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Towards personalized medicine: the evolution of imperceptible health-care technologies

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Abstract
Purpose – When wearable and implantable devices first arose in the 1970s, they were rigid and clashed dramatically with our soft, pliable skin and organs. The past two decades have witnessed a major upheaval in these devices. Traditional electronics are six orders of magnitude stiffer than soft tissue. As a result, when rigid electronics are integrated with the human body, severe challenges in both mechanical and geometrical form mismatch occur. This mismatch creates an uneven contact at the interface of soft-tissue, leading to noisy and unreliable data gathering of the body’s vital signs. This paper aims to predict the role that discreet, seamless medical devices will play in personalized health care by discussing novel solutions for alleviating this interface mismatch and exploring the challenges in developing and commercializing such devices.

Design methodology/approach – Since the form factors of biology cannot be changed to match those of rigid devices, conformable devices that mimic the shape and mechanical properties of soft body tissue must be designed and fabricated. These conformable devices play the role of imperceptible medical interfaces. Such interfaces can help scientists and medical practitioners to gain further insights into the body by providing an accurate and reliable instrument that can conform closely to the target areas of interest for continuous, long-term monitoring of the human body, while improving user experience.

Findings – The authors have highlighted current attempts of mechanically adaptive devices for health care, and the authors forecast key aspects for the future of these conformable biomedical devices and the ways in which these devices will revolutionize how health care is administered or obtained.

Originality/value – The authors conclude this paper with the perspective on the challenges of implementing this technology for practical use, including device packaging, environmental life cycle, data privacy, industry partnership and collaboration.

Keywords Research, Innovation, Personal health, Nanotechnology, Biotechnology, Forecasting

Paper type General review

Introduction
Our body is an ocean of physical patterns: heartbeats, respiration, muscle movements, neural activity, and many more. These patterns contain information-coded messages that can be excavated, refined and defined. To do so, we need sophisticated interfaces to effectively access and evaluate such information – yet we are only just beginning to develop the needed tools. Traditional electronics are up to six orders of magnitude stiffer than soft tissue (Liu et al., 2017). As a result, when we want to integrate electronics with biology, there are severe challenges in mechanical and geometrical form mismatch. Stiffness mismatch creates an uneven contact at the interface of soft-tissue, leading to noisy and unreliable data gathering of the body’s vital signs. This dichotomy in mechanical properties between traditional electronics and soft tissue is the main challenge that needs to be addressed in the development of conformable medical devices.
electronics and soft biological tissue causes user discomfort, which gives rise to a host of issues such as low device lifetime and low probability of public adoption. As we cannot change the form factors of biology yet, we instead have to design and fabricate conformable devices (i.e. ones that are flexible and stretchable) that have the same shape and mechanical properties to match those of soft body tissues. These devices will help us listen to our health patterns by conforming to the body, providing higher quality biometric information, achieving accurate location specificity and enabling seamless user experiences.

To gain further insights into our body, we can use these mechanically adaptive devices to collect and convert essential patterns into beneficial forms. Specifically, these devices can enable continuous real-time monitoring at the location of interest, resulting in high quality and large-scale data collection. Combining this data with signal processing and machine learning tools will drastically improve the accuracy and timeliness with which medical professionals can diagnose deviations from regular health patterns. These devices, therefore, will enhance therapy by closing the feedback loop between accurate detection of symptoms and treatment of conditions. Thus, the vital information extracted from the body using mechanically adaptive devices can change the way we do science, improve the way we monitor and protect our health and advance our ability to help others.

Wearable and implantable devices have predominantly been rigid, as they were conceived in the early 1970s, when the first hearing aid was developed (Mills, 2011). How can we bring conformability to this field? The past two decades have seen a transformation in wearable and implantable devices brought about by research efforts in both industry and academia (Koydemir and Ozcan, 2018). Still, we are just at the beginning of an era of conformable devices that started in earnest with efforts by Bell Labs and IBM Research, where researchers experimented with polymer transistors formed on bendable sheets of plastic in the late 1990’s (Rogers, 2001; Kagan et al., 1999). These initial experiments, although targeted towards paper-like displays, turned out to have game-changing potential for the health-care system.

However, the current wearable market is still comprised mostly of hard, bulky smartwatches, wireless headphones and smart glasses that focus on fitness tracking. These fitness metrics – such as step count and heart rate – are certainly important, but future innovations should stray from these solved problems and instead foray into an unsolved space; personalized health care. Recently, efforts in academic research labs have pioneered this field. They are pushing the forefront of wearable and implantable devices toward mechanically adaptive solutions that will unravel and translate the multitude of signals coming from the human body. These advancements include sticker-like electronics for physiological sensing (Kim et al., 2011), self-powered pacemakers and biomedical sensors (Dagdeviren et al., 2014; Dai et al., 2003) and minimally invasive localized drug delivery systems for the brain (Dagdeviren et al., 2018).

In the upcoming sections, we describe two major necessities for developing and commercializing mechanically adaptive devices. These devices must:

- conform to the human body; and
- decode its variety of patterns, i.e. seamlessly extract and interpret its biological information.

Following these prerequisites, we forecast the following three key aspects for the future of mechanically adaptive biomedical devices, detailing how this technology will have an impact in various sectors:

1. changing the way we “do science”;
2. revolutionizing health care; and
3. harvesting energy for self-powered devices.
We conclude this article with our perspective on the challenges of implementation, including device packaging, environmental life cycle, data privacy, industry partnership and collaboration.

**Conforming to the human body**

The human body is soft and curvy, while traditional electronics are stiff and bulky. To overcome this severe mechanical mismatch, we fabricate materials, whether traditional or novel, to bend, stretch, and twist into arbitrary shapes. Currently, there are two main strategies to develop conformable devices:

1. creating new structures by thinning down existing, rigid materials; or
2. using newer, composite materials, which are inherently mechanically compliant, in existing structures (Rogers et al., 2010).

The first approach involves using hybrid structures that push the limits of traditional semiconducting materials. In these configurations, the hard material defines the active function, while the soft material defines the shape and mechanics. For instance, bonding hard ultrathin silicon films to soft elastomers creates artifacts that are more resistant to deformations. This method mimics how rigid aluminum can be made flexible and adaptable to a variety of surfaces by drastically reducing its thickness. Beyond traditional electronic materials, composites present another viable option. For example, organic semiconductors and elastomer-based conducting nanocomposites, albeit not as high performing as silicon, are highly conformable and increasingly functional. Together, these two strategies form the basic building blocks for developing bio-electronic devices with enhanced conformability.

**Decoding signals from the human body**

In conjunction to conformability, it is essential to further develop methods for interpreting the collected information. Application of signal processing and machine learning techniques will help us extract useful patterns from these datasets, ultimately increasing our ability to monitor our health condition. In a recent demonstration, conformable devices were used to measure heart rates from professional baseball players in the USA. The data generated used machine learning methods, and hence, revealed key insights on the athlete’s performance and vital signs during gameplay (Lee et al., 2018). In addition, researchers have demonstrated the feasibility of creating an entirely wireless, full-body sensor network (WBSN) for accurate spatio-temporal mapping of temperature and pressure (Han et al., 2018). The large amount of data generated from these sensor networks would be incomprehensible without the proper analysis techniques. With the appropriate models, however, the raw pressure data from the aforementioned WBSN’s can be translated to predict skin ulcers (Grap et al., 2017; Cox et al., 2016; Behrendt et al., 2014). Indeed, interpretive and predictive decoding techniques, when paired with conformable devices, will allow us to translate our bodily signals with an unprecedented level of precision and accuracy (Figure 1).

*Changing the way we “do science”.* Thus far, we have described the importance of both conforming and decoding as the two key pillars of electronics for health-care applications. These seamless electronic devices have the profound potential to directly alter many aspects of scientific research, ranging from access to information to the ability to ask new questions.

Biomedical research is unique, in that it leverages advancements of diverse fields such as electronics and materials science. Traditionally the problems pursued in this field have been limited by the tools made available to the medical researchers. Testing in these fields is often a cumbersome, lengthy process that is carefully constructed to protect patient safety and mitigate risks. Bringing a biomedical device or new pharmaceutical to market
can take between seven to twelve years on average and the process requires extensive resources (Reichert, 2003). By providing researchers with new tools for examining the human body, conformable devices may alter our methods of scientific inquiry by allowing us to acquire greater quantities of high-quality information, conduct human studies outside of the laboratory or hospital environments and probe environments that were previously inaccessible – such as the soft tissue of the human brain or the complex structure of the gastrointestinal tract (i.e. the “gut”). Scientists can now even prototype extremely realistic physical models of individual organs to conduct testing on, before interacting with actual patients (Murphy and Atala, 2014). Therefore, we can begin to re-contextualize these tools as helpful extensions of the human body for scientific researchers, by reducing barriers to information.

Current medical studies involving patients often require extensive, costly instrumentation that is difficult to use, reducing patient compliance (Haynes and Dantes, 1987). This significantly limits the scope of medical exploration. Unintrusive, comfortable, self-powered devices that can be worn for up to a few weeks will allow researchers to bring their studies out of the lab environment and into people’s homes (Choi et al., 2018). Continuous monitoring is extremely useful for pre-clinical studies in cases like chronic implants, understanding relationships between human behavior and health, and tracking fetal health during gestation. Researchers such as John Rogers (Kim et al., 2011), Zhong Lin Wang (Kim et al., 2011; Fan et al., 2012) and Muhammad Mustafa Hussain (Nassar et al., 2016) have fabricated devices intended for such purposes robustly and affordably. As researchers overcome existing barriers to manufacturing, these devices will become ubiquitous and scientists can broadly use them in natural contexts, rather than in artificial environments such as research laboratories. These types of devices can be easily deployed to the masses, allowing continuous collection of biometric data from millions of people through distributed data collection. Such a tremendous amount of data, used ethically, will help researchers to exponentially expand the reach of their work beyond what is currently feasible. The so-called “big data” generated by conformable devices will
conceive a disruptive new wave of predictive models for early disease detection, well-informed hypothesis testing around medical issues, and better, more personalized diagnosis of deviations in health. For example, presently, to understand individual sleep patterns, researchers must bring patients to an overnight laboratory stay (i.e. removing them from their standard environment) which can create an intrusive and unpleasant user experience (Kingshott and Douglas, 2000). Moving toward conformable devices, however, will enable us to collect data within the framework of daily routines, to truly understand human behavior such as during sleep.

The impacts of these devices is not limited to wearables; the soft mechanics of such systems will also allow us to probe locations that were previously inaccessible. One of the most promising areas that these tools can elucidate is the human brain (Canales et al., 2015; Minev et al., 2015). Cellular scale conformable electronic implants can potentially resolve complications from rigid brain probe studies that often lead to unintended secondary consequences altering auditory or gustatory perception (Cyron, 2016). Additionally, these conformable devices provide high spatial resolution and controlled stimulation of damaged brain areas in a localized fashion. Hence, in pre-clinical settings, such conformable devices can be particularly impactful in deciphering the relations between neural connections and cognition.

Another interesting application space is the integration of current advances in high-resolution imaging and molecular genetics with flexible integrated electronics. This work can help researchers understand various underlying neural networks and their impact on the physiology and behavior of individuals. A noteworthy advance in this regard was made by Park et al. (2015) wherein they demonstrated a soft, stretchable, wirelessly powered LED implanted in freely-behaving mice, configured for optogenetics experiments. Similarly, Minev et al. (2015) recently developed e-dura, a stretchable spinal cord implant that mimics living nervous tissue. The fully functional device, with stretchable active components for electrical and chemical stimulation at the point of injury, was implanted in paralyzed rats and evoked minimal immune response. Applying these conformable devices such as the stretchable LED and e-dura will significantly aid the way neuroscientists relate cognition to neuronal activity and in the development of novel tools for understanding disease.

As another instantiation of how conformable decoders are changing the methods of scientific inquiry, Dagdeviren et al. (2018) and Ramadi et al. (2018) developed a fully rollable and ingestible piezoelectric sensor that can be swallowed. Upon ingestion, the sensor unfolds along the stomach lining and measures the rhythmic contractions of the membrane. This can enlighten us with information about our bodily functions based on data collected in one of our most important, yet barely understood, organ systems: the digestive tract. Taking the research further, in clinical settings, such sensors can help gastroenterologists diagnose disorders of the gut.

Conformable devices have even begun to impact our food. John Rogers collaborated with Michael McAlpine, David Kaplan and Fiorenzo Omenetto to develop edible silk-based sensors to detect food quality and environmental information using fully digestible materials (Tao et al., 2012). Bonacchini et al. (2018) further developed ingestible electronics that can not only monitor food, but also aid in therapy and diagnosis inside the digestive system. Real-time probing of the complex processes of the digestive systems has been difficult, but ingestible devices can allow us to test elaborate hypotheses in their intended environments. Devices and concepts such as these equip the research community with invaluable tools that will empower them to investigate more challenging basic science questions.

If such bioelectronic wearable and implantable devices become more accessible and enable new modes of studying both human behavior and physiology inside and outside of the lab environment, researchers can collectively approach larger, more complex scientific inquiries. By probing complex environments, researchers can develop a comprehensive
understanding of the human body. Beyond that, the ubiquity of these devices will allow individuals to have ownership of their personal information. Accordingly, society can collectively approach medical questions from a systemic level. As expanded upon in the following sections, we can therefore explore continuous monitoring of health, leading to personalized medicine.

**Revolutionizing health care.** Under our current health-care system, people must go to hospitals and wait in long lines to get health checkups done. The current health-care system is analogous to the pre-cellphone era in which people waited in long lines outside public telephone booths to make calls. Today, people simply take out their personal phones to text or call whenever they desire. Conformable on-body (i.e. wearable) and in-body (i.e. implantable) health-care devices will allow us to advance to the “cellphone era” of health care so people will have immediate and real-time access to their health-care information, e.g. vital signs and nutritional levels.

We envision that conformable device technology will impact health care in three key ways:

1. By using conformable technologies, electronic devices will be placed everywhere in and on the human body. For example, neural lace (Strickland, 2017), a thin injectable mesh (Liu et al., 2015), can be implanted in the brain to monitor brain health. Neural lace can also electrically stimulate the brain to control symptoms of Parkinson’s disease (Statt, 2017). As discussed previously, the gut, often referred to as the “second brain” (Gershon, 1999), will no longer be an uncharted territory as ingestible devices will track gut health using biocompatible technologies. Additionally, heart problems will no longer be intractable due to self-powered implantable sensors that can control abnormal heart rhythms (Dagdeviren et al., 2014; Ma et al., 2016). Thus, using comfortable devices, we can get real-time, complete and personalized information about our bodies.

2. Using wearable and implantable devices, doctors will have access to a complete set of health measures to continuously monitor people’s health over time. As of now, human health is reduced to a few numbers, such as weight, body mass index (BMI) and blood pressure, but health care needs to focus on people’s holistic physical, mental, and emotional well-being. Conformable devices will allow us to monitor user’s electrophysiological signals to decipher their emotional health (Picard et al., 2001). Devices like Empatica Embrace and E4 can already measure user’s emotional states through their heart rate and electrodermal activity (EDA) (Li and Chen, 2006), but Empatica’s devices are neither flexible nor self-powered and therefore, not convenient for everyday use. By evaluating user health-care data based on an individual’s overall physical, cognitive, and emotional health, doctors will have a comprehensive picture of an individual’s health.

3. Conformable sensors will give us access to a wide range of health measurements in real-time so we can evaluate the immediate impacts of our decisions, such as by using real-time glucose sensors (Koh et al., 2016) to determine which foods cause a spike in our glucose levels. As a result, we will be able to adjust our lifestyles accordingly. In our everyday lives, it is difficult to evaluate the effects of actions on our health since we do not have access to real-time and continuous information regarding our bodies. Currently, people observe the long-term accumulated effects of their activities, such as lung cancer due to smoking, and by this point, the effects are impossible to reverse. With conformable sensors, people can observe the real-time impact of unhealthy activities on their body to proactively address issues. Real-time health-care information will also enable healthy habit formation due to the rapid positive feedback loop. Hence, real-time and personalized information will give individuals access to information so they can rationally make the decision to improve their behaviors and optimize their health.
As conformable devices usher us into the “cellphone era of health care”, people will gain access to their personalized and holistic health-care information. Doctors will be able to continuously and remotely monitor their patients to make better decisions about people’s health. Continuous access to health information will also encourage people to improve their habits, promoting preventive rather than reactive health care. Compared to our current curative health-care model, preventive health care is a more sustainable health-care model for our resource-constrained society. Therefore, conformable devices will empower individuals, health-care professionals and society as a whole to better manage human health.

Harvesting energy for self-powered systems. Technological advances have allowed humans to collect and transfer health-based information across the globe in seconds, harness energy from beating hearts and track and visualize data. Yet, wearable and implantable electronics devices still rely on outdated, traditional power sources and batteries. Batteries are often the heaviest and bulkiest components in medical devices, and their rigidity often clashes with the curvilinear nature of our body. In addition, common batteries are made from lithium polymers, containing substances that are highly toxic to human health and pollute the environment upon fabrication and disposal.

The usable duration of wearable devices is truncated by the lifetime of the battery: we use them for a specific activity and then we need to take them off and recharge the battery. For implantable devices, the case is even more severe: patients that use implanted pacemakers to regulate arrhythmias need to undergo surgery every five to seven years to replace the batteries. If we are to build devices that conform to the human body and decode our body’s signals, we also need to find ways to continuously supply energy sustainably.

A promising approach is to use energy from within: the human body is full of opportunities to harvest energy for self-powered devices and autonomous electronics (Wang, 2008; Dagdeviren et al., 2017; Dagdeviren et al., 2016). Our body continually produces kinetic energy. From footsteps, joint movements, muscle stretching, blood flow, to the contraction of the heart, lungs and diaphragm, these internal and external mechanical energies can be harvested through nanogenerator-based conformable devices. For example, at the time our heel strikes the ground when walking, we generate around 67 Watts of power (Starner, 1996). Harvesting even 1-5 per cent of that power would be enough to run many body-worn devices, such as mobile phones (Qi et al., 2010). There are two main categories of nanogenerators: piezoelectric and triboelectric. Piezoelectric nanogenerators (PENG) transform mechanical to electrical energy and vice versa via the piezoelectric effect, converting stress or strain on a material to electric charges and potential. On the other hand, triboelectric nanogenerators (TENG) produce electricity from mechanical energy through a combination of electrostatic induction and contact electrification due to friction between different materials. Despite many hurdles in research, the future of nanogenerators is still promising. It is currently one of the fast-growing fields in novel energy harvesters with an exponential growth of research outputs over the years (Li et al., 2017). Flexible PENG devices that can intimately conform to the surface of the heart (Dagdeviren et al., 2014) or the gastrointestinal tract (Dagdeviren et al., 2017) and harvest energy from their contractions, for example, could be used to power body implants such as a cardiac pacemaker (Dagdeviren, 2016). Coating a TENG layer on threads and embedding the TENG threads into a fabric or a shoe could also independently power wearable electronics, through the kinetic energy harvesting from body movements, such as walking and running (Wang et al., 2016; Zhu et al., 2013).

Several efforts have also been conducted to harvest biochemical energy from the glucose of internal body biofluid (Hansen et al., 2010) and sweat lactate secreted during human perspiration, both using biofuel cells (Jia et al., 2013), as well as bacteria in saliva via microbial fuel cells (Mink et al., 2014). A working prototype of fully functional self-powered
ingestible devices has been recently demonstrated (Nadeau et al., 2017). These devices use a biocompatible galvanic cell that can power an ultra-low-power sensing, drug-delivery, and wireless transmission electronic from stomach acid in a capsule form-factor. Furthermore, there is a constant temperature gradient on the skin interface between the human body and the ambient air, which can be harvested by wearable thermoelectric generators (Leonov and Vullers, 2009). The aforementioned conformable energy-harvesting devices can be tailored to various wearable and implantable electronics based on their specific application, location and power requirement. Conformable energy harvesters will help us take a step towards a self-sustainable ecosystem of on skin and implantable electronics for the human body.

Perspectives

Research on conformable devices has come a long way since their inception in the 1990’s. Market analysis indicates that the market size for printed, flexible, and organic electronics will grow by 2.5 times in the next 10 years (Das and Harrop, 2013). Currently, stretchable electronics make up a small segment of this field, however, as they emerge from R&D, they have an immense growth potential. Additionally, yearly patent registration data corresponding to printed electronics was fitted to a growth curve (Yoon et al., 2014). It was found that starting in 2013, technological developments of printed electronics have entered the maturity stage, with a remaining life of 8.5 years in this phase prior to commercialization. Although the field of conformable electronics has grown steadily for two decades, there remain challenges to be addressed, specifically regarding environmental impact, data protection and privacy, manufacturing and scale-up, and formation and fostering of collaborations.

Environment

As systems and processes are developed to fabricate devices that aid in understanding our own internal well-being, it is equally important to be careful not to destroy our external environment. Researchers should optimize every step of the design process to create methodologies that are truly sustainable. In realizing this goal, we should tend to minimize harmful processes and/or materials from the development stream, and focus on abundant materials rather than those that are difficult to acquire (Kirchain et al., 2017). Another venue could be transient electronics which can dissolve at the molecular level in target medium (Dagdeviren et al., 2013; Hwang et al., 2012). By optimizing the materials used and engineering the dissolution of the devices, the environmental impact of electronics can be greatly minimized.

Data privacy

Privacy and access to data are important issues that many stakeholders face and should care about. As memory storage takes extra power, the data collected in electronic devices is typically sent wirelessly to a computer interface for analysis using a data acquisition system. The collection of massive datasets requires the critical examination of matters of privacy. A crucial component of this examination stems from an understanding of where this data is collected from and how it is used. For example, health patterns reveal deep insights about our daily activities, and we may very understandably want to keep these patterns private, sharing only at our own discretion. The implementation of these devices, therefore, requires rigorous efforts to protect the consumer. Users must be assured that their sensitive health information is only shared with their doctors and not with third parties such as insurance companies. It is key that scientists and policy makers come together to make laws and required policy that ensure data privacy while avoiding overprotection that hinders technological development (Data overprotection, 2015). By establishing data-protection
laws and policies, we could avoid data scandals such as the 2018 incident involving Facebook, Inc. (Aziza, 2018). Together with data collection and the essentials for law foundation, the field would move forward in coming years.

Industry

There are many barriers to industrialization of these new technologies. Often, device reliability and durability are not high enough in comparison to existing technologies. Sometimes, development costs are simply too high due to challenges of mass fabrication and deployment that do not significantly allow lower costs compared to research lab fabrication methods (Sevilla et al., 2014). Mass production of products such as in Shenzhen, China, however, does promise to fasten the progression of conformable electronics (Lindtner et al., 2015). By designing devices with industrial considerations in mind, researchers can facilitate the process for commercializing important technologies with lifesaving abilities and advantages for humanity (Rojas et al., 2014). For example, the first demonstration of voice recognition was in 1982 in industry; however, it was only in recent years that this technology has become mainstream in our phones, after more academic research. Many prominent researchers in the field, such as Zhong Lin Wang, acknowledge these sentiments (Lai et al., 2017), and others such as Muhammad Mustafa Hussain are exploring much cheaper device fabrication methods to expedite the industrialization process (Nassar et al., 2016) of comformable devices.

Collaboration

We should also guarantee that our society and policies are aligned with our technological advancements. Rather than reactively evaluating the interplay between the government, society, and research, researchers can play a vital proactive role in approaching these developments by connecting all of the relevant stakeholders. In the spirit of fostering conversations across many sectors, engineers and doctors should collaborate to ensure that they are approaching the problem from multiple relevant perspectives. By sharing the intellectual property and resources, establishing strong relationship between researchers in industry and academia is a key step to developing sustainable and achievable scale-up manufacturing process. Elon Musk's Neuralink is leading this effort by promising to make their IP open source and by making design considerations with massive scale-up in mind (Minev et al., 2015).

