Khulna University Studies Special Issue ICSTEM4IR: 625-639, 2022

ORIGINAL ARTICLE **SCIENCE & ENGINEERING**

THE 4th INDUSTRIAL REVOLUTION (4IR) and SUSTAINABLE DEVELOPMENT

Dr. Md. Noor Un Nabi and Fatema Tuj Zohora*

Business Administration Discipline, Khulna University, Khulna-9208, Bangladesh

KUS: ICSTEM4IR-22/0118

Manuscript submitted: July 01, 2022 Accepted: September 27, 2022

Abstract

Industry 4.0 (The 4th Industrial Revolution – 4IR) is an emerging ecosystem based on a connection between machines and humans. I4.0 has delivered new production technologies that maximize output while maximizing resource use. An increasing number of companies are reaping the benefits of technological advancements. I4.0 has the potential to provide sustainable industrial value creation across social, economic, and environmental aspects by enhancing resource efficiency. Human advancement, resource utilization, and commercial relationships all fall under the umbrella of sustainable development (SD). Traditional business problem-solving methodologies are being challenged by the I4.0 notion of sustainability, which calls for a shift toward a more systematic and quantifiable approach to dealing with sustainable development. Transformational business models include the triple bottom line and take into account many stakeholders as well as the wider community and environment. social, economic, and mental environment make up the three pillars of long-term viability. It is vital for business models in transforming to value delivery processes for sustainability, making them significant drivers of competitive advantage and overall SD. The paper focus is on the tools and procedures utilized to conduct a thorough examination of these components. This study proposes a quantifiable 4IR framework to map the broad spectrum of sustainable development. This framework is linked with the existing industry 4.0 environment and quantifiable sustainable nodes to measure businesses in the digital era that are potential for sustainable development.

Keywords: Industry 4.0 (4IR), technology, transformational business model, triple bottom line, sustainable development

Introduction

Industry 4.0 was originally envisioned as the fourth industrial revolution (Xu et al., 2018). Trends in technology refer to the sophisticated digital technical advancements that enable the growth of the new digital industrial technology known as Industry 4.0. It currently entails the digital transformation of both industrial and customer markets, from the development of smart production to the digitization of all value delivery nodes

*Corresponding author: <fatematujzohora16@gmail.com>
DOI: https://doi.org/10.53808/KUS.2022.ICSTEM4IR.0118-se

(Schroeder et al., 2019). Apparently academic, government, and stakeholders relate Industry 4.0 to the digitalization and smartification of factories, distribution routes, and value chain participants (Kang et al., 2016; Liao et al., 2017; Qu et al., 2019). To enhance comprehension of the Industry 4.0 notion, previous scholars have typically described this phenomenon in terms of its underlying value principles and technological developments (Zheng et al., 2018) .These value principles enable manufacturers to anticipate the adaption progress of Industry 4.0 and provide them with the innovative knowledge necessary to deliver solutions required for the changes to Industry 4.0 (Ghobakhloo, 2020).

In terms of digitization, there are some technology based approaches (Luiz et al., 2018) .Still, the Industrial Internet of Things (IoT) and Cyber-Physical Production Systems (CPPS) are not the self-technology products (Ghobakhloo, 2020) .IoT and CPPS rely on AI, machine-to-machine communication, semantic technologies to develop a dynamic cyber-physical control system ensuring efficiency and reliability of industrial operations (Sisinni et al., 2018). Overall, none of the technology trends work on their own (Gilchrist, 2016) in the business environment. They need a proper dependance and interoperability for making sure that different parts of a value network, like control systems, smart equipment and machinery, smart materials , customers, decision systems, and labor, can connect, and share data in a coordinated way (Tortorella & Fettermann, 2017; Zheng et al., 2018).

According to the scholars, advanced technologies, and machine intelligence are all linked in an Industry 4.0 environment, which allows them to communicate with one another, adapt to the environment, and make their own choices without the need for any human intervention (Gilchrist, 2016). As the actual power of Industry 4.0, connectivity and information may have paradoxical effects on triple bottom line (economic, environmental, and social) sustainability (Julian M. Müller & Voigt, 2018). Sustainability encompasses the preservation of economic and social resources in addition to natural resources (Choi & Ng, 2011; Ford & Despeisse, 2016) .The United Nations describes sustainability as a movement aimed at addressing the eternal global problems of injustice, inequality, peace, climate change, pollution, and by providing a better and more sustainable standard of living for all, including future generations. Despite the fact that sustainability is a relatively new idea, its origins lie in long-standing movements such as conservationism and socioeconomic justice (Caradonna, 2014).

Within the concept of industry 4, business sustainability come across everything from product design and testing to organization management are is included in a value-added chain. This amalgamation needs a transformational business model and business strategies, which include extending the "connected enterprise" idea to include all of a company's business partners and customers as well as their value-added chain (Dobrowolska & Knop, 2020). According to the researchers, technology has the ability to impact production in terms of functionality, quality, and quantity by connecting an expanding number of sectors to society (Holtgrewe, 2014) . Modern IT solutions are being implemented across the whole value chain, allowing for the production of customised products for a specific consumer and linked value chains. Advanced information and communication technologies allow manufacturing to be adapted to the needs of the customers while ensuring low costs and great quality. The transition of the sector is being accelerated by new technology-based business models, which are transforming the market structure. Many sectors of management will face new obstacles as they try to adjust to the new digital world architecture (Furukawa & Shida, 1966; Sony & Naik, 2020) .A company's profitability and competitiveness are determined by the business models it employs. As the current corporate landscape evolves, new strategic behaviours emerge. Managers nowadays are expected to adopt more advanced management concepts and practices (Sony & Naik, 2020) . According to this business model, assets are used to maximise the value it can provide to customers while simultaneously securing its own position to take over that value. All aspects of a company's business model may benefit from innovation, which is critical to delivering added value to the company's customers.

The business model represents the economic repercussions of the strategy's implementation. The function of the strategy is emphasised in the model since present and future revenues are created by the items given to clients as well as the competitive approach to the market (Grabowska & Saniuk, 2022a), Businesses

that are always looking for new and creative methods to work together with their various business partners, whether they customers, suppliers, or general partners, in order to grow their operations and take advantage of opportunities such as servitization. An example of this would be a paradigm in which innovation is included into the business model (Brasseur et al., 2017) and transformed into traditional to transformative in the 4IR environment. Transformational business models begin with participation, which is followed by inclusiveness and universal access (Berre et al., 2019) Because of the ideals of information sharing, creating solutions that produce value for the firm and society, product responsibility, and listening to the voice of stakeholders (Bluszcz & Manowska, 2021; Moradi et al., 2021; Pile, 2018; Xie & Wang, 2020). A bibliographic study has conducted with the purpose of determining the most recent findings from research carried out in this field as well as determining the primary research foci addressed in a variety of different scientific publications. However, the research questions are RQ1: What is the concurrent evidence of value delivery and industry 4 environment? and RQ2: How transformational business models leads to sustainable development?

