENT: HOW SUSCEPTIBLE ARE JOBS TO COMPUTERISATION?*, September 17, 2013, http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

¹³ Shelly Palmer, *The 5 Jobs Robots Will Take First*, February 26, 2017, <https://www.shellypalmer.com/2017/02/5-jobs-robots-will-take-first/>

3. Report writers, journalists, authors, and announcers
4. Accountants and bookkeepers
5. Doctors

Granted, at times those that report these sorts of change statistics tend to exaggerate the scale of the change and the speed at which the change will occur.

While some accountants, bookkeepers, and auditors will likely lose their jobs if they don't tune their skills appropriately; it is better to think about all this not in terms of our jobs but rather to consider the tasks that we perform. What are automated are specific tasks not necessarily entire jobs. Further, the volume and the pace of displacement due to automation are rising.

Also, while some jobs are lost, completely new jobs can be created. For example, the introduction of the automobile led to a decline in horse-related jobs. But, entirely new industries emerged which had a significantly positive impact on employment. Not only did the automobile industry grow fast, increasing jobs in that sector; but jobs were also created motel and fast-food industries to serve all the motorists and truck drivers who drove those automobiles¹⁴.

Another good example is automated teller machines (ATMs). You might think that ATMs would significantly reduce the number of bank tellers. And, in fact, it did. The average number of bank tellers fell from 20 per branch in 1988 to 13 per branch in 2004. But because the cost of running a bank branch went down because of the ATM, banks were allowed to open more bank branches to better serve customers because of the reduced labor cost of bank tellers. The total number of bank branches increased by 43% over that same period, so the total number of bank tellers actually increased¹⁵.

The Rise of the Machines: Enablers of Change

Computers are machines. There are tasks that machines are good at performing. Likewise, there are tasks that machines are less adept at performing and even some tasks which they cannot perform at all¹⁶. The same is true for humans. There are some tasks humans are very good at performing and there are tasks where machines are better than humans.

¹⁴ Georgios Petropoulos, *Do we understand the impact of artificial intelligence on employment?*, <http://bruegel.org/2017/04/do-we-understand-the-impact-of-artificial-intelligence-on-employment/>

¹⁵ Georgios Petropoulos, *Do we understand the impact of artificial intelligence on employment?*, <http://bruegel.org/2017/04/do-we-understand-the-impact-of-artificial-intelligence-on-employment/>

¹⁶ TED Talks, Kevin Kelly, *How AI can bring on a second Industrial Revolution*, https://www.ted.com/talks/kevin_kelly_how_ai_can_bring_on_a_second_industrial_revolution

So what are computers good at? Here is a list:

- Structured problem solving
- Routine tasks
- Arithmetic and other types of mathematics

Here is what humans are good at and things that computers generally cannot do at all or have a very tough time performing such tasks:

- Unstructured problem solving
- Non-routine tasks
- Creativity
- Innovation
- Intuition
- Improvising
- Exploration
- Imagination
- Judgement (such as making a tough decision from incomplete information)
- Politics
- Identifying and acquiring new relevant information
- Compassion

It has been my observation over the years that technical people have a tendency to overstate the capabilities of technology and that most business professionals have a tendency to underestimate the capabilities of technology.

Human-machine Teaming

An episode of the NPR program TED Radio Hour, *The Digital Industrial Revolution*¹⁷, helps you sort through the facts and the fiction to better understand your future which is rapidly arriving. There is one important point that this radio program is getting very right that most people tend to get wrong.

Who is the world chess champion today; a computer or a human? In 1997, IBM's Deep Blue¹⁸, a machine, was the champion.

¹⁷ National Public Radio, TED Radio Hour, *The Digital Industrial Revolution*, April 21, 2017, <http://www.npr.org/podcasts/510298/ted-radio-hour>

¹⁸ IBM, Deep Blue, <http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/>

Today, a computer is no longer the world chess champion. Neither is a human. Today, a team of computers and humans working together can beat any computer or any human working alone¹⁹.

