ACHIEVING THE TRIPLE BOTTOM LINE THROUGH BIG DATA ANALYTICS

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ABSTRACT

Sustaining growth and maximising profitability over the long-term are the main goals for businesses to survive in todays' competitive markets. However, the current sustainability agenda is pushing firms to extend their focus beyond traditional economic goals to include environmental and social goals. Achieving sustainability outcomes is based on the ability of a firm to deal with the conflicting relationships between triple bottom line (TBL) pillars (economic, social and environmental performance). While the rapid evolution of big data technologies has provided different opportunities for organisations, such as improving economic, social and environmental performance, there is relatively little research on the managerial and academic understanding of how employing big data analytics could help to establish sustainable development outcomes based on the TBL approach. This book focuses on finding ways of improving corporate sustainability in digital era, hence we hope that this chapter might contribute to this investigation by pointing out how big data analytics could be utilised to achieve all three dimensions of TBL sustainability.

Keywords: Business Sustainability, Triple Bottom Line, Big Data Analytics, Economic Sustainability, Environmental Sustainability, Social Sustainability

INTRODUCTION

Sustainability is an everlasting theme in both literature and practice due to several critical global challenges. For example, poverty is one of the key social challenges; since the number of people who are living below the poverty line equate to 736 million people in the world, meaning these people live at or below approximately $1.90 USD per day (WorldBank, 2015). Another major

challenge is the environmental problem arising from climate change. It is clearly shown that the current worldwide resource footprint requires approximately 1.5 planets to sustain existing life, and by 2030, two planets will be required to sustain consumption (Moore et al., 2012). As discussed in the famous publication in 1972 (Meadows et al., 1972, p. 211): "The earth's interlocking resources the global system of nature in which we all live probably cannot support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology". Due to these global challenges, industry, academic institutions and public sectors have started to pay more attention to sustainability issues. In particular, sustainability research has increased tremendously in order to improve our understanding to cope with environmental and social problems, including a reduction in energy use and climate change while fighting with human rights abuses at the same time.

Climate change is one of the key challenges facing sustainable development for contemporary business and society. Extreme climate-related disasters result in vulnerability for people and challenge both governments as well as companies (Haney, 2017). Moreover, it is widely recognized that current violations associated with climate change are set to make addressing climate change an irresistible issue for future generations (Besio & Pronzini, 2014). Interestingly, the present global and national legislations are inadequate in protecting the ecosystem around the world. Focusing on short-term temporary solutions leads to poor environmental management (Coyle & Simmons, 2014). As a result, environmental sustainability has become a necessity.

Environmental sustainability addresses how environmental management strategies are used as tools for increasing a company's profits and enhancing its image. Organisations should sustain their growth and maximise profitability over the long-term (Gupta, 2015). However, companies can achieve economic sustainability by using the assets of an organisation efficiently and by balancing economic (profit), social (people), and environmental (planet) measures to create profitability and ensure growth indefinitely (Oberoi, 2014). The current sustainability agenda is pushing businesses to extend their focus beyond traditional economic goals to the triple bottom line approach (TBL). The TBL concept is also referred as P3 (people, planet, and profit) (Elkington,

1998), this is because it simultaneously takes into account social, environmental and economic issues in order to create higher business value and sustain long-term success (Carter & Rogers, 2008).

Digital technologies such as the internet, social networking and mobile technology create huge amount of data every second (Kauffman & Donato, 2012). Big data analytics (BDA) is the process of using advanced technologies to examine big data in order to uncover useful information (e.g., hidden patterns) to make better decisions across business processes among functions or companies (Waller & Fawcett, 2013). In particular, BDA provides beneficial information allowing managers to manage their business more effectively according to social, economic, and environmental measures. Economically, BDA can increase profit (Schroeck, Shockley, Smart, Romero-Morales, & Tufano, 2012) and market share, maximise sales and financial productivity (Manyika et al., 2011) as well as return on investment (Chen et al., 2012). Environmentally, BDA could reduce environmental footprint (Van Rijmenam, 2014) and induce a reduction in emissions (De Gennaro, Paffumi, & Martini, 2016). BDA could also help firms to respond to social, environmental, and social changes in an uncertain environment. By doing so, BDA can improve a company's sustainable performance (Hazen, Skipper, Ezell, & Boone, 2016).

