

# An Integrated Approach towards Determinants of Factors of Technology and Drivers for Achieving Sustainability in Industry 4.0

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## Article Info

Volume 82

Page Number: 16601 - 16618

Publication Issue:

January-February 2020

## Article History

Article Received: 18 May 2019

Revised: 14 July 2019

Accepted: 22 December 2019

Publication: 28 February 2020

## Abstract:

With rapid technological developments with the onset of Industry 4.0, newer technologies are being employed across all sectors. And also with rising environmental concerns and businesses facing more volatility, complexity and risk every day than ever before there is a dire need to adjust to this volatile environment through leveraging the data that is readily available through the use of technology and staying ahead of the game by attaining sustainability in business towards people, process and machines. Hence, an exploratory research has been performed for understanding different sustainable models available and a business scorecard is proposed for achieving sustainability in Industry 4.0 through the use of smart technologies which will facilitate the same across both manufacturing and service industries.

**Keywords:** Sustainability, UN SDGs, Industry 4.0, Business Models, Smart Supply chain.

## 1. INTRODUCTION:

The Industry 4.0 was introduced in World Economic Forum in 2015, and now every industrial sector is in the race towards adopting newer technologies to stay ahead of the competition by addressing customer requirements and achieving sustainability in their operations for surviving in the dynamic market. Industry 4.0 can be described as the next phase of digitization across all sectors, which is driven by huge volumes of data, 24 hours connectivity, human-machine and machine-machine interactions and last but not the least use of analytics for efficient decision making about future and present using past data (Baur, 2015). Most of the research has been done on introducing of Industry 4.0, its advantages with the usage of newer smart

technologies for increasing productivity and efficiency. It can be seen that every industrial sector from small scale to large scale is in rush for adopting Industry 4.0. The most crucial factor is being overlooked by many industries in adopting Industry 4.0 and that is sustainability. Sustainability is one the major focus of Industry 4.0, it constitutes sustainability across employee workforce, operations, efficiency, processes, quality, and most important towards environment. Hence it is necessary to look from sustainability perspective how Industry 4.0 can revolutionize the environment. Organized manufacturing is the biggest private sector employer in India. Overall, more than 30 million people are employed by this sector (organized and unorganized) and will therefore

become the driving force of growth. The sector will further push growth in the rural areas where more than 5 million manufacturing establishments are already running. Government aims to achieve 25 per cent GDP share and 100 million new jobs in this sector by 2022.

The use of AI, deep learning and data mining will allow industries to offer real time analysis and help them in optimizing maintenance and reliability, proactively identifying and mitigating low probability yet high consequence events, improving operations management system for better identifying and eliminating sources of risk and value loss. It will also help in risk visibility by optimizing data and information management thereby, making industries more efficient and saving time and money with process optimization.

## 2. LITERATURE REVIEW:

The Industry 4.0 application varies across all sector, hence different authors have described the same in their own way according to the study involved. Industry 4.0 constitutes achieving various goals like sustainability, automation etc. through the use of technology. Hence its application varies across all sectors and can be adopted as per usage. The sustainability across industries should be mapped in accordance with the UN SDGs set for nations. So as to achieve sustainability at all fronts, UN SDGs needs to be incorporated within the business across all sectors using the Industry 4.0. Since no research has been made in integrating SDGs into businesses using Industry 4.0, hence an attempt is made for achieving the same. For employing sustainability at full scale in any business, it needs to be integrated at various levels like Business models, Employee workforce, Manufacturing sector, Service sector and Ecological environment.

### 2.1. INTRODUCTION TO UN SUSTAINABLE DEVELOPMENT GOALS

UN Heads of State and Government in September 2015, came together to set the world on a path towards sustainable development through the adoption of agenda of Sustainable Development by 2030. This agenda includes 17 Sustainable Development Goals which set out quantitative objectives across the social, economic, and environmental dimensions of sustainable development – all to be achieved by 2030. The

SDGs provides a framework for achieving a better and more sustainable future for all. The SDGs are set with the objectives of addressing various global challenges including equality, poverty, environmental degradation, economic growth, innovation etc. which are being faced across developed and developing economies. Hence the SDGs acts as a lifeline connecting the future with the present. The goals provide a framework for shared action “for people, planet and prosperity,” to be implemented by “all countries and all stakeholders, acting in collaborative partnership”(Getting Started with the Sustainable Development Goals, 2015).

Therefore, a discussion has been made for employing SDGs and their importance in businesses contributing to achieving sustainability across every stakeholder. Firstly, (Pederson, 2018) have discussed the importance of integrating UN SDGs into business. The UN SDGs were preceded by Millennium development goals or MDGs which constituted 8 key focus areas between the time periods 2000 to 2015. The MDG were mapped taking into consideration the political agendas whereas SDGs were mapped taking into account 360<sup>0</sup> sustainability perspective towards people, businesses and planet. A case study of a biotechnology company Novozymes which had incorporated SDGs is discussed. The company started its business by incorporating sustainability activities for controlling operational and SC risks, subsequently they shifted their sustainability focus towards customers and products and finally when UN SDGs came, they merged the sustainability and business goals for achieving business innovation and development. UN SDGs can be incorporated into any company’s goals and policies via memberships of United Nations Global Compact (UNGC), International Chamber of Commerce (ICC), World Business council for Sustainable Development (WBCSD) which will help in providing the guidelines for achieving the same. Hence incorporating SDGs will help businesses in achieving sustainability across operational, environmental and social level thereby providing them competitive advantage in the dynamic market conditions where the business focus has shifted from profit centric to consumer centric. Secondly, (Jovane, Selinger, & Stock, 2017) have discussed competitive sustainable globalization (CSG), due to rapid globalization, industrial growth had also brought global challenges along with it pertaining to

all the verticals of sustainability. Through CSG, an attempt is being made to cope up with the existing challenges and also to take preventive and precautionary actions for future challenges for ensuring sustainability along with industrial growth. Sustainability along with globalization were discussed in accordance with reports of various global stakeholders like IMF, UN, WWF and WTO etc... Future perspective and challenges were discussed for mapping the specific challenges and finding measures to counter them. Smart Sustainable Manufacturing is identified as an enabler for achieving CSG and global and local approach was viewed for the same. Since value creation is the driving purpose of every business, value system engineering was developed taking into customer's perspective. Smart Business models for sustainable manufacturing, creating awareness through education and leveraging innovation were identified as crucial factors for achieving CSG. And lastly, (Moldavska & Welo, 2019) have discussed the assessment of corporate sustainability in manufacturing. The assessment was formulated keeping in mind the involvement of SDGs in business operations of any manufacturing firm. Existing gaps, challenges and shortcomings were discussed thoroughly for manufacturing sustainability assessment for identifying how to integrate sustainable practices and sustainability performance as major gaps were existing around this. A conceptual model was developed for integrating different criteria's pertaining to sustainable manufacturing and sustainable world in an organizational model.

