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IoT- and Big Data-Driven Data Analysis Services for Third Parties, Strategic Implications and Business Opportunities

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ABSTRACT

This article describes ubiquitous sensing devices, enabled by wireless sensor network (WSN) technologies, now cut across every area of modern day living, affecting individuals and businesses and offering the ability to obtain and measure environmental indicators. Proliferation of these devices in a communicating-actuating network creates an Internet of Things (IoT). The IoT provides the tools to establish a major, global data-driven ecosystem that also enables Big Data techniques to be used. New business models may focus on the provision of services, i.e., the Internet of Services (IoS). These models assume the presence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated. Different business models may support opportunities to create revenue and value for various types of customers. This article contributes to the literature by considering, a first, knowledge-based management practices, business models, strategic implications and business opportunities for third-party data analysis services.

KEYWORDS

Big Data, Business Models, Data Analysis Services, Internet of Things, Knowledge-Based Management Practices, Opportunities, Small and Medium Enterprises, Small Business, Strategic Implications

1. INTRODUCTION

The much-discussed Internet of Things (IoT) provides a set of tools enabling a major, global data-driven ecosystem that encourages the development of devices (or Things) to collect data and produce unprecedented amounts of information about the parameters and items in the world around us. These devices encompass the gamut from pedometers to seismographs. When put in the hands of people and organizations, this information can make every area of life, including business, more data-driven.

Things are not really a new concept. People have been using sensors to collect scientific data for centuries. What is different now is the interconnection of all these devices, producing ever more granular data sets. Further, the data is becoming more and more accessible, potentially to everyone. To put that data to work, people need to make sense of it. When massive amounts of data become accessible and understandable, the implications are enormous for civic life, personal health and business.

Until now, much attention and effort have gone in the development of business models for the provision of services in this data-driven ecosystem in the context of the IoT, sometimes referred to as

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the Internet of Services (IoS). These business models assume the existence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated by any party. However, not every business model may support opportunities that generate revenue or value, nor may they be suitable for different types of customers. Therefore, other business models should also be considered (Lokshina et al., 2017a).

A discussion of the infrastructure is outside the scope of this paper. The paper assumes that a significant time will be needed for deployment. Regulatory clarity and appropriate permissions in addition to possible privacy and national security issues must be addressed.

This paper makes several contributions to the literature. First, the paper considers knowledge-based management practices and business models, strategic implications and business opportunities for third-party data analysis services. It complements other research about the positive effect of knowledge management on companies' innovative performance. Second, the paper discusses access to information generated by third parties in a new context of analysis, i.e., as a prerequisite to data analysis services and in relation to Big Data techniques and potential opportunities. Third, the paper evaluates strategic implications for American and European small and medium enterprises (SMEs) that use IoT in their data-driven ecosystems. It complements prior research about the positive effects of information and communications technology (ICT) tools and competencies on business performance.

Finally, this paper also has some social implications since governments are interested in using the latest technologies to promote the best social climate for their citizens. The paper assumes that an obvious consequence of using the latest technologies will be a broader scope of deliberative democracy. However, the legal framework of the latest technologies is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security create management and governance problems. These issues have not been solved completely by the current service architectures. The latest technologies can also become subject to power politics subject to the risks of cyberwar, cyber terrorism and cybercriminality.

The current research has several limitations. First, the study of a single context of analysis could reduce and limit the generalizability of results. There is, therefore, a need for additional research to determine whether knowledge management and ICT capabilities play the same role in other high-tech contexts. Second, the research is limited by the choice of companies involved. Further research could document additional quantitative and qualitative examples where SMEs have developed strategic opportunities by providing technical and consulting services to other businesses.

This paper is comprised of six sections and is organized as follows. Section two reviews the generation of data and value in global data-driven ecosystems and evaluates the effects of IoT and Big Data on knowledge-based management practices. Section three considers issues related to building business models in global data-driven ecosystems and examines new business models operated by American and European SMEs. It evaluates the strategic implications and business opportunities in IoT- and data-driven data analysis services for third parties. Section four contains conclusions, followed by acknowledgement and references.

2. ASSESSMENT OF IOT AND BIG DATA EFFECTS ON KNOWLEDGE-BASED MANAGEMENT PRACTICES IN DATA-DRIVEN ECOSYSTEMS

2.1. Views on the Generation of Data and Value in the Context of IoT

The example of a commercial airliner provides a scenario for understanding how IoT data is collected and information is generated (Lokshina et al., 2017a). For the purposes of controlling the airplane and verifying the correct operation of its components, a multitude of parameters are measured. The values of these parameters are recorded and, in real-time, analyzed for artifacts. Additional parameters are recorded for offline analysis, for maintenance purposes or for use in case of an incident. Additional data is collected outside the plane, such as the flight path (i.e., by air traffic control), weather (i.e., by meteorological services), and information from nearby planes. Further information may be available from sources that are not professionally or institutionally related, such as video and photographic material generated by aviation enthusiasts. The data corresponding to operation and the components that are specifically recorded in the plane are owned by the specific parties according to agreements among the manufacturer, supplier, owner, and user in compliance with the rules established by the aeronautics authorities. The additional data collected outside the plane is likely under different ownership subject to the control of professional or institutional-related organizations. However, access and ownership to the data from other sources, such as aviation enthusiasts, may be subject to other rules.

The concept of the IoT is not new. It is, however, changing the game for data access. When people can visualize and interact with this data and information, even blend it with their organization's other data assets and knowledge, entirely new insights can be reached. From jet engines bolted on airliners to pacemakers embedded in hearts, the increasingly obvious interconnection of devices means that people can see our world in completely new ways. Ultimately, this empowers innovation that is not only data-driven but could also be human-centric (Lokshina et al., 2017a).