Considering the vital role of BDA for business success in several industries (McAfee et al., 2012), BDA and sustainability for firms have recently received interest from researchers. However, most of these studies offer conceptual evidence. Some existing empirical studies indicate the influence of BDA on three dimensions of the sustainability (i.e. environment, social and economic), but they remain fragmented rather than comprising all aspects in a coherent manner (Song et al., 2017). Few authors have attempted to study the impact of BDA on economic performance (Akter et al., 2016; Gunasekaran et al., 2017; Wamba et al., 2017) whilst others focus on the impact of BDA on environmental sustainability (De Gennaro et al., 2016; Koseleva & Ropaite, 2017). However, the studies related to BDA and social sustainability are scarce (Song et al., 2017). Consequently, studies

focusing on the impact of BDA on the TBL dimensions of sustainability in combination are still underdeveloped.

Additionally, there remains a lack of practical insights into how organisations utilise BDA to leverage sustainability. Therefore, this chapter aims to focus on the following questions and offer several insights from previous studies that might help to answer them:

(1). What is the relationship between sustainable development and the TBL?

(2). How could big data analytics be utilised to achieve all three dimensions of sustainability?

This chapter presents a conceptual study to discuss how to achieve sustainability by utilising BDA. The next section introduces the TBL approach in examining three dimensions of sustainability (economic, environmental and social performance), followed by a section that introduces BDA and provides examples of how they could contribute to sustainability. The final section summarises the link between the TBL and BDA, and it concludes by offering suggestions for further studies.

UNDERSTANDING SUSTAINABILITY THROUGH THE TBL

Sustainability, in its most general conceptualization, indicates meeting the needs of the current generation without encroaching upon the requirements of the future generation (Brundtland,1987). However, corporate sustainability indicates the balance among social, economic, and environmental goals of an organisation (Hansen & Schaltegger, 2016). The sustainability of a firm is its ability to satisfy the needs and requirements of current stakeholders while developing continuous investment and managerial strategies to ensure future profitability, social well-being and environmental protection (Pantelic, Sakal, & Zehetner, 2016).

Initial studies have, to some degree, been concerned with social responsibility and its impact on business performance (Filios, 1983; Sturdivant & Ginter, 1977). Despite these early studies, environmental sustainability had dominated the majority of studies on sustainability - focusing

mainly on the impact of environmental aspects on the business's financial performance (Gil, Jiménez, & Lorente, 2001; Klassen & McLaughlin, 1996). This trend has been overturned in the 2000s where new streams of studies are interested in adopting a more comprehensive approach towards performance inspired by the TBL.

In the TBL framework, the substantial dimensions of sustainable development have been used, directing environmental, social, and economic objectives within a business context (Blewitt, 2014). Ultimately, the health or success of an organisation should not only be evaluated by its traditional financial value, but also by its social or ethical values and environmental practices (Gimenez et al., 2012; Slaper and Hall, 2011).

The TBL has been receiving more attention from profit, non-profit and government sectors. As a result, the TBL is the most reported and cited framework for addressing sustainability activities of an organisation (Alhaddi, 2015). The TBL emerged during the mid-1990s and was developed by John Elkington, who sought out a method for assessing the performance of organisations in the USA (Elkington, 1994). The TBL concept has been presented through a framework that endeavours to concurrently concentrate on social, economic and environmental issues and strive to work harmoniously within these three performance domains in order to create greater business value and sustain long-term success In other words, it incorporates the three dimensions of performance: social, environmental, and economical. That is why, the TBL framework is known as the three P's: people, planet, and profit (Alhaddi, 2015; Elkington, 1998).