Scientists should work closely with their intended user base to truly understand their needs, and policymakers have to converse with academics and scientists to respond to the immense potential disruptions. This collaborative environment is reflected at the MIT Media Lab and its membership consortia with dozens of companies. The Media Lab goes beyond boundaries in known disciplines by promoting an anti-disciplinary culture that combines seemingly different research areas. With the financial support of the member companies, researchers at the lab dive into unanswered questions that can fundamentally change the way people live, communicate and engage with the world. The established financial and technological nature of the industry perfectly complements the scarcity of resources academic research faces. As the field evolves, we encourage consideration regarding the impact that bioelectronic medical technology may have on human life, and the role that each individual and organization can play in this evolution.

Conclusion

We have come a long way in terms of technologies that allow us to ‘listen’ to the human body. The stethoscope was man’s first attempt at listening to the beating heart with a physical device. Now we have electrocardiography machines that continuously monitor human heartbeats, yet we still have humans attached to a machine with cumbersome
wiring. To gain further insights into the human body, we need conformable devices that can live on or in the human body and invisibly merge with the user to help decode human health in a real-time, continuous, seamless and effortless manner. At the MIT Media Lab, we believe that the best way to predict the future is to actually make it. To realize this vision of a better future, we combine media, arts and sciences. Thus, in this paper, we have highlighted attempts towards a future of conformable devices for health care, and underscored the ways in which those conformable devices will radically change the face of human health care and personalized medicine for the better. In our next paper, we will take a comprehensive look at the impact of conformable devices on not just health care, but also on fashion, art and music, infrastructure and transportation, climate and space exploration.

References


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Scenario-planning in strategic decision-making: requirements, benefits and inhibitors

Danielle Meyerowitz, Charlene Lew and Göran Svensson

Abstract
Purpose – The purpose of this paper is to explore the corporate requirements, benefits and inhibitors of scenario planning in strategic decision-making.
Design/methodology/approach – This paper is based on a sample of 15 case studies with executives in the South African context to reveal the perceived corporate requirements, benefits and inhibitors of scenario planning.
Findings – From the cases, it is evident that industry-, organizational- and leadership-related factors enable or inhibit scenario planning. Requirements, benefits and inhibitors are revealed in strategic decision-making.
Research limitations/implications – Further research to determine supportive tools and technologies for enabling scenario planning across multiple contexts is needed.
Practical implications – This paper expands insights into the requirements, benefits and inhibitors of scenario planning in strategic decision-making.
Originality/value – Given the increasing complexity of the business environment, a framework of scenario thinking is presented and recommend greater emphasis on developing strategic decision-making competence, changed mindsets and organizational agility.

Keyword Scenario planning
Paper type Research paper

1. Introduction
As the rate of change increases, business leaders make decisions in complex and uncertain business systems (Sargut and McGrath, 2011). Within these systems, organizational survival depends on executives’ strategic agility, where contrasting capabilities, flexibility and ‘mindful responses’ enable the longevity of firms (Lewis et al., 2014). One of the key requirements to obtain such agility is strategic foresight (Hammoud and Nash, 2014). Strategic foresight entails a set of methods, processes and tools available to leaders in their decision-making (Vecchiato and Roveda, 2010; Vecchiato, 2012).

Corporate foresight is a source of future competitive advantage. According to Rohrbeck et al. (2015, p. 2), it “creates value through providing access to critical resources ahead of competition, preparing the organization for change, and permitting the organization to steer proactively towards a desired future”.

Scenario planning is one such tool that assists leaders in making sense of the unknown future. World War II already offers excellent examples of how military planners developed a series of alternatives in response to potential enemy actions. Business leaders, faced by increasingly complex contexts and armed with knowledge of game theory and increasing computer processing power, quickly adopted the use of strategic foresight through scenarios...
There is a fundamental assumption that scenario-planning is a universally useful tool to enable executives to make better decisions. Arguably, having greater insight into potential futures gives greater flexibility and more intuitive responses to whatever future occurs. To be useful, scenario-planning needs to be effective. Ramírez et al. (2017) list as requirements for effective scenarios a) multi-party perspectives; b) a willingness to invest time and resources; and c) understanding plausible rather than possible futures, thus incorporating the element of likelihood. In this study, we seek to understand what further requirements there may be for successful scenarios, what executives may seek to gain from such activities and what may prevent them from using them in an emerging market context. In other words, the research objective is to explore the corporate requirements, benefits and inhibitors of scenario-planning in strategic decision-making.

This article offers theoretical considerations of the requirements of scenario-planning, benefits, challenges and systemic requirements thereof. It then shows the research methodology and key findings from this qualitative study of the actual utilization of scenario-planning. This leads to research and managerial implications as well as conclusions to overcome the inhibitors and optimize the benefits thereof.

2. Theoretical considerations

2.1 Corporate foresight

As organizations seek to remain agile in an uncertain environment, corporate foresight tools, such as scenario-planning, may prove useful in strategic decision-making. Corporate foresight requires organizations to incorporate three practices in decision-making by perceiving the drivers of change to lessen uncertainty, prospecting what the effects of these signals of change will be on the organization and probing what action the organization should take (Højland and Rohrbeck, 2018). Corporate foresight has many benefits, such as enabling innovativeness through organizational learning (Yoon et al., 2018), greater vigilance as seen in the intensity of research and development activities (Kum, 2017), as well as organizational profitability and growth in market valuation (Rohrbeck et al., 2017 in Højland and Rohrbeck, 2018) to mention a few.

Given the growing interest in the value and requirements of corporate foresight, exploring the specific value, needs and also inhibitors of scenario-planning is significant.

2.2 Requirements of scenario-planning

Literature suggests that the success of scenario-planning is contingent upon proper information usage, an effective process, as well as the nature of the scenarios themselves.

First, effective information usage and processing in scenarios require proper understanding of socio-political and economic systemic forces, industry trends and competitor behavior (Wilson and Ralston, 2006). Furthermore, scenarios could be affected by both decision-making and leadership styles as well as internal and external environmental information (Chermack et al., 2010). Harris (2014) cautions against common mistakes in scenario processes such as focusing on the wrong variables, ignoring real threats or inadequate research. The collective wisdom of the organization, insight into the company’s risk/return preferences and clear focus on core issues only may also be required (Werner, 1990).

Second, the process needs to be appropriate. In multi-step scenario processes, each step has specific skills requirements attached to it (Chermack, 2011). Ineffectiveness in any of the steps, be it the inputs provided, exercises used to develop scenarios or implementation of actions will result in poorer scenario-planning. The time and energy requirements of generating scenarios, as well as stakeholder behavior and scenario-planning team interactions, may also impact effectiveness (Chermack and Nimon, 2013; Cairns et al., 2016).
Third, the output of the planning needs to be “believable, internally consistent, and compelling” and sufficiently differentiated to be of value in strategy (Wilburn and Wilburn, 2011, p. 172).

Overall, the literature suggests that strategic decision-makers operating in complex contexts may benefit from scenario-planning when information and process elements result in effective scenarios. The question still needs to be answered whether these benefits are realized in practice and whether scenarios are suitably developed.

2.3 Benefits of scenario-planning

The theorized benefits of scenario-planning are contained in definitions thereof, such as Chermack and Lynham (2002, p. 376), who define it as: “a process of positing several informed, plausible and imagined alternative future environments in which decisions may be played out for the purpose of changing current thinking, improving decision-making, enhancing human and organization learning and improving performance”.

Considering the Shell case, scenarios enable decision-makers to pre-evaluate their options (Duncan and Wack, 1994) and enable institutional learning and adjustment of business models (de Geus, 1988). Chermack and Swanson (2008, p. 133) argue that scenario-planning, which helps people to see things differently, is a key strategic learning tool and a better way of strategizing as it involves a wide range of organizational members and explores the “emergent nature of the contextual environment”. They hold that scenarios offer a pre-experience of the future and a means to anticipate and avoid crises.

At the same time, a useful framework developed by Van der Merwe (2008) indicates eight strategic ways in which scenario-planning may be used and associated with benefits, such as: the ability to test for robustness of decisions; developing a common perspective; engaging people; aligning policies; focusing strategic conversations; sustaining organizational development; probing assumptions about the environment; as well as advancing personal strategies in coaching. Most pertinently, the framework highlights the ability to develop scenario thinking which is “embedded in all decision-making” (p. 225). Anecdotal case evidence of companies shows both that worst case scenarios can encourage proactive responses to environmental changes and chaos, and that scenarios are more effective than predictions in anticipating future events (Wilburn and Wilburn, 2011).

McWhorter and Lynham’s (2014) review of literature indicates further benefits of scenarios, namely: changed institutional and collective learning, increased strategy development and execution capability with clarity of strategic options, organizational performance and several organizational behavior-based improvements such as cross-functional communication, disagreement management and coaching of leaders. Chermack et al. (2015) found that scenario-planning improves the perception of the creative organizational climate. Specifically, participants perceived it to develop freedom and a sense of independence, trust and emotionally safe relationships, time to explore new ideas and a spontaneous playful atmosphere.

Overall, this high-level review shows that there are many premised benefits of scenario-planning, some dealing with enabling strategic capability and others relating to organizational behavior. Research findings to support theorized benefits are sparse however. Chermack and Nimon (2013) admit that the majority of relationships between scenario-planning and theoretical outcomes still remain to be investigated.

2.4 Inhibitors in scenario-planning

Along with the various requirements and benefits of effective scenarios mentioned above, this study emphasizes the inhibitors in scenarios. To make sense out of complex
environments, humans need to build connections or “scaffolds” between tacit or new knowledge and codified knowledge, to which meaning has already been assigned (Brockmann and Anthony, 2002).

The scenario-planning tool introduces leaders to tacit knowledge outside their frame of reference and enables them to assign meaning to it. This process develops decision-makers’ anticipation abilities and “foresight attitude” (Bootz, 2010, p. 1589). In simple terms, this means that decision-makers question their own assumptions, frames of reference and knowledge sources. As knowing is a prerequisite of scenarios, it is important to note that not everything is knowable, but there are inhibitors.

Snowden’s (2003) Cynefin model differentiates among inhibitors of what is known, where cause and effect is understood and predictable, what is knowable, where sufficient data would move it into the realm of the known, what is complex, where in social systems the cause and effect can only be deciphered after the event and what is chaotic, where cause and effect are not recognizable. This seems to suggest that the value of scenarios may only be discerned after events have taken place, as most scenarios are developed for social systems.

One may argue that the ability to anticipate and think about multiple futures enables strategic agility or the ability to have “flexible, mindful responses to constantly changing environments” (Lewis et al., 2014, p. 58). Furthermore, the development of scenarios often helps explore paradoxical views and forecasts of the future and brings to the fore contrasting priorities for executives (Ringland, 2010). Thus, scenarios at individual level bring about new insights and anticipatory thinking to overcome inhibitors and, at collective-level challenge, set knowledge frames.

In scenario analysis, there are several inhibitors to overcome. Chermack et al. (2010) believe that the process requires deeper thinking regarding environmental forces in events. Wilson and Ralston (2006) name intuition, creativity to generate alternatives and curiosity about the environment and opportunities as scenario requirements. To explicate, intuitive thinking is fast and emotionally charged judgments outside conscious awareness and reasoning (Smith, 2008). This is essential as no amount of analysis will offer a decision-maker a clear answer to handle inhibitors in the complex system of business.

Nevertheless, larger organizations tend to discourage intuitive decision-making in favor of rules, procedures and more deliberate processes (Matzler et al., 2014). Interestingly, Chermack and Nimon (2013) found that decision-makers shift from rational decision-making styles to intuitive styles after scenario-planning. Creative thinking to handle inhibitors may occur through the scenario process when the imagination is stretched (Ringland, 2010). Curiosity is the desire to gain new knowledge or experiences. This desire stimulates exploration (Litman and Spielberger, 2003).

One may argue further that during scenario exploration phases, analytical thinking skills to handle inhibitors are required too, especially with the use of tools such as SWOT and internal analysis mentioned by Chermack (2011), and therefore, analytical and intuitive reasoning have to complement each other (Evans, 2014).

In sum, the review of pertinent literature reveals the theoretical value of scenario-planning in strategic decision-making. Although there are several premised strategic and behavioral benefits thereof, contextual and process-related variables determine the usefulness of scenario-planning. A key prerequisite of useful scenarios is proper thinking skills to handle inhibitors and gain the benefits of scenario-planning.

3. Methodology

The study explores the requirements, benefits and inhibitors of scenario-planning by strategic decision-makers operating in the fast-paced complex context of South Africa, the
conditions that enable or inhibit the use of scenario-planning as well as the perceived benefits thereof.

An inductive qualitative design was used. This study focused on executives in South Africa with strategic decision-making responsibilities and who are likely to practice strategic foresight in large companies and industries such as mining, services, manufacturing and energy. A selection of fifteen executives was obtained through non-probability purposive sampling (Table I). Accordingly, only executives responsible for strategic decisions for the overall organization (e.g. chief executive officers, managing directors, executive chairmen) or departments of larger organizations (e.g. group head, deputy director, senior manager strategy) were included to represent the ‘typical case’ of strategic decisions-makers in this context (Saunders and Lewis, 2012).

Face-to-face semi-structured in-depth interviews were conducted, and data saturation occurred after the 12th interview. This means that very few new themes or codes emerged after the 12th interview, suggesting diminished value to conduct further interviews (Bowen, 2008; Guest et al., 2006).

The average duration of each interview was 50 minutes with a total duration of 744 minutes. With the consent of the participants, the interviews were recorded and transcribed independently. The data were analyzed through thematic analysis (Braun and Clarke, 2006). This involved the generation of a list of codes inductively by observing similarities or patterns in the data through human review as a first phase of analysis. In the second phase of analysis, responses were re-examined inductively through ATLAS.ti software (Friese, 2011) to provide certainty that all responses were coded. Supplementary codes were created and responses were re-examined and numbered in relation to the novel codes.

More than one numerical value (corresponding to the codes) was assigned to responses that fit conceptually into more than one code. The coded responses were then examined to

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age</th>
<th>Occupational Level</th>
<th>Organization</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>64</td>
<td>Managing Director</td>
<td>Logistics company</td>
<td>Services</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>65</td>
<td>Group Head of Function</td>
<td>Mining company with global presence</td>
<td>Mining</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>52</td>
<td>CEO</td>
<td>Manufacturing division of large JSE listed group</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>36</td>
<td>Deputy Director Operations</td>
<td>Insurance company. JSE listed</td>
<td>Services</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>37</td>
<td>Head of Function</td>
<td>Financial services group operating across Africa and other emerging markets. JSE listed</td>
<td>Services</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>52</td>
<td>CEO/Managing Director</td>
<td>Industrial division of large JSE listed group</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>32</td>
<td>Head of Function (Growth)</td>
<td>Division of a large JSE listed financial services conglomerate</td>
<td>Services</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>59</td>
<td>Executive Chairman</td>
<td>Investment company. JSE listed</td>
<td>Mining &amp; Manufacturing</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>47</td>
<td>Head of Function</td>
<td>Financial services group operating across Africa and other emerging markets. JSE listed</td>
<td>Services</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>43</td>
<td>Head of Function</td>
<td>Top four bank in South Africa. JSE listed</td>
<td>Services</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>57</td>
<td>CEO/Managing Director</td>
<td>Manufacturing company part of large JSE listed group</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>57</td>
<td>Manager Commercial Area</td>
<td>South African based global oil company</td>
<td>Energy</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>43</td>
<td>CEO/Managing Director</td>
<td>South African subsidiary of a UK based group inter alia manufacturing</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>38</td>
<td>Senior Manager (Strategy)</td>
<td>South African-based international integrated chemicals and energy company operating globally</td>
<td>Energy</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>42</td>
<td>CEO/Managing Director</td>
<td>Large business services company in South Africa</td>
<td>Services</td>
</tr>
</tbody>
</table>

Note: “JSE = Johannesburg Securities Exchange"
provide certainty that the responses that were previously coded were conceptually relevant, and to exclude irrelevant responses, before response frequencies were determined. Categories were determined until clear themes emerged that were compared to themes in literature (Bowen, 2008).

In line with the principles of qualitative research, the research offers rich data on the benefits and inhibitors of scenarios in strategic decision-making in the South African context. Credibility was ensured through suitable semi-structured interview processes, the rigor that the thematic analysis process offers and triangulation of findings with the literature.

4. Empirical findings
4.1 Perceived requirements of effective scenarios

Table II provides an overview of the perceived requirements for scenario-planning processes to be effective. Effective use of scenario-planning was not industry specific in this study, with mining, manufacturing, services and energy companies making use thereof, although not in every case.

The findings suggest that adequate time, people and resources need to be allocated to planning:

- Sometimes it is not enough in a boardroom with two hours allocated. So we take out a day and we sit in jeans and tops and we say, fine guys, where are we and where do we want to be and where is everybody else? (8)

- We don’t play that out as well as we could and that again is linked to skills and competence. You want the kind of people who can think about that. (5)

The value of a dedicated space for strategic decisions also emerged:

- My best strat room is the [room name] [...] When you go in there you will see what I mean. It is very easy to speak about anything and you can grab your coffee right there. It is very interactive. The tools come up. The things come up on the board and it has a 360 vision. You are inside the [company] building and they bring in the guys from the offices as and when we need them for whatever reason so you have total access to all resources within the [room name]. It is amazing. (8)

A more pertinent finding seems to be that the culture of the organization should support a consultative approach and empower people and decision-making:

- It’s people who provide insight that you wouldn’t otherwise have encountered or you wouldn’t have known. So they provide the kind of value that you actually find useful to be able to make the right decision or an insightful decision. (5)

Another respondent put it this way:

- It is liberating if you empower other people to also give their input [...] If you open it up and you say, listen guys this is what I think is going to happen and this is what I think we should do, what do you think? You stimulate people to such an extent that my management team is starting to anticipate things and they will come to me and say, don’t you think we should look at this or this and this. (10)

The leadership group needs to embrace openness, curiosity and an anticipatory attitude to enable the use of scenario-planning in strategic decisions. For instance:

- So you are open and amenable to various inputs to your board and various inputs to your board’s strategy based on industry skills availability. So it is not one man who comes up with all the strategies. You listen to a lot of people and get more input. It is important to know
sometimes which inputs you require. It is even better to know where to find that input that you require. (8)

You have to be calm and you have to be open minded. If you do that then you can use all of your models and all of those things but you cannot make a good decision if you are not calm and you can’t make a good decision if you have already decided before you want to make it. (10)

Finally, the scenarios developed should be relevant and actionable:

So the effectiveness of scenario analysis is how do I link [...] what would I do today and that may include preparing for other scenarios and what would I do given a set of scenarios? If your scenario analysis does not give rise to those sets of actions then you are almost wasting time. (9)
4.2 Perceived benefits of scenario-planning

Table III offers the data defining several benefits of scenario-planning in strategic decision-making.

The results confirmed two types of benefits relating either to strategic capability or to aspects of organizational behavior. The executives cited several strategy-related benefits of scenario-planning as illustrated below.

**Increased business agility:**

You are going to be having a business that is more prepared for changes, more flexible in its thinking, we are going to be more prepared and able to change faster when these things do change […] It creates new opportunities if you have scenarios, you may identify new opportunities for your business - not just risks. (14)

**Identification and mitigation of potential risks:**

Are you able to say, well I acknowledge your risk but I am going to act anyway and I am going to mitigate against the risk? I think the thing about empowering people to do exactly that is essential. (4)

**Development of business case robustness:**

The scenarios […] affect your planning around your own environmental responsibilities as a manufacturing group. (8)

So scenario-planning is a very important element when it comes to the end of the work that we do […] And the result of that is either we have to go and do more work or there is nothing here to be worried about or we have identified something that is really significant that we need to raise awareness of in the business. (5)

The behavioral benefits that emerged were:

**Shifts in leadership thinking:**

So those […] scenarios then play out in that manner then that they affect your thinking […] You don’t have to change what you are doing but you can think differently about how you do it going forward. (8)

**Development of a future orientation and anticipatory mindset:**

So the only way you can address that shortfall [business models focusing on the past instead of the future] is through scenario-analysis. So you’ve got to bring into your sphere of thinking what could happen that you have not yet experienced. Otherwise all you are doing is looking backward. (9)

**Opportunity for participation in business strategy:**

I find one of the big challenges is really getting people to participate in a planning stage – and I think scenario-planning is very good for that as it forces the guys to think about it. (13)

The participants did not explicitly mention improved decision-making, organizational learning, improvement in communication or human and organizational performance as cited in literature.

4.3 Inhibitors of scenario-planning

The executives mentioned four inhibitors of scenario-planning. The results appear in Table IV and the findings are discussed next.

