BIG DATA AND CONTINUOUS MONITORING:

With the advent of the Internet era, the global flow of information across countries, economies, industries, and companies has reached a point that far outpaces human capacity to make sense of it.

A SYNERGY WHOSE TIME HAS COME?

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In today's increasingly complicated governance, risk management, controls, and compliance landscape, both external audit firms and internal audit functions leverage recent advances in technology to revolutionize the way that audits are conducted. Specifically, both internal and external auditors are combining big data and analytics and exploiting greater access to detailed industry information to help them better understand the business. Moreover, these technology-driven capabilities have greatly enhanced their capacity to pinpoint key risks and strategic issues and deliver enhanced quality and coverage while providing more business value. Information and insights are

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now gleaned not only from financial transactional data in a company's general ledgers, but also encompasses a wide variety of sources such as email, social media, video, voice, and texts providing mountains of unstructured data. In this connection, Broxup has emphatically asserted: "Continuous monitoring, auditing and exception reporting will increase operational efficiency and reduce risks."[1]

With the advent of the Internet era, the global flow of information across countries, economies, industries, and companies has reached a point that far outpaces human capacity to make sense of it. As we have become "data rich but information poor," Nobel Laureate Herbert Simon's trite observation rings true: "A wealth of stimulus creates a poverty of attention." Indeed, it was Herbert Simon who first articulated the concept of "attention economics" rather persuasively, when he observed:

> In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.[2]

Continuing this line of reasoning, Simon perceptively noted that many designers of information systems incorrectly represented their design problem as *information scarcity* rather than *attention scarcity*; as a result, they built systems that excelled at providing more information to people, when what was really needed were systems that excelled at filtering out unimportant or irrelevant information.[3]

At the dawn of the 21st century, Davenport and Beck persuasively argued that the most significant problem in today's business world is not competition, lack of skilled employees, or an uncertain economy but rather an attention deficit, an "organizational ADD" problem.[4] With the emergence of big data in the following decade, this organizational ADD problem is probably getting worse as selection of relevant information and prioritization of action steps becomes the single most important thing for organizations. Such prioritization requires a judicious balancing act; the fundamental question becomes how to execute in the now while thinking about the future. Fortunately, in the last decade, advances in technology have also unleashed immense capabilities in continuous monitoring (CM), possibly presenting a solution to this identified organizational ADD problem. In addition, CM has considerable significance for "data governance applications," ensuring better quality and data relevance and providing a basis for information integrity.[5] Taylor asserts that while analytics can remove guesswork from decision-making, companies must still know what information is needed.[6] Internal audit functions are uniquely positioned to assist with such determinations, as described later.

CM enables organizations to assess business performance, business risks, and associated control processes in a timely, economical, and effective manner. CM initiatives can be designed and targeted so as to mitigate risk, enhance performance, reduce cost, achieve regulatory compliance, improve business process efficiencies, strengthen internal controls, and, ultimately, drive value in a myriad of ways for organizations. Most importantly, CM permits use of the Pareto 80–20 rule to prioritize intelligently focusing on the most important things without, for instance, "making the urgent drive out consideration of the important."[7]

Consider the comments of Anne Milley, a senior director at the SAS Institute: "It starts with an analytical view of data — what are you measuring and are you measuring what matters?...How are people in your organization armed to make better decisions using the data, processes, and analytical methods available?"[8] Indeed, this represents the larger context of CM: to monitor but to also collect relevant information that can be profitably analyzed in order to yield

IN THE LAST DECADE, ADVANCES IN TECHNOLOGY HAVE ALSO UNLEASHED IMMENSE CAPABILITIES IN CONTINUOUS MONITORING, POSSIBLY PRESENTING A SOLUTION TO THIS IDENTIFIED ORGANIZATIONAL ADD PROBLEM.

actionable insights. Such an orientation can be particularly valuable for government agencies who have implicit permission from citizens to collect large amounts of information. The internal audit function in several organizations is uniquely positioned to understand and leverage the capabilities of CM applications for governance, risk management, and compliance.