The IoT is a system that relies on autonomous communication of groups of physical objects. The IoT, in context of the digital revolution, is an emerging global communications/Internet-based information architecture facilitating the exchange of knowledge, services and goods. It is expected that the main domains of the IoT will be transportation and logistics, healthcare, the smart environment (home, office and plant, all integrated into the environment), and personal and social areas (Durkin & Lokshina, 2015; Lokshina & Lanting, 2018a; Evans, 2012).

The realms of ubiquitous society (i.e., the multiverse) are considered in Table 1. Leaders, managers and planners must understand the fundamental nature of three elements of reality: time, space and matter. The new service designs, architectures and business models are needed in the multiverses as well as in the universe. Managers must work to manage these critical eight realms of the ubiquitous society (Evans, 2012).

The applications of the IoT are numerous, focusing on smart things and smart systems. These applications include smart homes, smart cities, smart industrial automation and smart services. IoT systems provide better productivity, efficiency and better quality to numerous service providers and industries (Durkin & Lokshina, 2015; Lokshina et al., 2017b).

The IoT is based on social, cultural and economic trust and the associated trust management skills (i.e., developed security services and antifragility operations). Critical issues of the IoT security field are trusted platforms, low-complexity, encryption, access control, secure data, provenance, data confidentiality, authentication, identity management, and privacy-respecting security technologies (Lokshina et al., 2017a).

Security of the IoT requires data confidentiality, privacy and trust. These security issues are managed by distributed intelligence, distributed systems, smart computing and communication identification systems (Lokshina et al., 2017b).

Finally, key systems of global economy are markets, networks and crowds. The IoT can be found among these key systems of global economy (Evans, 2012). There most likely exists significant potential for smartness among these key systems. Data, information and knowledge about communication and interaction of these systems are vital issues for the future of management (Lokshina et al., 2017b).

The Internet of Intelligent Things (IoIT), defined by experts as smart Machine-to-Machine communication, provides considerable potential for crowdsourcing of markets and networks. The IoIT provides also much potential for smart networking (between markets and networks and between various networks). This paper assumes that one obvious consequence of IoIT will be a broader scope of deliberate democracy. Additionally, the legal framework of the IoT/IoIT is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security create management and governance problems. These issues have not been solved completely by the current service architectures. The latest technologies

Table 1. Realms in the ubiquitous society and in the multiverse

Variables			Realm
1. Time	Space	Matter	Reality
2. Time	Space	No-matter	Augmented reality
3. Time	No-space	Matter	Physical Reality
4. Time	No-space	No-matter	Mirrored Reality
5. No-time	Space	Matter	Warped Reality
6. No-time	Space	No-matter	Alternative Reality
7. No-time	No-space	Matter	Augmented Virtuality
8. No-time	No-space	No-matter	Virtuality

can also become subject to power politics subject to the risks of cyberwar, cyber terrorism and cybercriminality (Evans, 2012).

Finally, the IoT will be central for the collection of Big Data, captured from artificial intelligence (AI) applications, the environment, human beings, and robots.

2.2. Views on the Generation of Data and Value in the Context of Big Data

Big Data is defined as high-volume (i.e., terabytes to exabytes of existing data to process), high-velocity (i.e., streaming data, milliseconds to seconds to respond) and/or high-variety (i.e., structured data, semi-structured data, unstructured data, text, multimedia) information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation (Gartner, 2012). It does not arise out of a vacuum but, rather, is recorded from some data-generating source. For example, consider people's ability to sense and observe the world around them. These experiences can range from the heart rate of an elderly citizen and the presence of toxins in the air people breathe to the planned square kilometer array telescope (which will produce up to 1 million terabytes of raw data per day). Similarly, scientific experiments and simulations can easily produce petabytes of data today (Gartner, 2012; Mayer-Schonberger & Cukier, 2013).

Much of this data, when considered in isolation, appears to be of no interest and can be filtered and compressed by orders of magnitude. One challenge is to define these filters in such a way that they do not discard useful information. Research is needed in the science of data reduction so raw data can be intelligently processed to a size that its users can handle while not missing "the needles in the haystacks". Furthermore, online analysis techniques are required to process such streaming data on the fly since it is too expensive to store first and reduce afterward.

The second big challenge is to automatically generate the right metadata to describe what data is recorded as well as how it is recorded and measured. Another important issue here is data provenance (i.e., the source of data). Recording information about the data at its birth is not useful unless this information can be interpreted and carried along through the data analysis process.

Generation of data and value in the context of Big Data involves multiple distinct phases, each of which introduces challenges (Lokshina et al., 2017a; Lokshina & Lanting, 2018b). While the promise of Big Data is real, there is currently a big gap between its potential and its realization. Heterogeneity, scale, timeliness, complexity, and privacy problems with Big Data impede progress at all phases of the process that can create value from data. Data analysis, organization, retrieval, and modeling are other fundamental challenges.

The many novel challenges and opportunities associated with Big Data necessitate rethinking many aspects of these data management platforms while retaining other desirable aspects. Appropriate investment in Big Data will lead to a new wave of fundamental technological advances that will be embodied in the next generations of Big Data management and analysis platforms, products, and systems. These research problems are not only timely but have the potential to create significant value in the American economy for years to come. However, these problems are also difficult, requiring rethinking data analysis systems in fundamental ways. A major investment in Big Data, properly directed, can result in major scientific advances as well as the foundation for the next generation of advances in science, medicine, and business (Lokshina et al., 2017a; Lokshina & Lanting, 2018b).

2.3. Views on IoT and Big Data in the Context of Knowledge Management

The Data-Information-Knowledge-Wisdom (DIKW) model is an often-used method, with roots in knowledge management, to explain the ways to move from data to information, knowledge and wisdom with a component of actions and decisions. Simply put, it is a model to look at various ways of extracting insights and value from all sorts of data, big, small, smart, fast and slow. It is often depicted as a hierarchical model in the shape of a pyramid and known as the data-information-knowledge-wisdom hierarchy, among others.