4.3.1 Current levels of uncertainty in the market. Although some perceive scenario-planning as an adequate response to uncertainty (Chermack, 2004), it is interesting to note that in
<table>
<thead>
<tr>
<th>Case</th>
<th>Benefits (key themes)</th>
<th>Sample quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategy-related benefits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Increases business agility</td>
<td>We are able to make decisions with speed and flexibility, we are able to make decisions hugely quickly</td>
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<tr>
<td>3</td>
<td></td>
<td>So it is not so much about, for us in any case, not so much about what the vision is and where you want to go, etc. We know what drives us; we need to provide certain financial results. The question is, ‘how is the best way of going about it?’; besides from keeping the money in the bank to create that return. And I think that to a large extent determines our strategy- what we need to do. It is not driven by a vision or there is a big goal</td>
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<td></td>
<td>[as part of strategy] looking at scenarios like how exposed we are to commodity prices. I think what is normally done first is to decide on what your vision is, but we decided to do it the other way and understand the market to develop the vision and mission around that</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>You are going to be having a business that is more prepared for changes, more flexible in its thinking; we are going to be more prepared and able to change faster when these things do change... It creates new opportunities if you have scenarios, you may identify new opportunities for your business - not just risks</td>
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<td>4</td>
<td>Mitigates risks</td>
<td>Are you able to say, well I acknowledge your risk but I am going to act anyway and I am going to mitigate against the risk? I think the thing about empowering people to do exactly that is essential</td>
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<tr>
<td>9</td>
<td></td>
<td>So you want to try and make sure that there is a high risk, you are aware of those risks, and you make sure that you mitigate around it that there is a low probability of that risk happening</td>
</tr>
<tr>
<td>1</td>
<td>Creates business case robustness</td>
<td>I often find missing in academic understanding of strategy is that it presumes to a large extent that you can control your destiny... To a large extent you don’t! Things happen and unforeseen things happen to you and it is a matter of how you deal with those, what your capability is... how do you handle things that happen and what is your ability to spot opportunities, and most importantly, probably opportunities that others don’t see or are too scared to grasp, and how do you marshal your available resources</td>
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<tr>
<td>8</td>
<td></td>
<td>The scenarios... affect your planning around your own environmental responsibilities as a manufacturing group</td>
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<tr>
<td>9</td>
<td></td>
<td>So I am a big fan of scenario analysis... [financial and statistical] models leave out everything that could happen in the future that you have not experienced yet. Which by definition means it is a shortfall. So the only way you can address that shortfall is through scenario analysis. So you’ve got to bring into your sphere of thinking what could happen that you have not yet experienced. Otherwise all you are doing is looking backward</td>
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<tr>
<td>14</td>
<td></td>
<td>We know what are the big things that are changing, we keep an eye on it and forecast it, the rate of change and we also do robustness checking, or scenarios... sensitivities if you want: if it happens slow or faster and what we will do, that is happening and it is updated annually or sometimes biannually or quarterly, depending on the rate of change</td>
</tr>
<tr>
<td><strong>Behavioral benefits</strong></td>
<td></td>
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<tr>
<td>5</td>
<td>Shifts leadership thinking</td>
<td>And by doing that [defining scenarios at executive level] there are fewer challenges at that level because we are almost gone through the process of being challenged along the way and by the time it gets to them they are more or less on board so they’ll be like okay, that makes sense</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>So the scenario planning does affect you in that way. You don’t have to change what you are doing but you can think differently about how you do it going forward</td>
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<tr>
<td>10</td>
<td></td>
<td>Sometimes out of nowhere someone will say something and I will say, I have never thought of that</td>
</tr>
<tr>
<td>8</td>
<td>Builds future orientation</td>
<td>They play out in this way, in that you understand the bigger picture, the macro picture. They give you that understanding of the macro picture and it helps you to look at situations in that manner. You don’t get frightened easily by micro pictures</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>So the only way you can address that shortfall [business models focusing on the past instead of the future] is through scenario-analysis. So you’ve got to bring into your sphere of thinking what could happen that you have not yet experienced. Otherwise all you are doing is looking backward</td>
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<td>13</td>
<td></td>
<td>I find one of the big challenges is really getting people to participate in a planning stage – and I think scenario planning is very good for that as it forces the guys to think about it</td>
</tr>
<tr>
<td>14</td>
<td>Enhances participation in business strategy</td>
<td>You are going to be having a business that is more flexible in its thinking</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>I find one of the big challenges is really getting people to participate in a planning stage – and I think scenario-planning is very good for that as it forces the guys to think about it</td>
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<td>Case</td>
<td>Inhibitors (key themes)</td>
<td>Sample quotations</td>
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<td>------</td>
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<tr>
<td>2</td>
<td>Uncertainty in the market</td>
<td>That was the harsh reality. And the political framework we were operating in. So while there was scenario-planning clearly going on, and very competent scenario-planning... it gave them options but within the realities of the framework of policy or the political situation within the context of the institution or shareholder demands. So only within that could they put their strategies into place.</td>
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<tr>
<td>4</td>
<td>So if you are making a two year assumption anything could happen in two years. You could have a major financial crisis that blows out all of your assumptions. So those types of things happen pretty much all the time so you have to be able to assess what you are doing with assumptions.</td>
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<td>6</td>
<td>I do not know what is going to happen tomorrow – what do you want me to tell you what is happening in 5 years’ time?</td>
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<td>7</td>
<td>So we are not a big long-term scenario planning type organization. We’re a lot more agile and a lot more responsive and as a result the value of long term planning I do not think is relevant to us as an organization... But that is as far as our scenario planning goes, we really, we prefer to be agile around our approach. We prefer to have data dictate to us how we manage our pipeline.</td>
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<tr>
<td>11</td>
<td>I would be fascinated to know how many people are using five year planning in a world where product life cycle is so short. There are so many disrupters that come into the market that can mess those plans up radically.</td>
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<tr>
<td>14</td>
<td>We were probably lacking in that when we developed the corporate strategy: there was a view and it was tested under various assumptions and it was giving the rate at which we would grow and what businesses we would participate in, was sort of accepted. Then I think we were caught on the back foot when the external environment changed as much as it did from past year.</td>
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<td>14</td>
<td>And I think the more scenarios you put in place, the more management feels that you don’t know what is going to happen. We also have to limit the number of ways things can change; to me two or three is the most you should have. You have to manage that uncertainty and doubt, otherwise you are opening up everything. You have to have a realistic view that it is going to be this or this.</td>
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<tr>
<td>2</td>
<td>Lack of agility of scenarios</td>
<td>So even though I reported into the board we did not get a chance to go and change the board scenarios... You didn’t pursue it regardless just because it was set as a scenario at a board level.</td>
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<tr>
<td>4</td>
<td>We prefer to be agile around our approach. We prefer to have data dictate to us how we manage our pipeline.</td>
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<tr>
<td>4</td>
<td>A lot of people look at all of the high road scenarios and say well this is the most elegant and profitable business case. The reality is one... if one variable does not play out in favor your entire structure collapses.</td>
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<td>6</td>
<td>Look I can never say, one can never say that you think scenario planning is rubbish. Because there is a place for it. There is certainly a place for it: you have to think about tomorrow and what happens if this happens and that happens. I have no doubt that there are companies in this country that do proper scenario planning. And they think this is the right thing to do. For me and it is just my own personal view, flexibility is the name of the game. So never ever ignore what these scenarios say but I do not believe you have to go into 50 different scenarios, some say 50 shades of grey, and work out what all these things are. Because the world is just an ever changing place.</td>
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<td>8</td>
<td>You could not scenario plan that. That is why I am saying... there are times when it works and times when it does not quite work, but you cannot sit back and not plan because then you are planning to fail.</td>
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<tr>
<td>15</td>
<td>These are different scenarios, where are we going to go – no, it changes too quickly and it is so much effort spent on that.</td>
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<tr>
<td>1</td>
<td>Disconnect between scenarios and outcomes</td>
<td>The ambiguity we are trying to embrace is wide... So there is a tipping point beyond which we cannot go and I have got to be very mindful as to where those barriers are, to say ‘guys you are too far over there, come back’.</td>
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<tr>
<td>2</td>
<td>Even a scenario that identifies that we are going to do this and issues came into play and then you never pursued it.</td>
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<tr>
<td>2</td>
<td>The board went ahead and pursued it at enormous expenses and it is still playing out as we sit here. Every year they just wrote down another 4 billion or 5 billion.</td>
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<td>3</td>
<td>So you play out those possibilities to see how you should react to that. It does not leave you with a lot of options though, but at least you have thought about it.</td>
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<td>3</td>
<td>I mean if I had to go and map out, do an official structured scenario plan, the branches and options and what have you are going to have will be very limited, because there are only so many things that you can do. There are only so many things that can happen.</td>
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<tr>
<td>3</td>
<td>So that is what I mean by limited; there is so much that you can do, there is not a lot of options that you can plot out in terms of what can happen and how you are going to react to it.</td>
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*(continued)*
practice, uncertainty hampers the input into the scenario-planning process and may ironically lead to the lack of utilization thereof. One respondent noted:

That was the harsh reality. And the political framework we were operating in. So while there was scenario-planning clearly going on, and very competent scenario-planning […] it gave them options but within the realities of the framework of policy or the political situation within the context of the institution or shareholder demands. So only within that could they put their strategies into place […] There were bigger ultimate forces at play. (2)

Global and local economic pressures heighten uncertainty and impacts strategic decisions too:

We were probably lacking in that when we developed the corporate strategy, there was a view and it was tested under various assumptions and it was giving the rate at which we would grow and what businesses we would participate in, was sort of accepted. Then I think we were caught on the back foot when the external environment changed as much as it did from last year, what is happening currently is the corporate strategy is being reviewed and the robustness of this under various scenarios is being tested

Having multiple scenarios may even raise levels of uncertainty. Wack (1985) recognizes that the multiple alternatives that scenarios present could be threatening to senior decision-makers who prefer to make choices using judgment based on certainty and facts. One respondent said:

And I think the more scenarios you put in place, the more management feels that you don’t know what is going to happen […] We also have to limit the number of ways things can change; to me two or three is the most you should have. You have to manage that uncertainty and doubt, otherwise you are opening up everything. You have to have a realistic view that it is going to be this or this. (14)

<table>
<thead>
<tr>
<th>Case</th>
<th>Inhibitors (key themes)</th>
<th>Sample quotations</th>
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<tbody>
<tr>
<td>4</td>
<td>Yes I think the difference or the key success is not the agility in thinking it is the agility in doing. So it is no use scenario planning if you are not going to do anything about it. So you know you have got to attack your scenarios. You only scenario plan for your advantage. So if you are not going to do anything to create advantage then why scenario plan?</td>
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<td>5</td>
<td>From a scenario planning perspective, I do not know the organization does that [implementation] much in terms of actually understanding depending on the route they go, this is the result we are ‘gonna’ get to. And you see that a lot in failed projects</td>
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<td>12</td>
<td>It is difficult to really say here is real value out of that exercise. I guess it is because you do not see that until the next generation or the next decade. You cannot see it in the financial results at the end of the year […] I guess a lot of the shifts that are being done, the ideas that have popped out of somebody’s early morning not being able to sleep and an idea comes out. That probably has more impact and more visible impact than going through a full scenario-planning exercise</td>
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<tr>
<td>14</td>
<td>We were probably lacking in that when we developed the corporate strategy, there was a view and it was tested under various assumptions and it was giving the rate at which we would grow and what businesses we would participate in, was sort of accepted. Then I think we were caught on the back foot when the external environment changed as much as it did from last year, what is happening currently is the corporate strategy is being reviewed and the robustness of this under various scenarios is being tested</td>
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<tr>
<td>3</td>
<td>Impracticality of the process</td>
<td>And everybody has got to come back to me with a comment. Sometimes there is nothing, sometimes there’s something; but you weave all of that into the scenario; into the strategies at the end of the day without calling it scenario planning or strategic discussions</td>
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<tr>
<td>15</td>
<td>Typically, the executives would lack the detail to go beyond the unpacking. They would talk conceptually around the unpacking and conceptually around the impact and conceptually around their resulting management action</td>
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<tr>
<td>9</td>
<td>So the methodology: that it is the missing link. So methodology, if you read scenario-planning books there is a lot around the theory and the concept, then very little about the how</td>
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<tr>
<td>14</td>
<td>It takes a lot of time to plan for things that may or may not have happened, and I think we have to be realistic in the number of scenarios we run…</td>
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These findings suggest that scenarios may not fully prepare leaders for the unexpected and, contrary to theory, even raise feelings of uncertainty for some.

4.3.2 Scenarios are not agile or responsive enough. Several leaders were critical about scenarios and strategic planning. The next three quotes illustrate this:

There is no such thing as five years. I don’t know what is going to happen tomorrow, what do you want me to tell you what is happening in five years’ time. (6)

We prefer to be agile around our approach. We prefer to have data dictate to us how we manage our pipeline. (4)

I would be fascinated to know how many people are using five year planning in a world where product life cycle is so short. There are so many disrupters that come into the market that can mess those plans up radically. (11)

In theory, Chermack et al. (2015) have positioned scenario-planning as an enabler of organizational agility. It would seem that in practice, cumbersome scenario processes could inhibit agility in strategic decision-making. Schoemaker’s (1995) call for continual scanning of the environment may present solutions to this challenge. Decision-makers may require continual alerts of changing trends, rather than static long-term plans.

4.3.3 Disconnect between scenario-planning and outcomes. Scenarios are often developed years before the impact of the environmental forces may be seen on the company. According to the findings, a sense of disconnection may occur between the time of planning and the ultimate outcome of events. In the complex context, several unanticipated extraneous events may also determine actual outcomes, which reinforces doubts regarding the effectiveness of scenario-planning:

It is difficult to really say here is real value out of that exercise. I guess it is because you don’t see that until the next generation or the next decade. You can’t see it in the financial results at the end of the year. […] I guess a lot of the shifts that are being done, the ideas that have popped out of somebody’s early morning not being able to sleep and an idea comes out. That probably has more impact and more visible impact than going through a full scenario-planning exercise. (12)

It appears that to optimize the benefits of scenarios, organizational strategists need tools and processes that facilitate an understanding of non-linear relations between company actions and outcomes.

4.3.4 Questionable practicality of process. Several of the executives interviewed mentioned the costs of the process, echoing Wilburn and Wilburn’s (2011) view that scenario-planning is time- and resource-intensive. The following comments illustrate:

I don’t have enough resources; I need to invest in that. If we had teams of analytical people we might happily do more scenario-planning but we don’t. (15)

It takes a lot of time to plan for things that may or may not have happened, and I think we have to be realistic in the number of scenarios we run […] (14)

If scenario analysis does not give rise to those sets of actions then you are almost wasting time. (9)

This implies that unless scenarios enable the proactive prevention of the potential negative impact of unexpected events in experience, few will adopt the extended process required for full scenario-planning sessions.

One person also commented on lack of capacity of executives to anticipate probability of events:
Typically the executives would lack the detail to go beyond the unpacking. They would talk conceptually around the unpacking and conceptually around the impact and conceptually around their resulting management action. (9)

4.3.5 There also seems to be insufficiencies in the facilitation of scenario sessions

So the methodology. That it is the missing link. So methodology, if you read scenario-planning books there is a lot around the theory and the concept, very little about the how. (9)

5. Discussion of findings

The findings of this study suggest poor utilization of scenarios in strategic decision-making in the South African context, linked to practical inhibitors, process inadequacies and environmental constraints, despite the potential benefits thereof.

Based on the findings of this study, a research implication is that trend focused probability computation in scenario-planning may have become superfluous for most executives making decisions in a complex world. It would seem from the findings that strategic decision-makers in this context favor a plausibility over a probability approach to scenarios. As per Ramírez and Selin (2014), a plausibility approach suggests that decision-makers do not seek to predict a given future over others, but instead create multiple potential futures through scenarios. In response to this, we propose that strategic decision-makers require growth in scenario thinking competencies that create a changed mindset to develop strategic agility for organizations through practices of inter alia intuitive logic.

Furthermore, as demonstrated by Ramírez, Roodhart and Manders (2011), the integration of strategic decision-making, scenarios thinking and technological innovation requires the creation of domains or structures with distinct prerequisites, such as effective engagement of senior management, careful selection of projects connected to business and an actionable vision, to grow business value. Domains need to be continually tested and should interlink not only technologies, strategies and scenarios with each other, but also with the external system.

Given the multiple requirements and inhibitors of scenario-planning revealed in reported findings, to gain benefits, there may be a need for simplified methodologies and practical tools to allow decision-makers to be better prepared for uncertain futures. There is also a need for technological support for agile decision-making.

Given the time constraints of scenario processes, we propose that investments should be conducted into time-saving software solutions for the computational, trend- and cross-impact analyses to free executives up to practice scenario-thinking and agile decision-making. For example, Voudouris et al. (2014) demonstrate how the innovative computational software-based ACEGES model enables continuous scenarios specifically for the natural gas industry. Making use of artificial intelligent agents the model yields trend scenarios. Future research may explore the use of machine learning and artificial intelligence as enablers of scenario thinking.

Beyond trends-based software solutions, executives need to develop intuitive logic and strategic agility. The findings suggest that agility is critical to the executives and, for many, is based on taking a series of smaller decisions and continually scanning the environment, rather than large-scale decisions based on a number of stories about futures. Frequent decisions may prevent the inertia that follows from multiplying options.

Therefore, practitioners could explore how ‘un-smart’ technology that presents continual and relevant information to decision-makers could be of benefit. Such technologies may help support an agile future-oriented mindset. Practitioners may also focus on the development of simple exercises that shape intuitive logic. As it is recommended that the methodologies support the maintenance of the community benefits of scenarios
development, the exercises may be integrated into board and managerial meetings and communication, rather than once-off strategy sessions.

6. Research implications

Given variability in the use of scenario-planning processes, essential process requirements and the implications of benefits and inhibitors, the use of scenarios thinking in strategic decision-making should be improved. Figure 1 provides an overview of the key findings of this study.

Figure 1 indicates that there are multiple requirements, benefits and inhibitors involved in scenario-planning, all of which become relevant to take into consideration in strategic decision-making. The requirements for the process to work includes not only a culture in which leaders are open to uncertainty and enable strategic choice, but also practical requirements of the right resources, spaces and planned time to allow for it. The emerging market managers recognized the value of scenario-planning. It is of strategic value to organizations, where risks are identified and mitigated, the business becomes agile and the business case robust through scenario-planning. Beyond strategic decision-making benefits, it brings opportunity to develop the leaders’ thinking, future orientation, as well as alertness and offers the opportunity to participate in strategic decision-making. Despite these benefits, reluctance to use scenario-planning stems from a mismatch between the turbulence of the business world and a perceived rigidity that develops once scenarios are formulated, along with mismatched outcomes and impractical processes.

A balanced view of scenario-planning indicates that the benefits of the process have been marred by the application thereof in decision processes. This was already the case in the early 1980s where Klein and Linneman’s (1981) multi-case analysis showed that companies varied in the degree to which managers understood and were involved in scenarios, and the degree to which scenarios were integrated or ad hoc in either the corporate or divisional planning processes.

Although in practice strategic decision-makers understand the importance of remaining mindful of risks, they may neither have the time available to generate scenarios, nor see the
links between plans and outcomes. Cultivating an integrated scenario thinking competence remains an essential prerequisite of strategic decision-making, and this may be augmented through tools and processes supportive of both trends analysis and iterative decision-making.

With that in mind, the framework of integrative thinking in strategic decision-making displayed in Figure 2 highlights the need to not only develop computational processes to define interdependencies, which may be performed by artificial intelligence, but also to develop agile mindsets that support the formulation of adequate responses to evolving futures.

Kaplan and Beinhocker (2003) state that although companies have invested financial resources and time in strategic planning, few executives see the benefit of such investment. According to them strategic planning, which may include scenarios, is not about creation of strategy, but about preparing people’s minds to make good strategic decisions.

7. Managerial implications

The findings compiled in Tables II to IV provide a foundation of several research implications of meeting the requirements, gaining the benefits and handling the inhibitors of scenario-planning, such as an integrated framework of thinking skills in strategic decision-making rather than relying on scenario-planning as a tool, as shown in Figure 2.

Decision-makers need draw on both intuitive and rational processes, as well as divergent and convergent thoughts in scenario-planning. There is no prescribed sequence implied, but the logic would suggest that decision-makers need to uncover many new ideas about likely events and potential responses through divergent thinking linked to intuition.

Divergent thinking has been defined as the thinking style that yields novel, unique ideas and explores many possible solutions, as opposed to convergent thinking aimed at generating a single answer to problems (Guilford, 1967).
Decision-makers need to balance intuitive thinking with reflective thinking (Evans, 2014). Drawing on information from the past, decision-makers should determine the optimal decision rule that will maximize the possibility of the best outcome (Schoemaker and Russo, 1993; Schul and Mayo, 2003). Rational thinking is supported by the evidence-based thinking as defined before (Baba and HakemZadeh, 2012).

Systems thinking then helps overcome the limitations associated with complex systems when the decision-makers have to consider the organization’s relationship to its environment as well as the dynamic and complex non-linear relationships, interdependencies and influences between the organization and the world in which it operates (Caldwell, 2012). Systems thinking (taking into account the hierarchy of systems at play) and reflective practice will improve scenario processes (Lang and Allen, 2010 in Ramírez et al., 2010).

Powell (2014) states that there is a mutuality between systems thinking and scenarios thinking as scenario analysis presupposes assumptions about the behavioral characteristics of the predicted future system. The cluster of rational, systems and evidence-based thinking constitutes the logical thinking required in strategic decisions.

Intuitive and divergent thinking is also used to determine a range of possible responses to plausible futures. When considering these responses, strategic decision-makers require options thinking skills (Driouchi and Bennett, 2012) to allow flexibility and risk mitigation.

Real options thinking “embeds a firm’s ability to sequence, stage and reverse commitment in the face of uncertainty” (Driouchi and Bennett, 2012, p. 41). Ultimately, to encourage action based on the cumulative insights from the intuitive and rational processes, decision-makers need to rely on convergent thinking (Guilford, 1967) to choose a best first action.

Therefore, scenarios thinking forms part of a web of thinking competencies that enables positive strategic decisions in the face of uncertainty and complexity. Figure 2 offers a series of simple questions that decision-makers may ask while developing strategic decision-making competencies. Hacklin and Wallnöfer (2012) point out that dominant mental frames impede strategic change and inform strategic thinking. It is proposed that by utilizing the different thinking skills and mental frames of the collective, decision-makers can allow agility in thinking about the future.

8. Conclusions and suggestions

Given the increasing complexity of the business environment, this study contributes to a framework of scenario thinking that stresses greater emphasis on developing strategic decision-making competence, changed mindsets and organizational agility. Further, it contributes to identify a set of requirements, benefits and inhibitors of scenario-planning in strategic decision-making. From the cases studied, it is evident that industry-, organizational- and leadership-related factors enable or inhibit scenario-planning.

We conclude that the findings reported expand the insights into the requirements, benefits and inhibitors of scenario-planning in strategic decision-making.

We recognize a number of limitations in this study that offer a foundation for future research to assess validity, reliability and transferability of the findings reported. The study was conducted only in an emerging market context. It only offers insights into practitioners’ perceptions of the benefits, inhibitors and enablers of scenario-planning in strategic decision-making. Nevertheless, these research limitations provide opportunities for further research in other emerging markets. A longitudinal study could measure the extent to which scenarios display the perceived benefits.

Further research to determine supportive tools and technologies for enabling scenario-planning across multiple contexts is needed. For example, research may explore the
technologies that enable trend awareness, strategic thinking and decision-making and changed mindsets. The proposed framework of integrative thinking in strategic decision-making may be used in practical workshops with executives to broaden their thinking and lay a foundation for more effective scenario-processes.

References


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Improving predictions of international business environments: China as a case in point

Marina Yue Zhang

Abstract

Purpose – Firms engaged in international business necessarily make predictions about the business environments in which they operate or seek to enter, on the basis of which they make a number of strategic decisions. The purpose of this paper is to consider the difficulties there are in making accurate predictions and how the process might be improved.

Design/methodology/approach – The paper examines predictions made in 2007 by ‘China experts’ about what the Chinese business environment would look like in 2017. Their predictions were accurate in respect of around two-thirds of the issues they were asked to consider. This paper focuses on the one-third of issues about which they were wide of the mark and examine the likely reasons.

Findings – The predictions of the 2007 study were accurate in respect of around two-thirds of the issues the China experts on the Delphi panel were asked to consider. The reason that they were wide of the mark on about one-third of issues could be attributed to two main factors: the 2008/2009 Global Financial Crisis and the appointment in 2013 of Xi Jinping as the President of China. These events precipitated changes in direction in the Chinese business environment that had not been (and could not have been) anticipated by the Delphi panel.

Originality/value – Very few Delphi studies have been subject to a follow-up examination of the accuracy of their predictions. This paper contributes a discussion the various methodologies that firms can use to improve their forecasts of international business environments.

Keyword China

Paper type Research paper

1. Introduction – assessing international business environments

Given the substantial resources, financial and other, that are involved in engaging in international business, especially insofar as that extends beyond mere exporting, it is imperative that firms undertake predictions about what the future might be in markets and countries of interest. Various ‘levels of intelligence’ (Williamson, 1994) – some micro, firm specific, others more macro, associated with the larger environment within which the firm operates – are required as the basis for strategic planning. Assessments must be made of market potential; hence, economic forecasting and market research are fundamental in this analysis and a variety of techniques have evolved for this purpose (OECD, 2011). However, as Robock and Simmonds (1989) observed, techniques for forecasting national institutional environments are not nearly as well-developed. Doh and Lucea’s (2013) more recent observation that insufficient attention is paid to non-market aspects (“social, political and legal arrangements”) of the global environment suggests that this inattention is ongoing. Though the two are, of course, interdependent, in all likelihood, this unbalanced attention reflects the reality that market factors (likely demand, etc.) are (or appear to be) somewhat easier to predict than non-market factors. Political risk forecasting emerged several
decades ago (see, for example, Kobrin, 1979; de la Torre and Neckar, 1988) in the international business arena to assist firms make a more balanced assessment of what they were facing. However, a proper assessment of international business environments requires a more comprehensive approach than just measuring risk, albeit that the dimensions of political risk are numerous (Brown et al., 2015; Ring et al., 1990). It must also include an appraisal of a wide range of factors that might impact the firm, both positively and negatively. Further, to be useful, the evaluation must not just be about the current attractiveness of a particular location, but how it might change. In summary, firms require both short- and long-term forecasts and ones that consider an array of variables and their possible interaction. Forecasting models that are too narrowly conceived or focus too heavily on the things that are easily measured, at the expense of the things that are difficult to measure, will be unhelpful, at best, or possibly even catastrophic. Furthermore, while those firms will seek to identify what factors they can control (as well as how to do that), the reality is that many factors that will impinge on their international operations are, in fact, uncontrollable.

The most fundamental challenge that firms face in international business environments is acquiring data and information, of whatever type, that will be useful in decision-making. As Winkler et al. (2015) note, too many firms are inadequately equipped to get and process information, especially in emerging markets. They face two major information contingencies: uncertainty, or a lack of information, and equivocality, or lack of clarity about the information they do have. The danger, as Ansoff (1980, p. 143) so astutely observed (though more generally, and not particularly about international management), is that:

[...] it is implicitly assumed that enough is known about an event to permit estimation of its impact on the enterprise and also selecting a specific response. The lack of knowledge comes from uncertainty either about the occurrence of the event, or about a particular outcome, or about the effect of a particular response.