Hence, the SDGs made by UN doesn't only concern political or nation perspective, they takes into account every aspect and how it can make an impact in improving the present and creating a safe future. And it can be observed from the above discussion that UN SDGs should be integrated with an organization's goals which will help business in achieving sustainable development.

## 2.2. SUSTAINABILITY IN INDUSTRY 4.0

The Industry 4.0 application varies across all sector, hence different authors have described the same in their own way according to the study involved. Industry 4.0 constitutes achieving various goals like sustainability, automation etc. through the use of technology. Hence its application varies across all sectors and can be adopted as per usage. And sustainability in businesses refers to

interlinking the industry and society to address the dynamic changing market scenarios, environmental conditions and consumer demands. And also prepping for reducing resource consumption and achieving sustainability across all segments of businesses for ensuring safe future for coming generations. Hence, Industry 4.0 which is a great technological revolution for business, is looked upon through sustainability perspective and discussion has been made regarding the same.

In the literature reviewed for Industry 4.0, (M. S. Reis & Gins, 2017) have discussed the evolution of Industrial Process Monitoring under the influence of Big Data which is a part of Industry 4.0. The three dimensions of Industrial process monitoring are Detection, Diagnosis and prognosis. (Vaidya, Ambad, & Bhosle, 2018) have elucidated the scope of Industry 4.0 in terms of its understanding, application, challenges, opportunities and future prospects. (Kamble, Gunasekaran, & Gawankar, 2018) have discussed various research approaches, current status and an integrated framework of process, technologies and sustainability for Industry 4.0. (Dalenogare, Benitez, Ayala, & Frank, 2018) elucidated the impact of Industry 4.0 in improving industrial performance, operations, and products through the use of smart technologies. (Lu, 2017) discussed the role and scope of various smart technologies existing in Industry 4.0 for overcoming the existing challenges, increasing interoperability and for integrating people, services and things.

(M. S. Reis & Gins, 2017) explained the aim of IPM is to achieve operation safety and security of the people and the assets along with minimizing the total downtime of the processes. And as most of the time is used up in detection, diagnosing and troubleshooting actions, until the identification and analysis of the root causes. So as to address this, multivariate statistical process monitoring is done for diagnosis and the next wave through IPM is prognosis which will lead to the interaction between Process, Reliability and Maintenance, with mutual benefit of individual operations and of overall system and thereby plant. (de Sousa Jabbour, Jabbour, Foropon, & Filho, 2018) have discussed the role of critical success factors impacting Industry 4.0 for revolutionizing sustainable manufacturing. An integrated framework was developed for understanding the synergy between environmentally sustainable manufacturing and Industry 4.0. The various critical

factors identified were Top management commitment, Organizational change readiness, Management leadership, Strategic alignment, Training and capacity building, communication, Project Management, and Empowerment etc... Lastly, **(Kamble, Gunasekaran, & Sharma, 2018)** discussed the potential barriers in India that are creating hindrance for Manufacturing organizations for employing Industry 4.0 in their business operations. The relationships among the barriers and their dependence power was recognized through interpretive structural modelling and fuzzy MICMAC analysis. Identification and classification of the barriers, revealed direct and indirect effects of all the barriers on the Industry 4.0 adoption. The findings will also help the policymakers for a close understanding of the Industry 4.0 adoption method and also about the barriers impeding its implementation.

Hence, Industry 4.0 does take into account all aspects for improving industrial performance not only through smart technologies but on the foundation of achieving sustainability across all its stakeholders and it represents that how technology acts as a driver for achieving the organizations growth and sustainability goals.

### 2.3. SUSTAINABILITY ACROSS BUSINESS MODELS

For ensuring longevity of businesses, the sustainability should be involved in the businesses from the business models to lay a strong foundation which will lead to saving time, effort, money and also for delivering more value through products and services in future. Hence an attempt has been made for understanding different types of business models and how sustainability perspective can be incorporated into the businesses pertaining to all sectors.

Firstly, research work done on business models are being reviewed to have better understanding of the work done in this field. **(Geissdoerfer et al., 2017)** have discussed and explored the development of Cambridge business model which is helpful for achieving business model innovation (BMI) efforts and also map the same for organizations. The model developed is explored using it as a case study for a social start up for checking its applicability. The design implementation gap is made up of 3 components Concept design, Detail design and Implementation. The results from the same helped

in developing processes and tools in linking the design implementation gap in sustainable BMI for organizations. And **(N. M. P. Bocken & Short, 2016)** have discussed sufficiency driven business model. It incorporates customers as central idea in focus for achieving sustainable business model. As business should focus on satisfying their needs rather than promoting wants and fast fashion. To achieve this sufficiency is looked upon as a driver for developing sustainable business model innovation. Three frameworks were introduced for SBM for developing sufficiency driven BM. Barriers and enablers are represented for sufficiency driven BM. Whereas **(Oertwig, Jochem, & Knothe, 2017)** have discussed value creation networks that has become the most important factor in success of any business. The idea was discussed keeping manufacturing organizations as focus as complexity has increased manifold with varying customer requirements in the global market. Hence, it has become vital to include customers and all the stakeholders in the value chain by making the value chain transparent through development of sustainable business model. Sustainability across business model will not only provide transparency in the value chain but will also help in providing competitive advantage to the businesses by helping in creating global value creation networks. And for service sector, **(N. Bocken & Prendeville, 2017)** have discussed SBM through service design. The paper took into account every participant in the value chain and how will they be benefitted while adopting sustainability in their practices through service design. The paper had integrated service design with BMI which helps in determining the exact activity which will provide value in the value chain.