Therefore, the paper aims to portray a systematic literature review under the concept of industry 4th, Business models and sustainability. With the the systematic review tool Rayyan the whole literature review are conducted. Given that previous industrial revolutions resulted in profound and rather unanticipated economic, environmental, and social transformations, academia should pay close attention to the sustainability effects of Industry 4.0. Despite being in its infancy, it is anticipated that the unexpected or unanticipated effects of Industry 4.0 and digital transformation on triple bottom line sustainability would be significant (Jabbour et al., 2018; Kamble et al., 2018). Digitizing manufacturing and commercial processes and deploying smarter equipment and devices may bring a variety of benefits, including improved production capacity, resource efficiency, and waste reduction (Tortorella and Fettermann, 2018).

Literature Review

An ecosystem view of 4IR and sustainable development model

Using cyber-physical systems that employ intelligent technologies, it is feasible to monitor, control, and make choices in real time along the full value chain (Kale, 2014). Industry 4.0 is a revolution in the production control approach, which includes dynamic machine adjustments triggered by the flow of information about the workpiece. Connectivity in Industry 4.0 at the level of the factory requires broadband communication, including sensors and actuators of devices in real time and wide area network settings (Chui et al., 2016). New digital technologies deployed in smart factories need the creation of new management paradigms and business models (Burcharth et al., 2014). The observed changes encompass a vast array of economic and social developments(Antonio et al., 2020). The evolution of globalisation, the constantly changing environment, the networked economy, and open inventions result in the development of novel business models. Open business model concepts (Cohen et al., 2017; Sarasini et al., 2021; Wiprächtiger et al., 2019) including theoretical specifics and practicality. A company's transformational business model is described as a collection of actions, techniques, and execution times that utilise its resources to provide the greatest value for the client and protect its position for value acquisition (Grabowska & Saniuk, 2022a; Peñarroya-Farell & Miralles, 2021; Weiblen, 2014). The business model of the 4IR era may be characterised as a blend of social and technological architecture-based business operations. Flexible procedures (based on digital technologies) comprise the technical architecture (Brodny, 2022; Grabowska & Saniuk, 2022b). The **Figure 1** shows three layers of the socio-economic system and three main chunks of industry, government and university all are surrounding a business firm. Within the industry fourth environment and the global dynamics an individual firm needs the help of government, collaborated industry and the concerned academia support. This figure portrays a basic 4IR ecosystem view for an individual firm.

The Figure **2** shows the second triple helix model which is an approach for developing an innovation system that utilises the innovation process. In a Triple Helix process, the system is not the mechanism by which the process is carried out; rather, the system is the end aim. Innovation Systems outlines "the movement of technology and information among individuals, businesses, and institutions" with several essential aspects.

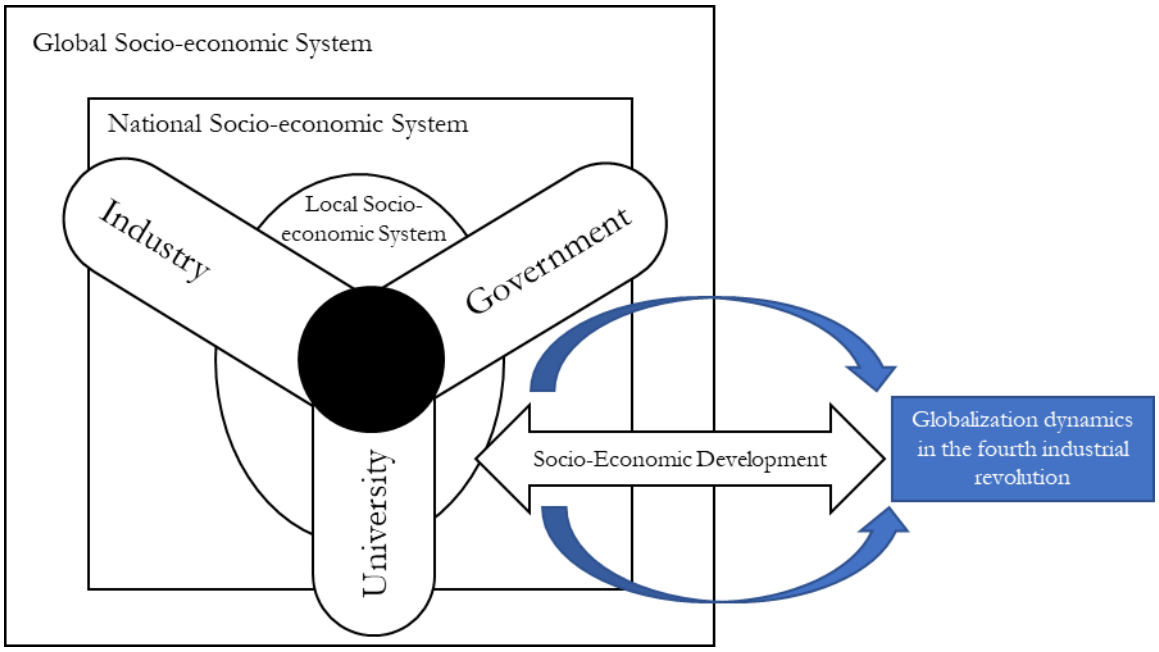

Figure 1. The Triple Helix in The Industry 4th Environment adapted from (Chatzinikolaou & Vlados, 2019).

The firms themselves are the primary players in this paradigm; the university, the government, and any other actors play roles that are obviously subordinate to or auxiliary to those of the firms. The evolutionary micro-analytical dimension of the economic system, which attributes to the firm the core role in the developmental process in the fourth industrial revolution era.

Too many developing nations have followed a route to economic development that is unsustainable in the long run. For instance, producing equipment that was extremely harmful to the environment and had been phased out in wealthy nations was brought in. Sustainable development refers to the development which fulfils current needs without compromising future generations' capacity to production. The notion was first applied to natural resource depletion, but it has since been expanded to cover economic development, environmental protection, food production, and social organisation. Resource depletion, environmental degradation, growing inequality, and population expansion may arise from high-tech enterprise, economic prosperity, and increased quality of life. Innovation, which involves changes in the physical and social environment, invariably generates questions of sustainability.

It is generally agreed that sustainable development is achieved when there is a safe and positive synergy between economic, environmental, and social factors, which in turn benefits human beings, the environment, and the economy. The triple helix model, which is based on how actors interact, has been improved. This is especially true for addressing the SDGs. University-industry-government (U-I-G) triple helix for innovation to achieve knowledge-based regional economic and again the social development and a university-public-government (U-P-G) triple helix, which is a dualistic unity of opposites. Both the U-P-G and the U-I-G have a complementary role to play for one another. It is possible to include a key component in the model by generating a parallel interaction axis, which allows for its inclusion without compromising the dynamic features (Diepenmaat et al., 2020).

