Leveraging technological factors and strategic alliances to achieve sustainable development goals

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Abstract: The United Nations General Assembly approved the 2030 Development Agenda proposal, which included 17 Sustainable Development Goals (SDGs) and 169 related targets. Many countries have committed to achieving these SDGs by 2030. Through access to resources and information, connectivity, and research activities, technology, and innovation policies are important in achieving the SDGs. However, how the 2030 development agenda can harness technologies and innovations to achieve the SDGs by 2030 remains a challenge. We identified eight factors related to technology and innovation that should be considered for SDG success by 2030. We looked at how the identified factors interacted and linked them to the SDGs. The modified total interpretive structural modelling (m-TISM) technique is used to develop a hierarchical model and define the common interconnections between the identified technological factors. The implications of the findings are interpreted and discussed.

Keywords: sustainable development; technology management; strategic alliances; TISM; policy.

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1 Introduction

According to a resolution passed by the United Nations General Assembly (UNGA) in New York, the most aspirational sustainable development agenda by 2030, with 17 Sustainable Development Goals (SDGs) and 169 associated targets, should be in place by 2030. In the next 15 years, the new 17 SDGs and 169 targets will encourage adequate action in various domains that are crucial for society and our planet (Le Blanc, 2015). The UNGA's proposal for the 17 SDGs prioritises the development, transfer, and diffusion of environmentally friendly technologies and innovations for developing nations. The establishment of technological facilitation mechanisms (TFMs) for knowledge production and technology transfer are also significant objectives of the UNGA proposal on the SDGs (Pisano et al., 2015). The proposed SDGs can be achieved through a variety of technological approaches.

Science, technology, and innovations can help to raise living standards, combat climate change, and improve society and the global economy (Dinesh and Sushil, 2019, 2021; Porter, 2000). Technology and research are critical to achieving the development agenda goals. The science and technology forum (STF) and the TFM, for example, are already putting their potential for transformational action to work in several SDGs (Kamath, 2018). Knowledge is created through technological engagement, and information flow aids in raising income levels and accelerating societal development. Gherheș and Obrad (2018) published research on the impact of ICT, artificial intelligence, and the ultimate effect of technology on the SDG, such as sustainable cities (SDG 11), good health (SDG 3), and climate action (SDG 13), in their respective IEEE and ACM digital libraries. Research has also looked into technological problems, communication, networking, and resource availability in the context of sustainable development. However, the question of how to use technology and innovative approaches to achieve the SDGs remains unanswered. The link between various technological factors and policies and SDG progress is still unknown. Policymakers and practitioners must grasp the evolving nature of technology by focusing on the current technological perspective and how it aligns with the SDGs of the future.

Because of the gaps in prior research, this study aims to identify and analyse the numerous technological factors that have a significant impact on the SDGs. The study will address issues such as how to align technologies, research, and innovations in a hierarchy for the SDGs. What are the various technological forces that influence technological regulations, and how do they influence them? How can we manage and shape technological factors in a productive ecosystem in order to achieve the SDGs? In order to address the research gaps identified above, this study developed a hierarchical model for SDGs. As a result, the research objectives for this current study are as follows:

1. To identify and investigate the various technological factors that influences the planning and development of SDGs.
2. To develop a hierarchical conceptual model of technological factors identified to better understand technology management practices for SDGs.

A literature review was used to identify eight technological factors in the current study. These factors were examined further and used to develop a hierarchical model of identified technological factors for SDGs. The model was developed using an modified total interpretive structural modelling (m-TISM) technique (Rajan et al., 2021a, 2021b; Sushil, 2017).