That is how the power of computers will be harnessed in the Digital Age; by human and computer teamwork. Humans are good at some tasks; not as good at other tasks. Computers are good at some tasks; not as good at other tasks. Teaming humans and computers together and leveraging the strengths of each is how work will get done in the future. You already team with machines, such as electronic calculators, which can do math faster and with less errors than humans.

In the first industrial revolution, steam engines amplified the power of our muscles. In the fourth industrial revolutions, computers will amplify the power of our brains²⁰. Human capabilities augmented by computer capabilities are one important way productivity will increase in the fourth industrial revolution. Assisted by computers, humans will spend fewer hours on noncore tasks and more on client service and creative work²¹.

Increased Productivity from Human-machine Collaboration

How much savings will be realized from this human-machine collaboration? That is hard to say precisely, but one study states how much the federal government might save²²:

“At the high end, we estimate within the next 5-7 years, as many as 1.1 billion working hours could be freed up in the federal government every year, saving a whopping \$37 billion annually. Ultimately, AI could potentially free up 30 percent of federal employees’ time. State government savings in time and money could be similar percentages.”

Also, think of something. Who do you want deciding how all these automated processes work? Consider this observation²³ by then president Barack Obama related to driverless cars,

¹⁹ TED Talks, Garry Kasparov, *Don't fear intelligent machines: work with them*, https://www.ted.com/talks/garry_kasparov_don_t_fear_intelligent_machines_work_with_them

²⁰ Shelley Palmer, *Stop Saying AI Can't Replace Humans*, <https://www.linkedin.com/pulse/stop-saying-ai-cant-replace-humans-shelly-palmer>

²¹ Dr. Peter Viechnicki, William D. Eggers, *How much time and money can AI save government?*, <https://dupress.deloitte.com/dup-us-en/focus/cognitive-technologies/artificial-intelligence-government-analysis.html>

²² *What the future of artificial intelligence in government?*, <http://houseofbots.com/news-detail/504-1-what-the-future-of-artificial-intelligence-in-government>

“There are gonna be a bunch of choices that you have to make, the classic problem being: If the car is driving, you can swerve to avoid hitting a pedestrian, but then you might hit a wall and kill yourself. It’s a moral decision, and who’s setting up those rules?”

Automation, such as autonomous vehicles, is made possible by machine-readable rules that enable the automation. Who do we want writing those rules? Software developers? Probably not. Accounting professionals need to be involved in the creation and maintenance of the rules that drive many of these automated processes that impact them. Auditors need to understand how these processes work, what the rules are, and understand how to test if things are working as expected.

Digital General Purpose Financial Report

The general purpose financial report is currently getting a face lift²⁴. While what goes into financial reports is not really changing, how information is conveyed by that report is changing a lot. Paper-based and even electronic versions of financial reports were not understandable by computer processes. But XBRL-based structured digital financial reports²⁵ are understandable by machines. Public companies have been submitting XBRL-based financial reports to the U.S. Securities and Exchange Commission for over five years now, perfecting these digital financial reports.

Most professional accountants still don’t understand how to correctly convey the meaning represented by the complex logical information which makes up a financial report in the machine-readable XBRL structured format. Most professional accountants still don’t understand how to create the business rules that help make sure they did not make mistakes in conveying that meaning. Most professional accountants are not leveraging currently available technologies to automate things such as financial reporting and disclosure checklists. Most certified public accountants don’t really understand how to audit information conveyed by an XBRL-based structured digital financial report. But all that is all slowly changing.

²³ Wired, The President in Conversation With MIT’s Joi Ito and WIRED’s Scott Dadich, *Barack Obama, Neural Nets, Self-driving Cars, and the Future of the World*, <https://www.wired.com/2016/10/president-obama-mit-joi-ito-interview/>

²⁴ Charles Hoffman, *Conceptual Overview of an XBRL-based Structured Digital Financial Report*, http://xbrl.azurewebsites.net/2017/IntelligentDigitalFinancialReporting/Part01_Chapter02.1_ConceptualOverviewOfDigitalFinancialReporting.pdf