The traditional DIKW model states the following (Ackoff, 1989; Davenport & Prusak, 1998):

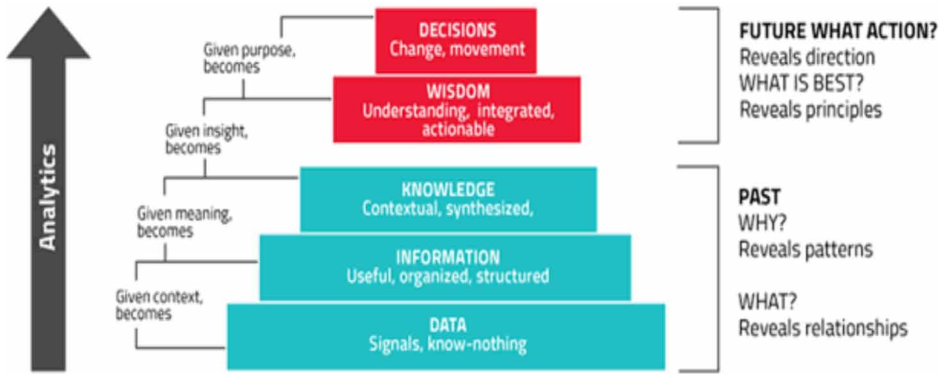
- Data is the result of a relatively accurate observation, and it may or may not be inspired by a problem to be solved. Data comprises objective facts, signs and numbers, and it does not need relationships with other elements to exist. However, if each data is taken individually, it does not communicate anything and does not contain any meaning.
- Information, deduced from the data, includes all data, giving it meaning and gaining added value compared to the data. Information is the choice to put some data in a context, fixing some as premises, and making a series of inferences, then drawing conclusions. These conclusions are called information.
- Knowledge is the combination of data and information, to which is added the opinion of expert persons, competence and experience, to build an asset that can be used to aid decision-making. Knowledge cannot be lost in the same way in which one can lose data and information. Knowledge is always individual and cannot be transmitted because it is generated from the individual's previous experience and knowledge; what one can transmit is only the narration of the experience.
- Wisdom is immaterial, intangible. Wisdom is the judgement, the ability to add value and is unique and personal. Wisdom is something that goes beyond the concepts of information and knowledge and embraces both, assimilating and transforming these into individual experience. Wisdom accompanies knowledge and allows to make the best choices.

Additionally, the DIKW model is viewed as an attempt to categorize and simplify the key concepts involved in cognitive processes, especially when there is a need to manage large amounts of data. Big Data does not necessarily mean more information. The belief, rather widespread, that more data equals (Silver, 2012). Among Big Data, there are obviously interpretable data and data that cannot be interpreted, sometimes because of lacking metadata or place/time references (Lokshina et al., 2017b). Among the interpretable data, there are relevant data, i.e., the signal, and irrelevant data, i.e. noise, for our aims (Lokshina & Thomas, 2013). Relevance is a characteristic of data, not only subjective (i.e., what for one is the signal could be noise to another), but also contextual (i.e., what may be relevant depends on the context to be analyzed).

Therefore, a criterion to decide whether it makes sense to think of an analysis based on Big Data would be to think about the interpretability, relevance and whether the process could extract really new information from the mass of data. However, the essence still stays the same: looking at what to do with data lakes and turning data through Big Data analytics into decisions and actions, as shown in Figure 1.

The DIKW model, as all ways of considering things in a structured way, has been discussed and analyzed from various angles with some suggesting omitting wisdom and others debating the exact

Figure 1. Actions and decisions in the DIKW model



definitions and the relationships between them. Instead, what should be considered is the aspect of decision and action. Without decisions and actions there is little sense in gathering, capturing, understanding, leveraging, storing and even discussing data, information and knowledge. Decisions and actions, in this regard, relates specifically to business and customer outcomes, i.e., creating value in an informed manner (Lokshina et al., 2017b; Lokshina & Lanting, 2018a). However, in the bigger picture, the decisions and actions can simply be learning, evaluating, computing or anything else.

2.4. Assessment of IoT and Big Data Effects on Knowledge-Based Management Practices

Organizations use information and knowledge both for improving the quality of decisions and for legitimizing decisions including those decisions made by poor knowledge (Blair, 2002). There is a difference in views on knowledge in decision-making. Knowledge is seen either as a static asset owned by an organization or as a social construction emerging from interaction. The static view on knowledge implies the manageability of knowledge, whereas social view emphasizes that knowledge cannot be managed, only enabled (Marr, 2015). The social view considers the role of information technology (IT) as useful but not critical. Reflecting the differences in the role of IT, including the IoT and Big Data, the two views on knowledge behavior, rational and symbolic, have also contributed two different knowledge management strategies.

Adopting the conventional view of IoT and Big Data, this paper suggests that the true value of IoT and Big Data in decision-making lies on their ability to simultaneously promote bounded rational behavior, i.e., to provide the best possible information and limit symbolic use of information. More generally, this paper assumes that IoT and Big Data predict the new start of knowledge management, as well as revisions of the DIKW model.

For instance, Jennex & Bartczak (2013) state that society and organizations manage by planning. Resources are limited, time is limited, and planning applies thought before action. The output of planning is a plan or strategy, a statement of how something will be done. Society and organizations need to have a strategy for managing the layers and technologies, including IoT and Big Data. Jennex & Bartczak (2013) suggest the basic components of a knowledge management strategy can be generalized and used to manage decisions and actions in the revised DIKW model, including the following:

- Identification of users of the knowledge pyramid layers and transformation processes.
- Identification of actionable intelligence needed to support organizational/societal decision-making.
- Identification of sources of the Big Data, data, information, and knowledge.
- Identification of Big Data, data, information, and knowledge to be captured.