2 Literature review

2.1 Background of SDGs and technology management

Sustainable development is also known as 'sustained growth or progress', and it is defined as development that satisfies the requirements of the present generation without affecting the ability of future generations to meet those demands (Cash et al., 2003). The three most essential pillars of sustainable development are social advancement, economic growth and environmental improvement. In order to achieve sustainable development, the United Nations Sustainable Development Summit (UNSDS) in September 2015 established the Sustainable Development Objectives 2030 Agenda, which contains 17 goals and 169 related targets. The 2030 Agenda for Sustainable Development is a global initiative that aims to ensure the sustainable development of all countries by 2030, starting with the USA. Within a decade, the SDGs will work to promote global well-being, healthy living, social development activities, capacity building, and development assistance for underdeveloped nations (Terama et al., 2016). Global cooperation and access to science and technology in developing countries are among the goals of SDG 17, which also aims to promote sustainable development, science, and technology while also enabling technology, knowledge sharing under mutually agreed-upon terms, global cooperation, and access to science and technology in developing countries, and the dissemination and diffusion of environmentally friendly technologies. The 2030 Agenda for Sustainable Development is divided into five sections: introduction and definition, declaration, SDG and target, strengthening and revitalising the global alliance, and follow-up and review. The introduction and definition section is followed by a section on the definition of sustainable development. Science, technology, and innovation have been highlighted as crucial ways of accomplishing the SDGs by 2030, and the United Nations Technology for Development (UN TFM) was founded as a result of the 2030 Agenda. Science, technology and innovation (STI) regulations and policies are being developed with assistance from the United Nations Conference on Trade and Development (UNCTAD). These regulations and policies are intended to promote technological development, dissemination, and transfer as well as the global development agenda (Salami and Soltanzadeh, 2012). Among the goals of the SDGs are to improve the quality of life and health of people living in remote areas as well as technological advancements in infrastructure and finance, industrialisation, capacity building, business improvement, multi-stakeholder alliances and partnerships, policy and institutional coordination, information access, knowledge enhancement and innovation (Dhir and Sushil, 2017; Dhir and Dhir, 2020; Lamba et al., 2020; Nilsson et al., 2016; Rajan et al., 2020a). According to the UN TFM, there is a multi-stakeholder collaboration for the SDGs that involve member states as well as the commercial sector and civil society organisations, UN agencies, scientific communities and others. For the purpose of strengthening multi-stakeholder collaboration, the UN Secretary-General (UNSG) has organised a ten-member committee to provide assistance for TFM initiatives. This group of ten members, which includes representatives from the scientific community, the International Council for Science (ICSU), the American Association for the Advancement of Science (AAAS), the International Institute for Applied Systems Analysis (IIASA), and other private stakeholders, is responsible for the operationalisation of the technological platform. The relevance of STI in the creation of the SDGs is generally accepted. Countries participating in the 2030 Agenda, according to the UN Secretary-Synthesis General's Report, must improve technological capacity building, international cooperation in relevant scientific engineering, public R&D spending, solution-driven initiatives, and innovation activities in order to achieve the SDGs by 2030.

2.2 The need for technology and innovation policies for SDGs

Science and technology will be required to bring about transformative change in the economy and society, as well as to provide new solutions to a specific problem (Stirling, 2007). The use of technology to achieve SDG can boost productivity, improve healthcare and education services, open up new markets, and spur economic growth. In collaboration with businesses, academia, and civil society, governments and policymakers must take a proactive and purposeful approach to achieve the SDGs through technology and innovation. In order to take advantage of the socio-economic benefits offered by cutting-edge technologies, the necessary technological infrastructure and research and development capabilities are required (Gold et al., 2001). To encourage human skills, knowledge, and experimentation in innovative products and services while maintaining the necessary safeguards, standard and adaptive technology and research policy are required (Griggs et al., 2013). Previous works have proposed various contributions to technology transfer, technological developments and eco-technologies (Bozeman, 2000; Shi et al., 2010), inter-disciplinary science approach (Graham, 2002), and socio-economic policies for the development of society and economy (Bozeman, 2000; Shi et al., 2010), and socio-economic policies for the development of society and economy (Graham, 2002). As a result, the three pillars of sustainable development, such as economic growth, social equity and environmental protection, can be linked to technology and innovation policy. For the development of new products and services, improving the quality of life, increasing employment opportunities (Frey and Osborne, 2017), developing new sources of renewable energy, ensuring food security and health, and thus achieving SDG, innovation, and research should be encouraged (Ben Amara and Chen, 2021; Gunasekaran et al., 2016; Ikram, 2021; Mazzucato and Semieniuk, 2018). According to the United Nations' approved literature review, we discussed the need for innovation and technology, as well as adaptive policies, in the context of 17 new SDGs.