The challenges that are being faced during SBM adoption needs to illustrated and methodology for rectifying the same has been represented. **(Evans, Geissdoerfer, & Vladimirova, 2018)** have discussed the key factors involved in adoption of new business models and had also discussed the existing challenges for achieving business model innovation. The challenges identified in the adoption of business model were triple bottom line, methods and tools, external relations, resources, mind set and technology innovation. Lastly, performance measurement and key criteria's are discussed in a sustainable business model across manufacturing and service sector. **(Pieron, Pigozzo, & Mcloone, 2018)** have discussed and

elucidated sustainability factors across business models for including sustainability criteria in the development of circular business models. Sustainable business model innovation is challenging to achieve due to various factors pertaining to circular economy but it provides competitive advantage to the firms adopting it in the long term. Twenty four sustainability criteria's were recognized based on primary research for their inclusion in the development of circular business model. (Naomi, Evans, & Monteiro de Carvalho, 2016) have proposed an integrative framework for measuring performance and identifying sustainable innovation across sustainable business models. The need of going beyond incorporating sustainability via environmental and social initiatives was discussed by incorporating sustainability across their business models and thereby delivering value to its stakeholders. The framework developed was applied across two manufacturing and 2 service sector companies for measuring their performance and identifying the innovation initiatives by them.

#### 2.4. SUSTAINABILITY ACROSS MANUFACTURING SECTOR

If we look at the Supply chain and manufacturing point of view, (Stock & Seliger, 2016) have presented a research review on the micro and macro perspectives of Industry 4.0. The different dimensions outlining it are, Vertical integration, End to end engineering and horizontal integration. (Chung, Kim, & Lee, 2018) have discussed an innovation for dynamic supply chain (SC) design and operations using the concept of smart factories which will help in sharing common procedures for customized production by using cloud based system. Since achieving sustainability across the organization towards its people, process and machines is most important part and needs to be particularly looked at. (Mani, Delgado, Hazen, & Patel, 2017) have discussed and analyzed big data analytics (BDA) applications in extenuating SC's liability towards society by also exhibiting the ways to attain sustainability goals. SCM faces various threats as accidents, SC inefficiencies, delayed shipments, rising utilities costs and constantly evolving and rising expectations of consumers that undermines SC's efficiency. Employing BDS at both operational and strategic levels is considered vital for achieving sustainability. Especially for SC's operation and planning phases. BDA has been widely used for solving complex problems associated with inventory, logistics and

procurement. Using the sampling method major risks recognized for the SC were process, demand, supply, control, and environmental risks. The social issues were also recognized from the study as workforce safety, theft of vehicles and goods, tracking, fuel economy, excessive fuel consumption, workforce health, route optimization, proof of delivery, unethical workforce activities, workforce security, traffic violation, Unscrupulous workforce behavior, natural calamities and over-speeding. With the application of BDA and IoT for Surat Milk Union Limited (SUMUL) following observations were being made, With application of BDA in mitigating SC and social risk, companies were able to predict various social problems like workforce safety, health, security, vehicles, unethical behavior etc., along with SC planning through BDA. And this will further lead to the goal of achieving environmental, economic, and social sustainability.

Firstly we have looked at supply chain, manufacturing and concept of smart factories, wherein (Chung et al., 2018) identified three properties of smart SC as instrumented, interconnected and intelligent (smart). Flexibility in the smart SC is recognized in terms of process flexibility, product flexibility, design flexibility, SC flexibility, collaboration flexibility and strategic flexibility. Customer's collaboration from design to delivery is crucial for providing smart solutions and services to the end consumer. Customer can directly send his/her requirement and through cloud computing that data will reach the factory where desired product can be manufactured using AI, and data analytics. This characteristic will help in increasing the flexibility as well as effectiveness of SC involved. A smart SC along with additive manufacturing will widen the scope of opportunities and flexibility in manufacturing for customized production. And since flexibility is a multi-dimensional and smart SC's can take advantage of this opportunity. Hence, cloud – based network manufacturing systems like FaaS (factory as a service) can be adopted as one of the procedure smart SC's to meet individual requirements flexibly. (Stock & Seliger, 2016) discussed the scope of vertical integration as lying across networked information systems, for horizontal integration the scope as lying across the supply chain and in end to end integration lying across the entire product life cycle. Crosslinking of stakeholders can be seen from acquisition of raw material to the sale of product and also in products and equipments along

PLC at the macro level perspective. And horizontal integration along with vertical integration can be seen in smart factories at the micro level perspective. Different opportunities for achieving sustainable manufacturing through Industry 4.0 was presented for both macro and micro perspectives. The opportunities recognized was by combining the current industry trends and strategies with future requirements of Industry 4.0 for achieving sustainable manufacturing. (Shankar, Kumar, & Kannan, 2016) have discussed and analyzed the factors for smart sustainable manufacturing by a proposed architecture using a case. The factors were identified and studied using analytical hierarchy process (AHP), an application of MCDM approach. The common drivers identified for advanced sustainable manufacturing are Quality, Financial benefit, Stakeholders, Customer's expectation, Delivery speed and performance flexibility, Compliance with regulations, Environment conservation, Optimize usage of resources, Green purchasing, SC requirement, Green innovation, Education & Training, Employee welfare, Internal motivation, Market capabilities. The result was drawn using AHP analysis and after analysis it was found that the principle element of emerged as first priority was quality, and further ranking of drivers helped in the understanding of decision makers to reevaluate their procedure for achieving sustainable manufacturing strategies. The integration of smart technologies with sustainable practices will lead to automation and hence increasing revenue of the companies. The analysis also took into account social elements such as resources conservation, stakeholder satisfaction, employee ergonomics and safety, green concerns.

## 2.5.SUSTAINABILITY ACROSS SERVICE SECTOR

Industry 4.0 is majorly looked upon in terms of improving industrial performance for manufacturing firms but in reality it takes into account both manufacturing and service sectors. Service sector play a very crucial role in creating and delivering more value to the customer that can be applied in manufacturing firms and service sector. Firstly, (Rennung, Luminosu, & Draghici, 2016) have explored the inclusion of service sector within Industry 4.0. Since earlier the focus of Industry revolution mostly revolved around production environment, hence there is a dire need to look from service sector purview. Service networks projects were identified and analyzed using scientific

approaches under Industry 4.0 framework. A model was developed for recognizing the scope of service sector in adopting new technologies using various scientific approaches.