- Identification of how captured Big Data, data, information, and knowledge is to be stored and represented.
- Identification of technologies, including the IoT, to be used to support capturing and processing Big Data, data, information, and knowledge.
- Generation of top management support.
- Establishment of metrics for Big Data, data, information, and knowledge use.
- Establishment of feedback and adjustment process on the effectiveness of actionable intelligence use.

Additionally, this paper highlights the following organizational dimensions as possible drivers and functions that enhance the use of Big Data at organizational level:

- Interpretation of operating environment: open system.
- Agency: network (i.e., organizations as information flows).
- Accountability: horizontal + vertical.
- Organizational copying mechanism: foresight-based resilience.
- Leadership: business intelligence.
- Information flows: intra-organizational.
- Innovation philosophy: open.
- Production logic: service-based logic (i.e., customers first).
- Change philosophy: immanent, emergent, cyclical.

Certainly, there are some organizational drivers that enhance Big Data utilization in data-driven ecosystems. As organizations operate in open system as networks, the role of information becomes a valuable commodity. Knowledge, based on information from intra-organizational information flows and incorporated to organizational life through the mechanisms of foresight and planning, is the foundation of business intelligence. This requires a new understanding on the organization's accountability function, with an emphasis on measuring and analyzing accountability both vertically (i.e., reporting the outputs and outcomes of an organization from the bottom up) and horizontally (i.e., reporting to constituents including customers, citizens and the media).

This new requirement of understanding concerns the innovation and change philosophy held by organizations (Bresciani et al., 2017; Lokshina et al., 2017a; Scuotto et al., 2017). The innovation paradigm opens because of the availability of information – tomorrow's strategies and innovations are developed together rather than in organizational silos. Big Data also strengthens the transformation from mass-production logic towards more customized and personalized-production logic. To achieve advantage in the increasing completion, more focus should be put on both the products and services that organizations deliver.

Jennex & Bartczak (2013) conclude the goal is a top-down strategy approach based on decisions and actions. However, it can be noted that the digital revolution in management process, by developing and utilizing smart solutions like utilization of IoT and Big Data, impact strategies based on decisions and actions as in business and customer outcomes, creating value in an enlightened way (Lokshina et al., 2017a; Lokshina & Lanting, 2018a).

3. ASSESSMENT OF STRATEGIC IMPLICATIONS AND BUSINESS OPPORTUNITIES IN IOT- AND BIG DATA-DRIVEN DATA ANALYSIS SERVICES FOR THIRD PARTIES

3.1. Building Business Models in Data-Driven Ecosystems

Sometimes it is difficult to understand where small business owners fit into the larger entrepreneurial sphere in which they operate. If, as the IoT implies, all the technology in the world will eventually be connected to the Internet for easy control and access, what will be the impact on small businesses on both a micro and a macro level?

Several important factors should be considered (Lokshina et al., 2017a):

- Progress will be gradual. Because the IoT will develop over time, small business owners should not fear that their company will immediately become obsolete. Perhaps, some small business owners have already invested in technologies including wireless Internet, mobile devices, analytical software, cloud storage or virtual servers. Whether owners realize it or not, they have already begun to adapt to changes in the world around them. That progressive outlook has permitted them to stay on pace with the development of the IoT.
- Technological advances are already available and affordable. Some of the semiconductor components that are so central to most IoT applications have shown much more functionality at lower prices than were available in the past. Newer processors, such as the ARM Cortex M, use only about one-tenth of the power that most energy-efficient 16-bit processors used only two years ago. This leap forward in technological capabilities has been most apparent in the evolution of smart watches. While the first of these products released just four years ago boasted 400-megahertz single processors and simple three-axis accelerometers, today's smart watches include 1-gigahertz dual-core processors and high-end, six axis devices that combine gyroscopes and accelerators. Meanwhile, the prices of the chip sets used in these products have declined by about 25 percent over the past two years.
- Increased integration is useful. The emergence of more integrated system-in-package and system-on-a-chip devices is helping to overcome some of the challenges by addressing power, cost, and size factors.
- Emerging standards are promising. Over the past two years, semiconductor players have worked collaboratively with industry associations, academic consortiums as well as hardware, networking, and software companies to develop formal and informal IoT standards. AT&T, Cisco, GE, IBM, and Intel have cofounded the Industrial Internet Consortium. Their primary goal is to establish interoperability standards across industrial environments. This would enable, for example, data about fleets, machines and facilities to be accessed and shared more reliably. Other groups have been focused on standardizing the application programming interfaces (APIs) that enable basic commands and data transfer among IoT devices.
- Connectivity standards are becoming superior. The current cellular, Wi-Fi, Bluetooth and ZigBee specifications and standards are sufficient to handle most IoT applications on the market. Some applications, however, require low-power, low-data-rate connectivity across a range of more than 20 meters - an area in which cellular technologies and Wi-Fi often fall short. New technologies to address this need are emerging from sources including LoRa, 5G, Bluetooth and Weightless interest groups. The Weightless Special Interest Group (SIG), for example, is an interest group comprised of technology companies exploring the use of free wireless spectrum to establish an open communications protocol. These standardization efforts will enable those IoT applications that require broadly distributed sensors operating at lower power over a low-cost spectrum. Those applications might include temperature and moisture sensors used in agricultural settings.
- Sensor technology will increasingly drive the IoT. Devices can be programmed to sense the environment and to share that information, such as the location of items or temperature readings,

over the Internet. Small business owners who understand how, when, and where sensors can be used will benefit the most from new and existing technology.