²⁵ Mohini Singh and Sandra Peters, CPA, CFA, CFA Institute, *Data and Technology: Transforming the Financial Information Landscape*, <http://www.cfapubs.org/doi/pdf/10.2469/ccb.v2016.n7.1>

By all accounts, the process of creating an external financial report is an extremely inefficient process. Here is a list of how some describe that process:

- The CFA Institute calls for "...greater efficiencies within the current inefficient system" [of creating financial reports]²⁶.
- The consultancy Gartner points out, "...average Fortune 1000 company used more than 800 spreadsheets to prepare its financial statements"²⁷
- Ventana Research says, "...for larger companies, assembling the periodic external reports typically is an inefficient and error-prone process."²⁸
- PriceWaterhouseCoopers points out, "...old school manual processes..." and "commonly cut and pasted, rekeyed, or manually transferred into word processing and spreadsheet applications used for report assembly and review process steps"²⁹

While the process of creating an external financial report might not seem inefficient when being measured against current practices, procedures, processes, and mentalities of those thinking that the way financial reports are created is "the only way" to create such reports; and while it is hard to measure the effectiveness and efficiency of new practices, procedures, and processes because they don't exist yet; when new practices, procedures, and processes do exist the increase in productivity will be measurable and clear, and they will be substantial.

Human-machine Collaboration to Create Financial Reports

How do we know productivity gains will be substantial? For the past five years a software developer and I have worked to create, to the best of our knowledge, the world's first expert system for creating financial reports. We admit that the expertise offered by the system is currently rudimentary but it is effective and it is useful and it does prove the idea. Our current expert system for creating financial reports is somewhat like comparing the first successful airplane created by Orville and Wilbur Wright, Wright Flyer, to say a Boeing 747. Yes, there is a significant amount of room for improvement. But, just like the Wright Flyer proved that sustained flight is possible; our expert system proves that artificial intelligence technology can

²⁶ CFA Institute, *DATA AND TECHNOLOGY: TRANSFORMING THE FINANCIAL INFORMATION LANDSCAPE*, June 2016, <http://www.cfapubs.org/doi/pdf/10.2469/ccb.v2016.n7.1>

²⁷ Nigel Rayner, Neil Chandler, *XBRL Will Enhance Corporate Disclosure and Corporate Performance Management*, April 23, 2008, <http://unstats.un.org/unsd/nationalaccount/workshops/2008/newyork/IG22.PDF>

²⁸ Robert Kugel, Ventana Research: Making XBRL Reporting Easy, February 13, 2009, <http://businessfinancemag.com/technology/ventana-research-making-xbrl-reporting-easy>

²⁹ Mike Willis, PriceWaterhouseCoopers, *Disclosure management: Streamlining the Last Mile*, March 2012, <https://www.pwc.com/gx/en/xbrl/pdf/pwc-streamlining-last-mile-report.pdf>

be leveraged in the process of creating a financial report and it helped to figure out exactly how to make the technology work effectively and more efficiently than current processes.

As has been said, “The best way to predict the future is to create it³⁰.” Yes, it can be hard to separate science-fact and science-fiction. But participating in the creation of new technologies or trying out new technologies before they are ready for commercial use does have its advantages³¹. The typical professional accountant is generally too busy working and producing to fiddle around with possible new technologies that might provide productivity improvements. But those that do lift their heads up from the daily grind of using current practices, processes, and procedures; can often see new ways that can be employed to solve those same problems that are more effective and efficient than current approaches.

While understanding the big picture is important, the devil is in the details. You need to figure out how to appropriately apply technology to your advantage.

Audited Without Manual Interference

The conclusion of a paper, *Imagineering Audit 4.0*, written by Jun Dai and Miklos A. Vasarhelyi and published by the *Journal of Emerging Technologies in Accounting*³² provides a succinct and in my opinion accurate assessment of where Industry 4.0 and auditing is headed.