Even though businesses aim to attain the most profit, it is significant that the business's aim focuses on not only short-term (financial) benefits but also long-term (ethical and environmental) benefits as well. A business measures its performance and success by using the TBL framework, addressing environmental, social, and economic objectives within a business context (Goel, 2010). Rogers and Hudson (2011) suggest the TBL framework aims to attain a consistent and balanced focus on traditional financial value, environmental behaviours and social or ethical value in order to create greater business value and sustain long-term success (Carter & Rogers, 2008). In other words, organisations cannot be successful in the long run if they fail to take into account social, economic

and environmental issues (Elkington, 2004). This chapter builds the foundation of the outcomes of sustainable development on the TBL performance pillars as shown in Figure 1.

From a performance standpoint, TBL exhibits optimal conditions for overlap of the three dimensions. Elkington (1998, 2004) posited there are activities a firm can engage in which have a positive effect on both society and the natural environment, resulting in long-term benefits and competitive advantage. Porter (2006) concurs in his discussion of the potential benefits for firms employing the same logic guiding their core business strategy with those of the firm's social responsibilities. The author further posits this can be a source of competitive advantage, as well as enhancing a symbiotic relationship between the firm and community, resulting in both the firm's success and mutual reinforcement from the community.

The TBL approach motivates managers to balance their activities in order to achieve not only economic, but also environmental and social outcomes. By doing so, it allows firm strategies to embrace sustainability by performing well in three dimensions: economic, social, and environment. The following subsections summarise each dimension and its importance for sustainability.

Profit/Economic performance and sustainability

Different business activities play a vital role in maintaining the economic system, not only for the present day but also for future generations. All these activities seek to contribute to profit maximisation at the firm level. Traditionally, business financial success is measured by using conventional accounting measures such as profit and revenue. Managers consider profit as the cornerstone of their business in order to survive in a competitive market and to boost its long-term sustainable growth (Gupta, 2015). However, how can managers achieve both profit and sustainable growth?

Companies become economically viable if they achieve economic sustainability. Economic sustainability indicates using the assets of an organisation efficiently and balancing economic (profit), social (people's) and environmental (planet's) measures to create profitability and ensure growth indefinitely (Oberoi, 2014). Within a corporate context, economic sustainability means the improvement of the short-term and long-term shareholders' value as well as the building of a strong financial foundation for the continued survival of a company (Steurer, Langer, Konrad, & Martinuzzi, 2005).

According to the TBL approach, the economic pillar refers to the influence of the organisation's business practices on the economic system (Elkington, 1997).The economic sphere ties the business growth to economic growth and ultimately contributes to sustainability (Spangenberg, 2005). Organisations can achieve economic value and support the people of tomorrow when they make serious attempts to integrate environmental issues into their strategic planning process (Ross, 2015). Their business strategy, operations, and supply chain processes must all integrate social and environmental concerns. One of the popular examples is the Swedish furniture company IKEA. In 2016, IKEA raised its sales to $37.6 billion, but it did not consume all the profit. Instead, the organisation used its profits in recycling waste material, including the remnants of trees, which were transformed into new products. Now, IKEA is recognized as a company that runs an operating system of "zero waste to landfill" (Parinduri, Marlanfar, & Halim, 2019).

Green et al (2012) reveal that the economic performance dimension of the TBL approach is mainly related to reducing costs associated with energy consumption, purchased materials, waste discharge, waste treatment, and disposal. Some alternative sets of indicators of economic performance include sales, and brand image (Schaltegger & Burritt, 2014). These alternative metrics are related to the sustainability performance of a firm since sustainable practices of a firm could attract customers, which result in a better brand image as well as sales (Schaltegger & Burritt, 2014).