When well implemented, CM uses sophisticated tools and has powerful capabilities in review and analysis, including performing predictive analytics. CM approaches possess the potential for surfacing deep insights into ineffective and inefficient business processes, understanding and addressing risks as they develop and mature, and enabling preemptive or responsive action to be taken. Recent advances in technology have further accentuated the importance of CM, and it shows every sign of becoming an important adjunct to strategic decision-making by organizations of all sizes. Perhaps given their familiarity with continuous auditing efforts, Ramamoorti et al. document the key role played by the internal audit function in promoting and supporting CM initiatives.[9]

Emergence of big data

The emergence of big data has highlighted the value of data-driven approaches to business intelligence and strategy. According to IBM, some 2.5 quintillion bytes of data are created every single day, and research firm IDC claims that more than 1.8 zettabytes were added in 2011 alone, asserting that the world's data volume is doubling every two years.[10] It is now projected that there will be a 4,300 percent increase in annual data gathered by 2020. Computer Sciences Corporation, portraying the rapid growth of global data in Zb (units of computer storage equal to 1×10^{21} bytes), from 2009 onwards when the size of total data was 0.79 Zb (≤ 1 Zb), finds that in 2020, the size of total data will be some 35 Zb, with 28 Zb being enterprise managed and 10.5 Zb being enterprise created.[11] With such astronomical numbers, it is quite evident that the conversation must turn to what can be done with such a huge avalanche of data. Clearly, we find ourselves in a "data rich, information poor" situation.

Gartner, the research firm, defines big data as high volume, velocity, and variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making.[12] However, efforts are being made by companies to extract information from large volumes of data by asking focused and targeted questions of internal and external information almost as soon as and, in some cases, even while it is being generated. Specifically, organizations use sophisticated tools to "improve business efficiency, spot trends and opportunities, provide customers with more relevant products and services, and increasingly, to predict how people, or machines, will behave in the future."[13] Of course, from an audit perspective, there is a fourth "V," namely veracity, or the underlying truth, reliability, and factual basis and content of the data being so analyzed. Hence, Peters, CEO of the Chartered Institute of Internal Auditors, U.K., notes in his blog: "Big data is an area of emerging risk that internal auditors must embrace to meet the new expectations placed on them."[14]

Many believe that big data could help enhance customer offerings as well as inform risk management and audit activities. It is intuitive to argue that the more data you have, along with appropriate technologies to analyze it, such as data visibility, patterns, associations, and correlations, the better you can:

- comprehend what's happening with the enterprise;
- identify potential concerns, including control gaps; and
- utilize existing controls to mitigate risks.

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Commenting on the steadily increasing requests for analysis of large chunks of data, Neil Frieser, VP of internal audit at Frontier Communications, thoughtfully observes: "You've got an explosion in the data, a dramatic reduction in cost of storing that data, and then you've got the tremendous improvements in quality of getting the data out, plus advances in predictive analytics, which allows you to take all that data and look in front of you."[15]

Gartner estimates the 2011 spending for business intelligence, corporate performance management and analytics applications, and performance management software stood at $12.3 billion and grew 7 percent in 2012.[16] Each of the "big five" vendors in this space (viz., SAP, Oracle, IBM, SAS, and Microsoft) is closely watching this exploding market and increasing sophistication of tools. Big data tools such as Hadoop and Spark and NoSQL platforms such as MongoDB and Cassandra all have the ability to handle massive amounts of data — encompassing both structured data available from relational databases or unstructured data such as free text, videos, and images. Big data lends itself to cloud computing applications rather naturally and is optimized for dealing with unstructured data. Nevertheless, it must be appreciated that the quality of the underlying data is always an important concern. You simply cannot make a silk purse out of a sow's ear.

In the 2015 Magic Quadrant, Gartner defines business intelligence and analytics as a software platform that delivers 13 capabilities across three categories: enable, produce, and consume.[17] Vendors are also assessed for the support of the following four main use cases:

1. centralized business intelligence provisioning;
2. decentralized analytics;
3. governed data discovery; and
4. original equipment manufacturer/embedded analytics.

Gartner proceeds to state that "by 2018, data discovery and data management evolution will drive most organizations to augment centralized analytic architectures with decentralized approaches."[18]

Two basic approaches to strategy and decision-making

In logic and reasoning, there are two ways of arriving at a conclusion: deductive reasoning and inductive reasoning.[19] Philosophically, business strategy and decision-making also follow the same logic; they are either conceptual and top-down or data-driven and bottom-up.