“Audit 4.0 utilizes data collection equipment such as sensors, embedded computers, and software modules to collect data across the entire company and its outside entities, such as suppliers and customers, via a network in close-to-real time. Data analytics techniques are employed to build models upon these data for the purposes of monitoring product quality, identifying machine faults, saving costs, and facilitating decision making. Audit by exception is used to bring attention to major issues in a largely automated audit. The audit process strongly relies on a mirror world representation of processes and a strong analytical interlinking of not only financial but especially nonfinancial to financial linkages. Finally, the approach will substantially rebalance the concepts of lines of defense, will be applicable to many types of assurances (external, internal, specialized), and will be mainly automated.”

In another paper, *DATA Act 2022: Changing Technology, Changing Culture*³³, published by Deloitte and the DATA Foundation, the authors provide a vision of what is possible to achieve

³⁰ BarnRaisers, attributed to both Abraham Lincoln and Peter Drucker, <http://barnraisersllc.com/2013/12/12-reasons-predict-future-create/>

³¹ Shelly Palmer, *Automate or Die*, <https://www.shellypalmer.com/2017/04/automate-or-die/>

³² Jun Dai and Miklos A. Vasarhelyi (2016) *Imagineering Audit 4.0*. *Journal of Emerging Technologies in Accounting*: Spring 2016, Vol. 13, No. 1, pp. 1-15., <http://aaajournals.org/doi/abs/10.2308/jeta-10494?code=aaan-site>

by the year 2022 should *The Digital Accountability and Transparency Act of 2014*³⁴ be implemented effectively:

“By 2022, if all goes well, spending information will also be automated: reported, exchanged, and *audited without manual interference*. Systems will deliver reports instantly; grantee and contractor software will communicate automatically with agency and government-wide systems.”

The DATA Act is not an isolated example; it is part of a broader trend referred to as RegTech³⁵. Someone, somewhere will begin employing the technologies of the *Fourth Industrial Revolution*. Professional accountants and auditors will then be forced into changing. But these changes will occur and the institution of accountancy may or may not be ready. And these changes will likely occur sooner than you might realize.

The statement “audited without manual interference” implies that manual audit steps are not added value, rather the manual audit steps are unnecessary friction which should be removed from the system.

Be Proactive; Get Retraining, Adapt, and Prosper

While it has been the case that in the past it has been the tendency for most professional accountants to be reactive rather than proactive; and while it is likely the case that professional accountants and auditors will be reactive to this current round of technology improvements; you don't have to be reactive.

Be proactive³⁶. Based on what I can tell, in my view the transition of the accounting profession will pick up steam over the next three to five years and will be running on all cylinders by that time.

Unfortunately, the education system used to create the next generation of accounting professionals is not outputting these new leaders with the right skills and is unlikely to change any time soon. In fact, I had one accounting student tell me that their professor told them that the skills they are learning in college were obsolete.

³³ Deloitte and the DATA Foundation, *DATA Act 2022: Changing Technology, Changing Culture*, <http://www.datafoundation.org/data-act-2022>

³⁴ DIGITAL ACCOUNTABILITY AND TRANSPARENCY ACT OF 2014, <https://www.congress.gov/113/plaws/publ101/PLAW-113publ101.pdf>

³⁵ R.J. Voster BEng, *RegTech: closing the circle; Will Regulatory Technology (RegTech) digitize regulation?*, <https://www.compact.nl/en/articles/regtech-closing-the-circle/>

³⁶ Shelly Palmer, *Automate or Die*, <https://www.shellypalmer.com/2017/04/automate-or-die/>

However, there are ways to work around the educational system's current deficiencies. Professional accountants need to learn how computers reason. Don't fall for the "learn to code" hysteria³⁷.

Besides, this Wired article, *End of Code*³⁸, has the sub title "Soon we won't program computers. We'll train them like dogs." That is a very succinct and accurate statement. But I do disagree with one thing Wired is saying. Business professionals will train software using business rules, not code.

Computers reason using the rules of logic. For now, what professional accountants should do as part of their formal education is go to the philosophy department of your university and take a course in formal logic. That is the basis of computer reasoning, the rules of logic. Literacy as to the rules of logic and reasoning used by computers, which can be taught in less than 40 hours, will help you understand the capabilities of computers and how to harness those capabilities.