The function of the university is becoming increasingly important in both Twins, with U-I-G working to encourage innovation and economic growth as an engine, while U-P-G seeks to ensure that growth

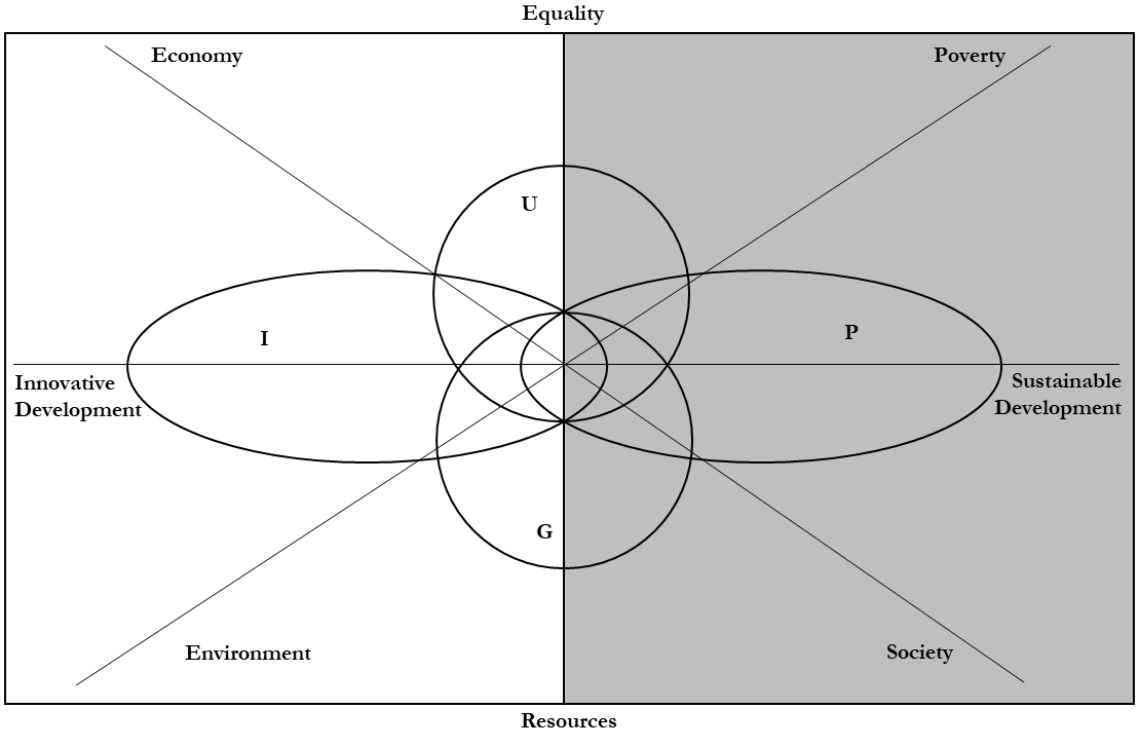

Figure 2. Triple Helix for Innovative Development and SDG adapted from (Zhou & Etzkowitz, 2021).

occurs in sustainable ways, as a balancing wheel/speed (Etzkowitz, 2015). In the U-I-G, it is expected that universities with an entrepreneurial spirit will lead the way in regional innovation and help new businesses get off the ground. Figure 2 shows how industry is likely to change. Triple Helix Twins to encourage innovation and long-term growth. In both Twins, the role of the university is becoming more important, which could lead to research that changes things (Gosselin, 2005). In the U-I-G, it's expected that universities with a lot of entrepreneurs will lead the way in regional innovation and help start-ups. Industry is expected to reorganise itself in a network-like way so that it can take in more information from the outside. Civic universities in the U.P.G. are also expected to play important roles in promoting sustainable development (Zhou & Etzkowitz, 2021)

Materials and Methods

This research design combines (i) bibliometric co-occurrence analysis and (ii) a systematic literature review (Kraus & Dasí-rodríguez, 2020) to give a full picture of the current state of 4IR, sustainable development and transformational business model research. The literature analysis helps people understand 4IR better by pointing out and evaluating the most important research paths in the field. Both studies' data came from and were put together with the help of the Scopus database. The study looked at articles from journals in the academic fields of business, management, accounting, economics, econometrics, finance, and decision sciences that had been published or were approved for publication up to 2020. The researchers used the phrases " Transformational Business Model" and "Fourth Industrial Revolution and Sustiable development " in their titles, abstracts, and keywords. With the help of the VOSviewer programme (Eck & Waltman, 2017), a co-occurrence analysis was done to see how the information node network was set up (Donthu et al., 2020; Mas-

tur et al., 2021). From 441 articles to 203 articles are sorted. The Figure 3 depicts the text mining from 2016 to 2022 with relationships among the industry 4IR and transformational business models. All of the important keywords have pointed through the analysis. The strength and relevance of the linkages are represented by both the interconnection lines connecting the nodes and their size (Donthu et al., 2020; López-Rubio et al., 2021). Table 1 shows the bibliometric table showing the most cited papers within the clusters 4IR, sustainability and business model.

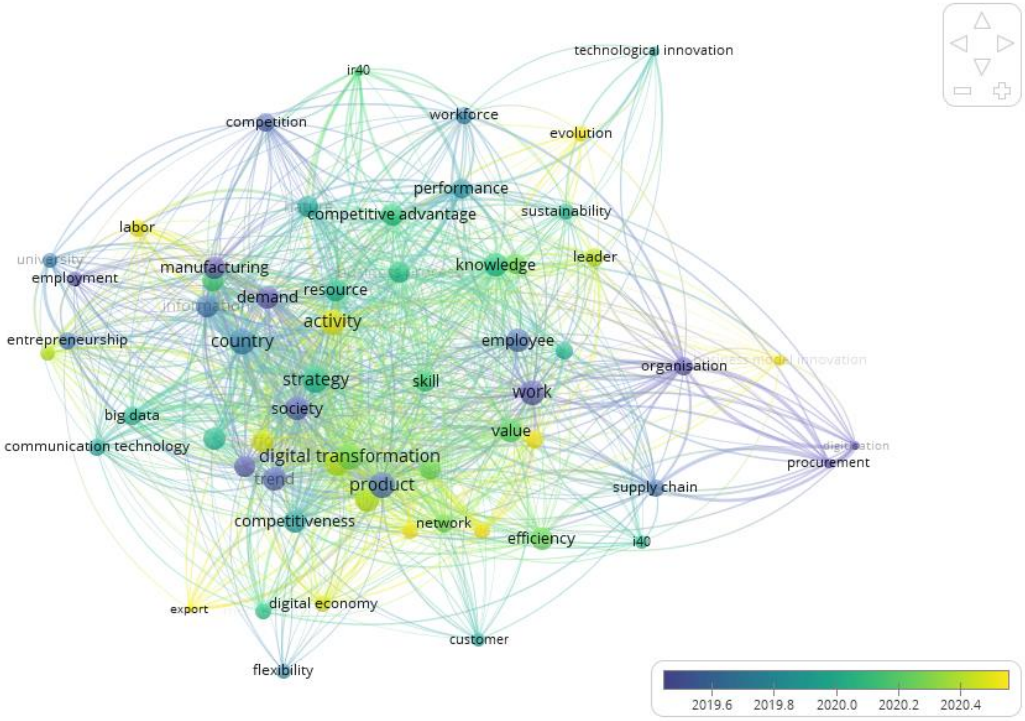

Figure 3. Text Mining From 2016-2022.