Deductive reasoning happens when a decision-maker works from the more general information to the more specific. Sometimes this is called the top-down approach because the decision-maker starts at the top with a very broad spectrum of information and works their way down to a specific conclusion. For instance, a sales and marketing manager might begin with a theory about his or her topic of interest, such as what strategy is likely to increase sales volume, say discount pricing. From there, he or she would narrow that down into more specific hypotheses that can be tested. The hypotheses are then narrowed down even further when observations are collected. This ultimately leads the manager to be able to test the hypotheses with specific data, leading to a confirmation (or not) of the original theory and a conclusion.

BIG DATA LENDS ITSELF TO CLOUD COMPUTING APPLICATIONS RATHER NATURALLY AND IS OPTIMIZED FOR DEALING WITH UNSTRUCTURED DATA. NEVERTHELESS, IT MUST BE APPRECIATED THAT THE QUALITY OF THE UNDERLYING DATA IS ALWAYS AN IMPORTANT CONCERN.

Inductive reasoning works in the opposite way, moving from specific observations to broader generalizations and theories. This is sometimes called a bottom-up approach. The decision-maker begins with specific observations and measures, detects patterns and regularities, formulates some tentative hypotheses to explore, and finally ends up developing some general conclusions or theories. Naturally, all big data approaches by construction, and by definition, involve inductive reasoning.

Inductive reasoning is commonly used in science; however, it is not always logically valid because it is not always accurate to assume that a general principle is correct. This is also the Achilles' heel of all big data approaches that exploit correlational insights and not causal ones.

By nature, inductive reasoning is more open-ended and exploratory, especially during the early stages. Deductive reasoning is narrower and generally used to test or confirm hypotheses. Most social science research, however, involves both inductive and deductive reasoning throughout the research process. The scientific norm of logical reasoning provides a two-way bridge between theory and research. In practice, this typically involves alternating between deduction and induction.

One of the biggest challenges in big data approaches is the quality of the input data, whether structured or unstructured. The best antidotes for bad data, especially in the context of inductive reasoning applications, use CM capabilities to sift through data in real time and preserve only validated, confirmed data. When used subsequently as inputs to decision-making, this strategy can make an enormous difference.

The importance of information integrity

To view the interaction of data, information, and people whenever real-world judgments and decisions are studied, we need a suitable frame of reference. We find such a frame of reference in the concept of information integrity.[20] Information integrity is the trustworthiness and dependability of information. The credibility of information depends on its source credibility. A 1995 *Economist Intelligence Unit* report announced that of all risks, the "information for decision-making risk" was paramount.[21] After all, the value of information to the decision-maker and problem-solver consists first of integrity, and then usefulness and usability.

Corporate governance failures can be viewed through the prism of information integrity. The concept of information integrity builds on the rather obvious and well-understood fact that people use information to make decisions. Information integrity failures can be traced back to one of the following: informational errors, ethical lapses and integrity failures, or a combination of both. Informational errors arise owing to:

- decision-makers receiving or using incomplete or unreliable information;
- decision-relevant information being unavailable;
- available information being irrelevant, non-actionable, opaque, or simply incomprehensible; or
- decision-makers relying on stale information arising through a variety of inadvertent, process-based causes.

Also, falling into this last category would be the law of unintended consequences, whereby the right information at the right time that is supposed to be available is not. Integrity failures also occur whenever information ends up being massaged or manipulated deliberately; bias is introduced purposefully, and people act unethically or fraudulently to shade information or make outright misrepresentations or fabrications. Given this backdrop, a careful root cause analysis of any corporate governance failure — frequently involving allegations of fraud — will lead to the inevitable causal diagnoses of information errors, integrity lapses, or both.

Two key observations could be asserted with reference to an information integrity framework.

An information problem may or may not be an integrity problem. Given its size and other ripple effects, this could lead to an information integrity failure. Significance of the information error is generally measured quantitatively; it is a question of the magnitude of the information error (i.e., by what order of magnitude are the estimates wrong? What is the margin of error?). However, there could be qualitative considerations, too. Thus, decisions based on faulty economic and market assessments about the pricing and sale of a product in a foreign jurisdiction could jeopardize the entire operation in that location, for example.

An integrity problem will almost always result in an information problem. This will sooner or later lead to an information integrity failure. It is not a question of if, but when a person with questionable ethics will choose to misrepresent something. With respect to the recent wave of insider trading prosecutions, consider that the individuals prosecuted were simply waiting for the opportunities to exploit non-public, market-moving information to their advantage. Significance

INFORMATION INTEGRITY IS THE TRUSTWORTHINESS AND DEPENDABILITY OF INFORMATION. THE CREDIBILITY OF INFORMATION DEPENDS ON ITS SOURCE CREDIBILITY.