Planet/Environmental Performance and Sustainability

Firms use natural resources and raw materials in manufacturing all the time. Consequently, the environmental performance of firms has a strong association with sustainable development. The environmental performance addresses corporations' behaviour as well as how environmental management strategies are used as tools for increasing a company's profits and enhancing its image (Morali & Searcy, 2013). The environmental pillar of the TBL refers to engaging in practices that do not compromise the environmental resources for future generations. It aims to protect and conserve biodiversity and the environment through efficient utilisation of natural recourses, waste management as well as reducing pollution such as greenhouse gas emissions. Alhaddi (2015) indicates that by protecting the environment, organisations achieve financial advantages from the reduction in operational costs (energy and water usage) and growing revenues from the improvement of innovative green products (Kearney, 2009).

Businesses face increasing pressure from customers and regulations to minimise the ecological footprint of companies (Morali & Searcy, 2013). In fact, the goal of reducing ecological footprint is not confined to the border of a firm. Companies need to conduct activities that could also reduce their ecological footprint throughout their supply chain. Unethical behaviours of supply chain partners damage the brand image of international corporations. For example, the multinational food company Nestle was accused of rainforest deforestation through its palm oil suppliers (Coombs, 2014). Therefore, organisations working closely with their supply chain partners might lead to providing sustainable products and services (Gold et al., 2010).

Achieving environmental sustainability requires new forms of engagement among policymakers, researchers and stakeholder to make a valuable contribution to minimising the ecological footprint (Martens, McEvoy, & Chang, 2016). Governments should embrace strategies to develop green industries like renewable energy and they should also set regulations to reduce carbon emissions (Misopoulos, Manthou, Michaelides, & Adebayo, 2019). On the other side, businesses should adopt environmental practices to minimise their footprint on the environment by adopting environmental practices such as efficient utilisation of natural recourses, waste management and cutting of pollution such as greenhouse gas emissions (Elkington, 1998; Song et al., 2017).

People/Social Performance and Sustainability

Social issues have recently been popular in debates on developing sustainability (Eizenberg & Jabareen, 2017). For example, human rights principles are included in the 2030 Agenda for Sustainable Development. However, people are a vital asset for any organisation, and every organisation should consider the interests of the people within the organisation (employees), while also taking into account its social impact on the community in order to nurture its long-term sustainable growth. This is because the people dimension of the TBL approach is focused on the organisation's impact on employees, community, and society as a whole (Arowoshegbe & Emmanuel, 2016).

The social line of the TBL indicates participating in beneficial and fair business actions that promote labour, human rights, and the community (Elkington, 1997). These actions provide value to society and "give back" to the community, such as non-discrimination and avoiding employing forced and compulsory labour (Arowoshegbe & Emmanuel, 2016).

Thanks to the rise of TBL-based reporting such as the Global Reporting Initiative, large businesses are paying more attention to assess the social, economic, and environmental impact of their operations (GRI, 2014). In particular, two reasons encourage businesses to consider the social dimension of the TBL approach when they publish social reports: achieving positive publicity and recognition for their actions as well as meeting the demands of investors (Tschopp, 2003). However, defining social sustainability is difficult because social values are dynamic, complex, and difficult to quantify. Recently, some studies have played a notable role in enhancing our understanding of social sustainability such as, investigating the principles of social sustainability, the conceptualisation of social sustainability and investigating of design for social sustainability that promote social sustainability in both outcome and process (Corsini & Moultrie, 2019; Eizenberg & Jabareen, 2017). For example, social sustainability could be referring to an ethical code of human growth and survival that should be achieved in a comprehensive, connected, fair, and prudent manner (Sharma & Ruud, 2003). Other studies consider social sustainability as an approach, comprising of social equity, social responsibility, social justice, health equity, labour

rights, development, and community resilience (Long, 2016; Takhar, 2015). In a way, Sabella and Eid (2016) relate social sustainability to human capital, social capital, and human well-being. Policymakers and scholars use many terms interchangeably, such as social sustainability, corporate social responsibility, and corporate citizenship, to indicate business leaders' roles to involve environmental aspects in the corporations' strategic plan.

