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Appendix 3.06.2 Reporting and audit disruption and new technology
Digital technologies that will affect reporting and auditing

Digital technology is developing at a pace. This chapter concentrates mainly on artificial intelligence (AI) because that is the sphere that we believe will impact on the audit market most significantly. AI has to the power to change the audit market in a disruptive way just as Uber, AirBnb, Netflix and Amazon have changed their sectors.

We have noted that so far reporting and auditing have failed to keep up with, or make any headway amongst the new developments we've reviewed. A number of standard accounting packages have kept pace with the best and latest technology, although the cost of switching can be prohibitive.

The technological developments which may affect accounting and reporting are many and varied.

- Devices vary from mainframes, mini and micro computers, work- stations and PCs, then laptops, tablets, smart phones, the ill-fated Google glasses, watches, and devices that are embedded in clothes. Input devices are increasingly mimicking humans (voice input), and are also being automated.
- The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electron- ics, software, sensors, actuators and connectivity which enables these objects to connect and exchange data. Each item is uniquely identifiable through its embedded computing system but is able to inter- operate within the existing internet infrastructure. We predict that the IoT will consist of about 50 billion objects by 2025 with a global market value of IoT of over £10 trillion.
- Multi-media (text, animation, graphics, photos, images and video) are now more or less standard. More is to come.
- Cables are being replaced by wireless technology. The 4G mobile network will metamorphose into 5G and 6G and onwards.
- Networking among computers and devices is standard as are databases – distributed and cloud based.
- Cloud computing is in its infancy but is already about to be replaced. Security and privacy apart, just about everything can be kept and processed in the cloud as wireless networks become exponentially faster with a rapidly increasing bandwidth.
- Fog and Edge computing extends the paradigm of cloud computing to the edge of the network, thereby facilitating information genera- tion and analytics to occur at the source of the data. The term Fog computing metaphorically conveys the idea that the advantages of cloud computing could be brought closer to data source just as fog is cloud that is close to the ground.
- Accounting systems are more and more dominated by purchased application software. These include big software companies, financial packages specialists (Xero, QuickBooks, Sage and about 50 others), generalized systems such as Accodex, tax systems, and the Big Four's own systems. The range of software packages is likely to reduce through mergers, concentration and some suppliers dropping out of the market. (However, we think the number of offerings is likely to increase in Asia, for language/cultural reasons.)
- Internet, intranets, e-commerce are already well established but there is change of an order of magnitude yet to come.
- Businesses have yet to make much use of neural networks, Bayes- ian probability, artificial intelligence or intelligent knowledge-based systems. But the use of such systems will explode during the next decade.

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Grey information and analytics

The World Wide Web that you can see and visit is only one five hundredth of the total web. Cloud computing and big data[1] all add to a rate of change. So, what is visible or can be found by search engines is a fraction of what is in the web. There will be over 50 billion devices connected to the internet by 2025 (with a world population of seven billion). Parts of Asia, and particularly China, will be well ahead of the West in this respect.

Big data, social media, messaging apps and grey data

Grey information includes big data, cloud computing, mobile apps, social media, games, private intranets, deep web, dark web and many more

digital apps and web storage applications.[2] This includes both information that a company owns and third-party sites (for example, information col- lected by Facebook, Google and others on everyone, analytic sites, social network interactions/analysis sites and so on).

Big data is sometimes defined as extremely large data sets, including all grey data that may be analyzed computationally to reveal patterns, trends and associations, especially relating to human behaviour and interactions. The distinguishing feature is that in order to find meaningful patterns, much IT investment is necessary to manage and maintain that data.

In theory, social media are computer-mediated technologies that facili- tate the creation and sharing of information, ideas, career interests and other forms of expression via virtual communities and networks. In practice, they have split down to Facebook type sites, Twitter type sites, mes- saging (WhatsApp, Messenger, etc.) and then specialist sites dealing with photos, music, dating or a host of other functions. Facebook is ahead in harvesting information on an individual level. Facebook's data harvesting and targeting is simply awe inspiring and it continues to gather more and more information – despite privacy concerns.

E-commerce

Electronic or e-commerce is a way of doing business over large electronic networks. E-commerce greatly facilitates transactions between compa- nies and consumers (B2C), between one company and another (B2B), and between individual consumers (C2C) – via sites such as eBay. The exponential growth of e-commerce is unstoppable. Amazon UK has about 16% (but growing fast) of the market followed by Tesco (9%) and then eBay (8%).[3]

Digital footprint

Every time anyone comes on to a website, they leave a digital footprint, including their email address, actual address, telephone numbers and all the information available on that person held in Google, Bing, Facebook, Safari and other sites. This data is hugely valuable and the types of use and extents to which the big tech companies can use it is frightening. There is more customer data available than ever before. This data can also be used by auditors and therefore has implications for auditing.