- Small businesses can become more efficient. The IoT, together with Big Data, will enable small businesses to operate more efficiently and to use their resources more effectively. Information will be provided on energy use and associated technologies such as thermostats, air quality monitors, lighting, and building security. For companies in service industries, remotely connected devices and sensors may allow service technicians to assess and monitor issues without having to make time-consuming trips.
- Security will become more important. With more data, information and connectivity comes a need for better security. Small companies must supplement new technologies with additional security measures and preventive action.
- Data and the IoT have been backed by influential supporters. These concepts are not just some new ideas with little traction. Rather, they are serious issues with worldwide powerful and influential supporters.
- The attention of suppliers has increased. IoT developer tools and products are now available. Apple, for instance, has released HealthKit and HomeKit developer tools as part of its latest operating system upgrade. Google has acquired Nest to catalyze the development of an IoT platform and applications.
- The impact of consumers on the IoT is significant. Demand for the first generation of IoT products (e.g., fitness bands, smart watches, smart thermostats) has increased as component technologies have evolved and their costs have declined. A similar dynamic occurred with the rise of smartphone usage. Consumer demand for smartphones jumped from about 170 million devices annually just four or five years ago to more than a billion devices in 2016 (Murray, 2016). The increase in orders coincided with a steep decline in the price of critical smartphone components.
- Business opportunities will increase. Numerous industry experts predict that hundreds, if not thousands, of unique business opportunities will arise from the growth of the IoT. Specific areas include increased customer service and personalization; the ability to address real-time threats, demands, and needs; improved process optimization; and more accurate and effective forecasting.

The most popular IoT applications and devices include (Lokshina et al., 2017a):

- Smart Home. This is likely the most popular IoT application now because it is most affordable and readily available to consumers. The Amazon Echo and Google Nest are among the hundreds of products on the market that users can control by using voice commands to make their lives more connected than ever. Users of Amazon Echo, for example, can tell its voice assistant, Alexa, to perform a variety of functions such as playing music, providing weather reports and sports scores, or even ordering on Uber. However, the interconnection of typical household equipment continues to be developing only slowly towards real industry standards.
- Smart Wearables. Watches and wearables are no longer just for telling time. The Apple Watch and other smartwatches on the market have turned into smartphone holsters by enabling text messages, phone calls, and more. Devices such as Fitbit and Jawbone have helped to revolutionize the fitness world by giving people more data about their workouts. The Fitbit One, for example, tracks steps, floors climbed, calories burned and sleep quality. The device wirelessly syncs with computers and smartphones to transmit fitness data in a chart format to monitor an individual’s progress.
- Smart Cities. The IoT has the potential to transform entire cities into smart cities by solving real problems faced by citizens daily. With the proper connections and data, the IoT can solve traffic congestion issues and reduce noise, crime and pollution. Barcelona, Spain, one of the foremost smart cities in the world has initiated several IoT initiatives to enhance smart parking and the environment.

- Smart Cars. Connected cars and vehicles are increasingly equipped with Internet access and can share that access with others, just like connecting to a wireless network in a home or office. AT&T, for example, added 1.3 million cars to its network during the second quarter of 2016, bringing the total number of cars it connects to 9.5 million (Murray, 2016). Drivers don't have to subscribe or pay a monthly fee for data to participate in the AT&T program.

Unlike managers at large corporations, small business owners and entrepreneurs have more freedom to explore and experiment with new ideas. Several opportunities can be explored (Lokshina et al., 2017a):

- Medicine. Hospitals collect a massive amount of data. But what if that information was connected to a central or aggregated intelligence-management structure that allowed for deep, complex analysis? Certainly, the distribution of drugs and monitoring of blood pressure is observed regularly by hospital staff. With the IoT, this data could be channeled into activities to dramatically improve care, reduce the length of stays and lower the transmission of diseases and infection rates.
- Manufacturing. The typical manufacturing facility might be made up of hundreds of tools and processes. Many of these likely produce intelligent data that could be used to improve efficiency. At an automobile manufacturing facility, dozens of tools are connected to networks and storage devices, but often, this information is kept in discrete silos. The IoT could deliver this information to a central intelligence forum, where it could then be used to more quickly improve processes and achieve operational goals.
- Retail. Historically, retail operations have had very few functions fully connected. Point of sales systems have been connected to inventory management systems and security systems have become intertwined with video, audio and sensory technology. Overall, however, this has been for the most part only on the individual store level and has provided little opportunity for retail franchises to manage. The IoT can play a central role in delivering the world-class consumer experience demanded by customers. Customer service representatives can quickly identify their callers, review their buying history and anticipate what they might want to purchase next. The IoT can allow for innovation, an increase in sales and a loyal customer base.

Small business owners and entrepreneurs will have opportunities created by investment and supported by data. Delivering data accurately will provide the greatest prospects. Key products and services that might be considered by enterprising parties include (Lokshina et al., 2017a):

- Sensor enablement. The benefits realized from the IoT are only as good as the data that feeds it. Development of sensors for the machines, gadgets, transportation systems and people that fuel IoT will continue to grow.
- Data analytics. The need to dig deep and provide well-informed recommendations based upon real-time data will increase astronomically. At first, such services might be performed by in-house staffers or by consulting firms. Over time, however, it will need to be done by business professionals who are well-versed in the specific skills. The need is increasing for intelligent software that can perform this type of analysis for business-minded end users for decision-making.
- Infrastructure investment. Deployment of the IoT requires strong, innovative and secure network infrastructures. More bandwidth will be required to handle the higher demand, data usage and new users because of increased reliance on the IoT. With projections from Gartner showing that by 2020, the IoT will support a base of 26 billion devices (Shein, 2015), the time to act is now. The opportunities to help deliver and consult related to the network infrastructure expansion continue to grow.

The IoT is slated to change business as usual. It will provide the opportunity to create unique, practical and innovative products and services for a new generation of consumers. Getting there will require hard work and ingenuity and small business owners and entrepreneurs are suited to deliver just that.