A little harder to work around is the skill and ability to represent information and convey meaning in machine-readable form and make sure you did so correctly. I have distilled the essence of this skill into 15 succinct principles, *XBRL-base Digital Financial Reporting Principles*³⁹. Principles help you think about something thoroughly and consistently.

While this ability tends to be above the capabilities of most professional accountants today, the required knowledge will decrease as software functionality improves. If you think about it, software must improve. There is no way the accounting department is going to rely on the information technology department to get financial reports out. That simply will never happen.

Once you have a base of knowledge then the next step is to help software vendors understand the software you really need. If you don't have the correct understanding of what you need because you have the right understanding; then you will tend to misdirect software vendors and send them down the wrong software creation path. That is what has happened for software used to create XBRL-based financial reporting by public companies. The quality of XBRL-based public company financial reports is not where it needs to be. Because of quality issues, the use of all that XBRL-based information suffers and the advantages of XBRL are hard to see^{40,41}.

³⁷ Basel Farag, TechCrunch, *Please don't learn to code*, May 2016, <https://techcrunch.com/2016/05/10/please-dont-learn-to-code/>

³⁸ Jason Tanz, Wired, *The End of Code*, <https://www.wired.com/2016/05/the-end-of-code/>

³⁹ Charles Hoffman, *XBRL-based Digital Financial Reporting Principles*, <http://xbrl.squarespace.com/digital-financial-reporting-pr/>

⁴⁰ *Public Company Quality Continues to Improve, Trend is Good*, <http://xbrl.squarespace.com/journal/2017/6/2/public-company-quality-continues-to-improve-trend-is-good.html>

Quality Digital Financial Reporting is Paramount

One huge mistake that software vendors make is misunderstanding the quality of a financial report. Financial reports cannot contain mistakes. Period. External financial reporting managers have processes, procedures, and practices of today yield extremely high-quality output. The “high-quality” part simply cannot change. Any new technology or innovation that reduces quality will basically never be adopted by the market. What can change is the manual effort that goes into creating those high-quality financial reports. The role of technology is to enable the appropriate tasks to be automated and managed by machine-based processes which frees up humans to perform tasks that only they can perform because they are simply not automatable because they require judgement, are non-routine, or are otherwise beyond the capabilities of machine-based processes. Professional accountants understand this distinction. Information technology professionals do not understand this distinction because they do not understand financial reporting and accounting deeply enough.

The accounting profession is leading other business domains into the Digital Age⁴². It may not seem like that, but it is true. This did not start in 1999 when the American Institute of Certified Public Accountants (AICPA) started the process of creating what has become the global standard XBRL. The process started in 1929 with the creation of U.S. Generally Accepted Accounting Principles, the semantics of financial reporting. Those semantics were tuned over a period of nearly 90 years. It continued with the creation of International Financial Reporting Standards (IFRS) beginning in about 1975. Getting these financial reporting semantics dialed in is the hard part. Representing those semantics in some technical format is easy as compared to creating the semantics in the first place.

Whether any specific government regulator such as the U.S. Securities and Exchange Commission makes this technology work appropriately or not is not really that relevant. The technology, if useful, will likely be adopted because it increases productivity. Until it increases productivity, it will not be adopted broadly. The market would be foolish to adopt something that does not work appropriately.

But when the first software vendor does make this technology work, then the world of accountants and auditors will change dramatically.

⁴¹ Understanding Logical, Mechanical, and Mathematical Accounting Relations in XBRL-based Digital Financial Reports, <http://xbrl.squarespace.com/journal/2016/12/15/understanding-logical-mechanical-and-mathematical-accounting.html>

⁴² Wikipedia, *The Information Age*, retrieved June 28, 2017, https://en.wikipedia.org/wiki/Information_Age

Three Key Technologies Building on Medieval Traditions

Accounting, which has existed for 7,000 years⁴³, even before the creation of formal number systems, is constantly evolving. Accounting is about to go through another significant phase in that evolution process. Professional accountants who adapt will thrive.