Assessing social performance effectively leads to improving social sustainability. Measuring social performance focuses on the interaction between the organisation and the community as well as responses to issues that are related to community involvement, employee relations, and fair wages (Goel, 2010). Social criteria are grounded in corporate social responsibility (CSR), which highlights an organisation's public acts of good citizenship (Luo & Bhattacharya, 2009; Orlitzky, Schmidt, & Rynes, 2003). According to the CSR literature, social performance has two main aspects: an internal aspect, which relates to employee well-being and equity and an external aspect related to community performance indicators, such as corporate philanthropic commitment (Jacobs, Singhal, & Subramanian, 2010; Montabon, Sroufe, & Narasimhan, 2007).

BIG DATA ANALYTICS

Technological innovations make vast volumes of data generated in the digital and physical world. The term "big data" (BD) was introduced to describe the data explosion, particularly in the digital world. Cisco estimated that the total amount of data generated by devices would reach 847 ZB per year by 2021 (Cisco, 2018). There are five 'Vs' which provide a comprehensive definition of BD: volume, velocity, variety, veracity, and value (Wamba et al., 2015). 'Volume' refers to a massive amount of a large number of records or data that consumes enormous storage. 'Velocity,' refers to either the speed or frequency of creating data and/or the frequency of delivering data (Russom, 2011). 'Variety' represents the data generated from various sources and formats and entails multidimensional fields of data consisting of unstructured and structured data (Russom, 2011). 'Value' indicates economically worthy insights and benefits which are generated from big

data by extraction and transformation (Dijcks, 2012). ‘Veracity’ ensures that the data used are trusted, authentic, and protected from unauthorized access and modification (Demchenko, 2013).

Technologies such as the internet create data every second (Kauffman & Donato, 2012). Thus, firms are dealing with different forms of data, including customer-generated content, user logs, and customer transaction records. Firms could extract business insights from BD through two stages: data management and analytics. Data management consists of different processes: from data acquisition, recording, extraction, cleaning, and annotation to integration, aggregation, and representation. Data analytics involves modelling, analysis, and interpretation. That is why the term BD analytics (BDA) helps us understand how BD is implemented to solve the real problems of companies (Cetindamar et al., 2019). In other words, BDA is the process of using advanced technologies to examine BD in order to uncover useful information (e.g., hidden patterns) to make better decisions across business processes among functions or companies (Waller & Fawcett, 2013). BDA is sometimes also defined as technologies (e.g. database and data mining tools) and techniques (e.g. analytical methods) that a company can employ to analyse large-scale, complex data for various applications intended to augment firm performance in various dimensions (Kwon et al., 2014). BDA consists of the application of multiple analytic methods that address the diversity of BD to provide actionable, descriptive, predictive, and prescriptive results (Wamba et al, 2015).

BDA has a dominant role in a variety of industries. For example, BDA enhances manufacturing and industrial automation (Wilkins, 2013). In the healthcare sector, BDA reduces operational costs and improve the quality of life (Liu, 2014). From the perspective of supply chain management, BDA helps to improve visibility, resilience and robustness (Gardner, 2013).

Studies argue that BDA can create significant value for the world economy, enhancing the productivity and competitiveness of companies and the public sector (Manyika et al., 2013). Also, it is argued that BDA could reduce the environmental footprint (Van Rijmenam, 2014).

THE USE OF BDA FOR TBL

Despite increasing attention about sustainability, there is relatively little managerial and academic understanding of how companies respond to sustainability issues. Most of the studies primarily focus on the strategy of sustainability (Engert, Rauter, & Baumgartner, 2016; Marshall & Brown, 2003; Sabella & Eid, 2016). While some others focus on the measurement of performance on sustainability (Paulraj et al. 2017), there are few studies on information technology utilisation and its impact on sustainability (Gunasekaran et al., 2017; Song et al., 2017).

With the rapid evolution of BD technologies, employing BDA could solve sustainability issues (Shdifat et al., 2020). The following subsections present how BDA could affect economic, social, and environmental performance of companies.