Secondly, the impact of product service systems in industry is discussed since in the case of both manufacturing and service sector, product – service relationship needs to be looked upon as they form the basis of addressing customer requirements along with enriching their experience. (Roy, Shehab, Durugbo, Khan, & Datta, 2019) have explored the impact of industrial product – service systems (IPS) on environmental sustainability and also discussed the existing inefficiencies. A framework was developed for achieving sustainability in the context of transforming IPS. It was observed that now manufacturers are also putting more focus on the service delivery to the customer as compared to traditional focus on manufacturing. Since service delivery creates a long term relationship and also enriches customer experience, hence more work should be put on creating and delivering more value to the customer. Secondly, service sector is looked upon with purview of sustainability since it lacks metrics for measuring sustainability. (Yadav, Abidi, & Bandyopadhyay, 2017) have discussed the development of environmental sustainability indicator for examining the performance of ITeS organizations on the parameters of sustainability. And how it helped large organizations to attain competitive advantage in the business market and had also illustrated that the lack of sustainability standards among small and medium organizations which is leading to poor performance over time. A concept of Organizational 3-environment was also proposed along with the development of e-environmental sustainability indicator profile for ITeS segment of IT industry. Lastly, (Plessis & Bam, 2017) have discussed and explored the scope of using the publicly available sustainability information for improving the current measures for reducing carbon footprint, reducing waste through recycling and company – wide initiatives. The key technologies identified for achieving the same are recognized as IoT, AI, Big Data and Cloud computing.

Hence it can observed that Industry 4.0 not only focuses on manufacturing sector but also on service sector. The service sector organizations have more scope of achieving the sustainability objectives adhering to their industry standards along with UN

SDG's and also optimizing their operations using the smart technologies.

## 2.6. SUSTAINABILITY ACROSS EMPLOYEE WORKFORCE

People contribute the most crucial and major towards sustainability, more than operations. This can be achieved when organizations workforce are also made part of it. UN SDG's took into account various goals which are for the welfare of the employees and also for their empowerment. Hence organizations sustainability objectives would be incomplete without the involvement of its employee workforce.

Firstly, **(Demirkaya, Özcüre, & Eryigit, 2011)** have discussed the importance of incorporating technology in HRM which will not only help in automation but in achieving sustainability across workforce. Primary data analysis was performed for identifying how technology can help in achieving sustainability in HRM and thereby increasing its effectiveness in organization's overall success. Secondly, **(Charms & Garcia-Blandon, 2019)** have discussed and explored the link between Sustainable HRM and Sustainable development goals. The steps for establishing the link between the two was explained along with the existing challenges. Since establishing a link between the two is crucial and can be achieved through the use of technological factors like IoT, AI, Knowledge centre, Machine learning etc., and other drivers like organizational framework, employee involvement and development programs. And lastly, **(Silvestre & Mihaela Tirca, 2019)** have discussed how achieving sustainability across workforce helps in developing a sustainability trajectory across the organization through innovation. The key technologies identified for achieving sustainability across Employee workforce were AI, Big data and social networks as they will help the organizations to get ideas from the workforce and also create some standard operating measures that needs to be followed by all the employees with the objective of reducing waste, improving efficiency and helping organization in achieving its sustainability goals.

## 2.7. SUSTAINABILITY ACROSS ECOLOGICAL ENVIRONMENT

The central idea behind the whole concept of sustainability is incomplete without considering the impact of industrial growth towards ecological environment. Environment not only provides raw material for production but is the main thing for the human existence, since with rapid industrial pollution and depleting ozone layer our planet is facing danger that if not addressed will lead to extinction of human kind and everything else with it. Hence it is very important to look at ecological environment aspect for achieving sustainability.

Firstly, **(Kwon & Lee, 2019)** had elucidated the strategic importance of three factors namely corporate reputation, operational efficiency and environmental sustainability on market valuation for high technology oriented organizations. Using complementary regression and neural network approach it was discovered that operational efficiency has the biggest impact on Tobin's Q, followed by the other two factors. Additionally, it was found that operational efficiency reflects efficiency-driven best practice and managerial proficiency and is a crucial determinant of Tobin's Q in advanced industries. Using models to estimate the interaction between these variables, it was discovered that environmental factor and its interaction with corporate factor has the biggest synergistic result on Tobin's Q, followed by the interaction of corporate factor and operational factor. Secondly, **(Beier, Niehoff, & Xue, 2018)** have discussed and explored on the impact of using IIoT will lead to achieving sustainability goals involving environmental dimension. Sustainable energy, transparency and resource efficiency were recognized as the three starting points for linking digitalization and a sustainable development of industries.

Hence with the usage of smart technologies and Industry 4.0 will not only help in improving operational efficiency and SDG's related to innovation and employee welfare but will also help in making the environment safer and greener. Environmental dimension of sustainability not only will help industries to grow but is crucial for very existence of humankind. Therefore appropriate measures should be taken for that to ensure growth and survival.

Table 1: Systematic Literature Review

S.No.	Topic	UN SDG's	Industry 4.0	Sustainability in Business Models	Sustainability in Manufacturing sector	Sustainability across employee workforce	Sustainability across Service sector	Sustainability towards ecological environment	Research Approach
1	(Pederson, 2018)	✓							Case Study
2	(Jovane et al., 2017)	✓							Exploratory
3	(Dalenogare et al., 2018)		✓						Quantitative
4	(Geissdoerfer et al., 2017)			✓					Case Study
5	(Moldavska & Welo, 2019)	✓							Conceptual
6	(Lu, 2017)		✓						Qualitative
7	(Pieroni et al., 2018)			✓					Quantitative
8	(N. M. P. Bocken & Short, 2016)			✓					Conceptual
9	(Vaidya et al., 2018)		✓						Conceptual
10	(Roy et al., 2019)						✓		Exploratory
11	(Oertwig et al., 2017)			✓					Conceptual
12	(Kamble, Gunasekaran, & Gawankar, 2018)		✓						Conceptual
13	(Evans et al., 2018)			✓					Exploratory
14	(Yadav et al., 2017)						✓		Exploratory
15	(Demirkaya et al., 2011)					✓			Quantitative
16	(M. Reis & Gins, 2017)		✓						Exploratory
17	(N. Bocken & Prendeville, 2017)			✓					Conceptual
18	(Shankar et al., 2016)				✓				Case Study
20	(Beier et al., 2018)							✓	Quantitative
21	(Mani et al., 2017)				✓				Quantitative
22	(Plessis & Bam, 2017)						✓		Exploratory
23	(Naomi et al., 2016)			✓					Quantitative
24	(Chung et al., 2018)				✓				Exploratory
25	(Charms & Garcia-Blandon, 2019)					✓			Conceptual
26	(Rennung et al., 2016)						✓		Conceptual
27	(Kwon & Lee, 2019)							✓	Quantitative
28	(Stock & Seliger, 2016)				✓				Exploratory
29	(Silvestre & Mihaela Tirca, 2019)					✓			Qualitative

### 3. RESEARCH METHODOLOGY

The research methodology involved comprehensive systematic review of literature involving 29 research articles as represented in table 1. And it connects the idea of sustainability across UN SDGs, Industry 4.0, Business models, Smart manufacturing and service industries, employee workforce and lastly the impact of all on the environment.