2.2.1 SDGs 1 and 2: end of poverty and food security

According to a survey, 1.3 billion tonnes of food is wasted each year, with 30% of all harvested food never reaching the market (Munesue et al., 2015). In addition, due to low agricultural productivity and floods or droughts, 815 million people go hungry (Sanlier, 2009). Similarly, the majority of people in developing countries live in poverty, and 10% of the world's employees (783 million people) live on less than US$1.90 per person per day (international poverty line) (Edward and Sumner, 2014). There are insufficient resources and income to sustain a poor lifestyle. Limited access to education, hunger, social discrimination, and malnutrition are all factors. SDGs are threatened and challenged by food security and poverty. As a result, effective techniques, information, and policies are required to alleviate the current situation. Technical investment and networks are needed in these countries to help with productivity, agriculture, advanced farming and financial services. For food availability and poverty reduction, this will necessitate good governance and policy, as well as connecting people to information and communication technologies (Hanjra and Qureshi, 2010).

2.2.2 SDGs 3, 4, 5 and 10: education, health, gender equality and inequalities

For a peaceful and stable world, education, health, and gender equality are critical. Education is critical to improving one's quality of life and ensuring long-term development. More than 265 million children are out of school, according to the survey, due to poor infrastructure, a lack of funds, gender inequality and caste discrimination (Kaul, 2001). Every day, over 17,000 children die as a result of health problems and poverty (Requejo and Bhutta, 2015). According to the survey, one out of every five girls aged 15 to 50 has experienced physical violence, and 750 million girls under the age of 18 have been married as a result of a lack of adequate safety laws and regulations (Deb et al., 2011). Education, proper healthcare, a proper regulatory framework, and technological inventions are required to achieve these SDGs around the world.

2.2.3 SDGs 6 and 7: water and energy

For the planet's inhabitants, clean water and renewable energy are critical. However, billions of people lack access to clean drinking water and energy due to poor infrastructure and poor economies. Three out of ten people lack access to safe drinking water, and over 1,000 children die each year as a result of poor sanitation and water-borne diseases. Food safety and health issues are harmed by a lack of clean water. Furthermore, global energy consumption increased by nearly 17% in 2015, and 3 billion people lack access to clean cooking solutions. To achieve SDGs, more investment in technology is required, as well as an appropriate regulatory framework to address issues related to clean water and energy.

2.2.4 SDGs 8 and 9: economic growth, employment and industrialisation

Due to low labour productivity, low unemployment, low wages, and limited employment opportunities, the living standard in many countries, particularly in developing countries, is low. Between 2018 and 2030, more than 460 million new jobs will be needed globally (Bloom et al., 2018). To reduce unemployment and improving economic status necessitates high productivity investment, as well as information and communications technology. Industrialisation and sustainable development necessitate the development of technology and innovation.

2.2.5 SDGs 11 and 12: sustainable cities and sustainable consumption

The population of cities is growing by the day. By 2030, urban areas are expected to house 60% of the world's population (Marsal-Llacuna et al., 2015). As a result, it necessitates effective urban planning and management. There are numerous challenges in maintaining urban cities, including proper land use, basic demand consumption, environmental conservation and recycling, transportation, water, job, and energy consumption, and transportation networks (Marsal-Llacuna et al., 2015; Spickermann et al., 2014). The population of urban areas is steadily increasing. By 2030, urban areas are expected to house more than 60% of the world's population (Crush and Frayne, 2011). As a result, effective urban planning and management are required. Urban cities face many challenges, including proper land use, basic demand consumption, environmental protection and recycling, transportation, water, employment, energy consumption and transportation network (Smith et al., 2014). Sustainable consumption aims to promote long-term infrastructure, resource and energy efficiency, and improved overall quality of life. This aids in the strengthening of the economy, overall development and poverty reduction (Gilg et al., 2005). Responsive technology and regulation are required to achieve the SDGs.

2.2.6 SDGs 13, 14 and 15: climate change, oceans, forest and biodiversity

Increased use of fossil fuels, land use, industrial processes, deforestation, and other human activities all contribute to climate change (Parmesan and Yohe, 2003). Climate change and deforestation have an impact on every continent, as well as the lives of people and animals around the world, and they result in biodiversity loss (Malhi et al., 2008). For example, between 1880 and 2018, the average global temperature increased by 0.85°C, CO_2 emissions increased by 50%, the amount of snow and ice decreased, and the sea level increased (Vincent et al., 2005). In this case, the technological approach (along with various regulatory and economic policies) is critical in preventing such problems (Mendiara et al., 2018). Innovation, technology transfer, training, and support are all critical to addressing these challenges for long-term development.