Impact of BDA on economic performance

Firms use BD technologies in order to capture vast amounts of data from several sources, such as radio frequency identification tags, web information, and social media activities (Davenport, 2014). These massive collected data can make radical changes in the way businesses manage their customers and their business models (Braganza et al., 2017, p.329).

In the current business environment, the firm dramatically relies on information systems and data analytics to build its competitive advantage (Chen et al., 2012; LaValle et al., 2011). Several studies indicate the business value of BDA solutions to enhance financial performance (Akter et al., 2016; Wamba et al., 2015; Wamba et al., 2017). BDA increases customer satisfaction and loyalty through improving corporate ability to meet their preferences (Wamba et al., 2017). In addition, BDA decreases customer acquisition costs (Wamba et al., 2015), which are critical factors for enhanced cash flows in order to enhance financial performance (Wamba et al., 2017). BDA can also increase profit and market share, maximise sales and financial productivity as well as return on investment (Schroeck et al., 2012). For example, BDA can help firms increase new

products and services creation, satisfy customer needs at the right time and place, expand into new markets, and improve sales and revenue (Columbus, 2014). The utilization of BDA in economic sustainability might be summarized under two key economic performance criteria: (1) profitability and (2) sales growth.

(1) Predictive analytics-based BDA and text mining can reduce costs and increase profits (i.e. waste and fraud reduction). For example, an Australian healthcare organisation uses CMC-I+Plus, an advanced analytical application providing claim-based intelligence to facilitate customers claim governance, balance cost, and quality (Srinivasan & Arunasalam, 2013). As a result, managers can use the patterns of predictive analytics-based BDA and text mining to review a cost and profit summary related to each healthcare service, identify any claim anomalies, and thus make proactive decisions that eventually lead into increased profitability.

(2) BDA can be used to enhance business value and firm performance by directly improving the sales. For example, personalised recommendation systems in Amazon generated 29% of Amazon's annual sales (JP, 2012). The success of this recommender system depends on advanced data analytic tools and methods. It combines data from different sources: search and web browsing history, purchase history, other customers' purchase and browsing history, related products available and current item in shopping carts. Amazon finds proper suggestions for new or existing customers by applying sophisticated mathematical algorithms (Linden, Smith, & York, 2003).

Impact of BDA on environmental performance

There is an increasing call to address environmental sustainability matters in light of the new forms of analytics and insight that big data could generate. BDA can be used to improve sustainability by exploring hidden patterns, unknown correlations, and trends (Wu et al., 2016). There have been several studies on BDA for approaching environmental issues as pollution, waste, resource depletion, and ecology disruptions. For example, in order to improve the urban air quality to protect human health and control air pollution, Zheng et al. (2013) proposed a semi-supervised learning method consisting of a spatial classifier involving spatial -related features (e.g., length of

highways) and a time classifier involving temporally-related features (e.g., traffic). This method provides fine-granularity air quality prediction in real-time based on limited air quality monitor stations.

Another important use of big data's real-time analytics is processing data instantaneously. IBM company's mainframe computer called "Deep Thunder" is designed to provide local, high-resolution weather predictions (Mukred & Jianguo, 2017). This mainframe computer could be used to predict the locations where the public is going to face outages due to weather conditions. Consequently, any company using "Deep Thunder" can take the necessary steps to prevent that or fix it right on time which leads to reducing the cost and optimising energy use for the company (Mukred & Jianguo, 2017).

Utilisation of big data in environmental sustainability can be discussed under four environmental performance categories: (1) enhancing energy efficiency, (2) reducing emissions of CO2 and gases, (3) adoption of cleaner manufacturing practices and (4) improving natural resource utilisation.

(1) One of the essential metrics to determine the degree of energy-savings is energy efficiency. BDA is considered an effective method to optimise energy use in order to reduce the relevant environmental impacts. BDA technologies collect data from different resources to extract valuable information to help create energy strategies. For example, energy efficiency in the building sector. BDA technologies could be utilised to analyse and understand individuals' energy consumption behaviour, which leads to improving energy efficiency and promoting energy conservation (Koseleva & Ropaite, 2017).