However, to succeed, small companies and start-ups will ultimately have to make a very crucial decision concerning their business models: either emulate Apple or emulate Micron. Therefore, they need to either focus on building a somewhat vertically integrated "product" company that sells a complete service under its own brand to consumers and businesses, or focus on being an embedded background player providing services or technology for established brands (Lokshina et al., 2017a; Lokshina et al., 2017b).

3.2. Assessment of Business Models Operated by American Small Businesses and Start-Ups in IoT- and Big Data-Driven Data Analysis Services

In this section, innovative business models in American companies have been reviewed, and experiences with data analysis services related to the IoT and Big Data have been evaluated. The rapid pace of technological change has been cited most often as the single biggest challenge facing American companies (Murray, 2016). The IoT will alter industry structure and the nature of competition as it reshapes industry boundaries and creates entirely new industries. Companies will be compelled to consider what type of businesses they are (Porter & Heppelmann, 2014).

In a recent survey of Fortune 500 CEOs, 67% indicated that, regardless of product or industry, they now consider their companies to be technology companies (Murray, 2016). It is anticipated that the commercial exploitation of this technology will result in the development of new applications and the wider deployment of existing applications (Elgendy & Elragal, 2014). External factors, like technological innovation, will stimulate the development of new business models (IBM, 2008; Hirt & Willmott, 2014).

With the pace and scope of change related to the IoT, managers are baffled by their choices for business models. The traditional models, often based on strategic management theories, may no longer exclusively apply to this changing landscape. To stay competitive, companies will need to change their model holistically, adapting and innovating in every dimension (Venkatraman & Henderson, 2011).

A business model describes the rationale of how an organization creates, delivers and captures value. A review of the literature reveals that business frameworks exist to facilitate the development of new business models. The most commonly used framework, the Business Model Canvas, identifies building blocks or components including customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.

Several IoT models have been developed (Chesbrough & Rosenbloom, 2002; Fan & Zhou, 2011; IBM, 2008; Li & Xu, 2013; Sun et al., 2012). The model specifically for IoT applications developed by Dijkman et al. (2015), was derived from literature and with practitioners in the IoT domain. Their research demonstrated that the most significant building blocks for IoT business models were value proposition, customer relationships, and key partnerships. A combination of these components is most important. The value proposition addresses what is delivered to the customer. It creates value for a customer segment beyond the product or service offered and describes the value in quantitative (i.e., price or speed of service) or qualitative (i.e., brand, design, customer experience, cost/risk reduction) terms (Barbato, 2015; Bucherer & Uckelmann, 2011; Osterwalder & Pigneur, 2010). Within the value proposition building block, convenience, performance and cost reduction could be considered the most important types (Chesbrough & Rosenbloom, 2002).

The customer perspective includes the customer segments served by the company, the channels used to reach customers, and customer relationships. The model for IoT applications will most likely focus on co-creation and communities.

Key partnerships with software and app developers, launching customers, hardware partners and data analysis partners are critical to shaping the IoT business models. Quinn (2000) has observed that innovations combining software and technology are prone to be outsourced. Dijkman et al. (2015) have suggested that incorporating IoT products into the product portfolio may be a specialization that is partly acquired through outsourcing.

The IoT is changing how value is created for customers and how competition among companies and industries is defined. There are implications for business model innovation organizations of all sizes and types, in both the public and private sector. If, as the Fortune 500 survey indicated, every company is a technology company (Murray, 2016), new business models will be needed to leverage the power of the IoT.

Entrepreneurs will be needed who can create new industries and new wealth from technological innovations. The barriers to entry for smaller and more innovative competitors will be lower because of the developments in technologies. Improvements in market and customer intelligence in every sector, gained by unlocking the insights available from big data, will support entrepreneurial activity.

New business start-ups will be attracted by the possibility of strategizing more precisely while reducing the level of uncertainty for their decision-making (Chan, 2015). Smaller businesses will be able to compete more effectively with larger, more-established firms because of the enhanced information and their ability to react more quickly and efficiently to changes in the market. To prepare for these changes, managers should begin to collect more data, recruit and retain the best digital talent, retrain existing staff and plan how to restructure the organization.

Competitive advantage can be gained by scanning the environment for emerging opportunities created by the IoT. Big Data is significant in its ability to provide information and knowledge for decision-making. The historic and real-time data generated through supply chains, production processes and customer behavior provide a host of opportunities to generate wealth when properly analyzed to reveal valuable insights. The main categories of organizations that can benefit from big data analytics include manufacturing, retail, central government, healthcare, telecommunications, and banking.

Chan (2015) discussed how organizations have already begun to integrate big data and the IoT applications into their business models. For example, Smart TVs installed at shopping malls provide an opportunity for companies to evaluate the effectiveness and return on investment of digital signage and point-of-purchase displays through Cloud Audience Analytics. A video “presence detection” solution, it provides shopper analytics with profiles by gender and age, for example. In real-time, appropriate advertising will be displayed and insightful information will be collected and reported to improve advertising effectiveness.

Collaborators include the provider of the analytic software and gateway; the provider of the mobile network and Cloud facility; and the advertiser that provides the advertising message. Each of the collaborators benefits from this arrangement. The advertiser receives data concerning the viewer profile, the return on investment and the effectiveness of the advertisement. The provider of the digital signage with the camera and transmission modem receives revenue from its role as the cloud service platform. Finally, the provider of the data analytics is enriched by the imposition of service charges.

Other companies recognize their role as providers of after-sale services, remotely monitoring and diagnosing issues in the system. Companies can apply technologies such as RFID to their specific industry and collaborate with other parties in their ecosystem (Lokshina & Thomas, 2013; Chan, 2015).

Information platforms offering comprehensive public transportation information can be developed using open data released by the government together with data collected from the Internet to offer comprehensive and up-to-date information for users. A large customer base can be built for use with advertising and other add-on features. Using a digital freemium business model, the application can be offered at no cost for users with its main source of revenue from mobile advertisements. Collaborators include complementary service providers, such as food delivery and taxis, which rely on location-based technology and generate revenue through service charge.