It is well recognized that the information needed to make critical decisions will be of various forms (Mendenhall et al., 1995). Some of it may be sourced internally, but much of it will come from outside the firm itself. Some of it will be in the form of hard data, but sensitive human analysis may be just as (or more) important. To use Ansoff’s (1980) terminology, while some of the signals may be strong, it is also critical to be alert to weak signals that may portend something even more important. Thus, foresight, and not just number churning, must be a key ingredient in discerning what is going on and how to deal with situations, involving not just forecasting, but such additional methods as “[...] scenarios, modelling, scanning, critique, timelines, future webs, brainstorming, imaging and creativity, back-casting, Delphi surveys, trend analysis, environmental scanning, extrapolations” (Tilley and Fuller, 2000, p. 154). As Reid and Zyglidopoulos (2004, p. 239) have commented, “Foresight is not a ‘mechanical process’ through which predictions about the future are generated, rather it is an understanding of the future based on an understanding of the underlying laws and factors or structures that are manifest in observable phenomena”.

Two of the methods most commonly used in the context of international business are Delphi analysis (Czinkota and Ronkainen, 1997, 2005, 2008; Nielsen and Thangadurai, 2007; Winkler et al., 2015) and scenario planning (Amer et al., 2013; Bradfield et al., 2005; Huss, 1988) with variations and embellishments such as cross-impact analysis (Gordon, 1994) and trend-impact analysis (Agami et al., 2008) designed to deal with the on-going complexities of the impact of events in international business environments. While those techniques have often been directed at academic analysis, many have been taken up and used for commercial advice to international firms by consultancy firms and advisory organizations such as think tanks (Brown et al., 2015). Such techniques might be especially appropriate – even necessary – in emerging markets, where the more procedural approaches to decision making based on quantitative forecasting models might not work...
well, as Winkler et al. (2015, p. 1120) point out, “Potential learning effects are rather tacit due to the time span between strategy implementation and feedback, the complexity of cross-effect relationships, as well as non-linear, hard to predict developments”.

2. Challenges in assessing the Chinese business environment

As an emerging market, China carries all of the challenges of prediction that attach to such markets (Hoskisson et al., 2000; Wright et al., 2005; Yildiz and Fey, 2012) – and then some. Besides being much larger, more dynamic and more complex (with the possible exception of India) than all of the others, it is notoriously opaque. This is a result of two main factors: long standing cultural beliefs in secrecy (Redding, 1990) and an authoritarian political environment (McGregor, 2010; Rosefielde and Leightner, 2018; Shambaugh, 2016).

An example of the challenges of making predictions about markets in China can be found in a recent paper (Zhang, 2016) examining the transition from second-generation to third-generation technologies in the telecommunications market in China, including China’s development of its own 3G standard. During the 13-year period examined in the study (2000-2013), there were a multitude of things happening in the policy environment, many of which are only clear in retrospect. The opaqueness in China found more generally is, as the paper shows, greatly magnified when government agencies are involved, a result of “fragmented authoritarianism” (Lieberthal and Oksenberg, 1988; Mertha, 2009) characterized by inter-ministerial competition which is marked by deep-rooted political involvement, frequent bureaucratic bargaining and weak legal enforcement (Shambaugh, 2013). As Zhang (2016, p. 548) points out, this often results in a protracted, disjointed and incremental policy-making process at both formulation and implementation. The probability for any firm in the telecommunication industry, let alone a foreign one, to have accurately predicted the final outcome of the transition, not to mention to have understood the convoluted twists and turns of the process, would have been very low.

The challenges in China go beyond assessing what it is happening and what might happen; there are also considerable limitations on how whatever does happen can actually be managed. Of the strategies that Mascarenhas (1982) identified for how firms cope with uncertainty in international markets – avoidance (obviating the problem by, for example, not operating in a particular country at all or demanding payment in a hard currency), control (keeping the environment from changing in ways that could adversely affect the firm, such as lobbying government, forming cartels and bribery), flexibility (means of increasing the firm’s adaptability to a changing environment, such as selling its products in multiple markets), insurance (literally, buying political risk insurance) and prediction (making assessments of all manner of market and non-market forces) – realistically, only prediction will work in China. Given the overall size of the market, the rapidity of its growth and its dominant position in the market for many goods and services, avoidance would mean missing out on many opportunities. Indeed, there are few companies that have made that choice; withdrawing would imply enduring a substantial decrease in the size of their business. In light of the recent crackdown on corruption and the emerging strength and confidence of the government in China’s own economic strengths (Economist, 2017), foreign firms have very limited prospects of exerting any meaningful control. Given the proportion of their business done with China and China’s dominant position in many world markets, the possibility for firms to adopt a posture of flexibility – configuring their operations in international business environments in such a way that risk can be spread across countries to minimize exposure to any one – is limited. Political risk insurance is certainly possible but is likely to be prohibitively expensive for most firms.

Numerous attempts have been made to predict China’s future, politically and economically since the PRC was founded in 1949. It is impossible to review anything like all of them or to summarize what they said. However, it is instructive to examine just two of them, one undertaken immediately after the end of the Cultural Revolution and just before the “Reform
and Opening Up” initiated by Deng Xiaoping in 1978 that was the catalyst for China’s rapid economic growth subsequently (Lin, 2012), the other undertaken just before the Global Financial Crisis in 2008. In the first (Smil, 1977), a Delphi study based on the views of 20 experts on Chinese affairs was combined with scenario analysis of China’s future. The Delphi panel saw the following 25 years as “[...] an era of stabilization, complicated, certainly, by many internal problems, but devoid of dramatic domestic campaigns and marked by a cautious foreign policy” (Smil, 1977, p. 481). Though they could not foresee how Deng’s pragmatic philosophy, maintaining China’s Communist political underpinnings while opening it up to capitalism (sometimes described as signally left, but turning right) would have such a dramatic impact on economic growth; their predictions were broadly accurate. The later work (Hoffmann and Enright, 2008) was a wide-ranging analysis by China experts of forces impacting China’s future and focused on scenario analysis to examine various possible futures for the country. It was deliberately not a forecast of the future but did argue that the future was likely to lie somewhere within the overall set of scenarios they outlined. Hoffmann (2008, pp. 9-15) noted that there were several key points that needed to be kept in mind by anyone seeking to understand how China’s future might evolve: China’s future will be profoundly different from its past; China has been far more resilient than many expected; China’s leaders have a very different worldview than leaders in the West; China will not simply follow the path suggested by others; China is not a monolith; government will continue to play an immensely important role in China’s economy; China’s rapid economic development does not necessarily correspond with business profits; China is multidimensional; and China’s future is best understood as the result of a confluence of forces rather than a single master plan. In short, he argued that the path ahead would not be linear but rather, would be complicated, impacted by a variety of interacting and complex forces.

Reinforcing the points made by Hoffmann (2008), a study of strategic failures by multinational firms in China (Reid and Zyglidopoulos, 2004), attributed much of the blame to those firms’ lack of foresight, holistic thinking and historical perspective, as well as what they called “the illusion of control”. Insufficient research and biased data interpretation led both to failures of understanding (what was happening) and failures of anticipation (the likely consequences of their faulty decisions regarding investments, partnerships, markets and so on).

3. Ten-year predictions of the Chinese business environment – and what actually happened

The focus in this paper is a study undertaken in 2007 to forecast the Chinese business environment in 2017 (Elliott et al., 2010). We aim to use this study to identify the challenges of making predictions about international business environments by comparing what was predicted with what actually happened.

The method used was the Delphi technique – an approach that has been labeled “the cornerstone of futures research” (Ono and Wedemeyer, 1994). It involves several rounds of opinion seeking and estimations by a panel of experts (whose identity remains unknown to one another) – in this case, 24 carefully chosen individuals with substantial professional experience and interest in Chinese business. In the first round, they were asked to identify important trends they believed would be likely to affect business in China over the coming decade. The authors of the study used content analysis to reduce the 120 issues mentioned by the respondents to 61 issues. In the second round, the panelists were asked to provide initial estimates of the likely movement – “Decrease Greatly”, “Decrease Moderately”, “Remain Unchanged”, “Increase Moderately” and “Increase Greatly” – in the 61 issues. They were also requested to rate both the “importance” of each issue and their self-perceived “expertise” in relation to each issue. In the third round, they were given the aggregated responses to the second round and asked to provide fresh estimates, upon
which the median value of each item and an inter-quartile range of estimates for each of the 61 issues was calculated. After these various iterations, there was a very high level of consensus about the likely direction of movement for each issue.

This paper reports a follow-up study of the previous study. Given that ten years have elapsed since the original forecasts were made, it is appropriate that an examination be made of how accurate those forecasts were. While it should be of interest to see where the predictions were accurate, from a practical point of view, it is of even greater interest and importance where they were not. As experts using a rigorous and highly regarded research methodology might be expected to have a high likelihood of getting it “right”, about what issues, and for what likely reasons, did they get it “wrong”?

Undertaking this follow-up examination was fairly straightforward. For many of the 61 issues, there was a clear answer about what had transpired; for example, the relative share of different sectors of the economy; the value of the Chinese renminbi relative to the US dollar; and rural and urban unemployment can all be assessed objectively through statistical data provided by the National Bureau of Statistics of China. There are, however, a number of issues where expert judgment is required about what has transpired. Six experts – two for each of the three categories of issue used in the original study – Economic; Political and Legal; and Social and Cultural – were, therefore, provided with the list of issues for their category (23, 15 and 23, respectively) and asked to indicate their views about the actual direction of movement – increase, decrease or no change – there had been in each of them over the period 2007 and 2017[1]. In the case of each of the 61 issues, there was consensus between these experts about what had actually transpired.

Tables I-III set out, for each category of issue, the accuracy of the original Delphi-generated predictions. The top portion of each table sets out the issues about which the predictions were correct, noting what that prediction had been. As it is the direction of the trend that is of fundamental concern, the question of whether the change was “great” or “moderate” is put aside and the focus placed on whether there had been an “increase”, “decrease” or “no change”.

### Table I

<table>
<thead>
<tr>
<th>Predictions were correct about</th>
<th>Increased/Decreased/Remained Unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td>The quality of banking systems and governance</td>
<td>Increased</td>
</tr>
<tr>
<td>The relative share of GDP produced by services</td>
<td>Increased</td>
</tr>
<tr>
<td>The global influence of Chinese corporations</td>
<td>Increased</td>
</tr>
<tr>
<td>The value of the yuan (RMB) relative to the US $</td>
<td>Increased</td>
</tr>
<tr>
<td>Reform of the taxation system</td>
<td>Increased</td>
</tr>
<tr>
<td>China’s contribution to global technological innovation</td>
<td>Increased</td>
</tr>
<tr>
<td>The effectiveness of capital markets</td>
<td>Increased</td>
</tr>
<tr>
<td>China’s global economic competitiveness</td>
<td>Increased</td>
</tr>
<tr>
<td>The reliability and trustworthiness of Chinese accounting systems</td>
<td>Increased</td>
</tr>
<tr>
<td>The scarcity of skilled labor</td>
<td>Increased</td>
</tr>
<tr>
<td>China’s stable access to global energy supplies</td>
<td>Increased</td>
</tr>
<tr>
<td>Economic prosperity in rural China</td>
<td>Increased</td>
</tr>
<tr>
<td>The economic costs of tax avoidance</td>
<td>Increased</td>
</tr>
<tr>
<td>Economic protectionism</td>
<td>Increased</td>
</tr>
<tr>
<td>The attractiveness of the tax regime for foreign companies investing in China</td>
<td>Decreased</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Predictions were incorrect about</th>
<th>Greater or less than predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>The relative importance of speculative investment in construction and property in China</td>
<td>Greater</td>
</tr>
<tr>
<td>The level of bureaucratization in economic and business affairs</td>
<td>Greater</td>
</tr>
<tr>
<td>The economic problems caused by lack of investment in infrastructure</td>
<td>Less</td>
</tr>
<tr>
<td>The economic performance of state-owned enterprises</td>
<td>Less</td>
</tr>
<tr>
<td>The relative share of GDP produced by manufacturing</td>
<td>Less</td>
</tr>
<tr>
<td>The relative share of GDP produced by agriculture</td>
<td>Less</td>
</tr>
<tr>
<td>The scarcity of skilled middle level managers</td>
<td>Less</td>
</tr>
</tbody>
</table>
The lower portion of each table sets out the items for which the predictions were incorrect. Again, to simplify matters, what is noted is whether, in relation to each issue, there had been “greater” or “less”, so, for example, in Table I, it can be seen that the prediction about the issue, “The relative importance of speculative investment in construction and property in China”, was incorrect and that, in fact, speculative investment in that sector was greater than predicted by the Delphi panel.

### Table II  Accuracy of predictions about political and legal issues

<table>
<thead>
<tr>
<th>Predictions were correct about</th>
<th>Increased/Decreased/Remained Unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td>China’s role in global political and economic affairs</td>
<td>Increased</td>
</tr>
<tr>
<td>The number of trained lawyers</td>
<td>Increased</td>
</tr>
<tr>
<td>The global superpower rivalry between China and the USA</td>
<td>Increased</td>
</tr>
<tr>
<td>China’s enforcement of international intellectual property laws and conventions</td>
<td>Increased</td>
</tr>
<tr>
<td>The strength, transparency and enforceability of business laws</td>
<td>Increased</td>
</tr>
<tr>
<td>The effectiveness of provincial legislation and local regulation</td>
<td>Increased</td>
</tr>
<tr>
<td>The independence of the Chinese legal and judicial system</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>The likelihood that the Taiwan issue will be peacefully and permanently resolved</td>
<td>Remained unchanged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Predictions were incorrect about</th>
<th>Greater or less than predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade friction with major trading partners</td>
<td>Greater</td>
</tr>
<tr>
<td>The influence of the military in Chinese political affairs</td>
<td>Greater</td>
</tr>
<tr>
<td>The problems in China’s relationships with regional neighbours</td>
<td>Greater</td>
</tr>
<tr>
<td>The likelihood of armed confrontation with the USA</td>
<td>Greater</td>
</tr>
<tr>
<td>The level of government censorship</td>
<td>Greater</td>
</tr>
<tr>
<td>The relative influence of the Communist Party in Chinese life</td>
<td>Greater</td>
</tr>
</tbody>
</table>

### Table III  Accuracy of predictions about social and cultural issues

<table>
<thead>
<tr>
<th>Predictions were correct about</th>
<th>Increased/Decreased/Remained Unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governmental recognition of the importance of environmental sustainability</td>
<td>Increased</td>
</tr>
<tr>
<td>Public investment in environmental protection</td>
<td>Increased</td>
</tr>
<tr>
<td>The relative economic influence of the urban middle class</td>
<td>Increased</td>
</tr>
<tr>
<td>The problems caused by a rapidly aging population</td>
<td>Increased</td>
</tr>
<tr>
<td>The adverse consequences of the ‘one-child’ policy</td>
<td>Increased</td>
</tr>
<tr>
<td>The erosion of traditional values among the younger generation</td>
<td>Increased</td>
</tr>
<tr>
<td>Environmental problems (air and water pollution)</td>
<td>Increased</td>
</tr>
<tr>
<td>The international standard of Chinese university graduates</td>
<td>Increased</td>
</tr>
<tr>
<td>The level of social security protection</td>
<td>Increased</td>
</tr>
<tr>
<td>Social disorder</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>Urban unemployment</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>Rural unemployment</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>Inland economic disadvantage</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>The level of social deviance</td>
<td>Remained unchanged</td>
</tr>
<tr>
<td>The quality of secondary education competence</td>
<td>Remained unchanged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Predictions were incorrect about</th>
<th>Greater or less than predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust based on effective law, good information and reliable procedures</td>
<td>Less</td>
</tr>
<tr>
<td>The level of corruption</td>
<td>Less</td>
</tr>
<tr>
<td>Occupational mobility</td>
<td>Less</td>
</tr>
<tr>
<td>The level of individualism</td>
<td>Less</td>
</tr>
<tr>
<td>Income disparities</td>
<td>Less</td>
</tr>
<tr>
<td>Trust based on interpersonal connections</td>
<td>Greater</td>
</tr>
<tr>
<td>The degree of economic inequalities between regions, cities and provinces</td>
<td>Greater</td>
</tr>
<tr>
<td>Materialism</td>
<td>Greater</td>
</tr>
</tbody>
</table>
Looking at the total picture, the Delphi panel experts were accurate in relation to two-thirds of the issues (40/61) and wrong about a third. The category of issues about which their predictions had the highest proportion of inaccuracy was “Political and Legal” and, in fact, all of the inaccuracies in this category pertained to political issues. Considering the inaccurate predictions across all three categories, careful scrutiny reveals two principal reasons:

1. In relation to Economic Issues, the 2008/2009 Global Financial Crisis (GFC) and China’s response to it explains much. While it had been predicted that the relative share of gross domestic product (GDP) produced by services would increase (and that happened), the share produced by manufacturing and agriculture was less than predicted. China’s response to the GFC was to provide a massive injection of funds into infrastructure, which led in turn to heightened speculative investment in construction and property. The government also took back greater control of economic and business affairs, leading to a higher level of bureaucratization. The push to further reform state-owned enterprises was put on the back burner, with the result that their economic performance was less than predicted.

2. In early 2013, Xi Jinping became the President of the People’s Republic of China and fairly quickly moved the country in a different direction to the previous leadership. His style was much more assertive than Hu Jintao’s, both domestically and internationally. While the Delphi panel had predicted about Political Issues that the relative influence of the Communist Party in Chinese life would decrease moderately, it actually increased. Domestically, this was reflected by (among other things) an increase in the level of government censorship. Internationally, there were greater problems with regional neighbors than had been predicted, greater influence of the military in political affairs, higher likelihood of armed conflict with the USA and greater trade friction with major trading partners (even before the election of Donald Trump as the President of the USA).

The consequences of these two major events – one economic and the other political – were a number of knock-on effects on some of the Social and Cultural Factors canvassed in the original Delphi study. Some things were “less” than predicted – the level of corruption, occupational mobility, individualism and trust based on effective law, good information and reliable procedures – while others were “greater” – materialism, economic inequalities between regions, cities and provinces and trust based on interpersonal connections. Logical explanations can be provided for each of these. For example, in relation to less corruption, President Xi very early in his term indicated that there would be a serious and widespread crackdown that was, in fact, implemented and which continues. As a further example, in situations of economic and political uncertainty, especially in a relationship-based society like China, it could be expected that greater reliance would be based on interpersonal trust that on institutionally based trust.

Soon after the GFC hit, Queen Elizabeth II was on an official visit to the London School of Economics where she engaged senior academics about the crisis. One of them is reported (The Telegraph, 2008) as saying, “She was asking me if these things were so large how come everyone missed it?” He said that he told the Queen, “At every stage, someone was relying on somebody else and everyone thought they were doing the right thing”. Whatever the reasons, it is apparent that economics and economic forecasting are imprecise arts rather than science and that the consequences, not just in China but everywhere, of the failure to predict the crisis were profound.

Similarly, it might be asked why political scientists were not able to forecast the implications of the rise of Xi Jinping. Of course, the closer to the decision about who would be the next president of China, the more likely it would have been that speculations about the outcomes would be accurate. As that decision was not made until some six years after the Delphi...
study reported on here, it was impossible to be clear. Indeed, had the apparent power struggle between Xi and Bo Xilai been resolved differently, one can expect that the direction in which China headed politically could have been very different.

In the next section, we explore what lessons this analysis of predictions versus actual outcomes carry for firms engaged in international business.

4. Improving firms’ predictions about international business environments

In seeking “lessons learned” from this specific case, we should first examine the predictive powers of the Delphi approach based on other studies, noting that follow-up studies of this type are rare. The most relevant to this paper, as they were undertaken in relation to international business, are the studies of Czinkota and Ronkainen (1997, 2005, 2008). In reviewing the accuracy of the predictions of four earlier Delphi studies they conducted, Czinkota and Ronkainen (2008) report “hit rates” of 82, 80, 65 and 89 per cent, averaging 79 per cent. While they make the point that inaccuracies are often about the expected rate and speed of change (rather than missing the change), they acknowledge that so-called “Black Swan” (Taleb, 2010) and other “big events” can throw forecasts out. It might be argued that in the case of the present case analysis, if the impact of a Black Swan event (the GFC) and the disjunction created by a “big event” (the leadership change from Hu to Xi) are removed, then the accuracy of the predictions is quite high, supporting the findings of the general validity of Delphi as a forecasting method (Landeta, 2006).

The question is not whether Delphi analysis is a reliable technique for forecasting. It is rather to confront the reality that Black Swan and big events do occur and to consider how they can be taken account of by firms impacted by them. In other words, if Delphi and similar forecasting techniques are employed by international business firms, then what needs to be done when some unexpected event knocks them off course to ensure that there is a quick reassessment of the situation, the likely consequences and the possible options.

Before even that, this case analysis reinforces on firms engaged in international business to use a variety of forecasting techniques. Certainly, they need much more than reliance on economic forecasting models (none of which predicted the GFC) or political risk models (which, despite having some merit, have been shown historically not to have predicted such momentous events as the overthrow of the Shah of Iran). Though both have their strengths, they often rely on a relatively narrow range of indicators that do not capture the complexity or fast-moving nature of real situations. If Delphi had been used in combination with, for example, scenario planning, then firms would have been able to more quickly than otherwise respond to what was happening by anticipating what might follow and to adjust their decision making accordingly, in an on-going iterative fashion. By its nature of typically binary options, scenario-planning forces decision makers to realize that the situation will not be “business as usual” or something that is “evolutionary”. Of course, the scenarios themselves need to be continually revised as the situation changes, quite possibly dramatically, before settling into a “new normal” state. As noted earlier in the paper, given the complexity and volatility of emerging markets, the combination of Delphi and scenario planning might be even more critical than in developed markets (Winkler et al., 2015) and in any event will be better than using one or the other (Duboff, 2007) or neither (de Mortanges and Allers, 1996).

A key, but often underestimated, ingredient is what Ansoff (1980) labelled simply “the human factor”. He was focused most particularly on the importance of having senior managers assume responsibility for “strategic issue management” and (even more problematically) “surprise management”, noting (p. 142) that they often refuse “[…] to accept new and unfamiliar issues as relevant to the business of the enterprise”.

VOL. 20 NO. 6 2018  FORSIGHT  PAGE 629
However, he recognized that those managers would need the advice of experts. Thus, while the strong signals of significant events would be recognized by line managers, experts – either internal to the firm or external consultants and advisers – would be necessary to pick up and interpret weak signals. The experts’ advice would be critical in dealing with events after they had occurred but should, in fact, have been incorporated into the development of various scenarios before those events. As Fuller and Loogma (2009) point out, foresight analysis is a much more holistic analysis of futures than just forecasting. Predictions about the future should be situated, among other things, in an understanding of the past, especially in a country such as China where that past is a significant part of people’s understanding of the present. Hoffmann’s (2014) macrohistorical approach to thinking about alternative futures of China suggests that the expert advice informing international businesses operating in China should incorporate individuals with a deep understanding of Chinese history and culture, as well as those with an holistic understanding of its business system which is a product of that (Redding and Witt, 2009).

While the expertise required to forecast events and analyze what actions should be taken in relation to things as they happen might be located in the firm’s headquarters (or, indeed, a third country), often the information that is required is locally situated, even in this digital era. The reason is that a deep understanding is often “tactile”, the feelings that experts have about a particular set of circumstances, especially where the signals are weak and “hard” information is scarce. Firms must, therefore, develop internal processes for communicating this kind of information and analysis, including having dotted lines of communication into senior levels at headquarters. The sources at the local level are most likely to be a combination of host-country nationals, “old hand” expatriate managers and experienced consultants. The expertise drawn upon will need to be both macroscopic and very specific (to the industry, the major stakeholders and decision-makers, location and so forth). While much of this process will be of an on-going, day-to-day, ear-to-the-ground type, there should also be “conference-style” analysis on a regular (monthly, biannual, annual – depending on the volatility of the situation) basis, as well as ad hoc “conferences” in the event of major changes. What constitutes a major change is not always obvious, underlining the need for expert judgment, not just algorithm-based measures. Further, it is one thing to identify critical events but quite another to, first, anticipate their consequences and, second, estimate the gravity of those consequences. Ultimately, senior management of the firm (and quite possibly the Board) will need to weigh up the subjective analysis against the objective measures. As Winkler et al. (2015, p. 1121) note, “[…] even in the dynamic institutional context of emerging markets, some features of the future can be considered foreseeable by at least some members of an expert panel”.