2.2.7 SDG 16: peace and justice

Issues such as sexual violence, human trafficking, and international murder must be stopped to promote peaceful societies to achieve sustainable development. In developing countries, the cost of bribery and corruption is 1.26 trillion US dollars annually; this amount can be used to uplift the poor people who are spending less than $1.25 a day. In order to deal with these challenges, there is a need to use more transparent and efficient policies and the latest technology to explore these issues (Farzanegan and Witthuhn, 2017).

2.2.8 SDG 17: partnerships to achieve the goal

Only international cooperation will allow us to achieve SDG. Information and technology development, as well as business and market development, can all benefit from collaboration and partnerships. Improving collaborative access to technology and knowledge will result in increased innovation and long-term development for everyone. SDGs necessitate collaboration between the public, private and civil society sectors.

2.3 Technology and innovation for sustainable development

Science and technology inventions have shaped our modern society around the world by introducing innovative changes to the entire system (Bloom et al., 2018). It considers technology and innovation to be the most important means of increasing societal growth, trade and socio-economic development, environment, agriculture, health, employment, business structure and security issues. Technology and innovation are critical for sustainable development, urbanisation, disease control, overpopulation, coping with climate change, soil protection, dealing with a water crisis, and increasing global trade in biotech products (Riahi et al., 2015). A good research and education policy encourages public sector innovation, as well as research and development and international collaboration (Edler and Fagerberg, 2017; Colombo et al., 2016). Through its various agencies, such as the FAO, UNESCO, UNIDO, WHO, and IAEA, the United Nations, for example, provides an important model for international research cooperation and supports capacity building (Hodder and Hodder, 2016). To address issues of sustainable development, a multi-dimensional approach is required due to the complex relationship between society, economy, and environment, as well as technology and scientific innovation. Eliminating the gap between technology and implementation can lead to more sustainable development for all of humanity in the future; however, this will necessitate a new regulation that fully integrates current and new technology. Sustainable development issues can be addressed by involving political, economic, social, and administrative technological rules, according to the Brundtland Commission Report. Cooperation in technology and research is critical to achieving a global sustainable development agenda. The main tool for achieving the SDGs should be global cooperation and technological alliances resulting from cross-border research projects (Franco and Haase, 2015). The political economy of increasing international trade and improving information technology infrastructure from the local to the national level is directly linked to the globalisation of technology, science and innovation (Freeman, 2015). Rayna and Striukova (2016) argue that involving technology companies and technical institutions can benefit business innovation in international markets. The technological alliance plays an important role in collaborative creativity and knowledge enforcement for global issues (Freeman, 2015). Policymakers who take innovative and flexible approaches to innovation and technology can help the world meet its sustainable development challenges. Government institutions and technical industries should promote effective policy development that systematically accelerates sustainable development in research and global cooperation activities; this will increase skills and knowledge relevant to SDG (Rogge and Reichardt, 2016). Frontier Science Program (FSP) and Intelligent Manufacturing System Program (IMSP), for example, are designed to improve scientific competence and knowledge in Japan through global collaboration (Thoben et al., 2017). The collaboration of technology companies and government institutions can boost research capacity, improve agricultural productivity, and generate global knowledge (Franco and Haase, 2015; Baumers et al., 2016). In terms of food security, employment, export income, and better access to knowledge, technological changes and development are critical to long-term development (Stratigea et al., 2015; Acemoglu and Restrepo, 2018; Dhir et al., 2020, 2021). Appropriate government regulation encourages collaboration between technologists, experts, scientists, and society in order to find appropriate solutions to sustainable development challenges (Guan and Yam, 2015). As a result, for long-term production and development, new ideas and technology exchanges should be encouraged. The government agency is critical in providing funding and enlisting the help of technologists to solve national problems.