The use of the components of value proposition, customer relationships, and key partnerships identified by Dijkman et al. (2015) will increase in importance as companies seek to develop their business models in response to the evolution of the IoT.

3.3. Assessment of Business Models Operated by European SMEs in IoT- and Big Data-Driven Data Analysis Services

Next, some experiences of European small and medium enterprises (SMEs) with data analysis services related to the IoT and Big Data have been evaluated. A critical approach (Scuotto et al., 2017) was followed, and anonymous data and information were presented so as not to interfere with the interests of the companies involved. The following scenarios are used to illustrate the issues involved in each case:

- Collection of information and privacy while safeguarding privacy of customers and third parties
- IoT data collection and data analysis
- Data collection suitable for Big Data purposes

Collection of information while safeguarding privacy of customers and third parties is a major issue especially in small organizations. It is difficult there to divide responsibilities and to avoid conflicts of interest. Questions arise such as who controls whom, who has access to which customer's information, and do customers and third parties support or endanger privacy?

- **Case A:** A small law office in Belgium. Contacts with customers and third parties go through a single e-mail address. For important written information, privacy for client and third parties is an option, not a guarantee.
- **Case B:** A medium size doctors' group in Switzerland. Contacts with customers (e.g., patients) and users are through a web-based, individualized communication system, with controlled, role-based access implemented for the group. However, customers and users tend to bypass what they perceive is a difficult system and use e-mails to others in the group, thereby undermining privacy protection. Furthermore, given the absence of effective standardization of eHealth interchange systems, the guarantee of privacy is compromised in communication among clinics and hospitals.
- **Case C:** A small real estate management agency in France. Contacts with customers and users are through a web-based, individualized communication system, with controlled, role-based access implemented for the group. However, in such an organization with a small number of employees, roles will inevitably overlap, and this risks to compromise access to financial data and information of the customers and users, which must be protected to respect their privacy interests. Collecting data and data analysis is a major challenge even for larger organizations.
- **Case D:** An elevator maintenance company in Italy. Modern elevators have sensors to gather data, but most installations do not support remote access to the observations collected. Therefore, data analysis is a low priority for this company. This does not support access to a preventative maintenance market. Data analysis is done on an ad hoc basis without the support of specialized tools.
- **Case E:** A utility meter data collection company in Italy. Energy consumption data is collected for town heating systems. Most installations do not allow remote, or even non-contact, meter reading because of perceived cost and privacy protection reasons (in comparison, the Italian electricity distribution network is more advanced in supporting both remote and contactless access). As a consequence, data analysis is a low priority for this company. This does not support access to an analytics services market.
- **Case F:** A utility meter data collection company in Belgium. All utility meter readings are collected for different distributor clients (i.e., water, electricity, and gas). Currently various methods of data collection exist including customer- and user-supplied information and ad hoc meter reading by agents. A transition is under way to implement remote and non-contact

reading of meter information. Data analysis is applied to verify all meter readings, identify a fair percentage of errors in documented information in reports as well as detect malfunctioning meters. The company also provides an analysis of consumption patterns to the distributors who relay the information to their customers and users.

Currently, few small companies have the motivation and resources to apply Big Data techniques. In many cases, they lack the competence to even evaluate the possible use of Big Data. The scenarios discussed above illustrate that a favorable environment for Big Data applications does not exist yet now.

The exception is Case F. Initially the objective of the company was to verify customer- and user-supplied meter readings to save costs for the company and its distributor clients. The use of Big Data techniques provided an analysis of consumption trends integrating historic consumption patterns with some other data such as temperature and holidays. These results could be of interest not only to the distributor clients but also to their customers and users. The company ensures privacy protection for customers and users with a web-based personalized system. However, customers accept the risk that Big Data techniques may make privacy-sensitive information more visible to the staff of both the utility meter data collection company and its distributor clients.

3.4. Assessment of Strategic Implications and Business Opportunities in IoT- and Big Data-Driven Data Analysis Services for Third Parties

Whereas business models for the IoT equipment and infrastructure have not been discussed in this paper, it must be emphasized that the provision of services based on IoT depends on the existence and access to the IoT infrastructure. Therefore, the speed with which the service market can develop may depend on the roll-out of suitable IoT infrastructure (Lokshina et al., 2017a; Lokshina & Lanting, 2018a; Scuotto et al., 2017).

It may be expected that organizations will invest in data collection with immediate commercial interest and will be hesitant to invest in data collection that does not immediately add to productivity or quality. For Big Data applications, organizations may therefore have difficulty getting access to the necessary data sets. Suitable data sets may exist within the primary interest of other organizations, therefore also subject to considerable privacy and confidentiality considerations and possibly financial obligations and restrictions.

One solution for this issue could be industry-wide access agreements across sectors for this purpose. Another solution, like one used by media services, could be the provision of access to data sets or packages of data sets via a broker or packager, possibly adding another level of anonymity. However, that, by itself, may also compromise the usefulness for Big Data purposes as well as for regulated clinical medical tests.

The expansion of the IoT and Big Data will have significant implications for small businesses. Currently, many enterprises are not able to take advantage of the IoT and Big Data. At present, only the largest of enterprises have access to the level of required resources. This means, then, that the large companies often dominated sectors of industries as they relied on their extensive resources (including financial and informational) to perform analysis and to support the required infrastructure. Larger operations, such as Coca-Cola, General Electric and Domino's Pizza, have already begun to use the resources of Big Data and the IoT to provide value to their organizations (Hayles, 2015). Tata Consultancy Services recently reported that 26 companies, 14 of them in the United States, plan to spend $1 billion or more each on IoT initiatives (Foreman, 2014; Shein, 2015).