There are three specific new technologies that can be leveraged to significantly improve and modernize accounting and financial reporting. Those technologies will transition into the mainstream over the coming years. Those three technologies are⁴⁴:

- XBRL-based structured digital financial reports
- Knowledge-based systems and other application of artificial intelligence
- Blockchain-based distributed ledgers

Single-entry bookkeeping⁴⁵ is how 'everyone' would do accounting. In fact, that is how accounting was done before double-entry bookkeeping was invented.

Double-entry bookkeeping⁴⁶ adds an additional important property to the accounting system, that of a clear strategy to identify errors and to remove the errors from the system. Even better, it has a side effect of clearly firewalling errors as either accident or fraud. This then leads to an audit strategy. Double-entry bookkeeping is how professional accountants do accounting.

Double-entry bookkeeping was the invention of medieval merchants and was first documented by the Italian mathematician and Franciscan Friar Luca Pacioli⁴⁷. Double-entry bookkeeping is one of the greatest discoveries of commerce and its significance is difficult to overstate. Which came first, double-entry bookkeeping or the enterprise⁴⁸? Was it double-entry bookkeeping and what it offered that enable the large enterprise to exist; or did the large enterprise create the need for double-entry bookkeeping?

Accountants think differently than non-accountants, it is part of their training. Non-accountants tend to not realize this and accountants tend to forget or take this for granted. XBRL-based structured digital financial reports, knowledge-based systems and other such applications of artificial intelligence, and blockchain-based digital global ledgers will enhance the invention of the medieval merchants.

⁴³ Wikipedia, History of Accounting, retrieved June 10, 2017, https://en.wikipedia.org/wiki/History_of_accounting

⁴⁴ Charles Hoffman, *Modernizing Accounting and Auditing: Three Technology Trends*, <http://xbri.squarespace.com/journal/2017/5/27/modernizing-accounting-and-auditing-three-technology-trends.html>

⁴⁵ Wikipedia, *Single-entry Bookkeeping System*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Single-entry_bookkeeping_system

⁴⁶ Wikipedia, *Double-entry Bookkeeping System*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Double-entry_bookkeeping_system

⁴⁷ Wikipedia, *Luca Pacioli*, retrieved August 30, 2016, https://en.wikipedia.org/wiki/Luca_Pacioli

⁴⁸ Ian Grigg, *Triple Entry Accounting, A Very Brief History of Accounting, Which Came First - Double Entry or the Enterprise?*, http://iang.org/papers/triple_entry.html

Accountants, don't underestimate the value of double-entry bookkeeping and the other processes, procedures, and techniques employed to make sure that everything "ticks and ties" and "cross casts and foots". These useful techniques, even perhaps better referred to as ingrained medieval traditions, should make their way into these new modern accounting techniques. These successful and important medieval techniques are still very relevant even in the digital age.

Accountants are Knowledge Workers

Knowledge workers such as professional accountants, whose jobs seem secure, are perhaps feeling threatened by technology. This threat by artificial intelligence and other technologies, perhaps, generates fear, uncertainty, doubt and maybe even dread within many different job categories. However, as long as professional accountants are willing and able to adapt to these changes, most professional accountants should be well-positioned to create more value than ever, augmented by machines that they understand how to work with and leverage.

The tremendous potential of the use of technologies to increase productivity in this Fourth Industrial Revolution to liberate resources offers tremendous opportunity to professional accountants faced with limited resources, more things being put on their plate, and expanding backlogs of work. It is highly-likely that new tasks for knowledge workers such as professional accountants will arise, many of which can only be performed by humans; making humans with the right skills even more valuable.

Managers can use these new technologies as a way to increase innovation among those they manage; encouraging their employees to create new ways to use liberated work hours to improve the services they provide to clients. The most forward-thinking managers will see these technologies as an opportunity to reimagine the nature of what and how professional accountants work, increasing the value they provide to their clients.

"I skate to where the puck is going to be, not where it has been." Wayne Gretzky, legendary Canadian hockey star. Don't skate to where the puck is. Understand where the puck will be and go there.