Towards Sustainability: The Manufacturers' Perspective

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Abstract. Moving towards more sustainable operations is a challenging goal for industries. The growth of interest in corporate sustainability performance has brought attention to the importance of accounting and transparency across economic, environmental and social dimensions. This paper provides an explorative study addressing sustainability from the perspective of industrial firms. The paper presents case studies on the application of the Triple Layered Business Model Canvas, which allows for relevant insight into how firms account for economic, environmental and social values. The findings show that while accounting for economic values is well taken care of, accounting for environmental values are at an initial stage, and accounting for social values are virtually lacking. Thus, the ability for the industrial firms to conduct a sustainability assessment is limited. The opportunities lie in the adaptation of digital technologies providing cost efficient feedback mechanisms for environmental and social values. This can support environmental and social accounting, giving industrial managers a decision management tool to guide their transition towards more sustainable operations, and aligning company goals with the UN Sustainable Development.

Keywords: Sustainability · Manufacturing · Triple layered business model · Digitalization

1 Introduction

Sustainability and digitalization are two terms that have gained increased attention since they are representing potential transforming forces of businesses and the society. Sustainability has moved from being a regulative pressure from the surroundings and a corporate buzzword, to becoming a concept that businesses have to relate to and implement in their activities [1, 2]. The growth of interest in corporate sustainability performance has brought attention to the importance of accounting and transparency across economic, environmental and social dimensions [3]. This study focuses on how industrial companies are accounting for economic, environmental and social values. The paper presents case studies on the application of the Triple Layered Business Model Canvas (TLBMC) [2]. TLBMC add an environmental layer based on a lifecycle perspective and a social layer based on a stakeholder management approach, to the traditional business model canvas. Among other tools for sustainability measurement

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(LCA, Social LCA, GRI) that are complex, time-consuming and require detailed data, the TLBMC gives an understanding of how organizations generate impacts and how to evaluate these impacts in terms of the triple bottom line perspective. The TLBMC also integrates the evaluation of impacts throughout supply chain to customer and stakeholders.

Financial accounting has evolved over several centuries giving companies a detailed, high quality, view of its financial operations. Accounting systems for environmental operations and social values are, however, under development [1, 3, 4]. Furthermore, the fourth industrial revolution based on innovations in technologies, smart materials and innovative manufacturing operations is a driving force for using technology for collection and handling data [5, 6]. Digitalization will play a vital role in providing data feeding the economic, environmental and social accounting systems, giving companies powerful business decision analytical tools to move towards making their businesses more efficient and sustainable [7].

In order to transform companies to become sustainable, a new theoretical and practical basis within operation management is called for. This paper explore how and to what extent the manufacturing companies currently are accounting for economic, environmental and social values. In-depth case studies were conducted in two companies, one in the maritime and one in the marine sector in Norway [8]. In these case studies, the Triple Layered Business Model Canvas (TLBMC) [1] was applied to identify how the companies' accounted for operations within the economic, environmental and social domains. Based on this, we discuss how digital technologies may contribute to improve measurement of environmental and social values.

2 Sustainability Accounting

Digital technologies provide the means for detailed accounting across the economic, social and environmental domains. Coupling digital technologies with sustainability principles can help companies to acquire information that is more accurate on their operations. Digitalization can be identified as one of the enablers of sustainability in terms of improving resource efficiency, manufacturing performance and as an opportunity to establish accessible data system and obtain flexible and smart use of data through application of information technology [7]. Of particular interest for our study is the ability of using technology to support the triple layered business model. For the economic layer, existing financial accounting systems have long been highly optimized giving companies detailed real-time data on the economic status of the company.

For the environmental layer, it is much harder as the operations are affecting our physical environment. Obtaining detailed real-time data on the environmental status can be done in a cost efficient manner by utilizing emerging digital technologies like internet of things (IoT). This creates intelligent assets that report on environmental factors of interest, including energy consumption, chemical constituents involved, temperature, and other physical conditions. IoT provide us with the means to link the physical world with the virtual world, allowing for detailed information on all aspects having an environmental effect. This enables calculation of the environmental bottom line in the same manner as the financial bottom line in the profit and loss statement.

Such detailed information is valuable input to management for further improvement of the environmental bottom line.

For the social layer, the use of social software emerging from innovations in social media is promising, as it can provide industrial companies with detailed data on social factors allowing the calculation of the social bottom line for a company. However, as identifying what social factors to measure for an industrial firm is an emerging area of research [4]. This study aims at contribution to this research by investigating how the companies currently are approaching triple bottom line accounting.