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Analytics

Analytics, or more correct, data analytics, is the discovery, interpretation and communication of meaningful patterns in data. It is most commonly applied to online information. In theory, this is especially valuable in areas rich with recorded information. Analytics relies on the simultaneous application of statistics, computer programming and operations research to quantify performance. In practice this is typified by Google Analytics which offers a (partly)[4] free enterprise analytics tools to measure website, app, digital and offline data to gain customer insights.

Of course, the most obvious information is about visitors to a site and their profiles. Then any interaction, conversion goal or transaction details on the site, and what visitors are also doing on other parts of the web too. The number of visitors, retention, conversion rates, time on site, new versus returning, loyalty of customer visits, income group, gender, location, device, operating system, screen size, reach, frequency are all important metrics and can be recorded by analytics and subsequently be analyzed and reported. Again this has implications for auditors and can used by auditors.

Possible impact of these technologies on auditing

Blockchain accounting

Forget the hype – a blockchain is a very simple concept: it is just a secure distributed ledger. The encryption process is ultra-secure as a number of people process the same transaction simultaneously and agree the result. Such people are called blockchain miners. See Appendix 1.06.1 for a further discussion. By and large the benefits of blockchains have been overstated.

Accounting ledgers merging

So taken as a given – we assume an advanced form of accounting using a new innovative multi-entry accounting spliced into a relational type database and using blockchains. Blockchains allow the possibility of having a single worldwide ledger containing all business and banking transactions[5] (at least in theory). That is probably too extreme, but certainly it would be possible to have a country-wide blockchain for accounting transactions. Or more likely several competing blockchains with an import and export facility. Or possibly an industry-specific, or regional blockchain for accounting transactions. It is also possible for the Big Four to run their own accounting blockchains for their cli- ent accounts and then hand over that portion of the blockchain to the rotating auditor.

At the moment all of the Big Four offer a range of blockchain applications and services. They are likely to grow, though there is resistance from the FTSE companies because they already have their hands full with other technological developments. It is commonly acknowledged that Deloitte was an early adopter of blockchain with its Rubix system launched in 2014. It also created a blockchain lab in Dublin, Ireland. But the other three firms have all now launched a variety of initiatives.

The more companies sign up to a single accounting blockchain the more efficient it is and the easier to verify transactions, report on them and to audit them. However, it would probably require government action to achieve such a result. (See Appendix 1.06.2 for a discussion of cryptocurrencies. This too has been over-hyped.)

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Data mining

One area that is particularly interesting for auditors is data mining tech- niques (not to be confused with blockchain or Bitcoin mining). Data mining is the process of discovering patterns in large data sets involving methods at the intersection of statistics, database systems and big data. It is an essential process in auditing where intelligent methods are applied to extract data patterns. For auditors, data mining can provide verification and authentication data.

Auditing impacts and extensions

Auditing has to stretch to encompass all grey data and of course the Internet of Things (IoT). Text messages on smart phones and social media comments will be vital too for an overall knowledge of the group being audited. If the senior executives at Steinhoff (see Chapter 8 in *Financial Failures & Scandals: From Enron to Carillion* in this series) had had their phones and all communications monitored by the auditors, then either there would not have been a set of missing items in the balance sheet or the allegedly fraudulent transactions would not have happened. It may sound far-fetched, but something akin to a 'big brother' approach in business has to be considered especially if the audi- tor is in some way liable or faces much greater fi or consequences.

Artificial intelligence (AI)

This is the big development for auditing. Gilly Lord, head of audit strategy and transformation at PwC, agrees that AI is rapidly transforming the face of audit for the Big Four, allowing them to analyze huge data sets with mind-boggling speed and efficiency.[6]

We agree but even so, think that is a far too narrow view. The tech giants are going much further. The big battle with AI systems is whether there should be one giant generalized AI system capable of doing everything (or a series of them) or whether we have more specialized AI systems. Google/Deep Mind are in favour of one all-powerful generalized AI system. Elon Musk (Tesla, Space X among others) was an initial investor into Google's Deep Mind, but left Deep Mind – which is now 100% owned by Alphabet (Google's parent since 2014).