Another important aspect of achieving global sustainable development is the involvement of technology-based firms in collaborative innovation and technology transfer (Ketata et al., 2015). Large technological industries and scientific partnerships can help to expand research activities. This could be the result of technological advancements and new technology for the country's development. Cooperation between global technology firms and researchers aids in the development of new knowledge as well as the development of technical capabilities and skills (Chen et al., 2016; Vásquez-Urriago et al., 2016). This necessitates the involvement of policymakers who are committed to long-term development. The country's technological infrastructure is important for research development and innovation. Information and communication technology infrastructure, transportation networks, product-testing facilities, standard organisations, research institution arrangements, and skills are all part of a country's technology infrastructure (Jin, 2019). A sufficient technical infrastructure is critical for the creation and development of science and technology; this technology facilitates the learning process, allows for the acquisition of knowledge, and allows for the effective implementation of technical changes. In almost every sector of the economy, technology infrastructure contributes to research and innovation. The availability of technical infrastructure is required for the creation and dissemination of technology (Donou-Adonsou et al., 2016). As a result, without adequate technological infrastructure, technology cannot be harnessed, and development is impossible. The overall process of the invention (including process), continuous improvement of innovation, and technological advancement are all examples of technological change and advancement. In order to achieve SDGs, the country or governing body must be prepared in a sustainable manner. A good research and education policy will have a positive impact on productivity, economic growth, and innovation (Darling-Hammond, 2016). Investment in research and innovation is made in a variety of ways in numerous research institutes for long-term economic development, and responsive and adaptive R&D policy may influence innovation and technological change. Cooperation among technologists, policymakers, and research institutions can help close the information gap, improve public sector innovation skills, and improve understanding of innovation systems for long-term development (Lu et al., 2015). Knowledge, awareness, skill-base improvement, and information growth can all be improved through cooperative education and training. Individuals from various fields, as well as their knowledge, skills, and creativity, are required for innovation and research. As a result, it is even more critical that policymakers establish adaptive regulations and policies to facilitate the sharing of knowledge and information (Safa et al., 2016). Through the establishment of clear standards and policies, adaptive regulations can provide opportunities for technological change and research collaboration. It promotes a company's desire for technological change, as well as innovation, product and process technology, entrepreneurship and business development (Alonso and Kok, 2018; Amalia and Korflesch, 2021; Gani et al., 2021; Nair et al., 2021; Liu et al., 2015).

Table 1 lists the technology initiatives that have been identified as having an impact on the SDGs.

Table 1 Identified technological factors to SDGs

Factor code	*Factor*	*References*
C1	Technological infrastructure	Freeman (2015), Jin (2019), Donou-Adonsou et al. (2016)
C2	Technological change	Stratigea et al. (2015), Acemoglu and Restrepo (2018)
C3	Responsive and adaptive regulation	Guan and Yam (2015)
C4	Engagement of technological companies	Franco and Haase (2015), Ketata et al. (2015)
C5	Technological alliances	Freeman (2015)
C6	Public sector innovation skills	Rogge and Reichardt (2016), Chen et al. (2016)
C7	Innovation and technology transfer	Pisano et al. (2015), Salami and Soltanzadeh (2012)
C8	Sustainable Development Goals	Edler and Fagerberg (2017), Colombo et al. (2016)

3 Research methodology

The modified interpretive structural modelling (TISM) is a novel extension of the interpretive structural modelling (ISM) technique, which is used to develop a hierarchical model of the factors of interest (Sushil, 2012, 2017, 2019). Numerous researchers and practitioners have successfully applied the m-TISM technique (Dhir et al., 2021; Sharma et al., 2021b; Sushil, 2017). The modified TISM process is related to the progress of a directed graph for a complex system between various sets of factors, which helps in transforming a poorly articulated mental model into a well-organised structure that can be employed for many explanations and theory building. This technique is used to address three fundamental questions: 'what', 'why', and 'how', which aids in the development of the conceptual model for the particular research domain (Rajan et al., 2020b, 2021a, 2021b). What is the fundamental unit of measurement for the concept? It takes into account the critical factors in the study's context. 'Why' these identified factors are connected and 'how' they are related to one another. These questions are examined in order to demonstrate the factors' hierarchical relationships (Sushil, 2017).

The steps of the modified TISM have been explained (Figure 1).

The factors were identified through a review of the literature (see Table 1). Second, pair comparisons of identified factors in the context of technology management and the SDGs were conducted based on the literature review (see Figure 2). The straight line depicts direct relationships, while the dotted line depicts transitive relationships. Appendix contains an explanation of each of the direct links.