Table 1. Paper citations, author name and year of the selected articles

Year	Author	Country of Research	Times cited
2016	Bogner, Eva; Voelklein, Thomas; Schroedel, Olaf; Franke, Joerg	Germany	36
2016	Erol, Selim; JÃ¤ger, Andreas; Hold, Philipp; Ott, Karl; Sihn, Wilfried	Austria; Austria	319
2016	Irisarri, Edurne; GarcÃa, Marcelo V.; PÃ©rez, Federico; EstÃ©vez, Elisabet; Marcos, Marga	Spain; Spain	12
2017	Efendioglu, Nesat; Woitsch, Robert	Austria	6
2017	Karacay, Gaye	Turkey	33
2017	Duarte, Susana; Cruz-Machado, Virgilio	Portugal	43
2018	Skilton, Mark; Hovsepian, Felix	United Kingdom	49

2018	Gromova, Elizaveta A.	Russia	12
2018	Munsamy, M.; Telukdarie, A.	South Africa; South Africa	4
2018	Dean, Mark; Spoehr, John	Australia	31
2018	Steffen, Barbara; BoÃŸelmann, Steve	Netherlands; Germany	6
2018	Muhammad, Bilal; Kumar, Ambuj; Cianca, Ernestina; Lindgren, Peter	Denmark; Italy	7
2018	Cabrita, M. R.; Cruz-Machado, V.; Duarte, S.	Portugal	4
2018	Prasetyo, Hoedi; Sutopo, Wahyudi	United Kingdom	32
2018	Bienhaus, Florian; Haddud, Abubaker	United Kingdom	135
2019	Yang, Heyoung; Kim, Su Youn; Yim, Seongmin	South Korea; South Korea	4
2019	Voitko, Serhii	Ukraine	4
2019	Ottonicar, Selma Leticia Capinzaiki; Valentim, Marta LÃgia Pomim; Mosconi, Elaine		3
2019	Kumar, Kaushik; Zindani, Divya; Davim, J. Paulo	India; India; Portugal	24
2019	Gromova, Elizaveta	Russia	3
2019	Hooker, John; Kim, Tae Wan	United States	10
2019	Grabowska, Sandra; Gajdzik, BoÅ¼ena; Saniuk, Sebastian	Poland; Poland	14
2019	Sagara, Hastimal; Das, Keshab	India	4
2019	Pukala, Ryszard	Germany	3
2019	Hahn, Gerd J.	Germany	88
2019	KarabegoviÄ‡, Isak; KarabegoviÄ‡, Edina; MahmiÄ‡, Mehmed; Husak, Ermin	Bosnia and Herzegovina	20
2019	Ayuni, Risca Fitri	Indonesia	5
2019	Harjanti, Istidana; Nasution, Faisal; Gusmawati, Nerifa; Jihad, Muhammad; Shihab, Muhammad Rifki; Ranti, Benny; Budi, Indra	Indonesia	5
2019	Lucato, Wagner Cezar; Pacchini, Athos Paulo Tadeu; Facchini, Francesco; Mummolo, Giovanni	Brazil; Italy	24
2019	KovaitÄ—, Kristina; Å Ã«makaris, Paulius; StankeviÄ□ ienÄ—, Jelena; KorsakienÄ—, Renata	Lithuania	2
2019	Schulz, Kai Fabian; Freund, Daniel	Germany	6
2019	KisiÄ‡, Svetlana; PetkoviÄ‡, SaÅ¡a	Germany	4
2019	Kwon, Minsu; Yu, Heonchang	South Korea	5
2019	Degtyaryova, Tatiana V.; Shcherbakova, Nadezhda V.; Katerinich, Oksana A.	Russia	2
2019	Sengoku, Shintaro	Japan	2

2020	Smuts, Stefan; van der Merwe, Alta; Smuts, Hanlie	South Africa	7
2020	Baloutsos, Stratos; Karagiannaki, Angeliki; Mourtos, Ioannis		2
2020	Nicoletti, Bernardo	Italy	7
2020	Ericson, Ã…sa; Lugnet, Johan; Solvang, Wei Deng; Kaartinen, Heidi; Wenngren, Johan	Sweden; Norway; Finland	3
2020	Cavalieri, Salvatore; MulÃ¨, Salvatore; Salafia, Marco Giuseppe	Italy	5
2020	Safrankova, Jana Marie; Sikyr, Martin; Skypalova, Renata		2
2020	Munsamy, Megashnee; Telukdarie, Arnesh; Dhamija, Pavitra	South Africa; South Africa	5
2020	Giustiziero, Gianluigi; Somaya, Deepak; Wu, Brian	Germany; United States; United States	3
2020	Aheleroff, Shohin; Zhong, Ray Y.; Xu, Xun	New Zealand; China	20
2020	Genkin, Eugene; Filin, Sergey; Velikorossov, Vladimir; Kydyrova, Zhamilya; Anufriyev, Kirill	Russia; Kazakhstan	6
2020	Akpan, Ikpe Justice; Soopramanien, Didier; Kwak, Dong-Heon (Austin)	United States; United Kingdom	49
2020	Tolkachev, S A; Bykov, A A; Morkovkin, D E; Borisov, O I; Gavrilin, A V	Russia	18
2020	Weking, JÃ¶rg; StÃ¶cker, Maria; Kowalkiewicz, Marek; BÃ¶hm, Markus; Krcmar, Helmut	Germany; Australia	70
2020	van Tonder, ChantÃ©; Schachtebeck, Chris; Nieuwenhuizen, Cecile; Bossink, Bart	South Africa; Netherlands	6
2020	Caliskan, Aylin; Ã–zen, YeÅŸim Deniz Ã–zkan; Ozturkoglu, Yucel	Turkey	12
2020	Kolyasnikov, Maksim; Kelchevskaya, Natalya	Russia	7
2020	Mahmuda, S.; Sigler, T.; Knight, E.; Corcoran, J.	Australia; Australia	2
2020	Popescu, Sorin; Santa, Roxana; Teleaba, Florian; Ilesan, Hannelore	Romania	4
2020	Van den Berg, Michiel J.; Stander, Marius W.; Van der Vaart, Leoni		3
2020	CantÃº-Ortiz, Francisco J.; Galeano SÃ¡nchez, NathalÃe; Garrido, Leonardo; Terashima-Marin, Hugo; Brena, RamÃ³n F.	Mexico	10
2021	Konina, Natalia	Russia	4
2021	Jin, Byoungho Ellie; Shin, Daeun Chloe	United States	3
2021	Averina, Tatyana; Barkalov, Sergey; Fedorova, Irina; Poryadina, Vera	Russia	6