In our review, we identified research gap in the following areas of sustainability in Industry 4.0: (1). The lack of standard sustainable development goals at a microscopic level which takes into account business models to industries, workforce and lastly the factors contributing towards the end, the

environment. (2) Lack of sustainability measuring parameters within the purview of customers and subject matter experts. Since every company's focus had shifted from profit-centric to customer centric. Hence a Business Balance Score Card was developed to address the same, which constitutes various sustainability parameters across 4 domains that are: 1. Customer Perspective (CP), 2. Internal Business Perspective (IBP), 3. Innovation and Learning Perspective (ILP) and 4. Financial Perspective (FP). These parameters are taken into consideration from the SLR and also from discussion with subject matter experts.

1. Customer Perspective (CP)		2. Internal Business Perspective (IBP)	
Goals	Measures	Goals	Measures
Customer Satisfaction (CS)	Good quality products and service, Customer support.	Employee Satisfaction (ES)	Working time, Health and safety, Comprehensive and transparent HR department.
Customer Involvement Programs (CSP)	Engaging customer through in-house experience.	QMS	Certifications, Savings, compliance and time taken for implementation.
Eco-friendly Products (EcFP)	Sustainable products, 3R philosophy	EMS	Electricity generated through solar panels, Water usage and release of treated pollutants.
Product to Water Ratio (PWR)	Amount of water used from raw material to delivery of finished product	Performance Recognition (PR)	Idea generation, Encouraging employees by organizing contests and giving awards.
Carbon footprint (CF0)	Creating metrics for carbon mapping for consumers.	Carbon footprint (CF1)	Internal Carbon pricing

Data Privacy (DP)	Preventing against cyber-attack through comprehensive firewall and safe networking.	Business Processes (BP)	Benefit sharing, common goal, common performance measures
		Legal Aspects (LA)	Legal framework, confidential information

3. Innovation and Learning Perspective (ILP)		4. Financial Perspective (FP)	
Goals	Measures	Goals	Measures
Sustainability Projects (SP)	Number of projects undertaken in a year at department level and organization level	Green Sales and Marketing (GSM)	Money spent, Media used for communication.
Composition of business portfolios (CBP)	Manufacturing of value adding products across value chain.	Sustainability Budgets (SB)	Money allocated and used half yearly and yearly.
Sustainable Value chain (SVC)	Reducing resource consumption	Green Energy Savings (GES)	Saving in terms of money, energy consumed/produced
Eco-friendly packaging (EFP)	Selecting vendors and building in-house capacity to reduce waste e.g. plastic packaging		
Data Security (DS)	No. of data breaches, No. of users affected.		

**Figure 1: Business Balance Scorecard for Sustainability Reporting**

### 5. RESEARCH QUESTIONS

The objective of this research project is to develop sustainability reporting framework which will be applicable towards both manufacturing and service industries in Indian context. The research investigated the current

limitations in the sustainability reporting framework for new and established firms. Hence a questionnaire was developed to check the validity of the sustainability parameters which can be adopted across industries belonging to every sector for achieving

sustainability across the stakeholders of the value chain.

achieving sustainability goals across organizations.

The research questions were made based on the Business Balance Scorecard as illustrated in Figure 1. Hence, following are the questions of the questionnaire:

1. How will you rate the importance of Customer perspective parameters for measuring sustainability?
2. How will you rate the importance of Innovation and Learning perspective parameters for measuring sustainability?
3. How will you rate the Internal Business perspective parameters for measuring sustainability?
4. How will you rate the importance of Financial perspective parameters for measuring sustainability?

The questionnaire responses were collected using the Likert scale, for checking the appropriate relevance of the parameters for

## 6. FINDINGS AND DISCUSSION

Around 30 responses were collected which were then analyzed to reveal the relative importance of the measures with sustainability parameters based on the Likert scale. The data was collected using 2 groups consisting of 15 responses. 1<sup>st</sup> Group consisted of subject matter experts (SME) and 2<sup>nd</sup> group consisted of customers with age group of 25 – 60. This was done to check the relevance with respect to company’s growth and also taking into account customer’s perspective since every organization’s focus is customer centric as compared to profit centric.in the past.

Table 2 represents the count of responses across different parameters. It can be observed that for product to water ratio only 15 responses were collected from 1<sup>st</sup> group as 2<sup>nd</sup> group were not aware regarding the relevance of product to water ratio in sustainability.

**Table 2. Count of responses from the questionnaire for different sustainability parameters**

Sustainability Parameters	Measures	Count of responses					
		Not related	Dependent	Important	Very Important	Directly related	No responses
Customer Perspective	Customer Satisfaction	0	2	7	10	11	0
Customer Perspective	Customer Involvement Programs	0	2	7	9	12	0
Customer Perspective	Eco-friendly Products	0	1	6	13	10	0
Customer Perspective	Product to Water Ratio	0	0	1	7	7	15
Customer Perspective	Carbon footprint	0	11	9	7	3	0
Customer Perspective	Data Privacy	3	2	7	8	10	0
Innovation and Learning Perspective	Sustainability Projects	0	1	8	13	8	0

Innovation and Learning Perspective	Composition of business portfolios	1	6	10	8	5	0
Innovation and Learning Perspective	Sustainable Value chain	0	1	6	13	10	0
Innovation and Learning Perspective	Eco-friendly packaging	0	1	5	12	12	0
Innovation and Learning Perspective	Data Security	0	11	9	7	3	0
Internal Business Perspective	Employee Satisfaction	0	2	7	14	7	0
Internal Business Perspective	QMS	0	2	7	9	12	0
Internal Business Perspective	EMS	0	0	6	13	11	0
Internal Business Perspective	Performance Recognition	0	0	4	16	10	0
Internal Business Perspective	Carbon footprint	0	11	9	7	3	0
Internal Business Perspective	Business Processes	0	2	7	10	11	0
Internal Business Perspective	Legal Aspects	4	5	8	5	8	0
Financial Perspective	Green Sales and Marketing	1	4	7	11	7	0
Financial Perspective	Sustainability Budgets	3	4	9	7	7	0

e							
Financial Perspective	Green Energy savings	0	3	7	13	7	0

Table 3 represents the summary statistics of the responses collected. It can be observed from the table that highest rating of all the measures is given to product to water ratio with mean of 4.4. It

represents that PWR as an important factor in the customer perspective when we talking about achieving organization's SDG's.