In December 2015, Musk announced the creation of Open AI, a not-for-profit artificial intelligence research company. Open AI aims to develop artificial general intelligence in a way that is safe and beneficial to humanity. By making AI available to everyone, Open AI wants to:

> counteract large corporations who may gain too much power by own- ing super-intelligence systems devoted to profi as well as governments which may use AI to gain power and even oppress their citizenry.[7]

Musk has stated he wants to counteract the concentration of power. In 2018 Musk left the Open AI board to avoid 'potential future conflict' with his role as CEO of Tesla as Tesla increasingly becomes involved in AI. The type of AI in Tesla cars or Google's Waymo, or Uber's self-driving car systems (currently some of the most advanced autonomous intelligent driving systems), is an example of a narrow, specialized AI system.

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Definitions

AI is not so much the application of human reasoning techniques by machines. We suggest that this is the wrong way to look at it. There are at least three basic core components that define the totality of artificial intelligence and expert decisions and the lesser intelligent knowledge- based systems. Traditionally such systems have been defined as knowledge bases, databases and database management systems, inference engines, user interfaces and knowledge-acquisition components. But that can be bro- ken down into:

1) systems which implement decision rules based on some type of data input;
2) systems as above but that interact with some sort of dynamic database in order to make a decision. The decision rules may be modified over time by the new data;
3) machine learning systems. As above, but with the true capability of the decision rules learning from past mistakes or success. In this case, there has to be some feedback mechanism to report back on past decisions.

s we have seen AI systems can be broken down into a) narrower special- ized systems (such as driverless cars as above) or b) generalized AI systems. There is always an element of machine learning where a computer system is fed large amounts of data, which it then uses to learn how to carry out specific tasks. Narrower AI is what we see all around us in computers today: intelligent systems that have been taught or have learned how to carry out specific tasks without being explicitly programmed how to do so. Your fridge may be automatically filled without human interaction; products are bought, meals cooked before any human decision is made; entertainment is automatically served; holidays automatically booked.

Generalized AI systems are very different and mimic a type of adapt- able intellect found in humans, which is a flexible form of intelligence capable of learning how to carry out vastly different tasks. The difference is they are specialized in everything and there is nothing they cannot do.

Machine learning

Machine learning is the vital part of AI that often uses algorithms to enable computers to 'learn', i.e. to progressively improve performance on a specific task – without being explicitly programmed.

Key to the process of machine learning are neural networks. These are brain-inspired networks of interconnected layers of algorithms, called neurons, that feed data into each other, and which can be trained to carry out specific tasks by modifying the importance attributed to input data as it passes between the layers. During training of these neural networks, the weights attached to different inputs will continue to be varied until the output from the neural network is very close to what is desired, at which point the network will have 'learned' how to carry out a particular task.

A subset of machine learning is deep learning, where neural networks are expanded into sprawling networks with a huge number of layers that are trained using massive amounts of data. Remember that a neural net is a function of a bunch of weights. By adjusting the weights, you can make the function behave differently. The machine learning works by doing the same operation millions or billions of times until it gets closer to the ideal or winning situation. One can see how this works for self-driving cars – you let the system drive for months on end and the degree of intervention by a human driver will gradually tail off. It is more difficult to see how this would apply to auditing; nonetheless we believe it will – just that the mathematics of the algorithm is more like the human brain including a degree of fuzziness and intuition.

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Advanced AI techniques use vast layers of neural networks with techniques such as backpropagation and reinforcement learning. The next technique is for AI systems to be self-programming – avoiding the need of any human intervention. Evolutionary computation is the process of using AI to help build AI. The use of evolutionary algorithms to optimize neural networks is called neuroevolution, and could have an important role to play in helping design efficient AI as the use of intelligent systems becomes more prevalent. Deep Mind uses many hundreds of layers of neural networks to facilitate fast learning. Google and Microsoft have moved to using specialized chips tailored to both running, and training, machine learning AI systems.

Some studies say that AI will evolve slowly[8] but we believe that whatever you may read about the speed of AI systems coming into the mainstream, you should think again. We believe the chances that AI will become commonplace by 2030 are great. Accounting, financial and auditing are prime suspects for their application. Think of the complexity of IFRS as it now, and then add an order of magnitude of more complexity. Think about the ever-expanding (currently 24 volumes or so) FCA handbook.

AI and the Big Four

Consider the common objective of the big accounting/auditing firms – to make a profit. All the Big Four have various AI systems and are developing more. Then think of AI systems becoming increasingly cheap through the use of Alphabet/Google and other open-source AI modules as part of their overall makeup, making AI systems more affordable. It is possible and perhaps likely that one of the tech giants or unicorns will develop an audit AI engine.