2021	Schiele, Holger; Bos-Nehles, Anna; Delke, Vincent; Stegmaier, Peter; Torn, Robbert-Jan	Netherlands	6
2021	Stupina, A A; Antamoshkina, O I; Ruiga, I R; Korpacheva, L N; Kovzunova, E S	Russia; Russia	4
2021	Motjolopane, Ignitia	South Africa	3
2021	Mariani, Marcello M.; Nambisan, Satish	United Kingdom; Italy; United States	7
2022	Grabowska, Sandra; Saniuk, Sebastian	United Kingdom	7

Proposed Framework

4IR Transformative business model for SD

The cyber-physical collaborative networks formed by this model's processes make it a transformational model that executes innovation. Changes to the business model and new ideas Industry 4.0's design principles, such as interoperability, decentralisation, and real-time capability, have changed the way businesses make and sell new products and services in a big way (Cusumano et al., 2015; Jiang et al., 2016). This enables the production of individualised product-based value (Luczak & Tran, 2017; Xie & Wang, 2020). The value and revenue supplied to the client distinguishes the various components of business model (Chui et al., 2016). When developing a business model in the 4IR age, the following questions must be addressed: What value does the firm provide to its customers? innovation in the field of the whole business model can save the firm in times of crisis and assure its continued growth. The profitability business models is enhanced by value delivery chain, resilience, collaboration (Trzaska & Mazgajczyk, 2020; Tsutsui et al., 2020). New enabling technologies are only used to improve the value creation architecture (key resources and activities) by making it more efficient and better at what it does (reducing costs, time, and mistakes, training employees, etc.) without addressing high risks. Value delivery (product and service offerings, customer segmentation, channels, and customer relationships) enhancement is another incremental innovation that focuses on customer interface improvement. With the advent of cutting-edge technologies companies are finding new ways to innovate their business models by focusing on the most important aspects of their core company while sharing the risk and leveraging the expertise and resources of their partners. In this way, the process of creating value at the focal firm is linked to the processes at the other firms. Embedded Systems, Big Data, Cloud Computing, and Intelligent Sensorization are just a few of the cutting-edge technologies that are being leveraged to create new business models for smart products and services. In our model we portrayed the framework.

The pervasive digitalization and modern solutions deployed in industrial automation result in a shift in management mindsets and the emergence of new business models geared toward the incorporation of intelligent, autonomous technology, remote control, and the enhancement of life quality (Arnold, 2016) Individualized cutomer knowledge is what differentiates the period of the black industrial revolution (Grabowska & Saniuk, 2022a; Sarasini et al., 2021). Accurate identification of opportunities, problems, and constraints brought about by 4IR allows intentional utilisation of emerging market opportunities and emerging market opportunities (Weiblen, 2014) .The Fourth Industrial Revolution involves the digitization of the economy, industry, and societal developments(Kang et al., 2016). In light of recent developments, it is now essential to develop open business models that are centred on the introduction of open technologies (Grabowska & Saniuk, 2022a; Khumalo, 2017; Schmidt et al., 2015). The **Figure 4** shows how integrated technology and innovation gives opportunity to create value in the business, the business needs a transformative change to work with the recent tech, innovation and new value opportunities emerged from advancement of technology and changes in need of the customers. This business output will be the value delivery to the society as well as adds more investment and collaboration with the 4IR ecosystem. The Fourth Industrial Revolution Industry 4.0 implements cutting-edge IT solutions in all parts of manufacturing, enabling

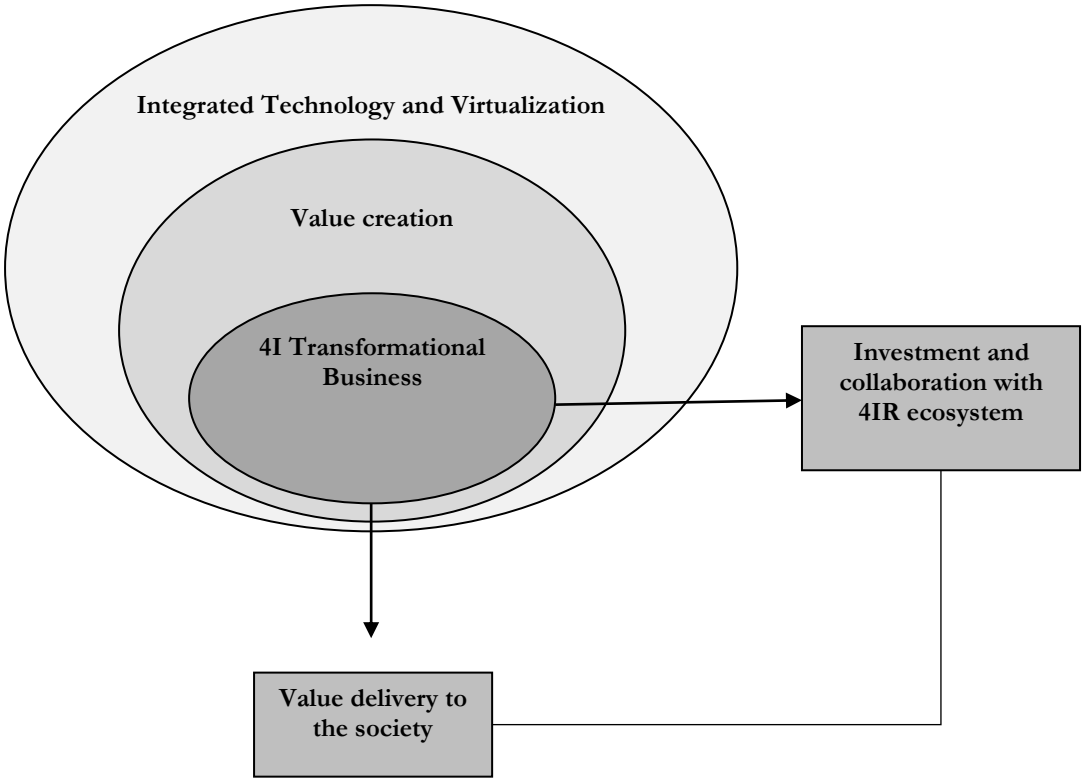

Figure 4. Value creation and 4I Transformational Business (own collaboration)'

not just customer-specific goods but also whole value chains (Brasseur et al., 2017; Brougham & Haar, 2018). Utilizing new information and communication technologies and open innovation, it is feasible to tailor manufacturing more precisely to consumer demands while retaining low prices, high quality, and high efficiency (Deloitte, 2020; Khan et al., 2021) this leads the value delivery to the society shown in figure 3. To do this, businesses collaborate with network partners to create cyber-physical systems. By leveraging a multitude of ideas, network relationships produce value. The integreation is also feasible to extract value by leveraging essential assets and resources (Moradi et al., 2021) .Companies operating under transformational business model seek novel ways of collaboration with all business partners along the whole value creation chain (Moradi et al., 2021; Xie & Wang, 2021) .transformational business models begin with active engagement in networks of collaboration, universal access, and inclusion (Pile, 2018).