**Table 3. Summary statistics of the Responses**

Summary Statistics						
Sustainability Parameters	Measures	Count	Mean	Median	Mode	Standard deviation
CP	CS	30	4	4	5	0.930949
CP	CIP	30	4.03333	4	5	0.948098
CP	EcFP	30	4.06667	4	4	0.81377
CP	PWR	15	4.4	4		0.61101
CP	CF0	30	3.06667	3	2	0.997775
CP	DP	30	3.66667	4	5	1.27366
ILP	SP	30	3.93333	4	4	0.81377
ILP	CoB	30	3.33333	3	3	1.07497
ILP	SVC	30	4.06667	4	4	0.81377
ILP	EFP	30	4.16667	4		0.819892
ILP	DS	30	3.06667	3	2	0.997775
IBP	ES	30	3.86667	4	4	0.845905
IBP	QMS	30	4.03333	4	5	0.948098
IBP	EMS	30	4.16667	4	4	0.734091
IBP	PR	30	4.2	4	4	0.653197
IBP	CF1	30	3.06667	3	2	0.997775
IBP	BP	30	4	4	5	0.930949
IBP	LA	30	3.26667	3		1.36463
FP	GSM	30	3.63333	4	4	1.07961
FP	SB	30	3.36667	3	3	1.25122

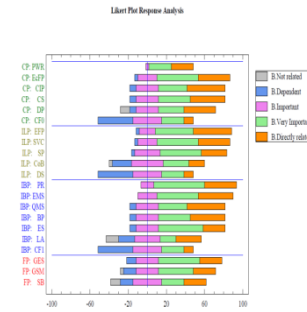
FP	GES	30	3.8	4	4	0.909212
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Data represented in Table 4 clearly represents the percentage of relation between the measures and response collected through the questionnaire. The data was analyzed using the software Statgraphics Centurion 18 – X64.

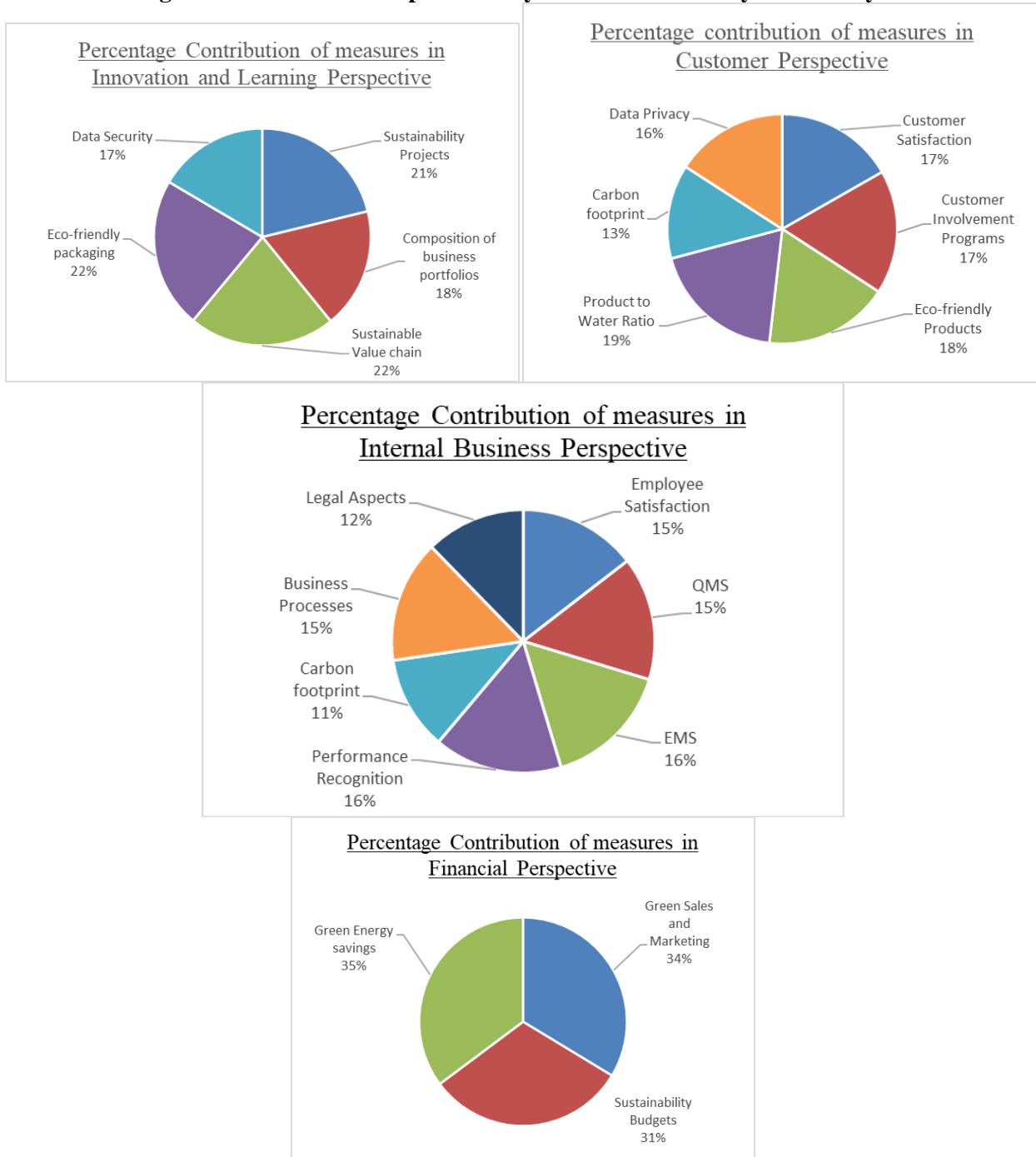
**Table 4. Percentage relevance of the responses collected across the sustainability parameter measures**