BIG DATA APPLICATIONS

TOPPLE RISK

Underwriting policies has always been a mix of art and science, but Claude Yoder, head of global analytics for insurance broker Marsh, says the advent of big data "added more of the science flavor." For example, it is no surprise that the taller a building, the more likely it is to fall over. With today's extensive data and predictive models, however, insurance providers can now quantify exactly how much more likely that occurrence is and put a price on its "topple risk." The enhanced analytics "doesn't replace underwriting; it complements it," Yoder says, which makes pricing "much more sophisticated" (e.g., harder for customers to negotiate as a result). (Source: Stuart, A., Big data: Starting small, scaling up, *Compliance Week* (July 31, 2012). Available at: https://www.complianceweek.com/news/news-article/big-data-starting-small-scaling-up#.Vo_m4Pk4GM8.)

GE'S PROFICY HISTORIAN HD

General Electric's customers use its Proficy Monitoring & Analysis Suite, an integrated suite of software for industrial data management and analytics used to monitor equipment and process data, to improve performance. GE's Proficy Historian HD, one of the six software modules in the suite, lets companies store very large data sets in a Hadoop cluster (many machines run the open-source software Hadoop, which can handle massive amounts of unstructured data) and then run advanced analytics on huge amounts of data to improve performance, troubleshoot problems, and predict and prevent failures in machines such as turbines or jet engines. "We use the software ourselves in our own monitoring and diagnostic centres to manage trillions of dollars in asset value," said Brian Courtney, general manager of GE Intelligent Platforms' Industrial Data Intelligence Software group. (Source: Taylor, P., Big data put under the spotlight as never before, *Financial Times* (June 26, 2013). Available at: http://www.ft.com/cms/s/0/4ffdc998-d299-11e2-88ed-00144feab7de.html#axzz3wfkBNMoP.)

of behavioral and integrity risks is mostly a qualitative judgment.

When the information integrity framework is suitably supplemented by insights from the behavioral sciences, we are positioned to competently perform a root-cause diagnosis of corporate governance failures, including those involving fraud. Obviously, the ability to marshal big data in such contexts would greatly enhance the quality of such analyses.

Internal audit function considerations

Prudently exploiting big data analytics can help internal auditors act as strategic advisors while controlling audit costs. Clearly, analyzing data to surface the nature and scope of actionable information is the critical imperative and the unprecedented opportunity for organizations. Accordingly, we present here a few dimensions and areas where internal audit can make enduring contributions from an operational perspective.

Strategy. Some key questions that are pertinent to bring up in this area are: What are management's plans for using big data and analytics for auditing, compliance, and risk management now and in the future? Does the company have a clearly articulated governance and enterprise risk management strategy regarding big data and analytics? This should be reviewed in light of the COSO's Enterprise Risk Management — Integrated Framework, as well as the updated framework that is being developed and forthcoming.[22]

Functional areas and business processes. In particular, it is important to ask how the company's internal audit, compliance, and risk management functions are leveraging big data and analytics to achieve business objectives and maximize return on investment. Has internal

BIG DATA APPLICATIONS, CONT'D.

HOW TO TACKLE BULLYING

University of Wisconsin researchers created a machine learning algorithm (a system that can learn from data) to spot bullying among the 250 million daily posts on Twitter. It found 15,000 bullying-related tweets a day and was able to identify the bullies, their victims, accusers, and defenders. This type of big data initiative could be used to identify children in need of help and intervention. Another project involving the mobile phone data of 50,000 people showed that it was possible to be able to predict the future locations of individuals with 93 percent accuracy — a showcase of how big data brings greater understanding of human behavior. (Source: Coplin, D., Information deluge can change the world, *Financial Times* (June 26, 2013). Available at: http://www.ft.com/intl/cms/s/0/fbec3082-d29e-11e2-aac2-00144feab7de.html#axzz3wfkBNMoP.)