Clearly, the likelihood of unpredictable changes in the business environment in China – and the impact of such changes on foreign business firms – is greater in some industries than others. For example, real estate is a sector which, for good reasons, foreign firms have generally stayed out of, largely because of behind the scenes “manoeuvring” of local firms that is completely beyond the wit of outsiders to understand and deal with. The pharmaceutical sector, however, is one to which – given the enormous market potential – foreign firms are greatly attracted, but where, especially since the ascendancy of Xi Jinping, much attention has been focused on corruption and price-gouging involving foreign firms (Fox, 2013). Foreign firms must, therefore, identify not just their overall exposure to possible changes in their particular business environment (relying on expert advice of the type already mentioned) but also bolster their intelligence-gathering resources accordingly, specifically concerning changes in government policy.
Looking back on the predictions of the Delphi study which is the focus of this paper (Elliott et al., 2010), it would have been interesting for the authors to reconstitute the panel both after the GFC and then after the appointment of Xi Jinping and asked for a reassessment of their initial predictions. For the reasons outlined in this section of the paper, such reassessments would not in themselves have been sufficient for firms impacted by those events. Frequent, on-going analysis would have been necessary to anticipate the consequences and make decisions to deal with them. If that were done, then the overall accuracy of the Delphi analysis would almost surely have risen, especially if combined with on-going assessments of scenario planning (Saritas and Oner, 2004). Though it was outside the parameters of this paper, it is our intention to undertake a further study that examines historically the impact of those events on firms that did, against those that did not, have mechanisms in place to forecast the situation they were facing in China. This will be a context- and location-specific appraisal of Bartlett et al. (2014) assertion that successful international firms develop significant “global scanning and learning capability”.

5. Conclusions

As Yogi Berra so eloquently noted, “The future ain’t what it used to be”. Forecasts – especially about the future – are very difficult to get right. “Black Swan” – impossible to predict but highly impactful – events can tear them to shreds. A famous British economist, Alec Cairncross (1969) wisely (and poetically) commented that, “A trend is a trend is a trend. But the question is, will it bend? Will it alter its course through some unforeseen force, and come to a premature end?” It is, therefore, critical that forecasts be regarded as being cast in jelly rather than stone, open to modification as critical, major events move the direction of things (cause a meltdown of the forecasts). That begs the question of how we know what events are direction changing and what are not. While there are numerous analytical forecasting tools to help that process, in the end, it is the judgment of experts – triangulated to zero in more accurately – that is required. Delphi and scenario planning techniques are still among the best methodologies for that (Saritas and Nugroho, 2012).

Internationally, as a result mainly of major changes to the political landscape – Brexit; the Trump presidency; on-going instability on the Korean peninsula, in the Middle East and in South Asia (all involving the potential for nuclear war); the emergence of populist-oriented parties; Russia’s on-going territorial claims in Eastern Europe; and China’s re-emergence as a major world player, among other things – are making the task of forecasting international business environments even more challenging than previously. All the more reason, then, why firms need to pay close attention not only to trends but also to specific events and their implications. Given the possibility of “Black Swan” events, their forecasting must also be such that it can be nimbly reprogrammed and both tactical responses and strategic readjustments made quickly on the basis of the best information available.

Note

1. The two economics experts were, respectively, a world-renowned Chinese professor of economics at Peking University, specializing in macroeconomics and a leading British economics commentator and journalist, based in Beijing for many years. The experts on political and legal issues were, respectively, a British management consultant who has lived in China continuously since 1978 and a Beijing-based Italian lawyer who has lived predominantly in China since 1994; both are bilingual. The two experts on social and cultural issues were, respectively, a Chinese-speaking Swiss national who is both an academic and a consultant in Beijing and a Chinese academic who has published many papers and two books on those topics.
References


Further reading

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Technology roadmapping in security and defence foresight

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Abstract

Purpose – This paper aims to provide an analysis of Spanish Defence National Foresight Exercise.
Design/methodology/approach – The analysis is based on a content analysis of public domain Spanish Defence National Foresight Exercise, and a study directed to analyse the impact on defence technological and industrial base.
Findings – Foresight studies on the defence and security environment uses hybrid methodologies, but rarely involve all the stakeholders, and specially the citizens. The authors place a particular emphasis on the impact of these defence and security foresight studies, and following policies to increase the competitiveness and advanced technologies in the future. The analysis of the Spanish contractors allows an evaluation of the roadmaps as a policy instrument for the industrial defence industry. The main challenges for the next exercises in the European countries are to increase the interest in the firms' intelligence systems, and the participation and representation of citizens as a way to guarantee their rights. Therefore, a technology roadmap must be complemented with other more participative foresight methods.
Originality/value – Foresight studies on the defence and security environment have been the subject of very few systematic analyses of impact. This paper makes a contribution to such analysis.
Keyword National foresight exercise
Paper type Research paper

1. Introduction

Foresight is considered a set of strategic tools that support government and industry decisions with adequate lead time for societal preparation and strategic response (Calof and Smith, 2010). However, there are very few systematic analyses available in the defence and security environment (James and Teichler, 2014).

To provide anticipation and intelligence for foresight exercises, especially if geopolitics and international affairs are relevant to analysis, some methodologies (i.e. mapping and scenarios) are conceived as common suitable methods by several countries. These methodologies can help foresee disruptive innovations and the remote chance of outlier “black swan” events (Saritas and Aylen, 2010; Teleb, 2007). The occurrence of unpredictable events (i.e. natural disasters, political instability, terrorism and asymmetric warfare, espionage, etc.) has a massive impact on citizens around the world, and since the recent terrorism events, Europe is more sensitized than ever with the Security and Defence (S&D) issues.

In the field of public decisions and science, technology and innovation (STI) strategy-making, defence technology is confronting increasing difficulties, new challenges and opportunities (Linstone, 2002). New and more complex tasks than ever are rapidly emerging in areas concerning S&D against new types of threats that require additional research and development (R&D) of new techniques (Thorleuchter and Van den Poel, 2011). Many S&D issues are always related to technological development, and technology...
Foresight exercises allow government priorities for technology investments and innovation policy issues to be addressed. Technology foresight exercises in this sector are challenging because they involve an overwhelming number of technologies that impact citizen security, geopolitics, as well as industrial and international policy. Moreover, stakeholder participation is sometimes at odds with national interests in several issues related to an exercise.

Technology roadmaps (TRs) provide visual descriptions and facilitate the structured dialogue essential to a foresight process (Barker and Smith, 1995). TR is a foresight method suitable for R&D planning because they provide a framework that links business to technology and helps identify relationships between existing and developing technologies, products, and markets over time (Lee et al., 2007; Phaal et al., 2004). However, TRs are not frequently used by Ministries of Defence (MoDs). In fact, we have not found a single published study in the form of a TR by any MoD – except Spain’s – and to our knowledge there are no published studies that analyse the impact of TRs on S&D firms either. In the Spanish Defence National Foresight Exercise, there is a TR for each goal of the defence strategy (published in 2010). This makes the Spanish exercise something unique that requires to evaluate its strengths and weaknesses and considers the conclusions for the European countries with common goals in politics for their industrial base. To determine the business impact of this exercise, we have carried out an ad hoc study among some Spanish MoD contractors which reveals part of the impact of policy-making on the contractors’ strategy process, as well as indicates the potential implications for these companies.

Our conclusions have implications for theory, policy and practice for the future exercises. Due to the nature of TRs, some limitations are inherent to the methodology and so more participation in the exercise and implications in the result disseminations are proposed. One of our contributions is the suggestion of using hybrid approaches to complement the TR to achieve more benefits. Another contribution is to urge MoDs to design a set of policy tools that improve the impact of national exercises on countries’ firms. For practitioners, recommendations are directed to strengthen their technology strategy considering commercial and political issues.

The article is structured as follows. Section 2 reviews the literature about foresight in security and defence technology. Section 3 presents and analyses the Spanish Defence National Foresight Exercise and the impact it has had on Spanish contractor firms. The article then continues in Section 4 with a discussion, and finally Section 5 collects the conclusions of our study.

2. Foresight in security and defence

2.1 A general vision

Historically, R&D in the defence sector has been an engine for the generation of innovations which are subsequently transferred to other products in the civil sector, such as the origin of the internet or the global positioning system. However, rising development costs, the growing branches of the technological areas related to S&D products and services, as well as their rapid changes favour the current tendency to use technologies designed for civil purposes, but also suitable for S&D needs, such as commercial-off-the-shelf software. Dual-use technologies have potential and/or current applications for military and civil purposes (Molas-Gallart, 1997), and their launch in the marketplace makes it even more difficult to study the foresight in S&D technologies separately from other technologies:

The planning and preparation of national defence strategies require a long-term approach, which should be multidisciplinary, participatory and contextualised with the geo-political and institutional frame of the country. As decisions about S&D issues have long-range impacts and
political implications, governments should shape them based upon a complex and politically shared foresight process (Corrêa and Cagnin, 2013, p. 1).

Most foresight exercises carried out by MoDs fulfil these characteristics. Moreover, sharing foresight expertise across government departments is also quite a challenge (Dreyer and Stang, 2013). The case of military foresight programmes in some countries is illustrative in this regard. While there is some cooperation between military and civilian foresight projects, military foresight programmes in many countries remain separate from work in other government departments.

In recent decades, several countries have conducted foresight exercises by MoD, and they provided information to all stakeholders with different levels of detail (Australia, 2011; Herz et al., 2006; Hundley and Gritton, 1994; Narula, 2013; Yasunaga et al., 2009). Most studies have confronted the individual vision of participants (research defence centres, universities, firms and experts in general) with the big picture shaped by everyone’s contributions. Thus, technology foresight in S&D can also integrate both science-push and market-pull approaches within the same strategic vision (Barker and Smith, 1995) and, as a result, reinforce the performance of national and supranational STI.

In 2014, the Chief Force Development of the Government of Canada published a study about their future security environment (Government of Canada, 2014). It is not a policy document and does not prescribe any capability requirements either, but it was generated through constant engagement with stakeholders. It contains geopolitical, economic, environmental, societal, STI, and military trends with a vision until the year 2040.

A revision of trends and megatrends in the USA has been predicted up to the year 2030 (National Intelligence Council, 2012). Among the topics that might affect S&D issues, technology and its diffusion is only a part of the report, and it is acknowledged as a game-changer. Since the 1940s in the USA, the RAND Corporation has had a significant role in shaping foresight, developing game-theory models of decision-making and military scenarios (Dreyer and Stang, 2013), and frequently producing technology foresight studies.

In the European Union (EU), researchers and intelligence analysts have developed several studies about strategic trends, major challenges and potential scenarios related to S&D issues. These include the studies by Missiroli (2013) and Amanatidou et al. (2012), and projects such as the SANDERA study on EU policy instruments for strengthening European synergy in defence research. However, all of the studies go beyond a technological vision and include issues about political affairs and geopolitical relations.

The first foresight programme of the UK (1993-1995) considered, among other issues, “Defence and aerospace” topics with an exercise based on the Delphi methodology (Georghiou, 1996). However, Keenan (2000) showed that their impacts were both delayed and diminished because the deliverables were delivered out of time. Nowadays, the UK publishes its description about a future S&D context in a separate communication. The last report extends until 2045 [Concepts and Doctrine Centre Development (CDDC), 2014] and its vision is presented in thematic and geographic areas. Among the issues that the report considers, defence capabilities have a small gathering of these areas. The first report of that sequence was a trend analysis supported by a wide external consultation of experts to make the information included in the report both comprehensive and independent.

Our review of the literature shows that most of the published S&D foresight reports are based on horizon scanning and trend impact analysis methodologies. MoDs and their associated agencies detect early signals of potentially important developments in geopolitics, the economy, society, the environment and climate change, STI, military technologies and capabilities, etc. New concepts are emerging every day to consider new strategic variables in the analysis.
2.2 Technology roadmaps for security and defence technology foresight

According to Kappel (2001), TRs are the most useful foresight method when coordination is otherwise difficult and the customers’ voices – the MoD, citizens, etc. – need strengthening. The discussion about how to balance qualitative and quantitative methodologies to inform this process has already been initiated (Zhang et al., 2015). Moreover, with the completion of TR implementation, any organisation might be assured that its required technology and infrastructure will be ready when needed (Gerdtsi et al., 2009), and at the same time that they might adopt a fast response to face “black swans” due to the high impact they have on human security. Under these assumptions, TRs developed by a MoD could be one of the best foresight methods for very intensive technology environments, as they suit their technological goals better than others.

TRs arise from the technical group areas required and desired, including research requirements (Phaal et al., 2004), and experts on technology are needed. Moreover, some issues related to the capabilities planning are secret or confidential because revealing them might pose potential danger to citizens or harm a MoD’s and their country’s interests. It should be noted that the final destination of S&D technology foresight exercises should be capability-based planning, which has become the gold standard for defence planning (De Spiegeleire, 2011). Due to the political and economic impacts of this planning, roadmapping is not only helpful for the stakeholders to share their knowledge and vision but also can work as a tool for new business creation (Yasunaga et al., 2009), which is a current need for the S&D industrial base in every country.

According to the development objectives of the TR by a government (Yasunaga et al., 2009), the goals of the TR in the focus area “Security and Defence” might be as follows: to enhance public understanding about the mission of the S&D investments; to help people in the R&D community understand future market trends and prioritise critical technology and built “common understandings” for planning dual-use technologies and consortia formed by different agents of the STI system; and to promote cross-sector alliances (academia–industry alliances, inter-industry alliances, etc.) to stimulate interdisciplinary technology. Therefore, the antecedents might be based on other methods such as horizon scanning or trend analysis – as many other national exercises embodied in the previous section have shown – given that they provide the specific context in which to analyse S&D issues.

Although an analysis of the level of implementation of the TR objectives (design and implementation) seems reasonable for evaluating the impact of the exercise, there is no consensus among scholars about a framework for foresight exercise evaluation (Sokolova, 2015). Among the classic evaluation criteria are the efficiency of implementation, their impact and effectiveness, the appropriateness of the objectives and the “behavioural additionality” criterion (Georghiou and Keenan, 2006). This last criterion provides a broader vision of the exercise evaluation. Additionally, it allows evaluating the actors’ behaviour resulting from the MoD’s intervention and whether the behaviour would be different. The analysis of ended TRs exercises contributes to the evaluation of TRs in the S&D context related to the design, implementation and results of the foresight exercise, as well as to the analysis of the impact of that exercise.

3. Spanish defence national foresight exercise

The literature examines the theoretical foundations of foresight, which generally recognises that there is a gap between practice and theory in the field (Hideg, 2007). Analysing the impact of public information about technological foresight provided by MoDs in Europe requires a review not only of the academic literature but also reports from the European Commission (EC), European Defence Agency (EDA) and National North Atlantic Treaty Organization (NATO). Thus, the extensive review evidences that the Spanish exercise
complies with the principles of future-oriented technology Analysis (FTA), which considers many forms of analysing future technology and its consequences: future orientation, participation, evidence, multidisciplinarity, coordination, action orientation and open foresight (Havas, 2005; Cagnin et al., 2008). The FTA is linked to innovation policy in two main ways: it is an advisory and strategic function and can focus on both the demand and supply side of innovation. Consequently, the analysis of the Spanish exercise has been conducted according to these principles.

To describe the tasks and the organisation of the Spanish exercise, we analyse every phase of the foresight process of Andersen and Rasmussen (2012). The first is the planning phase, which comprises the preparation and organisation of the foresight exercise. It includes the aim and motivation of the exercise, the target groups, the methods and participation. The second is the main phase, which produces sustainable knowledge, visions and future possibilities. It includes mapping (of several issues, including the scope, the system description and the strategic environment), generating foresight (future trends and visions), prioritising (among the alternatives) and planning (recommendations, action plan and policy implications). Finally, the third phase follows the exercise and comprises the dissemination of the results, the alignment of resources and stakeholders and the process of evaluation and learning. Due to the dates, the exercise was planned before the economic crisis of the European area, and so later budget cuts might have affected the main and follow-up phases. The next four subsections explain each of these phases for the Spanish exercise and the impact on defence technology and the industrial base of the country.

### 3.1 Planning phase: preparing and organising

The analysis which contributed to the technology foresight exercise was published in Spain in the *Defence Technology and Innovation Strategy (ETID)*. The performing organisation was the General Directorate of Armament and Material (DGAM), the governing body of the general state administration responsible for the direction, planning, implementation, and control of the procurement of weapon systems. It contributes to the ETID’s design in conjunction with domestic players. The exercise was designed by experts, and six functional areas or technological goals were defined relating to research and technology activities to cover the full spectrum of technologies of interest to the MoD. CapTechs from the EDA and NATO were analysed due to the agreements subscribed to in the R&D aims. Later, experts from Academia, industry and research centres contributed to the development of the roadmap.

The description of the characteristics and assessment of the Spanish exercise are shown in Table I. The analysis was realised according to public information of the exercise and based on the characterisation by Martin and Johnston (1999).

The typology of the FTA and its characteristic determination would enable important conclusions regarding the Defence Technology and Innovation Strategy and companies with related technologies. The Spanish Defence FTA typology (Table II) is outlined according to the issues of content and process, and the values according to (Cagnin et al., 2008, p. 32). The content is motivated by the development of know-how in some technological goals related to multiple technologies: armaments, ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance), platforms, personal protection, platforms and critical assets, and information and communication technology (ICT).

Its purpose is oriented towards action in the long term (more than 15 years) in the Spanish defence sector, with a high degree of uncertainty as to how this should be accomplished, as the EDTIB is under transformation due to overcapacity and the duplication of capacities throughout Europe. The FTA was a closed process where the experts were called to attend workshops, although the final elaboration was made by the MoD.
3.2 Main phase

The strategic environment in which the Spanish Defence Exercise was carried out was both the EU and NATO alliance. This phase is the main activity of the exercise because it is focused on mapping, generating of foresight, prioritising and planning.

The roadmaps for every technological sub-area are available in a public version in the web site (Spanish Ministry of Defence, 2015). For instance, the Roadmap for the Technology Goal TG 4.3.4 “To increase technological capabilities to reduce the physical load transported by combatants, reducing their dependence on batteries and increasing the energy efficiency of systems” is described as follows. Among the antecedents that are described in the left side of the figure, there are international and national projects and work groups. Some R&D projects carried out by civilian organisations and supported by the EC in its VII Framework Programme (FP7) are included. The RTO’s Task Group (SET-046) was formed by members from ten countries allied in NATO. This programme focuses on power management and reducing power consumption across all electronic systems, and specifically on the individual soldier war fighter to achieve the target mission duration carrying and using his/her future electronic equipment, using a power system of acceptable weight and volume. Another antecedent is the Spanish programme COMFUT “The Future Combatant”, which aims at an individual soldier integrated into a team that is able to fight on the digitised battlefield on which the future army will operate and that must also be able to fight and survive in a networked fighting environment. The Spanish MoD provides partial funding to projects proposed by companies whose objectives are national dual-use technologies via the “COINCIDENTE” programme, and H2B-M and FCSAI suit this TR.
3.3 Follow-up phase: disseminating and learning

To evaluate the successes and weaknesses of the Spanish exercise, we take into account the classic criteria of foresight exercise evaluation (Georghiou and Keenan, 2006): the efficiency of its implementation, its impact and effectiveness and its appropriateness. To test the efficiency, the right people have to be involved in the exercise; thus, the analysis of the TR dissemination and impact on the set targeted industry was required. Table III shows several success factors and weakness of the Spanish exercise. The instrumental use is guaranteed because the outputs of the foresight process are being used directly to inform decision-making processes (i.e. the COINCIDENTE programme).

The outcomes and outputs’ impacts and the effectiveness of the Spanish exercise are wider than the version of the TR for each technology goal. Although a common goal of the foresight is the reorientation of the STI system, during 2014 and 2015, the innovation and technology centres that depend on the MoD reorganised their structure under the technology centre named the National Institute for Aerospace Technology “Esteban Terradas” (INTA).

The last relevant element of the follow-up phase in a foresight process is learning. In the Spanish exercise, learning appears at many levels, not only inside the MoD, because many stakeholders were involved and with different agendas. However, one of the considerations for future S&D exercises might be a greater diffusion among all stakeholders. In order to evaluate the appropriateness of the results, the public policy intervention, and the alternatives that may occur, the key question concerns “behavioural additionality” (Georghiou and Keenan, 2006): What would the difference in an actor’s behaviour be as a result of the foresight intervention?

3.4 Impact on Spanish defence technological and industrial base

The Spanish security, defence, aeronautics and space firms invoiced 9.4bn (euros) in 2014, 82 per cent of which was provided from exports and 10 per cent of which was invested in R&D. This provided direct, stable and highly qualified employment to 49,994 people. This represented 1 per cent of Spain’s gross domestic product (GDP) and 5.5 per cent of the industrial GDP of Spain[3].

3.4.1 Cases selection and methods for analysis. To analyse the influence on strategic foresight in defence firms, from October 2014 to June 2015 we carried out a study of the MoD’s contractors. The case study methodology represents the best way to investigate the firms because it is especially applicable when studying phenomena that cannot be separated from their context and whose relations are too complex to use quantitative methods. The five firms studied (two large firms and three small- and medium-sized enterprises (SMEs) were chosen because they only have Spanish private capital, have patents in relevant business areas (with a direct effect or not in defence products and services) and are contractors at different levels of the supply chain, but also because they have direct contracts with the MoD for technology, products or services related to the scope of the ETID. The selection of firms covered the technologies for S&D incorporated in

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<td><strong>Successes</strong></td>
<td><strong>Weaknesses</strong></td>
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<td>Involvement of stakeholders</td>
<td>Limited involvement of users</td>
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<td>Process benefits</td>
<td>Influence on corporate foresight in defence sector’s firms</td>
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<td>Relating priorities to present and future spending</td>
<td>Slowing implementation into action</td>
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<td>Adaptation to national context of the priorities (STI-Spanish Strategy)</td>
<td>Low involvement of citizens</td>
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<td>Adaptation to the international defence context (Cap-Techs-EDA and NATO)</td>
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products, goods and services related to infrastructure, logistics support, vehicles, avionics, remotely piloted aircraft systems (RPAS), command and control systems, simulation, optronics, embedded electronics, armaments, ICT and software. These selection criteria enable us to analyse the Spanish firms that are more relevant in the S&D sector to analyse the influence the Spanish exercise made by policy makers had on the firms’ activities.

After the public documentation study of the MoD, we contacted experts in foresight and the defence economy from Spain, Colombia and Mexico to properly configure an interview outline for the semi-structured interviews that were conducted during the months of May and June 2015. The interviewed people were the R&D director managers of each firm, although some other employees with responsibilities related to technology and commercial issues were also consulted to reduce inconsistencies (Eisenhardt and Graebner, 2007). The interviews were recorded for more than 300 min and transcribed in nearly 100 pages about technology strategy and related issues, such as the technological information provided by the MoD. To overcome common method bias and improve internal and external validity and case study rigour, the data were triangulated (Gibbert et al., 2008). Organisational documents such as patents, collaborative projects with public support whose deliverables are published in open access, websites, financial reports and memorandums, and reports supplemented the interviews by providing additional insights into the context of the planning and generating of foresight in these companies. The appendices include the cross analysis among the selected topics at least in four cases in an axial coding process, where the categories are related to their subcategories tested in a previous open coding (Corbin and Strauss, 1990).