Sustainability Parameters	Measures	Total count	Not related	Dependent	Important	Very Important	Directly related	No responses
CP	CS	30	0.00%	6.67%	23.33%	33.33%	36.67%	0.00%
CP	CIP	30	0.00%	6.67%	23.33%	30.00%	40.00%	0.00%
CP	EcFP	30	0.00%	3.33%	20.00%	43.33%	33.33%	0.00%
CP	PWR	30	0.00%	0.00%	3.33%	23.33%	23.33%	50.00%
CP	CF0	30	0.00%	36.67%	30.00%	23.33%	10.00%	0.00%
CP	DP	30	10.00%	6.67%	23.33%	26.67%	33.33%	0.00%
ILP	SP	30	0.00%	3.33%	26.67%	43.33%	26.67%	0.00%
ILP	CoB	30	3.33%	20.00%	33.33%	26.67%	16.67%	0.00%
ILP	SVC	30	0.00%	3.33%	20.00%	43.33%	33.33%	0.00%
ILP	EFP	30	0.00%	3.33%	16.67%	40.00%	40.00%	0.00%
ILP	DS	30	0.00%	36.67%	30.00%	23.33%	10.00%	0.00%
IBP	ES	30	0.00%	6.67%	23.33%	46.67%	23.33%	0.00%
IBP	QMS	30	0.00%	6.67%	23.33%	30.00%	40.00%	0.00%
IBP	EMS	30	0.00%	0.00%	20.00%	43.33%	36.67%	0.00%
IBP	PR	30	0.00%	0.00%	13.33%	53.33%	33.33%	0.00%
IBP	CF1	30	0.00%	36.67%	30.00%	23.33%	10.00%	0.00%
IBP	BP	30	0.00%	6.67%	23.33%	33.33%	36.67%	0.00%
IBP	LA	30	13.33%	16.67%	26.67%	16.67%	26.67%	0.00%
FP	GSM	30	3.33%	13.33%	23.33%	36.67%	23.33%	0.00%
FP	SB	30	10.00%	13.33%	30.00%	23.33%	23.33%	0.00%
FP	GES	30	0.00%	10.00%	23.33%	43.33%	23.33%	0.00%

The figure 2 represents the Likert plot response analysis for the responses collected using the questionnaire. As it can be observed that orange region represents the direct relation between the sustainability goals with their respective groups. Whereas green, pink, blue and grey regions represents very important, important, dependent and not related regions signifying the relationship of the responses with the sustainability goals.



**Figure 2. Likert Scale Response Analysis from the Primary Data Analysis**



**Figure 3: Percentage Contribution of Measures in accordance with Business Balance Scorecard**

Figure 3 represents the percentage contribution of each parameter towards the Business Balance Scorecard parameters. It gives an overview regarding the parameters which are essential and forming the major part of the selected perspectives. The parameters are described in the Figure 1, which explains the overall idea behind the selected parameters.

## 7. CONCLUSION:

Sustainability across businesses, reflects the evolving interface between the society and industry at large wherein an era of natural resource depletion, global climatic changes and ecosystem degradation, and ever growing concern about the future among businesses as well as citizens is being seen across the planet. Given the less-than ideal state of the world economy going into the second decade of the twenty-first century, opportunity is something that needs to be seized wherever it arises. Climate-related revenues are expected to exceed two trillion dollars by 2020; these revenues include energy efficiency and renewable energy initiatives as well as the control of water and waste and pollution mitigation (*HSBC Equities and Climate Change, 2009*). Businesses that attempt to confront the causes of climate change before the problem grows worse, rather than simply reacting to its results, are positioned to create a healthier, more viable future for generations to come. Faced with a rapidly growing demand for sustainability products and new business models, companies in a broad range of sectors are using pressures from environmental challenges to innovate and create new sources of competitive advantage. And to achieve their targets where they lack is setting specific and accurate sustainability goals and parameters to achieve which takes into account all stakeholders involved in the value chain.

Various public and private organizations are present who all have their own sustainability indexes according to the businesses in which they are operating. It is difficult for a new firm or an existing firm to adhere to specific sustainability standards as they need to be updated regularly over a period of time. The areas covered under different sustainability standards are broadly divided into social, environmental and economic indicators. These indicators being broad doesn't give the real picture of the current condition of the operations of a firm.

So an attempt has been made for making standard sustainability metrics which will be applicable across both manufacturing and service organizations. The business balance card illustrated in Figure 1 takes into account sustainability in business from grass root level as from business models till its impact on environment. So all the stakeholders involved in between the two are connected and forms a major part in achieving sustainability goals. The response collected from subject matter experts and customers provide strong insights regarding the parameters that are need to be included in the Sustainability goals within industry 4.0 framework. Though a sample of 30 was taken into consideration for analysis due to time and other constraints, but it lays the foundation for future research since it identified the challenges and opportunities underlying across every stakeholder in the value chain. For future research, larger sample can be taken into account across different demographics and along with testing the above-mentioned parameters using a case study.

## 8. ACKNOWLEDGEMENTS:

I would like to express my deep gratitude to Prof. Papri Ray, my research supervisor, for her continuous guidance, enthusiastic encouragement and useful critiques of this research work. And I would also like to extend my gratitude to all the respondents for answering the questionnaire and giving their valuable inputs. Finally, I wish to thank my parents for their support and encouragement throughout my study.

## 9. REFERENCES/ BIBLIOGRAPHY:

1. Baur, C. (2015). *Manufacturing's next act*. Retrieved from <https://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act>
2. Beier, G., Niehoff, S., & Xue, B. (2018). More Sustainability in Industry through Industrial Internet of Things? *Applied Sciences*, 12. <https://doi.org/10.3390/app8020219>
3. Bocken, N. M. P., & Short, S. W. (2016). Towards a sufficiency-driven business model: Experiences and opportunities. *Environmental Innovation and Societal Transitions*, 18, 41–61.
4. Bocken, N., & Prendeville, S. (2017). Sustainable business Models through Service design. *Procedia Manufacturing*, 8,