The requirement of heavy capital investment created significant barriers to entry and prevented a level playing field for small businesses. The cost of IoT systems is expected to drop and the use of cloud services to store and analyze data will become more prevalent. These factors should reduce operating expenses and make the use of the IoT and Big Data more affordable for small businesses.

As digitalization becomes more commonplace, barriers to entry will be reduced. Because of these technologies, products and services will be commoditized, with small businesses competing with large companies for individual modules. The "plug and play" nature of digital assets will cause the value chains to disaggregate. Existing value chains will change resulting in opportunities for new business models (Kiel et al., 2016). This will permit focused, fast-moving competitors, many of whom can scale up more rapidly and at a lower cost, to enter the market (Hirt & Willmott, 2014). Entrepreneurs, using mined data to determine preferences of customers, will "cherry pick" subcategories of products and undercut prices on small volumes. This will force larger companies to do the same. Porter and Heppelmann (2014) predict that as the use of the IoT becomes more prevalent, the bargaining power of buyers and sellers will increase, and the level of competition will significantly increase.

It is expected the analytic tools required to process large volumes of data will become more accessible to small businesses, which will benefit by adopting Big Data strategy. However, new market entrants may need to rely on experts to provide technical solutions. There is a danger implicit in this arrangement since managers of small businesses may not have the expertise to supervise the experts. Additionally, by concentrating the responsibility primarily with outside consultants, there is an increased risk of conflicts of interest and potential ethical violations.

In a survey of small businesses conducted by AVG in 2014, 57% of the respondents expect the IoT to have a significant impact on their bottom line (Foreman, 2014). The opportunities for the use of IoT will be limited only by the imagination of entrepreneurs, and the key elements for successful ventures will be defined as follows: identify why a particular device should be connected, what data will be obtained, and what kinds of decisions can be made with that data.

Small businesses will have the opportunities to capitalize on the expansion of the IoT in several ways:

- Improve the efficiency of internal operations
- Create innovative products and services for consumers and other businesses
- Provide technical and consulting services to other businesses

The IoT can help small businesses improve the efficiency of their internal operations. It can provide control, optimization, monitoring and autonomy in organizations. Besides, small businesses can use security alarms and other sensor-based systems, such as IoT thermostats and air conditioners to control air conditioning and heating costs. With better access to data and the resultant better decisions, plants could be run more efficiently and more safely (Shein, 2015).

Employees will also be affected by the IoT and Big Data (Durkin & Lokshina, 2015; Lokshina et al., 2017a; Lokshina & Lanting, 2018a). Sociometrical badges provided to employees can be used to measure behavioral response data and are mapped to important metrics including sales, revenue and retention. (Lindsay, 2015). While large clients such as Bank of America and Deloitte are using the Humanyze sensors, one can only anticipate that the concept with eventually trickle down to small businesses eager to capitalize on the return on investment. The concept of "digital Taylorism," with its focus on quotas and efficiency, has the possibility to affect knowledge workers as well (Lokshina et al., 2017a; Lokshina & Lanting, 2018a). These innovations in large companies, once refined, will become standard metrics in organizations of all sizes.

By identifying existing problems or ideas, entrepreneurs can develop solutions using IoT and Big Data to create innovative products and services. Finally, small businesses can develop business opportunities by providing technical and consulting services to other businesses. The value of IoT goes beyond the data. Services are still needed to protect the data, perform analysis, and present the findings. Small businesses can be an integral part of these activities (Lokshina et al., 2017a; Lokshina et al., 2017b).

4. CONCLUSION

To date, much attention and effort have gone in the development of business models, for the provision of services in a major, global data-driven ecosystem in the context of IoT and Big Data. These business models assumed the existence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated by any party. However, not all business models may possibly support opportunities that generate revenue or value, or are suitable for different types of customers. Other business models should also be considered.

This paper makes three important contributions to the literature. First, the paper evaluated knowledge-based management practices and business models, strategic implications and business opportunities for third-party data analysis services. It complemented prior research on the positive effect of knowledge management on companies' innovative performance. Second, the paper discussed access to information generated by third parties in a new context of analysis, i.e., as a prerequisite to data analysis services and in relation to Big Data techniques and potential opportunities. Third, the paper considered strategic implications for small businesses that use IoT in data-driven ecosystems. It complemented other research about positive effects of ICT tools and competencies on business performance.

Finally, this paper also has some social implications since governments are interested in using the latest technologies to promote the best social climate for their citizens. In fact, the use of IoT in data-driven ecosystems provides much potential for crowdsourcing of markets and networks, as well as for smart networking. The paper assumes that an obvious consequence of using the latest technologies will be a broader scope of deliberate democracy. However, the legal framework of the latest technologies is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security create management and governance problems. These issues have not been solved completely by the current service architectures. The latest technologies can also become subject to power politics subject to the risks of cyberwar, cyber terrorism and cybercriminality.

Furthermore, the current research has several limitations. First, the study of a single context of analysis could reduce and limit the generalizability of results. There is, therefore, a need for additional research to determine whether knowledge management and ICT capabilities play the same role in other high-tech contexts. Second, the research is limited by the choice of companies involved. Further research could document additional quantitative and qualitative examples where SMEs have developed strategic opportunities by providing technical and consulting services to other businesses.

In conclusion, then, the offering and size of the market for third-party data analysis may be expected to develop as follows. The rate of development of the data services market will be limited by the speed of the roll-out of the relevant IoT infrastructure. For Big Data applications, dependency includes access to additional data sets. These, in turn, will be dependent upon roll-out, privacy and confidentiality concerns as well as additional conditions and constraints. Small companies will call on affordable and less sophisticated data analysis services by third parties. Large companies will call from time to time on the services of highly specialized data analysts, who maybe better referred to as difficult problem solvers.

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