CONTINUOUS MONITORING AS A BIG DATA PROJECT

At Blue Cross Blue Shield of North Carolina, Director of Audit and Risk Management Richard Supinski says the continuous monitoring process he started two years ago is "absolutely" a big data project with impressive results. Rather than looking at samples of processed claims drawn monthly and comparing them, Supinksi and his team of three put together a report within a week of the month's close that shows how many duplicate claim submissions the insurer received, which health-care providers were among the top offenders, and which show greatest increase in such mistakes compared to past months. As a result, duplicates as a percentage of all transactions have declined from about 14 percent to around 9 percent in the last two years. One of the most appealing options to Supinski is Infogix, which could stream data directly into easily digested dashboards on a daily, rather than monthly, basis. (Source: Stuart, A., Big data: Starting small, scaling up, *Compliance Week* (July 31, 2012). Available at: https://www.complianceweek.com/news/news-article/big-data-starting-small-scaling-up#.Vo_m4Pk4GM8.)

audit considered how data analytics can be used for validating and monitoring efforts in specific functional areas, such as internal controls (over financial reporting) as well as Sarbanes–Oxley (SOX) Section 404 compliance? Has the company explored how other functional areas (such as finance, supply chain management, and human resources) can utilize big data analytics to inform decision-making? In this connection, internal audit staffing models should evaluate whether they have the competencies and skill sets to undertake big data analytics efforts in a credible and scalable fashion. Peters notes, in his blog: "Internal auditors who work with big data will require knowledge of data analytics, statistical modeling, and IT security in order to provide assurance in this area."[23]

Data mining. It is important to remember that deeper data mining itself is not without consequences; it feeds into and further elevates the complexity and volume of big data and analytics. So, from a technology standpoint, the organization must review what steps are being undertaken to identify, capture, analyze, and use the most relevant, reliable, and timely data. How is data quality being assured so that the information integrity referred to earlier in this article is achieved? How is data governance managed to ensure the data can be used efficiently? With the recent spate of cybersecurity breaches, data security has become a continuing concern as well. Again, referring back to Milley's comment quoted earlier, organizations should strive to cultivate an analytics-focused mindset in the company's finance, risk, and compliance functions to ensure that data is collected, consumed, analyzed, as well as utilized in an optimal manner.[24] Internal audit functions need to consciously become the champion of such big data analytics imperatives within their organizations, while simultaneously promoting CM initiatives.

Continuous monitoring and data governance

As noted previously, for information to have integrity, we need the raw data to be of the highest quality and relevance. To ensure that we are dealing with quality data at every step of the data combining, aggregation, and/or analysis processes, we need the filters made available by CM. In other words, the discipline required for proper data governance is furnished by careful CM. CM also sits atop big data in a different way. It ensures that the results of big data analysis and insights are being appropriately leveraged in a timely fashion.

Earlier, we saw the dangers from a compromise of information integrity. By ensuring high levels of information integrity, CM makes big data not only more meaningful, but more powerful in impact. It is a prerequisite for dealing effectively (and efficiently) with big data projects. CM can also help evaluate whether the desired return on investment is achieved by undertaking big data initiatives.

Unless organizations have a robust CM initiative underway and take steps to yoke it to the big data collection, analysis, and deployment efforts, they will be ineffective in truly leveraging the potential offered by big data. In other words, marrying big data and CM is a necessity; it also represents an incredible synergy whose time has come. ■

NOTES

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5 Information integrity refers to the accuracy, consistency, and reliability of information across content, process, system, people, and environment. It is of first-order importance, as the value and usefulness of information are first and foremost a function of its integrity. When information integrity is compromised we are quickly led to the "garbage in, garbage out" (GIGO) syndrome. Even the best chef cannot make a good omelet out of bad eggs!

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16 *Op. cit.* note 12.

17 A Gartner Magic Quadrant is a culmination of research in a specific market, providing Gartner's assessment of vendors' relative positions with respect to their (analyzed) rivals within a market space. Gartner uses a graphical methodology with "completeness of vision" on the X-axis and "ability to execute" on the Y-axis and categorizes vendors as challengers (Y-high, X-low), leaders (X-high, Y-high), niche players (X-low, Y-low), and visionaries (X-high, Y-low). For additional information on the Gartner research methodology, see: http://www.gartner.com/technology/research/methodologies/research_mq.jsp.

18 *Op. cit.* note 12.

19 Babbie, E., *The Practice of Social Research*. 9th ed., (Belmont, C.A.: Wadsworth Thomson, 2001).

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22 "Enterprise Risk Management — Integrated Framework," COSO (Sept 2004). Available at: http://www.coso.org/documents/coso_erm_executivesummary.pdf.

23 *Op. cit.* note 14.

24 *Op. cit.* note 8.