- 292–299.
5. Charms, N., & Garcia-Blandon, J. (2019). On the importance of sustainable human resource management for the adoption of sustainable development goals. *Resources, Conservation and Recycling*, 141, 109–122. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0921344918303719>
  6. Chung, B. Do, Kim, S. Il, & Lee, J. S. (2018). Dynamic Supply Chain Design and Operations Plan for Connected Smart Factories with Additive Manufacturing. *Applied Sciences*, 1–16. <https://doi.org/10.3390/app8040583>
  7. Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, 204(December 2017), 383–394. <https://doi.org/10.1016/j.ijpe.2018.08.019>
  8. de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Foropon, C., & Filho, M. G. (2018). When titans meet – Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors. *Technological Forecasting and Social Change*, 132(October 2017), 18–25. <https://doi.org/10.1016/j.techfore.2018.01.017>
  9. Demirkaya, H., Özcüre, G., & Eryigit, N. (2011). An application on the impacts of human resource management in technology management of the companies. *Procedia - Social and Behavioral Sciences*, 24, 474–486. <https://doi.org/10.1016/j.sbspro.2011.09.045>
  10. Evans, S., Geissdoerfer, M., & Vladimirova, D. (2018). Sustainable business model innovation: A review. *Cleaner Production*, 198, 401–416.
  11. Geissdoerfer, Martin, Savaget, Paulo, Evans, & Steve. (2017). The Cambridge Business Model Innovation Process. *Procedia Manufacturing*, 8, 262–269.
  12. *Getting Started with the Sustainable Development Goals*. (2015). Retrieved from <http://unsdsn.org/wp-content/uploads/2015/12/151211-getting-started-guide-FINAL-PDF-.pdf>
  13. *HSBC Equities and Climate Change*. (2009). Retrieved from <https://www.hsbc.com.ar/rse/pdf/sustainability2009.pdf>
  14. Jovane, F., Selinger, G., & Stock, T. (2017). Competitive Sustainable Globalization. *Procedia Manufacturing*, 8, 1–19.
  15. Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, 117, 408–425. <https://doi.org/10.1016/j.psep.2018.05.009>
  16. Kamble, S. S., Gunasekaran, A., & Sharma, R. (2018). Analysis of the driving and dependence power of barriers to adopt industry 4.0 in Indian manufacturing industry. *Computers in Industry*, 101(March), 107–119. <https://doi.org/10.1016/j.compind.2018.06.004>
  17. Kwon, H.-B., & Lee, J. (2019). Exploring the differential impact of environmental sustainability, operational efficiency, and corporate reputation on market valuation in high-tech-oriented firms. *International Journal of Production Economics*, 211(December 2018), 1–14. <https://doi.org/10.1016/j.ijpe.2019.01.034>
  18. Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, 6, 1–10. <https://doi.org/10.1016/j.jii.2017.04.005>
  19. Mani, V., Delgado, C., Hazen, B. T., & Patel, P. (2017). Mitigating Supply Chain Risk via Sustainability Using Big Data Analytics: Evidence from the Manufacturing Supply Chain. <https://doi.org/10.3390/su9040608>
  20. Moldavska, A., & Welo, T. (2019). A Holistic approach to corporate sustainability assessment: Incorporating sustainable development goals into sustainable manufacturing performance evaluation. *Journal of Manufacturing Systems*, 50(November 2017), 53–68. <https://doi.org/10.1016/j.jmsy.2018.11.004>
  21. Naomi, S., Evans, S., & Monteiro de Carvalho, M. (2016). Sustainable business model innovation: exploring evidences in

- sustainability reporting. *Procedia CIRP*, 40, 659–667.  
<https://doi.org/10.1016/j.procir.2016.01.151>
22. Oertwig, N., Jochem, R., & Knothe, T. (2017). Sustainability in Model based planning and Control of Global Value creation Networks. *Procedia Manufacturing*, 8, 183–190.
23. Pederson, C. S. (2018). The UN Sustainable Development Goals (SDGs). *Procedia CIRP*, 69, 21–24.  
<https://doi.org/10.1016/j.procir.2018.02.004>
24. Pieroni, M. de P., Pigosso, D. C. A., & Mcloone, T. C. (2018). Sustainable qualifying criteria for designing circular business models. *Procedia CIRP*, 69, 799–804.
25. Plessis, J. A. du, & Bam, W. G. (2017). Scoping phase comparison of development opportunities by making use of publicly available sustainability information. *Procedia Manufacturing*, 8, 207–214.
26. Reis, M., & Gins, G. (2017). Industrial Process Monitoring in the Big Data/Industry 4.0 Era: from Detection, to Diagnosis, to Prognosis. *Processes*, 5(3), 35.  
<https://doi.org/10.3390/pr5030035>
27. Reis, M. S., & Gins, G. (2017). Industrial Process Monitoring in the Big Data/Industry 4.0 Era: From Detection, to Diagnosis, to Prognosis.  
<https://doi.org/10.3390/pr5030035>
28. Rennung, F., Luminosu, C. T., & Draghici, A. (2016). Service Provision in the Framework of Industry 4.0. *Procedia - Social and Behavioral Sciences*, 221, 372–377.  
<https://doi.org/10.1016/j.sbspro.2016.05.127>
29. Roy, R., Shehab, E., Durugbo, C., Khan, S., & Datta, P. (2019). An effective uncertainty based framework for sustainable industrial product-service system transformation. *Cleaner Production*, 208, 160–177.
30. Shankar, K. M., Kumar, P. U., & Kannan, D. (2016). Analyzing the drivers of advanced sustainable manufacturing system using AHP approach. *Sustainability (Switzerland)*, 8(8), 1–10.  
<https://doi.org/10.3390/su8080824>
31. Silvestre, B. S., & Mihaela Tirca, D. (2019). Innovations for sustainable development: Moving toward a sustainable future. *Cleaner Production*, 208, 325–332.
32. Stock, T., & Seliger, G. (2016). Opportunities of Sustainable Manufacturing in Industry 4 . 0. *Procedia CIRP*, 40(Icc), 536–541.  
<https://doi.org/10.1016/j.procir.2016.01.129>
33. Vaidya, S., Ambad, P., & Bhosle, S. (2018). Industry 4 . 0 – A Glimpse. *Procedia Manufacturing*, 20, 233–238.  
<https://doi.org/10.1016/j.promfg.2018.02.034>
34. Yadav, S. S. K., Abidi, N., & Bandyopadhyay, A. (2017). Development of the Environmental Sustainability Indicator Profile for ITeS Industry. *Procedia Computer Science*, 122(1), 423–430.  
<https://doi.org/10.1016/j.procir.2016.01.129>