3 The Triple-Layered Business Model Canvas (TLBMC)

The literature suggests a large number of frameworks and methodologies on sustainability. Some scholars propose various business models, for instance business models for sustainability and circular business models [1, 9, 10]. The TLBMC is a tool for developing sustainable business models. A business model (BM) is a conceptual model that integrates coherence of processes and information necessary for value creation of a firm [11]. The TLBMC tool extends the original business model canvas by adding two layers: an environmental layer based on a lifecycle perspective, and a social layer based on a stakeholder perspective. In combination, the three layers of the business model can show how an organization generates economic-, environmental-, and social value [1, 12]. According to Joyce and Paquin [1], there are horizontal and vertical coherences between each layer. The horizontal coherence of TLBMC is assured by examining each of three layers separately, while the vertical coherence combines the value creation of the three canvas layers [13].

The Economic layer encompasses the assessment of nine interdependent components, such as customer value proposition, segments, customer relationship, channels, key resources, key activities, partners, cost and revenues. The Environmental layer is based on a life cycle perspective of the environmental impact. The layer assesses environmental benefits and environmental impacts of the company. As the business model canvas evaluates how revenues outweigh costs, the Environmental layer aims at assessing whether the company's highest environmental impact is within their sustainability goals [1]. Following this approach, organizations might search for environmentally oriented solutions, especially when the environmental impacts are large. The Environmental layer consists of nine components, which together give the bottom line on environmental performance of the company.

The Social layer rests on a stakeholder management approach to explore an organization's social impact [1], seeking to balance the interests of an organization's stakeholders rather than maximizing the gain for the organization itself. Examples of stakeholders are employees, shareholders, customers, suppliers, and governmental bodies.

4 Methodological Approach

The sustainability accounting issues addressed in this paper are explorative in their nature, calling for an open and explorative approach. We have carried out in-depth case studies in two Norwegian companies. In order to find what data was available in the three layers in the TLBMC, we interviewed key personnel in the company, and investigating internal company documents. The TLBMC model was governing the questions as well as the document analysis. The findings lay the foundation for discussed how digitalization and Industry 4.0 can contribute to sustainability accounting along the three dimensions.

5 The Case Companies

The methodology of the TLBMC was applied on two companies from marine and maritime industries. The companies were selected based on their practices and focus towards sustainability. Company A is a maritime mechanical equipment supplier and is an important actor in the region's maritime industry. The company controls the complete value chain, involving various activities starting from design, manufacturing, marketing and after-sales service for maintenance and repair. The production facilities are located in the region. The firm focuses on providing maintenance, upgrade service for the equipment in order to extend the lifetime of equipment. The product range includes environmentally friendly products with lower energy consumption, low noise and vibration. Company B is a fishing company that provide catching, processing and delivery of fish fillets. It uses eco-friendly factory trawlers with hybrid propulsion and low nitrogen oxide (NOx) emission. The company focuses on sustainable harvesting techniques that minimizes emissions and utilize 100% of the fish and aims to provide a high degree of transparency as all fish caught are traceable. Both companies are categorized as small and medium-sized companies representing two different and important industries in Norway.

6 Findings

Most information related to the economic layer in the TLBMC was easy accessible by the companies' managers. The data and information for the environmental layer provided a generalized understanding of the impact of business operations on the environment. The study revealed, however, that there is a lack of data on greenhouse gas (GHG) emission for distribution and energy requirements during the operation. Some components of the social layer were difficult to define and measure, for instance, social value, scale of outreach and social impacts.

Company A emphasizes the differences regarding product types, as this have impact on manufacturing, energy consumption for product use, and finally the environmental impact. The products in Company A were very complex, which led to challenges in applying the TLMBC framework. Nevertheless, Company A makes several kinds of products and some of them were identified as environmentally friendly

products. They have lower energy consumption, lower noise and vibration than comparable products. The interviews revealed that Company A does not have a single accounting system for data. Data are distributed according to the organizational structure of the firm and separate pieces of data belong to specific department or to responsible of those employees. Consequently, there is a lack of a systematic approach to information storage with data organized in an accessible and structured way. Sustainability from the perspective of the TLBMC, was directed towards detailed review of all business processes, starting from raw materials delivery by suppliers, along the manufacturing, logistics, warehousing, towards customer use, and finally finishes at the end of use stage. For the environmental and social layers we were not able to map the different elements in the TLBMC due to the lack of available data.

Compared to Company A, Company B has a shorter value chain, which is mainly integrated in one vessel. In this case, fishing is one of the central activities of the company. However, information about fuel consumption and NOx emission were not available. General information about consumption level came from the shipbuilding company in Spain. To apply life cycle approach to the environmental value, it is imperative to take a broader view on the entire life cycle. Trading partners include firms who provide packaging material, processing factory manufacturers, fuel providers, and vessel maintenance companies among others. In this case, the conduction of a more comprehensive sustainability assessment was limited due to the absence of necessary information about suppliers that are part of the product's life cycle and hence are contributors to the emission level of the product. Table 1 shows the data and information collected for the Environmental Layer for both companies.