Thirdly, using Figure 2, the reachability and transitive matrix were developed (see Table 2).

Fourth, we partitioned the identified factors on a level basis. To accomplish this, the reachability matrix was partitioned into distinct levels (see Table 3).

Figure 1 Steps of m-TISM

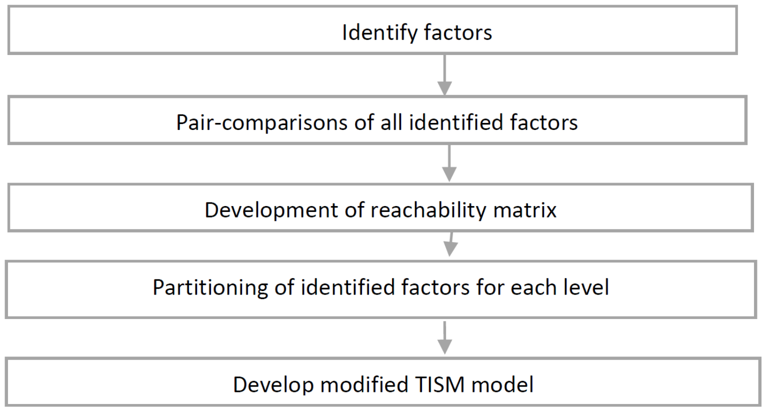


Figure 2 Successive comparison digraph (see online version for colours)

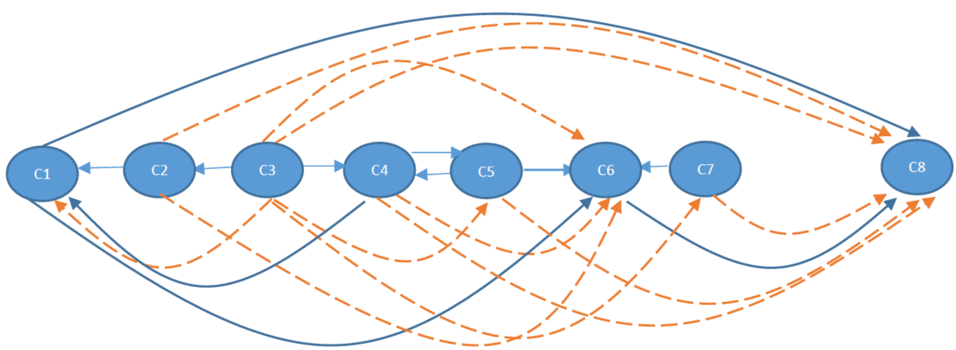


Table 2 Reachability matrix with transitivity

Elements	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*
C1	1	0	0	0	0	0	0	1
C2	1	1	0	0	0	0	0	1*
C3	1*	1	1	1	1	1*	1	1*
C4	1	0	0	1	1	1*	0	1*
C5	0	0	0	1	1	1	0	1*
C6	0	0	0	0	0	1	0	1
C7	0	0	0	0	0	1	1	1*
C8	0	0	0	0	0	0	0	1

Note: *Transitive links.

The level of the identified factors is shown in Table 4.