3.4.2 Case study results. The general perception about technology foresight – as a tool for making decisions – is that it has low relevance because they are more in need of ensuring specific contracts with the MoD with their current technologies and products. According to the managers of the firms, activities related to technology foresight are made mainly for big companies because they have more resources to plan and execute R&D projects (technology-push). These investments in time and resources may be useful in the future, even if they may not have a commercial purpose now (market-pull) or they are a potential failure. The interviewed firms are not familiar with the MoD TR because they do not include recommendations in the short term for them, and do not provide highly differentiated information from other sources. However, the large firms (more than three hundred employees) interviewed were more familiar with international organisation workgroups (EDA and NATO) and had even participated in some of them, and they had found the Spanish exercise to be coherent with their technology surveillance. As a result, their interest in the TR published by the MoD was only informative because they are able to launch R&D projects according to their own proper analysis, although the consultation on their related technologies for the public TR was a confirmatory input to keep on-going projects and ideas for new R&D projects in the future.

Figure 1 shows the relations modelled by Gephi software with the (Fruchterman and Reingold, 1991) algorithm applied to the semantic relations among the different issues concerning this technology strategy. More incidence in the responses was considered as more important according to frequency and occurrence in one to five firms (size of the node), and a different range of colours was used for issues related to technology (green), the environment (blue) or commercial functions (red).

These results from the interviewed firms indicate that the TR information published by the MOD (MOD-Roadmaps) is not as important to them as it should be, especially if we consider that the MoD is their major client. They acknowledged that it is beneficial for the firms to be involved in the Spanish exercise, although the information published for public use is not relevant enough to help define their technological strategy. Therefore, the information from the MOD is not an input for the strategic areas of the studied firms. However, they value that the information could be useful, especially in terms of preparing to
face technological discontinuities, and also for building alliances, developing strategic foresight and reducing the uncertainty in the firm’s technological area.

4. Discussion

Government funding of defence-related R&D influences innovation in civilian technologies, although this is still a controversial issue (Mowery, 2012). However, studies support that the collaboration between civilians and researchers incorporated in the MoD can influence the rate and direction of scientific activity (Colatat, 2015). Research in selected technological areas will increase the efficiency of military operations and will reduce human and environmental loses (Saritas and Burmaoglu, 2016).

The Spanish MoD might have chosen such a methodology to mobilise the changes that were required to face the future. Therefore, the main reason for this methodology is the modernisation of the security and safety systems and structures in a specific economic context where public budgets for defence are ramping down and where R&D for dual-use technologies is more urgent every day and foresight for S&D will have more impact on future investments.

The TR is considered among the analysis methods that are more relevant to the stages of commercialising and launching innovations, and that is precisely why the actors involved in the Spanish exercise could have lost opportunities. TRs work well in combination with most other methods because they provide a way for industry to play within its comfort zone of uncertainty, but involvement also means a key challenge as part of strategy or policy-making (Smith and Saritas, 2011; Zhang et al., 2015). More open and visionary exercises might reach desirable audiences that are not targeted with the current methods, including SMEs and citizens.

A policy toolbox is one of the desired responses after a foresight exercise, which is useful in this case to increase citizens’ S&D culture, as well as due to the benefits derived from it.
Likewise, technology foresight may orient innovation towards future users’ demands during the early phase of the innovation development, and it may also be useful in the growth phase of a technology (Kappel, 2001; Salo and Cuhls, 2003).

Our research shows that in the case of the Spanish Defence National Foresight Exercise, the TR has been mainly performed by specialists. However, the individuals in future societies will be more aware of being part of a single human community in a highly interconnected world. This means that increasingly individual empowerment requires more participation and foresight exercises should actively incorporate citizens. Citizens are more aware of the risks posed by a lack of security. Asymmetric warfare has the capacity to unpredictably and quickly unbalance the regular S&D plans. Therefore, the larger participation of citizens within the planning phase of foresight exercises may favour public investment in S&D. However, their nature (secrecy, confidentiality, etc.) makes this involvement more difficult in practice.

SMEs should also participate to improve the industrial base of Europe. Our study following the Spanish exercise shows the lack of interest or awareness among SMEs of the potential benefits of integrating the information supplied by the TR with the firm’s competitive strategy. European programmes on S&D should be more politically active to incorporate SMEs in their foresight exercises from the very beginning, that is, the exercise’s phase planning.

Other methods of exercise foresight allow the combination of experience, interaction, creativity and evidence in their planning and main phases. The participation of every stakeholder in defence and security issues (privacy over the issues should be assured) enables a better way to disseminate the results and increases the effect of innovation policies beyond the sector.

5. Conclusions

Our conclusions and the propositions for future empirical research are directed towards the impact analysis of Spanish technology foresight exercises in S&D issues regarding governments, firms and citizens. The qualitative and quantitative impacts of technology foresight exercises should pay attention to both the contribution of national S&D of their citizens, and to the science and technology system. Their contributions should be directed to improve efficiency, and the effect on their upcoming decisions.

Policy makers have an interest in maintaining and reinforcing a strategic industrial base of S&D firms with high-technology capabilities. The increasing specialisation requirements and dual-use technologies will allow access to new providers if they are capable of including technology related to the future developments when new R&D projects are launched. Therefore, the capability that an organization has built up in managing alliances makes an important contribution to the enhancement of alliance success (Draulans et al., 2003). As a result, collaboration between partners contributes to the development of long-term relationships, sometimes with the support of strategic players (i.e. MoDs or industry).

The results of national foresight exercises must be disseminated as much as possible and provide a forward-looking approach. A toolbox that benefits the stakeholder, specifically an industrial policy for the S&D sector, would be welcome. Some dual-use technologies are considered as game-changing, it means that can be applied to a relevant problem in a manner that radically alters the symmetry of military power between competitors. The use of game-changing technologies outdates the policies, doctrines and organizations. In this scenario, a well-known capacity of the industry by MoD, and sharing technology information can reinforce the final phase of the foresight exercise.

These exercises are contributions that favour the consolidation and specialisation in high value-added activities in all current and potential suppliers of products, goods and services for S&D purposes. In this context, primary defence contractors should have the resources...
and capabilities to feed big systems of technological surveillance and access experts to
develop novelties in a relatively short time. However, a large percentage of European
companies are small. Potential technology suppliers for S&D purposes could enhance
European competitiveness and the efficiency of public finance.

A desirable issue for future foresight exercises would be to increase citizens’ participation in
them, but it would be complicated in the field of S&D technology. However, society should
participate in a preliminary phase of the next exercise to contribute its vision of the
fundamental rights of citizens, the social component of the future decisions, etc.

The conclusions of our study should be interpreted in the light of its research
limitations. For instance, we have not tested the impact of the exercise on non-target
audiences (i.e. Spanish firms that have dual-use technologies), and we only use the
public information provided by the MoD for the analysis. Future studies about the
impact of foresight exercises in the defence sector should incorporate a wider focus
(i.e. citizens, research centres) because they influence and have implications for
strategic decision-making in science and technology systems. Therefore, the impact of
TRs should be larger than we have found and could even go beyond the S&D industry.
A longitudinal study could be useful to analyse the impact of every phase of the study
and improve the dissemination and learning phase that support new policy instruments;
the efficiency of the exercise could even be measured in economic terms for some of
the agents of the national system, such as firms.

Notes

1. The reasons to justify the design and the development of this exercise are not published. The
   authors are not policy makers, and they did not take part in any way in the Spanish exercise.
2. CapTech (Capability Technology group) is a working group of the EDA Research & Technology
   Directorate dedicated to a particular technology area. Their purpose is the generation of
   collaborative projects within the scope of technology and the support of EDA participating Member
   States in the preparation of wider programmes.
3. Data from TEDAE: http://tedae.org/es/acciones/la-industria-espanola-de-defensa-aeronautica-y-
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Summarizing the decadal literature in open government data (OGD) research: a systematic review

Stuti Saxena

Abstract
Purpose – This paper aims to summarize the open government data (OGD) research which has become an increasingly engaging domain for the academic community.

Design/methodology/approach – Scanning the literature on OGD, the paper underlines the different strands observable in the OGD-based research. The paper concludes with research pointers, limitations and implications for practitioners.

Findings – OGD has been investigated from different angles, and there is a need for more empirical investigation across contexts.

Originality/value – The paper serves as a reference point for OGD research.

Keywords Literature review, Open government

Paper type Literature review

1. Introduction

Primarily speaking, while conducting transactions with the citizens, public and private organizations on a day-to-day basis, the government agencies of any country assume the responsibility of retaining data regarding these transactions (Alexopoulos et al., 2014; Vieira and Alvaro, 2018). Furthermore, as the governments are transitioning into e-governments with the advances in the sphere of information and communication technology, public services are being delivered in a novel manner (Mpinganjira, 2015), and there is increased participation of users in e-government modalities. As an advanced stage of e-government, open government data (OGD) initiatives are being espoused by many governments these days (Adu et al., 2016; Huijboom and Van den Broek, 2011; Jetzek et al., 2014). OGD is also referred to as public sector information (PSI) or open public data (OPD). OGD landscape is like an “ecosystem” with seven key elements: “releasing and publishing open data on the internet; searching, finding, evaluating and viewing data and their related licenses; cleansing, analyzing, enriching, combining, linking and visualizing data; interpreting and discussing data and providing feedback to the data provider and other stakeholders; user pathways showing directions for how open data can be used; a quality management system; and different types of metadata to be able to connect the elements” (Zuiderwijk et al., 2017, p. 17). OGD may be defined as “machine-readable data (which is) discoverable, available, and downloadable through dedicated internet portals without cost to potential data users” (Dawes et al., 2016, p. 15). Data sets may be related to diverse sectors like science and technology, finance, transport, health, politics, environment, education and the like (Ubaldi, 2013). Governments should make certain that they release data sets in a well-timed manner and data sets should be complete, accessible and available and of good quality (Jaeger et al., 2012; Meijer et al., 2012; Martin et al., 2016;
Open data initiatives are instrumental in facilitating democratic processes by promoting transparency; cementing citizen trust; furthering citizen participation and engagement in decision-making; improvising policy-making and providing opportunities for stakeholders to collaborate among themselves as well as with the government, private sector and non-profit sectors to “re-use” OGD for generating innovative solutions to social problems (Attard et al., 2015; Chatfield and Reddick, 2017; Craveiro and Albano, 2017; Danneels et al., 2017; Janssen, 2011; Loureno et al., 2017; Marjanovic and Cecez-Kecmanovic, 2017; Martin, 2014; Mason, 2010; Wirtz et al., 2017a; Yang et al., 2015). Specifically, “OGD practice involves the publication of government data on a Web platform to meet the right of the public to know and also involves the mobilization of these data to create social value depending on how such data will be used” (Fan and Zhao, 2017, p. 402). Therefore, users harness these data sets to improvise upon their businesses or professional performance besides making major contribution to these data sets. Implicitly, OGD is known to stimulate innovation through collaboration between the government and the users (citizens, businesses, software developers) (Verhulst and Young, 2016). For instance, software developers and the government collaborate on the social coding platform GitHub to contribute towards the revamped version of the source code (Mergel, 2015). Summing up, the underlying ethical motives of opening data by the government are to ensure increased civic participation, transparency and public accountability in administration (Sieber and Johnson, 2015, p. 309).

Extant research shows that OGD initiatives of any government facilitate efficiency, economy and effectiveness in administration (Fernandes and Fresly, 2017; Janssen, 2012; Kassen, 2013; Ruijer et al., 2017a; Tough, 2011). OGD helps in boosting the economy of a country and has prospects for private and non-profit sectors (Jung and Park, 2015). For instance, in the private sector, firms and entrepreneurs have been harnessing OGD for building competitive advantage by gaining market insights, tapping business opportunities, improvising upon business processes and creating new products and services (Magalhaes and Roseira, 2017). However, there are concerns with opening of data sets by the government. For instance, there are secrecy issues on the part of the government which is reluctant to part with its valuable data in public for various reasons (Cuadrado-Ballesteros et al., 2014; Lee et al., 2012). Furthermore, there are cyber-threats which need to be tackled and in the absence of a robust IT-enabled surveillance infrastructure, opening of data sets may seem counter-productive to the government. Concomitantly, there are privacy protection issues which need to be tackled by the government for securing the trust of the citizens (Sanchez and Viejo, 2017). Finally, it is also important that any government possesses the requisite technological strength to ensure the long-term viability of the OGD initiatives undertaken by the government (Gunnlaugsdottir, 2015).

A comprehensive literature review of OGD research was conducted in 2016 (Hossain et al., 2016) where the extant literature was summarized and pointers were advanced for carrying forward the OGD-focused research. However, in the past two years, a lot of academic interest has been witnessed in the OGD domain and significant contributions – empirical and non-empirical – have been made. Therefore, it is pertinent to re-attempt a systematic literature review of the OGD-focused research for providing a better understanding of the onward progression of academic interest in OGD domain. The paper follows a systematic literature review approach to arrive at conclusions regarding the OGD research. The paper is structured as follows: Section 2 provides a brief on the research methodology; Section 3 provides an overview of the research strands identified in the extant OGD literature; and finally, Section 4 leaves concluding remarks, a brief about the academic and practitioner implications and the limitations of the study.
2. Research methodology

The present study seeks to summarize the published OGD-focused research. Therefore, for conducting a systematic literature review, we adopted a suitable literature search strategy wherein we identified the criteria for inclusion of studies for our present purpose (Kitchenham, 2004). We collected and analyzed papers in three phases: first, we collected published works in April, 2016; then, we studied research work in June, 2017 and finally, we probed studies in August, 2018. Specifically, we chose keywords as: OGD; Open Data; OPD; and PSI. We referred published works from Emerald, Science Direct, Taylor and Francis, Sage, and Wiley. To ensure that our review meets quality rigor, we retained papers that were published in peer-reviewed journals. Therefore, conference proceedings, working papers, unpublished dissertations, magazine articles and opinion articles remained outside our purview for the present. We found that until the systematic literature review of Hossain et al. (2016) had been published, most of the OGD-focused research was concentrated on providing a conceptual and theoretical base to the OGD domain. In the past two years, there has been a dramatic spurt of empirical and applied OGD-focused studies in different contexts.

3. Research strands identified in OGD-focused research

It has been deduced from extant literature that with the large number of OGD initiatives in the West, more academic interest has yielded research output in the West than in the other parts of the globe (Huijboom and Van den Broek, 2011; Janssen et al., 2012; Zuiderwijk and Janssen, 2014). For instance, OGD-focused research has been more potent in the USA and the European countries. However, of late, academic interest is brewing in the developing countries too (Saxena, 2017a, 2017b, 2017c, 2017d, 2017e, 2017f, 2017g; Saxena and Janssen, 2017; Saxena and Muhammad, 2017). At the same time, there is research veering around the bottlenecks in implementing OGD initiatives (Charalabidis et al., 2016). Likewise, there are more theory-driven research studies and less of empirical works in the OGD domain. Furthermore, there are studies focusing upon the propellers and bottlenecks in OGD initiatives.

Broadly, three strands emerge from the OGD research conducted so far:

1. OGD-focused research with theoretical and conceptual underpinnings;
2. applied (contextual) research; and
3. user-focused research.

The three strands are elaborated below (Also, Appendix).

3.1 Theoretical/conceptual research on OGD

As far as the conceptual/theoretical research on OGD is concerned, different strands have been picked up by researchers. Based on a review of 103 articles, Meijer et al. (2012) provided insights about the concepts of openness, transparency and participation as far as OGD initiatives are concerned. McDermott (2010) underlined the significance of OGD initiative in promoting transparency and accountability. The major limitation of the study was that it was contextualized in the USA. Therefore, generalization of the findings is not possible. In another study, the implications of tapping open data alongside Big Data technologies was underlined in the case of the Open Data initiative of Oman (Saxena, 2016). Saxena (2017f) underlines the significance of culture in OGD policies of countries such that some cultures are more “open” than the “others.” For instance, her study shows that with a “collectivistic” culture, Saudi Arabia’s OGD portal is more insular in comparison with that of The Netherlands and Japan which are relatively “individualistic.” Further, in another study, the basic fundamentals governing the conception and implementation of
OGD initiative has been underscored (Wirtz and Birkmeyer, 2015) wherein the defining features of Open Government have been enumerated. The basic drawback with this study was the absence of the contextualization of the findings. In another study, Zuiderwijk et al. (2012) underline the significance of OGD in terms of being re-used by different stakeholders. These authors also underlined the importance of metadata for any OGD initiative. Likewise, Janssen et al. (2012) investigated the advantages, adoption barriers and five myths associated with OGD by drawing insights from the views of the participants in different academic workshops. However, the drawback with their study lies in its being prescriptive in approach.

Susha et al. (2015) conducted an interpretive meta-analysis approach and five benchmarks were compared with regard to metadata (key concepts, themes and metaphors), meta-methods (methodologies underlying the benchmarks) and metatheories (theoretical assumptions at the foundation of the benchmarks). The authors concluded that it is important for governments to set comprehensive benchmarks for monitoring and evaluating the roll-out and implementation of OGD initiatives. Furthermore, OGD-focused research has contributed to some conceptual models as well. For instance, one of the models outlines the stages in the roll-out of any OGD initiative (Kalampokis et al., 2011b, 2011a) and another model expounds the degree of interaction among the stakeholders involved in the OGD initiatives directly or indirectly (Sieber and Johnson, 2015). Kalampokis et al. (2011a, 2011b) have classified OGD into “downloadable files” (data are available in simple formats), “linked data” (data are linked with another one and re-used), “direct data provision” (all data are available via a portal and synchronized with time) and “indirect data provision” (actual data are provided and the user is responsible for further aggregation and processing of the data). Therefore, a four-stage model (aggregation of government data; integration of government data; integration of government data with nongovernment data and integration of government data with nongovernment formal and social data) is identified by Kalampokis et al. (2011a, 2011b). However, the drawback of the study lay in being more technical in approach wherein the emphasis was laid down on the crude mechanistic dimensions of linked data. Saxena (2017b) provided a typology of countries on the basis of their OGD-adherence (“laggard,” “caged,” “forerunner” and “champ”) wherein the “Laggard” countries are the ones where there are hindrances associated with OGD implementation and OGD-usage; “Caged” countries are those with less propensity to implement OGD initiative but increased potential of usage by different stakeholders; “Forerunner” countries as those which hold high potential of rolling out an OGD initiative but low potential of usage by different stakeholders; and “Champ” countries as those which ranked high in terms of implementation of an OGD program as well as usage by diverse set of stakeholders (p. 219) (Table I).

Likewise, Sieber and Johnson (2015) provide four models which deal with the “nature of (OGD) delivery (which) shapes the way the data is used” (Sieber and Johnson, 2015, p. 310). Table II summarizes the four models.

Furthermore, in another study, an OGD life-cycle has been sketched wherein the major stages are data collection by the government, data selection and sorting, data refining, data publishing and data linking (Attard et al., 2015).

### 3.2 Applied (contextual) research on OGD

At another plane, OGD-focused research may be identified which is “applied” in nature and scope. By “applied”, it is implied that such OGD-focused studies were context-based and inferences were drawn based on the specific case studies in different countries or regions. For instance, the prospects and challenges of OGD initiatives in Australia were explored with particular focus on the societal culture which prevents trespassing into the privacy of the people (Hardy and Maurushat, 2017). Likewise, Saxena (2017g, 2017a) underlined the significance of OGD for the Gulf Cooperation Council (GCC) countries besides tracing the
challenges and prospects of implementing robust OGD initiatives across the GCC countries. Saxena (2017b) followed up her OGD investigation in the GCC context to underline the significance of harnessing OGD for furthering economic diversification aims of the GCC countries. Furthermore, a SWOT (strengths, weaknesses, opportunities, threats) analysis was conducted to analyze the Government 3.0 drives of Korea to appreciate open government efforts for open data, freedom of information, enhanced governance with citizens and interorganizational collaboration (Nam, 2015).

Table I  Typology of countries as per OGD implementation and facilitation for usage

<table>
<thead>
<tr>
<th>Country classification</th>
<th>Low potential for OGD implementation</th>
<th>High potential for OGD implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>High potential for OGD usage by citizens, businesses and the like</td>
<td>CAGED</td>
<td>CHAMP</td>
</tr>
<tr>
<td>Strategy to be adopted by the country</td>
<td>Forging ties and building networks with forerunners and/or champs might provide the right lessons to derive benefits from OGD implementation</td>
<td>Maximum social and economic value may be reaped from proper OGD implementation</td>
</tr>
<tr>
<td>Low potential for OGD usage by citizens, businesses and the like</td>
<td>LAGGARD</td>
<td>FORERUNNER</td>
</tr>
<tr>
<td>Strategy to be adopted by the country</td>
<td>Formidable barriers to derive social and economic value from OGD implementation</td>
<td>Social and economic value may be derived by generating awareness and forging collaboration among and with the users and policy makers</td>
</tr>
</tbody>
</table>

Source: Adapted from Saxena (2017b)

Table II  Citizen engagement models proposed by Sieber and Johnson (2015)

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data over the wall</td>
<td>This is the basic citizen engagement model wherein the government publishes data sets on the online portal directly. Basic features like downloading of data sets, visualization, mapping or sorting are allowed. Data sets are available in formats like PDF, Excel, etc. Programmatic access may be permissible via software-to-software interface (i.e. application programming interface or API). Users are encouraged to report errors in the form of feedback.</td>
</tr>
<tr>
<td>Code exchange</td>
<td>Government encourages the re-use of data sets for innovating products and services. Therefore, the government publicizes and promotes the OGD initiative by holding events, conferences, workshops or “app” contests. Software or application “app” developers, civic hackers and social entrepreneurs are encouraged to participate in such promotional activities.</td>
</tr>
<tr>
<td>Civic issue tracker</td>
<td>Citizens contribute to the existing data sets in many ways. For instance, citizens report of civic problems (e.g. fire, accidents, drainage problems, floods, potholes, etc.) which necessitate immediate action by the government authorities. By encouraging participation of citizens in the OGD initiative, the government is regularly informed about the civic issues and this facilitates in revising and updating the data sets (Dawes and Heilbig, 2010; Alexopoulos et al., 2014).</td>
</tr>
<tr>
<td>Participatory open data</td>
<td>As an ideal model wherein citizens and governments enter into a dialogue via the OGD initiative, there is active engagement and participation of citizens in the policy-making and policy-implementation stages. Citizens are encouraged to freely contribute towards the existing data sets via the online portal. Furthermore, all grievances of the citizens pertaining to the quality of the data sets are rectified in the prescribed manner. Data sets are qualitatively superior in this model with metadata and permit statistical analysis, interpretation, visualization and mapping.</td>
</tr>
</tbody>
</table>
Following a case study approach, Berrone et al. (2016) provide a framework for serving as a practical guide for both urban and private leaders to implement open data strategies in the city of Barcelona. In a case study presenting different models of open data utilization in The Netherlands, Janssen and Zuiderwijk (2014) outline six types of business models: single-purpose apps, interactive apps, information aggregators, comparison models, open data repositories and service platforms. In another study, features and content of open data portals of American cities were investigated, and it was concluded that the open data portals were in initial stages of development, and it was important that user-friendly features should be included in the open data portals for helping the users to comprehend the data with the help of mapping and visualization tools (Thorsby et al., 2017). The study by Huijboom and Van den Broek (2011) attempted a comparison of OGD frameworks across Australia, Denmark, Spain, UK and USA. Their study was primarily focused on appreciating the factors which facilitated or hindered OGD implementation.

A comparative study across Israel, GA and Uzbekistan was done to appreciate the nature and scope of OGD initiatives, and it was found that OGD initiatives are at a nascent stage and the degree of commitment of these countries towards institutionalization of OGD was less (Saxena, 2017c). Rothenberg (2012) followed a case study approach wherein the OGD frameworks of USA, UK, Canada and New Zealand were compared. The purpose of selecting these four countries lay in the marked similarities of culture among them. Furthermore, in another study, the OGD ecosystems of Mexico, Russia and USA were compared using a comparative research approach to assess the contextual factors which impact implementation of OGD initiatives in these countries (Styrin et al., 2017). Evans and Campos discuss about the OGD initiatives in the USA where the websites linked with OGD are reviewed (Evans and Campos, 2012). A two-year ethnographic study is conducted in several French administrations involved in open data programs, Denis and Goeta (2017) investigate the conditions of the release of open data and they conclude that the published data should meet the standards of human and technical intelligibility.