Of course, each of the Big Four will each say their AI system has a special characteristic and is better. KPMG has their advanced AI pack- age called Ignite. Deloitte partnered with Kira systems. All the Big Four have or are using IBM's Watson AI package. PwC is experimenting with autonomous drones, and as its mantra goes, 'AI will become part of PwC's DNA'. Deloitte has raised the concept of robotics for audits. But what- ever we say about the current use of AI by the Big Four will soon be out of date. Although, there is another albeit unlikely possibility: an AI audit system if sufficiently cheap could undermine the Big Four's scale advantages.

Gilly Lord has talked publicly about PwC's use of machine learning to audit journals. This is what two senior members of the Big Four have publicly said:

> We've not told it what to look out for, such as journals posted on a Saturday night or unusual amounts or unusual account combinations.

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The more journals and the bigger population you feed it, the better it gets at identifying what is a real anomaly.

One of Lord's colleagues piloted the machine learning in parallel with the regular human investigation of the data analyzed on a recent audit. The results, she says, were fascinating.

> The machine is identifying fewer anomalies for investigation – but it turned out that these were the real anomalies, the ones we needed to spend time on.[9]

Nick Frost, KPMG head of audit technology, said that some analytic tools are being applied to judgements that are based on predictions, such as asset impairment. These tools can review a client's forecasts for recovery of an asset and then apply predictive algorithms against those forecasts to come up with a probable value of the cash the asset will generate. What used to be a manual process is transformed into a multiple-scenario model that can be used to challenge the client's judgement. Frost says that these tools are incredibly powerful.

Now I can sit in front of an audit committee and say I am 90% sure that this asset is worth what you think it is. That's something I could not have done without the predictive algorithm.[10]

Technology and change in the audit process (practical considerations in the long run – 2025 onwards)

We will now consider AI systems for accounting and management information, operational systems. Let's assume that our subject area will use narrower specialized AI systems, i.e. even if they are generalized AI systems, they will be allocated a narrow, specialized task.

Accounting, in a multiple-entry system, will be performed by the firm's information system AI. It may also run all the management information systems and data collection necessary to take up an expanded reporting function, including much more non-financial information. If required, the AI system could produce the equivalent of an annual report every day using multiple accounting rules and multiple currencies. (Obviously, it will have access to all the accounting standards and have a view, or range of views, of what is true and fair.)

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An operational AI will run the website, factories, organize supplies, make decisions if the factory is entirely automated, reprogram robots and run the customer systems. This operational AI provides information to the information system AI. Imagining an internal audit AI system which interacts with the information system AI is not a stretch of the imagination. The interactions between these sub-AI systems can occur seamlessly. The audit AI system can interrogate the information system AI system. The final addition is the reporting AI system which can create standard or tailored reports to anyone with sufficient privileges and permissions.

Then there would be the external auditor's AI system. Without even considering the job implications, there are three pitfalls. The tech giants claim that each can be overcome quite easily and quickly but they still need to be overcome.

1) At some point the system has to learn. During that learning phase mistakes will be made. The case studies demonstrate that failures do occur, there are no two which are exactly alike. For example, on revenue recognition, the AI would have to be able to predict the likelihood of, for example, customers not paying up for either a good reason or some trumped-up reason. Will the AI systems learn from its mistakes in revenue recognition? An audit AI system will be constantly learning as regulations change and the economic and commercial environment changes. Perhaps that AI system is better able to adapt. But during the learning phase, errors might occur.

2) AI systems need to explain how they reached a certain decision or conclusion, or in accounting terms, a certain value. At the moment AI systems are notorious for not being able to explain how the hun- dreds of layers of neural networks actually reached a decision. You might need a second AI to monitor the first AI in order to explain its decision-making process. Although a solution will eventually evolve, even Google's Deep Mind is not finding this process easy (but surmountable).

3) Then there is the problem that AI systems can communicate between themselves even if they are initially programmed not to. As AI systems can program themselves, there is nothing to stop the audit AI system conspiring to do something with the company's information AI system. Maybe it could be just an agreement between the two AI systems to overlook something that subsequent events proved to be important. No one would know as the systems would specifically ensure that such communications and misstatements were covered or within acceptable boundaries. Such communications may be for a very good reason – to protect the viability of the firm being audited, and the audited AI system would be in some way bought off to turn a blind eye. So conspiring for small creative accounting or even the equivalent of AI fraud would be a real possibility.