Innovations enable the creation of value for customers (new goods, new ways of client service) and value for stakeholders (new products, new methods of client service) (environmental protection, new technologies, new value chains, the growth of effectiveness). There is a possibility that the business models themselves are the organisational innovation that is necessary for competitiveness. The advent of Industry 4.0 has been linked to the introduction and broad adoption of new business model innovations, (Julian M. Müller & Voigt, 2018) which may present triple bottom line potential (Evans et al., 2017) . The Figure 5 shows the Figure 4 with the sustainable development.

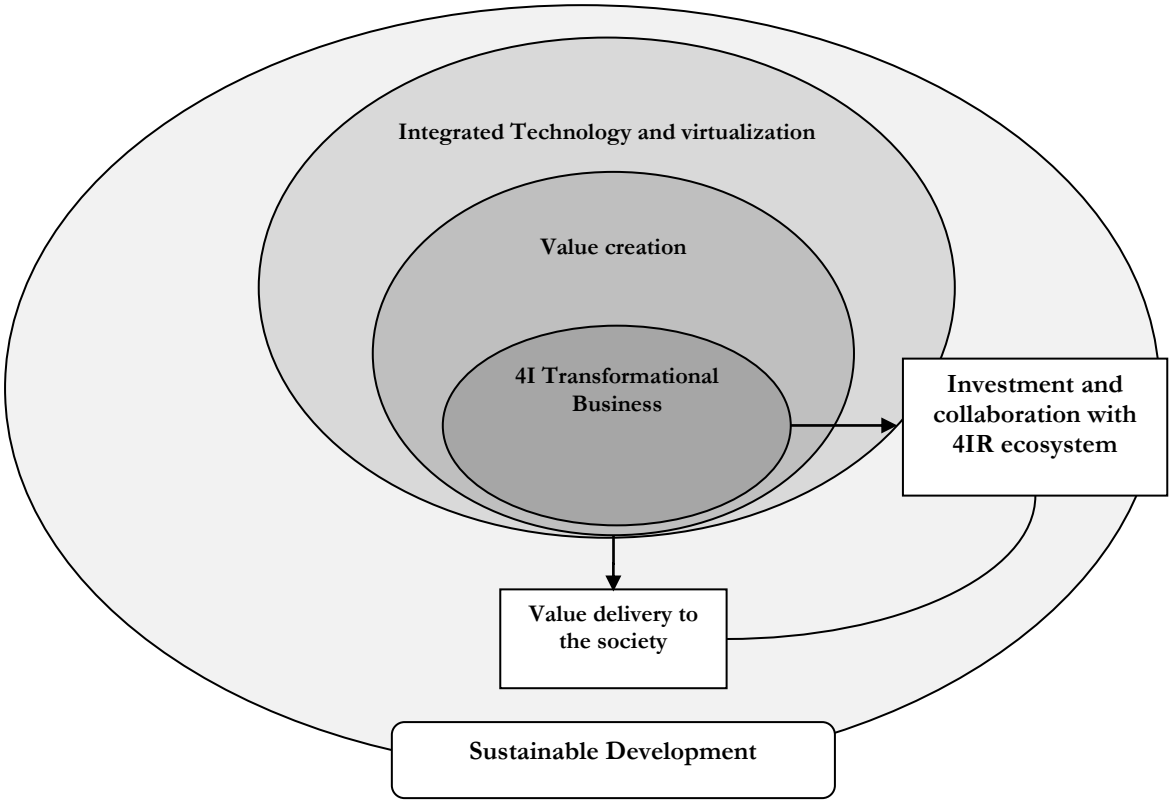

Figure 5. 4I Transformational Business and sustainable development (own collaboration).

Discussion

The Fourth Industrial Revolution is the inevitable path of change for the transformation of business models. Linking business models with innovation is essential owing to the concepts of information sharing, profit generation for the organisation and society, and product accountability (Birkel et al., 2019) .New business models and technology, as well as open developments, such as AI ,manufacturing, accelerate industry transformation processes by altering present business procedures and market structure. All of these artefacts provide new problems for management disciplines that must adapt to the digital world's architecture (Grabowska & Saniuk, 2022a, 2022b). Industry 4.0 refers to the incorporation of intelligent equipment and systems, as well as the modification of production processes, in order to boost production efficiency and provide the potential of flexible field-wide adjustments (Hofmann & Rüsch, 2017) . Technology is simply one component of Industry 4.0; other aspects, such as new ways of doing business and the role that people play in industry, are equally important (Julian Marius Müller et al., 2018) . Industry 4.0 is a concept that is connected with the Fourth Industrial Revolution. It encompasses all aspects of the value chain beginning with stakeholders and ending with customers with high-quality services. In our paper first we presented the helix framework from (Chatzinikolaou & Vlados, 2019) and connected with sustianble development which is the previous work of Zhou and Etzkowitz (2021) (Zhou & Etzkowitz, 2021) . the approach to integrate and use triple helices is to choose actors and design each of them according to the unique objective. The paper evaluated each triple helix and then combine a framework of business model. As the Triple Helix is stretched beyond innovation to targeted sustainable development, In any circumstance, it is necessary to understand who

are the major actors and organisers. If a new actor is more significant than an old one, it should succeed it in the triple helix structure In this paper, we showed how transformational business model can leads to SD with the framework of value delivery and collaboration. In contrast, a rise in production rate as a result of industrial automation would be accompanied with greater resource and energy consumption as well as increasing environmental problems (Beier et al., 2017; Liu and Bae, 2018). From the standpoint of societal development, digital transformation and industrial reorganisation are anticipated to significant (Benedikt & Osborne, 2016; Brougham & Haar, 2018).

Conclusion

The paper proposes value creation and deliver model that generates from transformational business model and thus by integrating the 4ir ecosystem. It is attached to the individual customer centric business model. This is a generalised model based on the global phenomena. The academician can use it as a simulation model. Further works can be done within the developing country context. Different testable variables can be added to the framework. The individual firm needs to adapt the disrupted innovation concept to change from traditional to transformational business model. The collaboration of industry and government paves the way of by imposing policy, amendments required to achieve the sustainability credentials.