Exploring the interrelations between digitalization and sustainability measurement, the findings reveal that the data requirements are high, especially regarding the environmental layer of the TLBMC. The case studies show that the information collected partly fulfills the requirements for production phase analysis for both companies A and B. For Company A, data on energy consumption in production facilities for 2012–2017 was received. According to the findings in Company B, the resulting data consisted of information regarding fuel used for catching, processing, freezing on the vessel, and storage/freezing after taken from the vessel per 1 kg of fish. The information for material phase for Company B provides particular insight on packaging materials. The first common issue for those companies is absence of the information from the suppliers, for instance, environmental impact from raw materials supply and logistics. Furthermore, customer use and end of life stages are not at the main scope of these companies. As a result, the responsibility for the product impact often ends when the suppliers' role finishes. At the same time, the information flow on business activities generally is not completely shared between supplier firms across the value chain. Consequently, based on the data and information collected during the interviews and secondary data assessment, the measured environmental impacts and benefits are not addressing total impacts and benefits of the activities of the companies in this study.

The findings show that important data and information related to environmental and social aspects are not available or even not accessible for the companies. For example, the information on products delivered by suppliers such as raw materials and equipment for Company A, and packing materials and processing factory for Company B, is missing. Radio Frequency Identification (RFID) technology can help to identify at what

Table 1. Data collected for the environmental layer for company A and B

Environmental layer	Company A	Company B
Supplies and outsourcing	***	***
Production	** Energy consumption Waste for recycling, hazardous waste	** Estimated fuel consumption
Materials	***	** Information about reduction of pollutants from supplier
Functional value	One type of mechanical system	1 kg fresh frozen fish
Distribution	***	***
Use phase	***	***
End-of-life	***	**
Environmental impacts	** Electricity use in production facilities Data on noise and vibration Hazardous waste	** NOx production Disposal of packing material
Environmental benefits	** ISO 14001 Three environmentally friendly products Waste for recycling and further processing	**Reduction of NO_x (2016–2017) 100% use of fish Modern trawler prevents catching of small fish which secure future stock

* - Data available
** - Partly available data
*** - No data

stage the components or equipment were produced along the supply chain, and the materials it consists of. This can contribute to simplify recycling processes by identifying how and where it can be recycled, or what components can be reused or replaced to extend the life cycle [14]. Furthermore, from the social and ethical perspective, RFID technology can trace the location history of a product and can prove the authenticity of a product, hence customers and firms can make more environmentally and socially informed decisions [14]. Additive manufacturing can offer opportunities to improve and optimize materials and design of a product in order to enhance recycling and remanufacturing of components and decrease waste [15].

Another essential phase for sustainability assessment is the use phase and end of life of a product, which also lacked data. Cyber-physical systems (CPS) that establish connective and communicative solutions can allow sufficient information exchange and control between humans, machines and products. The collection of data and information can be carried out through installed sensors, actuators and communication

technologies, which can be used to capture data on emissions of a product during the use phase for Company A. Thus, digitalization and novel emerging technology solutions are crucial for industrial sustainability accountability, directed to redesign for value creation in sustainable production and consumption.

7 Discussion and Conclusion

The case study findings of the TLBMC application emphasize that sustainability is a data- and information-demanding area. The study indicates that the case companies are at a stage of development where they are not capturing sufficient data and information along the supply chain in order to conduct overall sustainability assessment across the economic, environmental and social domains of sustainability. This indicates that the companies are not able to manage their processes in an efficient way towards their sustainability goals.

High data requirements for sustainability measurement underline the importance of digitalization of businesses. Digitalization from the perspective of business model for sustainability requires a common system for data and information, its processing and structuring. This will support the effective interpretation of data, which is crucial for business model redesign and sustainability assessment. This study illustrates the importance of data availability for sustainability measurement across each domain of the triple bottom line. Managers should consider the opportunities represented by digitalization, and provide support learning programs for employees to obtain the digitalization skills required [16]. The opportunities lie in adaptation of new technologies, which allow collection of data for the environmental and social layers in a similar manner as the economic layer.

Having said that, we acknowledge that the implementation of technology will not solve all challenges in the path to sustainable manufacturing and supply chains. Technology can contribute to collecting, sharing and analyzing data, but does not solve the trade-offs that have to be made between different and conflicting issues. In particular, there may be conflicting goals between the layers, which call for an interdisciplinary dialogue and approach, which cannot be solved by technology alone.

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