While underlining the complexity of open data initiatives in Taiwan, Yang et al. (2015) lend four perspectives: technology, organization, legislation and policy and environment. Taking the example of the National Health Service in England, Keen and his colleagues have probed into the possibility of tapping OGD held by health-care sector by using Big Data analytics (Keen et al., 2013). China’s OGD initiatives have been probed in terms of the major impediments to its implementation which are mostly linked with the concerns for privacy and national security (Piotrowski et al., 2009). Likewise, a study based in Africa aimed at understanding the extent of OGD implementation regarding the characteristics of an “ideal” OGD portal and the study was conducted in five (Ghana, Kenya, Sierra Leone, South Africa and Tanzania) out of the seven (Ghana, Sierra Leone, Tunisia, Morocco, South Africa, Kenya and Tanzania) OGD centers (Afful-Dadzie and Afful-Dadzie, 2017a, 2017b). Piscopo and his colleagues have attempted to predict community participation by invoking “Random Forests” – a machine learning technique – to investigate OGD at local levels in the UK (Piscopo et al., 2017). In another study, OGD initiatives at the Swedish municipality levels were probed using institutional, social, technical and economic angles (Lassinantti et al., 2014). Likewise, OGD initiatives in 561 municipalities of Brazil were probed with reference to their role in furthering transparency in government (Correa et al., 2017). In a study contextualized in the local government of UK, the role of OGD was assessed in terms of facilitating more factual, evidence-based and transparent policy decision-making and evaluation (Sivarajah et al., 2016).

In another study, Maseh and Katuu (2017) solicited responses from the legal professionals associated with the Kenyan judiciary and analyzed the success potential of the OGD initiative in Kenyan Judiciary. It was deduced in their research that the significance of records management was the major factor which was responsible for the success of the OGD initiative. In another study, an ecosystem approach was undertaken to probe the OGD
initiatives of St. Petersburg and New York, and it was concluded that the interaction between the human and the technical elements was responsible for the effective roll-out of the OGD initiatives (Dawes et al., 2016). In another study, Kassen (2013) investigated the OGD initiative in Chicago at the local level and underlined the significance of OGD initiative for effective collaboration between the government and the citizens. Further, Kassen (2013) underscored the merits of citizen engagement and citizen participation for the effectiveness of the OGD initiative. In Ghana, the research was undertaken by Ohemeng and Ofosu-Adarkwa (2015) to underline the major drivers and barriers in the roll-out of the OGD initiative. Further, their study underlined the importance of meeting the needs of the citizens as far as providing government information is concerned. Therefore, greater pro-activeness of the government departments is required for the implementation of the OGD initiative.

Piotrowski (2017) conducted a content analysis of the 62 commitments in the US Second Open Government National Action Plan and concluded that there are implementation challenges in terms of realizing the goals of transparency and participation of government agencies in furthering OGD drives. By invoking the modified Unified Theory of Acceptance and Use of Technology (UTAUT) model, an empirical research was conducted to underline the factors which impact the usage and adoption of OGD (Zuiderwijk et al., 2015). In another study which was technical in approach, Harris and Baumann (2015) investigated 21 policy and legal OGD sources pertaining to satellite Earth observation and deduced that OGD may also be used in private sectors to derive value. In another study contextualized in the City Council of Gerona (Spain), the role of strategic planning and management of OGD initiative was laid down to ensure that public accountability and transparency goals are better achieved (Serra, 2014). In a comparative study involving the OGD initiatives and policies of UK, USA, The Netherlands, Kenya and Indonesia (Nugroho et al., 2015), it was pointed out that quality of data sets should be taken into consideration as far as any OGD initiative is concerned.

### 3.3 User-focused research on OGD

Some of the research studies have been undertaken to investigate the dynamics involving the interaction between diverse set of users. However, there has been relatively little instances where the democratic ideals of OGD initiatives – participation and collaboration – are being realized (Hansson et al., 2015). Open Data is amenable for being a form of data activism and advocacy: requesting, digesting, contributing to, modeling and contesting data (Schrock, 2016). For instance, Bates (2014) undertook an interview-based research approach to underline the manner in which the stakeholders re-use the data sets in the UK context (Bates, 2014). In an empirical investigation based in Austria, the technology acceptance model (TAM) was adapted wherein a sample of 773 respondents was taken to investigate the extent of interaction and engagement with the OGD platform “LookatLinz,” and it was found that “perceived usefulness” and “perceived attractiveness” were significant predictors of user engagement and participation (Schmidthuber et al., 2017). In an empirical investigation conducted on a sample of 210 citizens in Germany, the extended TAM was deployed to underlie the relationship between the constructs (ease of use, usefulness, transparency expectancy, participation expectancy, collaboration, intention to use OGD, word-of-mouth intention concerning OGD), and it was found that all the five constructs were significant predictors of intention to use OGD and to collaborate among each other using word-of-mouth (Wirtz et al., 2017b).

In another empirical investigation conducted in India with a sample of 244 respondents, OGD use and acceptance among different users was probed, and it was concluded that OGD use has increased in the country and men are more likely to tap OGD than women (Saxena and Janssen, 2017). In another study, the significance of the involvement of policymakers, citizens, government, international organizations and private sector was underscored (Gonzalez-Zapata and Heeks, 2015; Ruijer et al., 2017b). In their study based
on Chilean OGD initiatives, Gonzalez-Zapata and Heeks count “academics” as secondary stakeholders who have “informal or non-essential planning and implementation roles in OGD” (pp. 445). In another study based on empirical investigation to ascertain the adoption of OGD “use” among researchers, civil servants and citizens, OGD “use” was classified as “to perform statistical analysis,” “for data linking (combining different data sets),” “to write academic publications,” “to perform investigations (non-scientific and non-policy),” “for political and policy-making decisions,” “for curiosity and/or recreation,” “for daily operation in work,” “for news reporting” and “other purposes” (Zuiderwijk et al., 2015).

4. Concluding remarks, implications and limitations of the study

The paper summarized the extant literature on OGD in a nutshell, and this may serve as a reference point for further research on OGD. Further research is required to assess the benchmarking in OGD initiatives so that the best practices may be identified for replication by others. Comparative research may be undertaken to underline the drivers and barriers in OGD initiative implementation. Apparently, empirical research is wanting in the OGD domain conceding that OGD is an emerging research domain among the academics. Furthermore, experimental settings should be able to lend further insights into the behavioral and applied dimensions of OGD initiatives. Governments have been forthcoming in launching OGD initiatives at national levels; however, it is important that OGD initiatives also take-off at the regional and local levels. Moreover, there is a need to ensure that the OGD initiatives are sustainable in the long run, and this may be achieved by ensuring that the quality of the data sets is maintained. The vision of the government should be clear in terms of the implementation of the OGD initiative so that the goals of transparency and accountability are met and there is increased trust and engagement of the citizens in policy-making and administration. Finally, the overall objective of the OGD initiative may be realized when the data sets are re-used for creating value, and this implies that the data sets should be re-used by a diverse set of stakeholders.

The study is limited in its scope owing to its descriptive approach. The study did not cover conference proceedings, monographs, dissertations, etc., and the same may be integrated in future works. The study also could not tap the working papers and monographs published in offline and online modes. Finally, the study did not include contributions made in languages other than English language. It may be appropriate to extend the contribution of the present study by taking cognizance of the aforementioned pointers.

References


Further reading
### Appendix

<table>
<thead>
<tr>
<th>Author/s</th>
<th>Context</th>
<th>Research methodology</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theoretical/conceptual research</strong></td>
<td></td>
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</tr>
<tr>
<td>Machova et al. (2018)</td>
<td>Provides a usability evaluation of governmental data portals and provide a list of best practices for improving stakeholders’ ability to discover, access and reuse of these online information sources</td>
<td>Case study</td>
<td>There is a lack of active involvement of stakeholders in the OGD initiative and there is a need for quality improvization of the OGD portals</td>
</tr>
<tr>
<td>Janssen et al. (2017)</td>
<td>Seeks to propose the concept of transparency-by-design to advance open government</td>
<td>General review of literature</td>
<td>OGD systems should inhere the concept of transparency by all means</td>
</tr>
<tr>
<td>Afful-Dadzie and Afful-Dadzie (2017b)</td>
<td>A comparative literature survey of Open Government Data (OGD) and Freedom of Information (FOI)</td>
<td>Topic modeling, text mining and document analysis methods</td>
<td>Four dimensions emerge for the success of OGD initiatives are: disclosure, publishing, access and cost of requests</td>
</tr>
<tr>
<td>Saxena (2017b)</td>
<td>Reviews the strengths and weaknesses of open government data (OGD) in the Gulf Cooperation Council (GCC) member states: Bahrain, Kuwait, Qatar, Oman, Saudi Arabia and the United Arab Emirates (UAE)</td>
<td>Documentary analysis</td>
<td>OGD policies of the GCC countries are at an early stage and merit institutionalization of robust OGD policy frameworks by the government</td>
</tr>
<tr>
<td>Huang et al. (2017)</td>
<td>Investigates the barriers to OGD release in China and proposes a theoretical framework for understanding OGD initiatives</td>
<td>Thematic analysis of literature</td>
<td>Three main themes have been identified as barriers to OGD release: institutional barriers, data integrity and quality barriers, and user participation barriers</td>
</tr>
<tr>
<td>Viscusi and Batini (2016)</td>
<td>Case study of open data concerning hospitals in the USA, Canada and Italy</td>
<td>Interpretive framework, conceptual modeling</td>
<td>Underlines the significance of conceptual schemas to understand public sector information to underline the public and social value of open data sets</td>
</tr>
<tr>
<td><strong>Applied/contextual research</strong></td>
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<tr>
<td>Kassen (2018a)</td>
<td>Examines open data platforms in more than 30 countries at local, sub-national, national and supra-national levels</td>
<td>Empirical data collected from online content and cross-jurisdictional analysis</td>
<td>Contextual administrative settings impact the OGD initiatives to a great extent</td>
</tr>
<tr>
<td>Vieira and Alvaro (2018)</td>
<td>OGD disclosure portals of some cities of Sao Paulo State</td>
<td>OGD platform is proposed for running apps linked with Smart Cities initiatives</td>
<td>With the validation of the proposed OGD platform, it was understood that the proposed platform would facilitate decision-making and provide solutions in administering Smart Cities</td>
</tr>
<tr>
<td>Gasco-Hernandez et al. (2018)</td>
<td>Comparison of three OGD training interventions in Spain, Italy and the USA</td>
<td>Case study involving interviews</td>
<td>Training interventions should take into account the context in which they are being conducted and the expectations of the users to derive value out of the same</td>
</tr>
<tr>
<td>Chatwin and Arku (2017)</td>
<td>Ghana</td>
<td>Qualitative field research techniques, including document analysis, in-depth interviews, and validation workshops</td>
<td>A confluence of citizen demand for openness, and willingness within the governance stakeholders, are motivating the pursuit of open government reforms</td>
</tr>
<tr>
<td>Chorley (2017)</td>
<td>England</td>
<td>Semi-structured interviews and a short descriptive online survey</td>
<td>There are challenges to records management at a local level as the OGD environment progresses further in the British public sector</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Author/s</th>
<th>Context</th>
<th>Research methodology</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hivon and Titah (2017)</td>
<td>Provides a conceptualization of citizen participation and investigates its effect on open data use at the municipal level in Montreal, Canada</td>
<td>14 semi-structured interviews with citizens involved in open data projects</td>
<td>Citizen participation is a key contributor to the use of open data through four distinct categories of participation, namely, hands-on activities, greater responsibility, better communication and improved relations between citizens and the open data portal development team</td>
</tr>
<tr>
<td>Grimmeleikhuissen and Feeney (2016)</td>
<td>USA</td>
<td>Integrative theoretical framework, survey data and observational data from 500 US local government websites</td>
<td>Structural, cultural and environmental variables impact the threefold dimensions (accessibility, transparency and participation) of open government</td>
</tr>
<tr>
<td>De Blasio and Selva (2016)</td>
<td>France, Italy, Spain, UK</td>
<td>Qualitative computer-assisted analysis of policy documents</td>
<td>OGD initiatives should lead to public–private collaboration and openness to facilitate open decision-making</td>
</tr>
<tr>
<td>Worthy (2015)</td>
<td>Examines a specific case of the “Transparency Agenda” of the government of UK</td>
<td>Surveys, Freedom of Information (FOI) requests, interviews, and media analysis</td>
<td>There is a gap between the aims and the impact of the Open Data initiatives</td>
</tr>
<tr>
<td>Zuiderwijk et al. (2014)</td>
<td>The Netherlands</td>
<td>Action design research (ADR), discussion sessions with civil servants</td>
<td>Five design principles for improving the publishing process of the data sets were identified</td>
</tr>
<tr>
<td>Tsiavos et al. (2013)</td>
<td>Greece</td>
<td>Case study using techno-regulatory theory</td>
<td>There are legal, technical, cultural and economic regulatory barriers that impede the proper institutionalization of an OGD initiative</td>
</tr>
<tr>
<td>Mutula and Wamukoya (2009)</td>
<td>East and South Africa</td>
<td>General review of PSI contained in records and implications for enhancing freedom of access to information, democracy and integrity in governments</td>
<td>The right to freedom to access of information needs to be bolstered in these regions</td>
</tr>
</tbody>
</table>

**User-focused research**

<table>
<thead>
<tr>
<th>Author/s</th>
<th>Research methodology</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kassen (2018b)</td>
<td>Case study approach involving stakeholder and policy analyses</td>
<td>There is a need for collaboration between the different stakeholder groups to realize the actual intent of the OGD initiatives</td>
</tr>
<tr>
<td>Kitsios and Kamariotou (2018)</td>
<td>Review of literature</td>
<td>OGD hackathons are instrumental in furthering entrepreneurial initiatives via start-ups, etc</td>
</tr>
<tr>
<td>Saxena and Janssen (2017)</td>
<td>Path analysis and multiple regression</td>
<td>There is an increased use and acceptance of OGD among the respondents—specifically the men (in comparison with women) and younger population (in comparison with other age groups)</td>
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</table>

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**Table AI**

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<tr>
<th>Author/s</th>
<th>Context</th>
<th>Research methodology</th>
<th>Key findings</th>
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</thead>
<tbody>
<tr>
<td>Saxena and Muhammad (2017)</td>
<td>Investigates the usage of OGD among professionals working in private sector and non-governmental organizations (NGOs) in Pakistan</td>
<td>Semi-structured interviews</td>
<td>While OGD use among the stakeholders is relatively less, involvement of stakeholders from the private sector and NGOs and other interested partners is required for an optimum usage of OGD in different economic sectors of Pakistan</td>
</tr>
<tr>
<td>Saxena (2017e)</td>
<td>Investigates the utility of Open Government Data (OGD) from the perspective of the PhD students in India</td>
<td>Semi-structured interviews</td>
<td>While some PhD students tap OGD for their research work, others use OGD as informational tools for broadening their general knowledge. At the same time, some PhD students do not refer OGD at all</td>
</tr>
<tr>
<td>Saxena (2017g)</td>
<td>Investigates the potential and extent of civic engagement in OGD initiative of Kazakhstan</td>
<td>Case study and documentary analysis</td>
<td>OGD initiative in the country has been successful in furthering e-participation and civic participation to a large extent</td>
</tr>
</tbody>
</table>

**Corresponding author**

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The use of open government data to citizen empowerment: an empirical validation of a proposed model

Md Nahin Hossain, Md Shamim Talukder, Md Rakibul Hoque and Yukun Bao

Abstract

Purpose – The purpose of this paper is to measure the impact of open government data (OGD) on citizen empowerment.

Design/methodology/approach – This study advances the body of knowledge on OGD by proposing an integrated research model based on transparency, accountability, participation and collaboration dimensions. The research model was empirically tested using 275 responses using the on-paper survey from the university students and professionals in Bangladesh. Data were analyzed using the structured equation modeling technique.

Findings – Findings revealed that transparency and participation have a positive and significant direct and indirect influence on citizen empowerment through accountability and collaboration. Overall, the four basic pillars of OGD such as transparency, participation, accountability and collaboration interrelated with each other and have the impact on citizen empowerment.

Research limitations/implications – This study has proposed an instrument that sums the dimensions of open government, which avoids tautology and redundancy among OGD dimensions. More research should be done to validate the proposed model and the instruments used in this study.

Practical implications – For the researchers, this study provides a basis for further refinement of individual models of empowerment. For practitioners, understanding the key constructs is crucial to design, refine and implement OGD systems and applications that empower citizens, create public values and strengthen the democratic process.

Originality/value – This research is the first step that empirically investigates the impact of OGD on citizen empowerment which is the ultimate goals of any democratic government.

Keyword Bangladesh

Paper type Research paper

1. Introduction

The contemporary process of social change is determined by the progress of the culture of transparency and accountability, the socio-technological advancement of the Web and the opening of public sector data (Gertrudiscasado et al., 2016). These circumstances force governments to rethink their models of social intermediation and transform the growing demand for access to open data and user participation in new mechanisms that enable citizen empowerment. Empowerment is a theoretical model for understanding the process and consequences of efforts to use control and influence over decisions that affect one’s life (Perkins and Zimmerman, 1995; Zimmerman and Warschausky, 1998). It is an intentional, ongoing process focused on group participation, an equal share of valued resources and has greater access to and control over those resources (Zimmerman, 2000). According to Rappaporn (1984), empowerment refers to gain mastery over one’s life by making their own decision.
In the case of information based on open data, which are designed so as to dynamically and actively transmit to citizens the information they need, Crucianelli (2013) argues that such arrangements favor open paths for reading and analysis that drive empowerment in decision-making. It enables individuals to make better decisions in their lives and increases participation in public policy making, service design and delivery processes (Abu-Shanab, 2015; Ubaldi, 2013). Particularly, open government data (OGD) is a dedicated data disclosure system that empowers citizens to make informed decisions regarding their personal affairs (i.e. finance, health care, energy and education) that can enhance the quality of their lives and foster democratic process (Ruijer et al., 2017). For example, American citizens are allowed to access information on flights operated by national airlines to make informed selections on the airline company. Furthermore, Right to Information (RTI) movement focused on access to public sector information that can create abundant scope for individuals’ better use of money, power and knowledge (Ubaldi, 2013). These are some of the ultimate mechanisms to foster empowerment process. While citizen empowerment is considered to be a critical factor of OGD initiative (Abu-Shanab, 2015; Ubaldi, 2013), little research to date has either rigorously explained the content of such empowerment or demonstrated the impact of OGD on citizen empowerment process.

Prior research tried to figure out the impact of open public sector data particularly on transparency, accountability, participation and collaboration (Abu-Shanab, 2015; Bertot et al., 2010; Parsons et al., 2011). Specifically, Zuiderwijk and Janssen (2014) develop a framework to compare open data policies, Veljković et al. (2014) developed an OGD benchmark, Abu-Shanab (2015) developed and empirically tested a re-engineered model of OGD use, and Harrison et al. (2012) created a model for open government ecosystems. Although several potential benefits of OGD were investigated regarding economic and/or political issue (Janssen et al., 2012; Saxena and Janssen, 2017). As past researches have investigated the impact of OGD on transparency, accountability, participation and collaboration rather than conceptualizing the impact on citizen empowerment, thus the present study covers this gap as its main objective. More specifically, this paper advances a conceptualization of citizen empowerment and develops a research model in order to link the proposed multidimensional construct empowerment based on the dimensions of OGD (i.e. transparency, accountability, participation and collaboration). Hence, the following research question was formulated in this study:

RQ1. What is the impact of OGD on citizen empowerment?

The contribution of this study is twofold. First, this study develops a new model of citizen empowerment based on the dimensions of OGD. Second, this study empirically shows the impact of OGD on citizen empowerment to reach a state of good governance.

2. Research model and hypothesis development

2.1 Citizen empowerment and open government data

The Open Government movement was first initiated in 2009 after Obama’s administration called for more efforts toward an open government. Open Government is also defined as publishing public sector information in an interoperable and standard format to enhance people’s access to data (Abu-Shanab, 2015). Open government also means enabling citizens to play new roles in their relationship with the government, and moving toward democracy that implies the right for citizens to collectively and individually participate in governance (Janices and Aguerre, 2013). The Obama administration defined the major three pillars of open government, namely, transparency, participation and collaboration (Obama, 2009). Later, these principles have been extended by different scholars to understand the open government concept appropriately into several interrelated...
dimensions such as data transparency, accountability, participation, collaboration and empowerment (Abu-Shanab, 2015; Harrison and Sayogo, 2014; Partnership, 2012; Veljković et al., 2014).

Open Data is data that is accessible to all stakeholders, can be used and reused and can be distributed freely (Stuti, 2018; Susa et al., 2015). Open government extracted this feature where it requires open transactions (data and operations) by governments that highlight transparency, accountability, participation and collaboration by all stakeholders in a country. Based on these arguments, we tried to map the concepts and activities related to the fundamentals pillars of open government and how they are connected. Such mapping is based on our understanding of open government. The proposed research model (Figure 1) illustrates our understanding of the domain and also maps the relationships that might cause some tautology in research between the basic pillars. The proposed research model consists of five dimensions: transparency, accountability, participation, collaboration and empowerment. The model implies a direction in implementation, requirements and level of value to all stakeholders. Attaining each dimension (starting with transparency and ending with empowerment) means that the value added to involved stakeholders is increased. With the movement from transparency to empowerment, more requirements are needed for the systems implemented by open government projects, and more advanced tools are used. The simplification of concepts in the research model represents a summary of all activities related to open government. The ultimate goal of open government is to facilitate the empowerment stage, where citizens make the decisions by themselves. Such decisions are expected to be enforced by the executive authority (represented by government). Before reaching such stage, the political system would be satisfied with the enhancement of the decision-making process through some consultation process and even advanced cooperation on tasks and issues. Such process is labeled collaboration and includes extensive and open communication (two way), feedback from citizens, partnership (with citizens, businesses and civil society bodies) and, eventually, the government will make the decision.

On the other hand, public administrators play a dual role in citizen empowerment process by influencing both its processes and its outcomes. First, they help to create the conditions for empowerment by shaping the venues in which the public participates and by providing information and other critical resources to build participant efficacy (Craveiro et al., 2016). Second, they positively consider public opinion and implement them in the decision-making process and report the progress of their implementation on a routine basis for the different stakeholders (Gertrudiscasado et al., 2016). This happens due to the rapid advancement in new technologies which are facilitating the OGD movement to become a key driver of citizen empowerment (Sandoval-Almazán et al., 2012).

In summary, the concept of open government could be in the following dimensions:

![Figure 1: Research model](image_url)
- data openness is mandatory with a certain level of quality and accessibility facilities for citizens;
- ensure government accountability for their actions and decision taken; and
- ensure citizens involvement in decision-making process of the state where citizens are empowered to choose their own decisions and manage government agenda.

Finally, OGD movement around the world through transparency, accountability participation and collaboration can be higher-level tools to foster democracy.

2.2 Hypothesis development

2.2.1 Transparency. Transparency is the first major pillar of open government initiative where higher-level transparency means better governance, more legitimacy and efficiency (Harrison and Sayogo, 2014). Transparency is defined as the extent to which governments make available data and documents to the public according to their needs, where they later assess governments’ actions and hold them accountable for their actions (Florini, 2007). Data openness is a necessary prerequisite for transparency, and it is being promoted around the world as part of the Open Government initiatives (Open data portals, 2011). Transparency can be further disseminated into the transparency of government operations, procedures and tasks (government transparency) and transparency of government-held data (data transparency) (Abu-Shanab, 2015; McGee and Gaventa, 2011). Transparency can be referred to as the opening public sector information and enabling citizens and entrepreneurs to access government-held data in a uniform way (Veljković et al., 2014). The transparency dimension of open government related to public records includes the following: accuracy, validity, security, preservation (Dawes, 2010), reliable, high quality (Harrison et al., 2012), comprehensiveness, relevancy and timely (Abu-Shanab, 2013).