(2) Regarding emission of CO2 and other greenhouse gases, BDA such as the analysis of extensive data based on the Global Positioning System (GPS) might be influential by improving systems management and planning. A study supported by the European Council (De Gennaro et al., 2016) declared that the main areas for reducing greenhouse gas emissions in the transport sector are turning to carbon-free or less carbon-intensive fuels and improving fuel efficiency. This study developed a methodology that provides a broad overview of data-processing platform applications designed to harness the enormous data potential of Europe's road transport policies. The platform

mentioned above uses data from navigation mobility-focused systems and driving styles. A preliminary pilot study was performed, and its basic algorithms were developed based on two sets of data from conventional fuel vehicles assembled using on-board GPS systems. The emissions model shows how evaporative emissions can be measured from fuel vehicles based on real-world driving data. That is why BDA technologies can facilitate the reduction of emissions and lead to sustainable development (De Gennaro et al., 2016).

(3) A combination with BDA and service-driven patterns that could help manufacturing firms to overcome the lack of complete data and valuable knowledge related to product lifecycle management. It could also encourage them to manufacture in a cleaner manner which leads to sustainable production and improve their sustainable competitive advantage (Zhang et al., 2017).

(4) BDA could improve the utilization of natural resources that play crucial roles in sustainable development. Rapid improvement in an economy might lead to adverse influence on the ecosystem. Hence, manufacturing firms should consider sustainable management of ecological resources and human resources (Song et al., 2017). For example, in 2015, the multinational company Unilever has achieved a zero-waste-to-landfill target at its more than 240 manufacturing plants in 67 countries (Unilever, 2015). In 2017, it had lowered water usage by 20% across 90 of its sites through using BDA and Internet of Things-enabled sensors. The company also raised its annual consumption of renewable energy, such as wind and solar power, to 28%. By 2020, Unilever expects to reduce its dependence on coal to zero and thus cutting greenhouse gas emissions by 43% (Howells, 2017). These actions will lead to a reduction in natural resource consumption and improve sustainable performance.

Impact of BDA on social performance

Social sustainability deals with social issues such as gender discrimination, inequality, poverty, education, diversity and wages. Firms address social issues by adopting different strategies, such as corporate social responsibility (CSR) reports. Approximately 60% of the world's largest companies have CSR reports on their corporate websites (Jose & Lee, 2007). These reports

are used to share their social practices with a varying degree of detail. For example, some firms even give data about the number of days lost due to injury to portray a safe working environment in their companies (Tate, Ellram, & Kirchoff, 2010). Although a firm's commitment level should be apparent in these reports (Jose & Lee, 2007), it is difficult to decide whether an organisation was implementing socially responsible activities or merely reporting to satisfy stakeholders (Kolk, 2003).

The development of information technology and sensor technology has enabled large-scale data collection from each supply chain partner (Mani et al., 2017). Those data could be potentially useful to reduce the lack of knowledge about social sustainability criteria and address social breaches in the supply chain. Therefore, BDA expected to find proper and accurate predictions, which can lead to enhancement in transparency in supply chains and mitigate social violations to achieve social sustainability (Keeso, 2014; Song et al., 2017; Wu, Guo, Li, & Zeng, 2016). Mani, Delgado, Hazen, and Patel (2017) employed BDA to mitigate supply chain social risk and demonstrate how such mitigation can help in achieving sustainability. The results show that companies can predict various social problems including workforce safety, fuel consumptions monitoring, workforce health, security, the physical condition of vehicles, unethical behaviour, theft, speeding and traffic violations through BDA, thereby demonstrating how information management actions can decrease social breaches.

There are two significant ways BDA might contribute to solve or mitigate social issues: (1) child labour and (2) health and safety.

(1) Child labour is one of the most visible issues in social sustainability (Yawar & Seuring, 2017). Although awareness is increasing on child labour and steps have been taken to cease child labour from many countries, changes in this issue do not come easily (or quickly) due to the embeddedness in the socio-cultural and economic structure of society.