References

Antonio, G., Angelo, C., Sanasi, S., & Rangone, A. (2020). *Opening up to startup collaborations : Open business models and value co-creation in SMEs Opening up to startup collaborations : Open business models and value co-creation in SMEs*. *1*, 1–30.

Arnold, C. (2016). *How Industry 4 . 0 changes business models in different manufacturing industries [rewarded with ISPIM Best Student Paper Award] How Industry 4 . 0 changes business models in different manufacturing industries Christian Arnold * Kai-Ingo Voigt*. *June*, 0–20.

Benedikt, C., & Osborne, M. A. (2016). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting & Social Change*. https://doi.org/10.1016/j.techfore.2016.08.019

Berre, A. J., Man, H. De, Lew, Y., & Ursin-holm, E. B. M. (2019). *Open Business Model , Process and Service Innovation with VDML and ServiceML*. *X*(X), 1–14.

Birkel, H. S., Veile, J. W., Müller, J. M., Hartmann, E., & Voigt, K. I. (2019). Development of a risk framework for Industry 4.0 in the context of sustainability for established manufacturers. *Sustainability (Switzerland)*, *11*(2), 1–27. https://doi.org/10.3390/su11020384

Bluszcz, A., & Manowska, A. (2021). *The Use of Hierarchical Agglomeration Methods in Assessing the Polish Energy Market*.

Brasseur, T., Mladenow, A., & Strauss, C. (2017). *Open business model innovation : Literature review and agenda for future ISSN 1998-0663 (print), ISSN 2587-8166 (online). August 2018*. https://doi.org/10.17323/1998-0663.2017.4.7.16

Brodny, J. (2022). *The Use of the Open Innovation Concept to Develop a Method to Improve Safety during the Mining Production Process : A Case Study of the Integration of University and Industry*.

Brougham, D., & Haar, J. (2018). *Smart Technology, Arti fi cial Intelligence, Robotics, and Algorithms (STARA): Employees ' perceptions of our future workplace*. *2*, 239–257. https://doi.org/10.1017/jmo.2016.55

Burcharth, A. L. D. A., Knudsen, M. P., & Søndergaard, H. A. (2014). Neither invented nor shared here: The impact and management of attitudes for the adoption of open innovation practices. *Technovation*, *34*(3), 149–161. https://doi.org/10.1016/j.technovation.2013.11.007

Caradonna;, & L, J. (2014). *Sustainability: A history*. Oxford University Press.

Chatzinikolaou, D., & Vlados, C. (2019). University-Industry-Government Linkages and the Helix Theory on the Fourth Industrial Revolution. *6th International Conference on Applied Economics "INSTITUTIONS & THE KNOWLEDGE ECONOMY," May*, 1–23.

Choi, S., & Ng, A. (2011). *Environmental and Economic Dimensions of Sustainability and Price Effects on Consumer Responses*. 269–282. https://doi.org/10.1007/s10551-011-0908-8

Chui, M. ., Löffler, M. ., & Roberts, R. (2016). *The Internet of Things*.

Cohen, B., Almirall, E., & Chesbrough, H. (2017). *The City as a Lab:* 5–13. https://doi.org/10.1177/0008125616683951

Deloitte. (2020). *The Industry 4 . 0 paradox Overcoming disconnects on the path to digital transformation*.

Diepenmaat, H., Kemp, R., & Velter, M. (2020). Why sustainable development requires societal innovation and cannot be achieved without this. *Sustainability (Switzerland)*, *12*(3), 1–26. https://doi.org/10.3390/su12031270

Dobrowolska, M., & Knop, L. (2020). Fit to work in the business models of the industry 4.0 age. *Sustainability (Switzerland)*, *12*(12), 1–18. https://doi.org/10.3390/SU12124854

Donthu, N., Kumar, S., & Pattnaik, D. (2020). *Forty- fi ve years of Journal of Business Research : A bibliometric analysis*. *109*(October 2019), 1–14. https://doi.org/10.1016/j.jbusres.2019.10.039

Eck, N. J., & Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics*, *111*(2), 1053–1070. https://doi.org/10.1007/s11192-017-2300-7

Etzkowitz, H. (2015). Making a humanities town: knowledge-infused clusters, civic entrepreneurship and civil society in local innovation systems. *Triple Helix*, *2*(1), 1–22. https://doi.org/10.1186/s40604-014-0012-z

Evans, S., Vladimirova, D., Holgado, M., Fossen, K. Van, Yang, M., Silva, E. A., & Barlow, C. Y. (2017). *Business Model Innovation for Sustainability: Towards a Uni fi ed Perspective for Creation of Sustainable Business Models*. *608*(April), 597–608. https://doi.org/10.1002/bse.1939

Ford, S., & Despeisse, M. (2016). *Additive manufacturing and sustainability : an exploratory study of the advantages and challenges*. *137*. https://doi.org/10.1016/j.jclepro.2016.04.150

Furukawa, K., & Shida, S. (1966). A Practical Comparison between Nitrous Oxide Dosimetry and Fricke Dosimetry for the Estimation of γ-RayEnergy absorbed in Gaseous Media. *Journal of Nuclear Science and Technology*, *3*(1), 41–42. https://doi.org/10.1080/18811248.1966.9732270

Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production*, *252*, 119869. https://doi.org/10.1016/j.jclepro.2019.119869

Gilchrist, A. (2016). *Industry 4.0*.

Gosselin, P. M. (2005). *Between Conflicts and Interests: A Socio-Historical Perspective; Triple Helix Book of Abstracts Torino*.

Grabowska, S., & Saniuk, S. (2022a). *Business Models in the Industry 4 . 0 Environment — Results of Web of Science Bibliometric Analysis*.

Grabowska, S., & Saniuk, S. (2022b). *Development of Business Models in the Fourth Industrial Revolution : Conditions in the Context of Empirical Research on Worldwide Scope Companies Located in Poland*.

Hofmann, E., & Rüsch, M. (2017). *Computers in Industry Industry 4 . 0 and the current status as well as future prospects on logistics*. *89*, 23–25.

Holtgrewe, U. (2014). New new technologies: The future and the present of work in information and communication technology. *New Technology, Work and Employment*, *29*(1), 9–24. https://doi.org/10.1111/ntwe.12025

Kale, V. (2014). *Guide to Cloud Computing for Business and Technology Managers: From Distributed Computing to Cloudware Applications* (Boca Raton (ed.)). CRC Press.

Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., Kim, B. H., & Noh, S. Do. (2016). *Smart Manufacturing : Past Research , Present Findings , and Future Directions*. *3*(1), 111–128. https://doi.org/10.1007/s40684-016-0015-5

Khan, I. S., Ahmad, M. O., & Majava, J. (2021). Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. *Journal of Cleaner Production*, *297*, 126655. https://doi.org/10.1016/j.jclepro.2021.126655

Khumalo, M. (2017). *The open business model in a dynamic business environment : A literature review*. *November*. https://doi.org/10.7166/28-3-1851

Kraus, S., & Dasí-rodríguez, S. (2020). *The art of crafting a systematic literature review in entrepreneurship research Content courtesy of Springer Nature , terms of use apply . Rights reserved . Content courtesy of Springer Nature , terms of use apply . Rights reserved* . 1023–1042.

Liao, Y., Deschamps, F., Freitas, E. De, & Loures, R. (2017). Past , present and future of Industry 4 . 0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, *7543*(March), 0. https://doi.org/10.1080/00207543.2017.1308576

Luczak, J., & Tran, M. (2017). University – Real Estate Industry Cooperation in Open Innovation in the Topic of Walkability (breakout presentation). *Journal of Transport & Health*, *7*, S54. https://doi.org/ 10.1016/j.jth.2017.11.089

Luiz, D., Nascimento, M., Alencastro, V., Luiz, O., Quelhas, G., Caiado, G. G., Garza-reyes, J. A., Lona, L. R., Tortorella, G., Luiz, D., Nascimento, M., Alencastro, V., Luiz, O., Quelhas, G., Caiado, G. G., Garza-reyes, J. A., Lona, L. R., Tortorella, G., & Garza-reyes, J. A. (2018). *Exploring Industry 4 . 0 technologies to enable circular economy practices in a manufacturing context*. https://doi.org/10.1108/JMTM-03-2018-0071

Mas-tur, A., Roig-tierno, N., Sarin, S., Haon, C., Sego, T., & Merig, M. (2021). *Technological Forecasting & Social Change Co-citation , bibliographic coupling and leading authors , institutions and countries in the 50 years of Technological Forecasting and Social Change*. *165* (November 2020). https://doi.org/10.1016/j.techfore. 2020.120487

Moradi, E., Mohammadbagher, S., Mohammadi, Z., & Mirzaei, A. (2021). Asia Paci fi c Management Review Impact of organizational inertia on business model innovation , open innovation and corporate performance. *Asia Pacific Management Review*, *xxxx*. https://doi.org/10.1016/j.apmrv.2021.01.003

Müller, Julian M., & Voigt, K. I. (2018). Sustainable Industrial Value Creation in SMEs: A Comparison between Industry 4.0 and Made in China 2025. *International Journal of Precision Engineering and Manufacturing - Green Technology*, *5*(5), 659–670. https://doi.org/10.1007/s40684-018-0056-z

Müller, Julian Marius, Kiel;, D., & Voigt, K.-I. (2018). *What Drives the Implementation of Industry 4 . 0 ? The Role of Opportunities and Challenges in the Context of Sustainability*. https://doi.org/10.3390/su10010247

Peñarroya-Farell, M., & Miralles, F. (2021). *Business Model Dynamics from Interaction with Open Innovation*.

Pile, T. (2018). *Pepperdine Digital Commons Developing a framework for open innovation*.

Qu, Y. J., Ming, X. G., Liu, Z. W., & Zhang, X. Y. (2019). *Smart manufacturing systems : state of the art and future trends*.

Sarasini, S., Sarasini, S., & Langeland, O. (2021). Business model innovation as a process for transforming user mobility practices Business model innovation as a process for transforming user mobility practices. *Environmental Innovation and Societal Transitions*, *39*(June), 229–248. https://doi.org/10.1016/j.eist.2021. 04.005

Schmidt, R., Möhring, M., Härting, R., & Reichstein, C. (2015). *Industry 4 . 0 -Potentials for Creating Smart*

Products : Empirical Research Results Industry 4 . 0 - Potentials for Creating Smart Products : Empirical Research Results. *April*. https://doi.org/10.1007/978-3-319-19027-3

Sisinni, E., Saifullah, A., Han, S., & Ulf, I. (2018). Industrial Internet of Things : Challenges , Opportunities , and Directions. *IEEE Transactions on Industrial Informatics*, *PP*(X), 1. https://doi.org/10.1109/TII.2018.2852491

Sony, M., & Naik, S. (2020). Critical factors for the successful implementation of Industry 4.0: a review and future research direction. *Production Planning and Control*, *31*(10), 799–815. https://doi.org/10.1080/09537287.2019.1691278

Tortorella, G. L., & Fettermann, D. (2017). Implementation of Industry 4 . 0 and lean production in Brazilian manufacturing companies. *International Journal of Production Research*, *7543*(October), 1–13. https://doi.org/10.1080/00207543.2017.1391420

Trzaska, R., & Mazgajczyk, E. (2020). *Industry 4 . 0 : Overview of Business Models in Additive Manufacturing*. 18453–18464.

Tsutsui, Y., Yamada, N., Mitake, Y., Sholihah, M., & Shimomura, Y. (2020). *A Strategic Design Guideline for Open Business Models*. *14*(5).

Weiblen, T. (2014). *The Open Business Model : Understanding an Emerging Concept The Open Business Model : Understanding an Emerging Concept*. *January*. https://doi.org/10.13052/jmbmit2245-456X.212

Wiprächtiger, D., Narayanamurthy, G., Moser, R., & Sengupta, T. (2019). Technological Forecasting & Social Change Access-based business model innovation in frontier markets : Case study of shared mobility in Timor-Leste. *Technological Forecasting & Social Change*, *February*, 0–1. https://doi.org/10.1016/j.techfore.2019.02.004

Xie, X., & Wang, H. (2020). How can open innovation ecosystem modes push product innovation forward ? An fsQCA analysis ☆. *Journal of Business Research*, *108*(October 2019), 29–41. https://doi.org/10.1016/j.jbusres.2019.10.011

Xie, X., & Wang, H. (2021). How to bridge the gap between innovation niches and exploratory and exploitative innovations in open innovation ecosystems. *Journal of Business Research*, *124*(November 2020), 299–311. https://doi.org/10.1016/j.jbusres.2020.11.058

Xu, L. Da, Xu, E. L., & Li, L. (2018). *Industry 4 . 0 : state of the art and future trends*. *7543*, 0–22. https://doi.org/10.1080/00207543.2018.1444806

Zheng, P., Wang, H., Sang, Z., Zhong, R. Y., Liu, Y., Liu, C., & Mubarok, K. (2018). *Smart manufacturing systems for Industry 4 . 0 : Conceptual framework , scenarios , and future perspectives*.

Zhou, C., & Etzkowitz, H. (2021). Triple helix twins: A framework for achieving innovation and un sustainable development goals. *Sustainability (Switzerland)*, *13*(12). https://doi.org/10.3390/su13126535