In democratic societies where citizens delegate authority for decision-making, transparency, accountability and participation function together to produce the information that citizens need to assess and validate the actions of their governments, thus providing an ongoing basis for the consent of the governed (Harrison and Sayogo, 2014). Transparency may be accorded with some conceptual primacy since, without information related to a policy domain, no further actions related to participation and accountability can take place (Grimmelikhuijsen, 2012; Michener and Bersch, 2013). It is also argued, information and communication technology (ICT) and innovative social media applications increase the scope and reach of transparency at less expense, and potentially creates new opportunities for participation and accountability (Bertot et al., 2010). Prior literature also suggests that transparency is a pre-condition for participation and accountability and have a positive influence on empowerment because it ensures that data are well-known, comprehensible, easily accessible and open to all for decision-making (Abu-Shanab, 2015; Heald, 2012; Khagram et al., 2013). Finally, Michener and Bersch (2013) have pointed out that transparency, participation and accountability are conceptually related and sometimes may co-occur in practice as well. On the basis of the aforementioned discussions, we proposed the following hypotheses:

H1. Transparency has a positive impact on accountability.

H2. Transparency has a positive impact on participation.

H3. Transparency has a positive impact on citizen empowerment directly.

2.2.2 Accountability. As mentioned above, government transparency also called accountability refers to the opening of government processes and operations to the public (Veljković et al., 2014). Accountability enabling citizens to make government transparent and make their governments accountable for its actions and takes responsibility for the results (Lourenço, 2013). Allowing people to see the internal government flows and investigate whether
their representatives have met their expectations (Harrison and Sayogo, 2014; Stuti, 2018). Information so provided becomes instrumental in enabling citizens to detect corruption and hold their governments accountable (McGee and Gaventa, 2011; Michener and Bersch, 2013). Accountability is a driver of effective service delivery, good governance and citizen empowerment (Batley et al., 2012). OGD can be a powerful tool for ensuring accountability by making information accessible and usable that enable citizens to analyze, process, combine and allow a new level of public scrutiny make an effective decision. In a democratic process where citizens delegate authority for decision-making (empowerment), transparency and accountability work together to produce the information that citizens required to assess and validate their government actions. Therefore, we postulate the following hypothesis:

\[ H4 \] Accountability has a positive impact on citizen empowerment.

2.2.3 Participation. Participation aims at including citizens in the democratic system by involving them in the decision-making process of the government (Parycek and Sachs, 2010). Particularly in OGD initiatives, participation is supported by Web 2.0 and social media applications which create an architecture for participation that enables users to be not only passive consumers of content and services but also active contributors and designers in their own right (Evans and Campos, 2013; Shadbolt and Hara, 2013). The use of innovative technologies helps people to share their ideas, receive their valuable feedback on various matters and involve them in the policy-making process (Abu-Shanab, 2015; Lee and Kwak, 2012). The emergence of the OGD movement combined with new technologies is becoming key enablers and drivers of citizen self-empowerment, higher e-participation and public engagement (Buckwalter, 2014). It indicates that citizens are invited more openly into a participative and empowering relationship with the government in relation to a number of matters which are part of the overall democratic process (Ubaldi, 2013). Therefore, we proposed the following hypothesis:

\[ H5 \] Participation has a positive impact on citizen collaboration.

\[ H6 \] Participation has a positive impact on citizen empowerment directly.

2.2.4 Collaboration. Collaboration is the most evident pillars of open government movement and closely related to participation (Reddick and Ganapati, 2011). User involvement is regarded as a source for participation and collaboration indicators. Thus, some argue that it is not clear whether the participation is collaborative or the collaboration is participatory in OGD dimensions (Martin et al., 2013). However, we consider these two dimensions differently in the scope of the expressive social media and the collaborative social media definitions. Expressive social media enables people to state their opinions by sharing text, picture video and music with others, while collaboration enables people to join their efforts with government and work together toward achieving a common goal (Kotler et al., 2010). Having these scenarios in mind, participation could be regarded as the tool that uses the input of the public through social media for the development of policy decisions and government services (Veljković et al., 2014). Consequently, collaboration can be perceived as the engagement of citizens, businesses and government agencies in complex tasks or projects that aim to produce specific outputs (Lee and Kwak, 2012; Veljković et al., 2014). Although the literature focused more on collaboration efforts between governmental agencies, the empowerment of people is reached by more collaboration between people and their government which is the ultimate goal of democracy (Abu-Shanab, 2015; Al-Dalou and Abu-Shanab, 2013). Therefore, the following research hypothesis is proposed:

\[ H7 \] Collaboration has a positive impact on citizen empowerment.

3. Methodology

In this section, research design, questionnaire and data collection procedure and data analysis are discussed.
3.1 Questionnaire design and data collection

Even though the measures used in this study have been used and validated in prior studies (Abu-Shanab, 2015; Harrison and Sayogo, 2014), a draft of the questionnaire was reviewed by key experts to ensure the understandability and ease aspects of the questionnaires from the respondents’ perspective. The pilot was conducted with 20 OGD users from the Department of Management Information Systems, University of Dhaka, two senior government officers who are currently working in OGD projects, and three university professors whose main research is in the area of e-government and management information systems. At the end of the pilot test, it was revealed that the respondents found the questionnaire to be simple and easy to understand, and at the same time quicker to complete in terms of the time needed for completing the survey. Very few and minor suggestions came in which were effectively addressed and incorporated in the final edition of the questionnaire in order to match Bangladesh OGD context.

In order to empirically test the six hypotheses constructed, the survey strategy was used in which the self-questionnaire was administered (Saunders et al., 2007). The questionnaire was developed in the English language to get information about the OGD dimensions. The questionnaire was divided into Part A, and Part B. Part A contained the demographic information regarding the respondents’ age, gender, educational qualifications, and OGD usage experience. All independent variables were measured using a five-point Likert-type scale with anchors ranging from 1 = “strongly disagree” to 5 = “strongly agree” were in part B. A total of 19 items were used to measure the independent variables. The criterion for taking the survey was determined as “having experience using OGD at least once in a lifetime.” It was considered that respondents would be able to understand the questions in the survey and consequently provide the best inputs for the study. Experience user is suitable for technology acceptance study because a sense of intellectual perspective is important in understanding and explaining the implications of OGD (Ahmad and Khalid, 2017).

Peled (2013) states that to date, open data is only beneficial to a limited number of users who have knowledge, skills and funds. Therefore, the target population for the survey was students and faculty members from universities, professionals from organizations who have experience, expertise and facilities to access and use open data. In addition, the targeted population was considered to be technology savvy, more familiar with online services and representative of an influential group in the society (Ovais Ahmad et al., 2013). In developing countries like Bangladesh, India and Pakistan, young generations (i.e. students) are the most active users of ICT-based services (e.g. e-government, m-payment, e-health) (Hoque, 2016; Ovais Ahmad et al., 2013). Furthermore, younger age users are more receptive to information technology and tend to be ready to use new technologies (Ahmad and Khalid, 2017; Al-Hujran et al., 2015; Chong et al., 2012). Therefore, it was considered that identifying their perceptions could be crucial for improving OGD systems development and as such their participation in the study could not present a significant threat to external validity.

The study distributed 300 survey questionnaires randomly to three universities and two IT firms. Regarding sample size, structured equation modeling (SEM) recommends a sample size of 200 as fair and 300 as good (Tabachnick and Fidell, 1996). Similar to that, Hair et al. (1998) recommended a sample size of 200 to test a model using SEM because 200 is a “critical sample size” that can be used in any common estimation procedure for valid results. Roscoe (1975) mentioned that in multivariate research like multiple regression analysis, the sample size should be at least preferably ten times or more as large as the number of variables in the study. In this study, there are a total of 19 items for independent and dependent variables for multivariate data analyses. Based on the aforementioned examples
and notions from previous studies, this study has adopted a sample size is 300 as SEM was the main tool being used for data analysis.

With permission from the five institutions, the survey questionnaires were distributed to the targeted sample group where the respondents were first informed on the purpose of the study by the authors. To avoid duplication of responses, the sample was drawn from June 2017 to August 2017. Participation in the study was voluntary and ensured privacy by using an on-paper survey (off-line survey). As it was a self-administered survey, the response rate was 100 per cent. In fact, a high response rate is viewed as an important criterion by which the quality of a survey is judged (Hox and De Leeuw, 1994) because a higher response rate implies less potential non-response bias (Shih and Fan, 2008). Returned questionnaires were manually scrutinized to ensure the correctness of data. Out of 300 responses, 13 were considered unusable because they had many missing response items and 12 were excluded because they had the same answer for all questions. Therefore, a total of 275 completed and valid responses were used for further statistical analysis.

3.2 Variables and measurement
All instruments were selected from the literature and were adapted for use in the context of OGD. Appendix 1 summarizes the items related to each construct of the proposed model and studies that served as a reference for their adaptation.

3.3 Data analysis
This study used second-generation multivariate data analysis method called SEM with a focus on partial least squares (PLS) which is an emerging path modeling approach to test and validate a proposed model and the relationships among the hypothesized constructs (StatSoft, 2013). SEM is a widely accepted pattern to measure the validity of theories with empirical data (Götz et al., 2010). SEM has been popularly used in many research areas, particularly in social science and IS (Williams et al., 2015). SEM has been used to model the complex relationship of multiple endogenous (independent) and exogenous (dependent) variables. SEM is considered the second generation of multivariate analysis, and it has over first-generation technique is the greater flexibility that researchers are allowed to:

- model relationships among multiple predictors and criteria variables;
- construct unobservable latent variables;
- model errors in measurements for observed variables; and
- statistically test a priori substantive/theoretical and measurement assumptions against empirical data (Chin, 1998).

In other words, SEM is capable of simultaneously assessing the reliability and validity of the measures of theoretical constructs and estimating the relationships among these constructs. In addition, PLS examines the psychometric properties and provides appropriate evidence on whether relationships might or might not exist (Fornell and Larcker, 1981). In this study, we performed data analysis in accordance with a two-stage methodology (Anderson and Gerbing, 1988) using SmartPLS 3.2. The first step was to test the content, convergent, and discriminant validity of constructs using the measurement model, while the second step was to test the structural model and hypotheses.

4. Results
4.1 Respondents’ demographic profile
Majority of the respondents were from a relatively younger generation. For example, 75 per cent of the respondents belonged to the age group 25-35 years where the majority of 80
per cent the total sample was from university (students and faculty members). The computer and internet literacy of the respondents were very high, approximately 52 per cent of the respondents have average five-year IT usages experience. The majority of the respondents (74 per cent) used OGD (economic and transport) monthly or few times in a month for academic research and different statistical analysis (Appendix 2).

4.2 Measurement model

The measurement model was assessed by examining the internal reliability, convergent and discriminant validity (Hair et al., 2013). Cronbach’s alpha (α) and composite reliability were used to evaluate reliability. Average variance extracted (AVE) and item loadings were used to assess convergent validity. The square root of the AVE and cross-loading matrix was used to assess discriminant validity. The value of composite reliability and Cronbach’s alpha should exceed 0.70 to meet the reliability (Hair et al., 2006). The value of the AVE and item loadings should exceed 0.5 to meet the convergent validity (Fornell and Larcker, 1981). The square root of the AVE of a construct should exceed its correlation with other constructs to meet discriminant validity (Henseler et al., 2015). The loadings, AVE, composite reliability and Cronbach’s alpha (α) are presented in Table I. The value of Cronbach’s alpha (α) for all construct is above 0.7 and the value of composite reliability for all construct is above 0.84 which are higher than the recommended level of 0.7. Therefore, all of the items in each construct have an adequate level of reliability. Table I also shows the loadings of all the items. All item loadings were greater than 0.70 and the AVE values of all constructs are above 0.57. Thus, the conditions for convergent validity are satisfied in this study.

The discriminant validity was assessed by the square root of the AVE and cross-loading matrix (Henseler et al., 2015). Table II shows that the square roots of the AVE for each construct were significantly higher than the corresponding correlations among the latent constructs. Results indicated sufficient discriminant validity of the constructs in our research model.

4.3 Structural model testing

The structural model was assessed to identify and quantify the path relationships among the constructs in the research model. The bootstrapping method was used to test the

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<th>Table I</th>
<th>Measurement model</th>
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<td>Construct</td>
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<tr>
<td>Accountability</td>
<td>ACC1</td>
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<td></td>
<td>ACC2</td>
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<td></td>
<td>ACC3</td>
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<tr>
<td></td>
<td>ACC4</td>
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<tr>
<td>Collaboration</td>
<td>COL1</td>
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<td></td>
<td>COL2</td>
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<td>COL3</td>
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<td></td>
<td>COL4</td>
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<tr>
<td>Empowerment</td>
<td>EMP1</td>
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<td></td>
<td>EMP4</td>
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<tr>
<td>Participation</td>
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<tr>
<td>Transparency</td>
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Notes: CR = Composite reliability; AVE = Average variance extracted
hypotheses at a significance level of 0.05 ($p < 0.05$) and the path coefficients (Hair et al., 2012). The relationship between the dependent and independent variables was tested by a path coefficient ($\beta$) and $t$-statistics. The $R^2$ value was used to calculate the percentage of the variance explained by the independent variables in the structural model (Klarner et al., 2013). The proposed model explained 57.4 per cent of the variance associated with citizen empowerment. The PLS results for the structural model are shown in Table III.

All seven hypotheses were supported in this study. The independent construct transparency had a positive and a statistically significant influence on accountability, participation and empowerment respectively ($H1$, $H2$ and $H3$) and participation had a statistically significant influence on collaboration ($H5$) and empowerment ($H6$). Finally, accountability ($H4$) and collaboration ($H7$) had a positive and statistically significant influence on citizen empowerment (Table III).

5. Discussion

The results indicate that the influence of transparency construct on accountability ($H1$), participation ($H2$) and empowerment ($H3$) is positively significant. As suggested Abu-Shanab (2015), the findings confirm the importance of transparency in citizen empowerment. This implies that, the extent to which OGD provides relevant, updated, accessible and usable information help citizens to take the right decisions and make their governments accountable for their actions. Transparency ensures data will be available, accessible and open to all that promote trust, increase participation and accountability (Bertot et al., 2010). After the introduction of RTI Act and Open government initiative, citizens can access public sector information, participate, give feedback in social media and make accountable to their administrators for their actions taken (Ministry of Finance, 2017). Actions and decisions taken by the government are now more transparent to the citizens and enable them to become more enthusiastic to participate in political activities. Therefore, our findings are the exact reflections of the present socio-political conditions of Bangladesh.

The analysis shows a significant finding with regard to the participation dimension. The results indicate that participation has a direct influence on citizen empowerment ($H6$) and

<table>
<thead>
<tr>
<th>Table II</th>
<th>Correlation matrix and square root of the AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construct</strong></td>
<td><strong>ACC</strong></td>
</tr>
<tr>
<td>ACC</td>
<td>0.759</td>
</tr>
<tr>
<td>COL</td>
<td>0.447</td>
</tr>
<tr>
<td>EMP</td>
<td>0.595</td>
</tr>
<tr>
<td>PAT</td>
<td>0.446</td>
</tr>
<tr>
<td>TRA</td>
<td>0.519</td>
</tr>
</tbody>
</table>

**Notes:** ACC = Accountability; COL = Collaboration; EMP = Empowerment; PAT = Participation; TRA = Transparency

<table>
<thead>
<tr>
<th>Table III</th>
<th>Structural model</th>
</tr>
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<tbody>
<tr>
<td><strong>Hypothesis</strong></td>
<td><strong>Path</strong></td>
</tr>
<tr>
<td>$H1$</td>
<td>TRA -&gt; ACC</td>
</tr>
<tr>
<td>$H2$</td>
<td>TRA -&gt; PAT</td>
</tr>
<tr>
<td>$H3$</td>
<td>TRA -&gt; EMP</td>
</tr>
<tr>
<td>$H4$</td>
<td>ACC -&gt; EMP</td>
</tr>
<tr>
<td>$H5$</td>
<td>PAT -&gt; COL</td>
</tr>
<tr>
<td>$H6$</td>
<td>PAT -&gt; EMP</td>
</tr>
<tr>
<td>$H7$</td>
<td>COL -&gt; EMP</td>
</tr>
</tbody>
</table>

**Notes:** $R^2$ for EMP = 0.574; Significant at $p < 0.05$
indirect influence through collaboration (H5). This result indicates that OGD initiative enables citizens to give their opinion, and using such opinion into consideration puts governments into the collaborative model with their citizens (Evans and Campos, 2013). With the recent development in social media applications and open government movement, citizens' participation in many government matters is increasing in Bangladesh. For example, Access to Information (A2I) arrange innovation competition for the university students on several issues such as how to reduce traffic jam, how to decrease pollution, how to minimize corruption, how to deliver e-services to all citizens and so on (Programme, 2011). Therefore, OGD initiatives enhance citizen empowerment process and ensure their involvement in government policymaking process by enabling collaboration with government.

Similarly, accountability is found to have a significant influence on empowerment (H4). This only points out that accountable government answer citizens’ queries and empower citizens to evaluate their performance (Lourenço, 2013). OGD can be a powerful force for public accountability by making existing information easier to analyze, process and combine, allowing for a new level of public scrutiny. Accountability and transparency enable governments to delegate authority for decision-making to their citizens (empowerment) and also enable citizens to validate the actions of their governments. By introducing the OGD initiative in Bangladesh, citizens can access and analyze public sector information to make effective decisions regarding their personal and professional purposes.

Another finding highlighted by the results is the importance of collaboration on empowerment (H7). The results indicate that different stakeholders can work together with government agencies to enhance people empowerment for a better democratic society. With the help of innovative technologies, citizens can access government information, provide necessary feedback and governments positively consider their feedback. Finally, empowerment of people is reached by more collaboration between people and their government (Abu-Shanab, 2015; Al-Dalou and Abu-Shanab, 2013).

6. Implications and limitations

6.1 Implications for theory and practice

This study makes a significant contribution to open government research from different perspectives. First, this study examines the impact of OGD on citizen empowerment. Citizen empowerment is the ultimate goal of all democratic societies (Abu-Shanab, 2015), but there is a lack of empirical and rigorous research addressing the impact of citizen empowerment through an innovative open government initiative. This study contributes to a better understanding of how OGD dimensions affect citizen empowerment. Second, the study develops several items for measuring participation and empowerment constructs. Future research may use these measurement-items in their models. Finally, the study provides an integrated model of citizen empowerment based on the pillars of OGD (i.e. transparency, accountability, participation and collaboration). This is the first and original model for citizen empowerment through OGD. We hope this model will offer opportunities for further research in e-government and open government research field.

Along with theoretical contributions, the findings of the study provide valuable guidelines to government policy-makers which can be used to revise, develop and implement effective open government systems. The Government of Bangladesh needs to promote the open government concept and try to attain the dimensions to reach a state of good governance by raising citizen empowerment. Good governance objectives can be served by releasing aggregated data, boosting economic growth may require specific data sets to be released to the business community, apps developers and individual users at a more granular level data in a timely manner and updated regularly to diffuse them vastly and rapidly to create empowerment opportunities.
Findings also suggest that to from transparency to empowerment, more requirements are needed for the systems implemented by open government projects, such as developing applications software for transforming, visualizing, analyzing, linking and assessing the quality of data sets and application programming interfaces (Zuiderwijk et al., 2015). Possible ways of achieving these objectives may include the following dimensions in government decision-making agendas: use of ICT such as internet to fully interact with citizens and businesses; opening data needed by citizens with the required level of quality and the convenient accessibility; make government accountable for its activities and actions; open the collaboration process with citizens toward a state where citizens are empowered to make decisions and control public agenda. Finally, the model of the study could also be applied in other research and for other national settings with homogeneous social and political context to that of Bangladeshi.

6.2 Limitations and future directions

Although the study systematically developed and validated an empowerment model based on the major pillars of OGD (i.e. transparency, accountability, participation and collaboration), this research was not without certain limitations. First, the research model was validated using the data gathered from the university students, faculty members and professionals from the public and private sectors. Future research could possibly look at more diversified sampling frame to see the significance of the relationships and the performance of the model. Second, the measures for the model should be viewed as preliminary and future research should fully develop and validate appropriate scales for each of the constructs and revalidate the model presented here with new measures. Finally, this study developed an integrated research model for citizen empowerment and proposed several linkages that start with transparency and ending with empowerment. Future research might offer different combinations of these constructs or extended the proposed model with others constructs like data analysis skills or knowledge.

7. Conclusions

Empowering citizens to make meaningful use of open data is a challenge somehow less central than others to OGD policies (Concilio et al., 2017). Little research to date has either rigorously explained the content of such empowerment or demonstrated the impact of OGD on citizen empowerment process. To fill this research gap, the study investigated the impact of OGD on citizen empowerment through an integrated model based on the major pillars of OGD (i.e. transparency, accountability, participation and collaboration). To validate our proposition, an empirical test was conducted using a survey from the university students and professionals in a South Asian country, Bangladesh. Data were analyzed using PLS method based on the SEM. Direct and indirect effects of the determinants influencing citizen empowerment were analyzed, and the most important ones identified were, namely, transparency, participation, accountability and collaboration. According to the authors’ observation, this is the first model to measure citizen empowerment based on the pillars of OGD. These findings open a new dimension of open government movement and appeal to focus more on citizen empowerment process. The policymakers and systems developers use the research findings to develop and implement an effective open government system.

References


Further reading

<table>
<thead>
<tr>
<th>Construct name</th>
<th>Measurement items</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency</td>
<td>TRA1. Information provided by OGD should cover all issues needed (comprehensive) TRA2. Information provided by OGD should be relevant to what citizens need TRA3. Government should make information accessible to all citizens TRA4. Government should make information accessible all time</td>
<td>Abu-Shanab (2015) and Harrison and Sayogo (2014)</td>
</tr>
<tr>
<td>Accountability</td>
<td>ACC 1. Citizens have the right to know the decisions and action taken by government ACC2. Citizens have the necessary information to evaluate government performance ACC3. Government agencies answer all questions by citizens ACC4. Citizens’ information should be protected from unlawful use</td>
<td>Abu-Shanab (2015) and Harrison and Sayogo (2014)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>COL1. Partnership perception should prevail with citizens, businesses and other civil society bodies COL2. Feedback for all communication and actions should be sent to all related/interested parties COL3. Government based on citizen’s collective feedback and participation does decision-making COL4. Improved ICT tools should be implemented to accommodate collaboration function</td>
<td>Abu-Shanab (2015)</td>
</tr>
<tr>
<td>Empowerment</td>
<td>EMP1. Final decision-making should be delegated to citizens. EMP2. Enforcement of decisions should be done based on citizens’ feedback. (Proposed by Authors) EMP3. Idea generation direction is mostly bottom-up (from citizens to government) EMP4. Citizens are responsible for shaping the final governance image. (Proposed by Authors)</td>
<td>Abu-Shanab (2015)</td>
</tr>
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</table>
## Table AII

Demographic characteristics and OGD usages

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<th>Descriptions</th>
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<tr>
<td><strong>Frequency of OGD use</strong></td>
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<td><strong>Respondents’ purposes of open public sector data use</strong></td>
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<td>For statistical analysis</td>
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<td>To write academic publications</td>
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<td><strong>Type of data</strong></td>
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<td>Transport</td>
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</tr>
</tbody>
</table>
Foresight
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Number 6

589 Towards personalized medicine: the evolution of imperceptible health-care technologies
Farita Tasnim, Atieh Sadraei, Bianca Datta, Mina Khan, Kyung Yun Choi, Atharva Sahasrabudhe, Tomás Alfonso Vega Gálvez, Irmandy Wicaksono, Oscar Rosello, Carlos Nunez-Lopez and Canan Dagdeviren

602 Scenario-planning in strategic decision-making: requirements, benefits and inhibitors
Danielle Meyerowitz, Charlene Lew and Göran Svensson

622 Improving predictions of international business environments: China as a case in point
Marina Yue Zhang

635 Technology roadmapping in security and defence foresight
Silvia Vicente Oliva and Angel Martinez-Sanchez

648 Summarizing the decadal literature in open government data (OGD) research: a systematic review
Stuti Saxena

665 The use of open government data to citizen empowerment: an empirical validation of a proposed model
Md Nahin Hossain, Md Shamim Talukder, Md Rakibul Hoque and Yukun Bao