Performance monitoring is an effective technique to measure supplier performance, which identifies the breach level of social issues across the supplier base. It includes both comprehensive audits using the code of conduct and focused assessments in specific high-risk areas such as child

labour. However, auditing for child labour in the lower tiers of supply chains can be difficult due to having a poor capability for capturing and reporting information about child abuses (Syafrudin et al., 2017). As a result, investment in advance technologies for data gathering and analysing from suppliers will assist in monitoring the performance (Mamic, 2005) that will ultimately help managers in deciding how to reduce social violations in supply chains in order to achieve social sustainability. An example of the use of BDA comes from the work of Thöni, Taudes, and Tjoa (2018). This study developed a novel model for social sustainability monitoring in supply chains based on a Bayesian network and big data analysis (text mining). A quantitative risk model continuously ranks suppliers based on their risk of breaching sustainability standards on child labour. A Bayesian network uses various data sources such as statistical data, social media (twitter), audit results, and public reports of child labour incidents, which helps to determine the breach likelihood for each supplier location. The model includes child labour incidents automatically from publicly available news sources using text-mining algorithms in order to improve child labour standards in the supply chain.

(2) BDA might contribute to the efficiency of health and safety performance of companies. Social media has become an essential channel used by firms to spread information and communicate with external parties. Official firm websites provide vast amounts of diverse information regarding firm performance and development. For example, a study (Wu et al., 2017) collected data from various types of data about light-emitting diode firms (such as qualitative data from management and social media data as well as quantitative data regarding operations) and employed a novel method based on big data analysis to develop sustainability by strengthening these firms capabilities to mitigate social risks, such as health and safety. This kind of different BDA models might be used to collect data regarding unethical issues from supply chain partners, such as health and safety, so that an international watchdog company could determine the breach likelihood along the supply chain base. As a result, this information might help managers to make decisions regarding reducing social violations in supply chains to achieve social sustainability.

CONCLUDING REMARKS

The overview reported in this chapter offer insights into the interplay between BDA and the three TBL elements. It is merely focused on one digital tool that is BDA, but the rest of the chapters in this book bring different aspects of digitalization and its impact on corporate sustainability. The chapter argues that the goal of long-term sustainability, meaning growing without harming the requirements of the future, requires the use of some managerial and technological tools. We argue that the TBL perspective might be an efficient managerial tool for companies. This perspective forces firms to perform well in three dimensions: economic, social, and environmental. In addition, we argue that BDA could be an effective and efficient technological tool while struggling with sustainability challenges. In the era of data revolution, stakeholders, such as shareholders and communities, have the power to press on a firm to consider the long-term impact of commercial activities on both the environment and society. BDA provides beneficial information allowing managers to manage their business more effectively according to social, economic, and environmental performances. In sum, employing BDA provides opportunities for companies to establish corporate sustainability in a competitive market.

To meet the demands of current and future stakeholders, this chapter recommends business managers and entrepreneurs to align their business, sustainability, and BDA strategies. BDA is a tool and it could be instrumental in overcoming TBL related challenges for companies. However, this might not be automatic and businesses might not efficiently utilize BDA. That is why there is room for the intervention of policy makers to motivate businesses to adapt and implement in their businesses as well as regulate its implementation. In fact, policy makers could themselves use BDA for the sake of society. For example, BD can shed light on social breaches in the business market that were previously hidden, such as gender discrimination and inequality. Proper and accurate predictions are founded from BDA, which help policymakers to put regulations promoting a workplace to achieve diversity, equality, and fairness.

However, due to its descriptive nature, it has two limitations that might be opportunities for researchers in the sustainability field. First, it is an overview of the literature that could lay the

base to develop a framework to examine the relationship between BDA and sustainability performance. Conducting empirical work in different industry settings and countries could enrich the knowledge on assessing BDA and sustainability performance as well as the impact of BDA on sustainability performance. Second, further studies might expand the scope of search to find out additional factors that might affect the impact of BDA on sustainability performance.

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