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There are some other issues which need to be considered:

1) Edge cases are complicated and unusual situations that cannot be foreseen during training or machine learning. AI systems are pattern- recognition engines, trained on thousands of examples in the hope that the rules they infer will continue to apply in the wider world. But they apply those rules blindly, without a human-like understand- ing of what they are doing or an ability to improvise a solution on the spot. Designers of AI systems worry how their machines will perform in edge cases.[11]

2) It will be some time before AI systems can work in auditing. We are probably talking about sometime past 2025 and possibly past 2030. But the rate of progress, including that being researched, invested in and offered by the Big Four, and others, shows that a time frame of 2025 is possible for some of our predictions to have started to occur. The effects of such progress will manifest itself before the middle of the 2020s.

Such fundamental technological evolutions, like the Internet and mobile phones, quickly populate the world and then evolve very quickly into a rapidly expanding technology with new versions or disruptive start-ups being launched every year. With this pace of change, it is likely that some new entrants will take the standard routines of Deep Mind, Open AI and others, and will be able to make our reporting, information processing and audit AI systems work effectively. It will not always be the big tech companies or the Big Four that will launch the new revolutionary ways and we think that there may be some new players.

We leave the last word to Hywel Ball, Head of assurance at EY who put this succinctly:

New technology is already having a big impact on the audit profession and the pace of change will only continue to accelerate…. Data analytics, artificial intelligence and robotic process automation are changing both what and how we audit. Enabling us to search, sift and sort through large quantities of data, from company reports to social media, these tools are helping auditors to identify potential areas of risk and to understand a company's performance at a more granular level. They are also providing insights into areas that were once thought to be impossible to measure, such as culture…. The availability of new technology and explosion of big data are also raising important questions around how audit delivers value in the knowledge economy. We have never before had so much information available about organisations' performance, and yet many companies are struggling to tell a clear story to their investors and other stakeholders about the long-term value they are creating. Added to a general declining trust in business, and it is clear that the audit profession has some big challenges if it is to reflect the changing demands of society.[12, 13]

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Notes

1   Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualization and information privacy. Most of this data is kept on web (private or public).

2   Not just the WWW.

3   'The top 500 ecommerce retailers in the UK' *Ecommerce News Europe*, 10 Feb- ruary 2017. Available at: https://ecommercenews.eu/top-500-ecommerce-retail ers-uk/ Accessed July 2017.

4   You have to pay for certain parts and certain more detailed data.

5   See this FRC publication for an excellent description of blockchains. We just disagree with their conclusion as to the speed and usage. Financial Reporting Council Lab, 2018, 'Blockchain and the future of corporate reporting: How does it measure up?', *Financial Reporting Lab, Financial Reporting Council*, June 2018. Available at: www.frc.org.uk/news/june-2018/publication-of-the-financial- reporting-lab's-repor
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6   Munro, R., 2018, 'Artificial intelligence and machine learning in accountancy – Part 1', *Accountancy Daily/Magazine*, 5 June 2018. Available at: www.account ancydaily.co/artifining-accountancy-part-1
Accessed June 2018.

7   Clifford, C., 2018, 'Elon Musk: "Mark my words – A.I. is far more danger- ous than nukes"', *CNBC Make It*, 13 March 2018. Available at: www.cnbc. com/2018/03/13/elon-musk-at-sxsw-a-i-is-more-dangerous-than-nuclear-weapons.html
Accessed April 2018.

8   Stanford University, 2017, '100 year study on AI kicks off its next report cycle', *One Hundred Year Study on Artificial Intelligence (AI100)*. Available at: https://ai100. stanford.edu/
Accessed April 2018.

9   Biebuyck, C., 2017, 'Audit automation', *Economia*, 7 September 2017. Quotes taken from *Economia* and reproduced with kind permission of ICAEW. https:// economia.icaew.com/. © ICAEW 2017. Available at: https://economia.icaew.com/en/features/september-2017/audit-automation
Accessed November 2017.

10   Ibid.

11   See for example: Leaders, 2018, 'The Kamprad test: IKEA furniture and the limits of AI', *The Economist,* 21 April 2018. Available at: www.economist.com/news/

leaders/21740735-humans-have-had-good-run-most-recent-breakthrough-robotics-it-clear
Accessed May 2018.

12   Wilcox, R., 2018, '2018: What's in store for accountants in the year ahead?', *Accountancy Daily/Magazine*, 2 January 2018. Available at: www.accountancydaily. co/2018-whats-store-accountants-year-ahead
Accessed January 2018.

13   The FRC published an excellent paper on AI in January 2019. Artificial intelligence and corporate reporting. Available at: https://www.frc.org.uk/ getattachment/e213b335-927b-4750-90db-64139aee44f2/AI-and-Corporate- Reporting-Jan.pdf
Accessed January 2019.