Table 3 Partitioning the reachability matrix into different levels

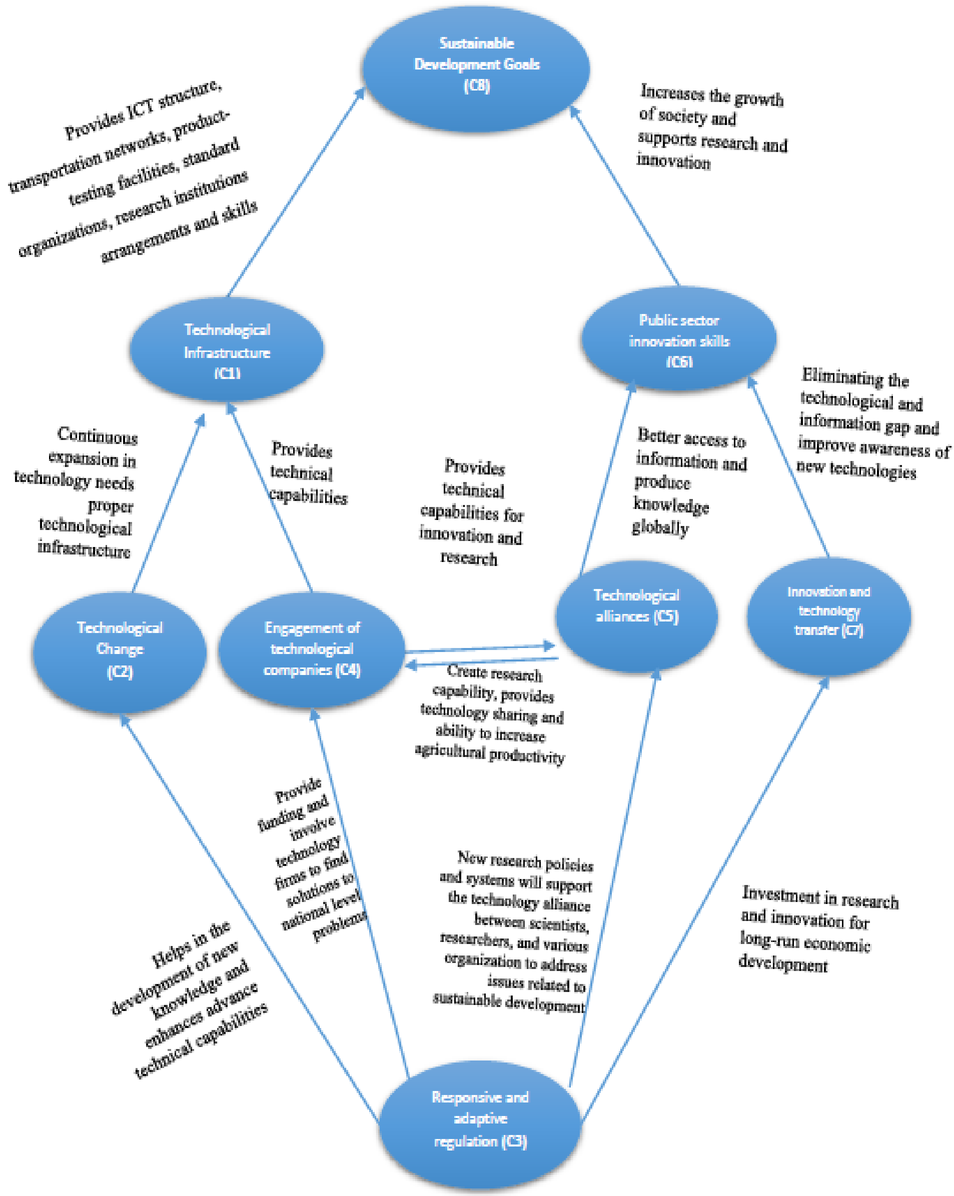
Elements	*Reachability set*	*Antecedent set*	*Intersection set*	*Level*
(a) Iteration-1				
C1	1, 8	1, 2, 3, 4	1	
C2	1, 2, 8	2, 3	2	
C3	1, 2, 3, 4, 5, 6, 7, 8	3	3	
C4	1, 4, 5, 6, 8	3, 4, 5	4, 5	
C5	4, 5, 6, 8	3, 4, 5	4, 5	
C6	6, 8	3, 4, 5, 6, 7	6	
C7	6, 7, 8	3, 7	7	
C8	8	1, 2, 3, 4, 5, 6, 7, 8	8	*I*
(b) Iteration-2				
C1	1	1, 2, 3, 4	1	*II*
C2	1, 2	2, 3	2	
C3	1, 2, 3, 4, 5, 6, 7	3	3	
C4	1, 4, 5, 6	3, 4, 5	4, 5	
C5	4, 5, 6	3, 4, 5	4, 5	
C6	6	3, 4, 5, 6, 7	6	*II*
C7	6, 7	3, 7	7	
(c) Iteration-3				
C2	2	2, 3	2	*III*
C3	2, 3, 4, 5, 7	3	3	
C4	4, 5	3, 4, 5	4, 5	*III*
C5	4, 5	3, 4, 5	4, 5	*III*
C7	7	3, 7	7	*III*
(d) Iteration-4				
C3	3	3	3	*IV*

Table 4 Factors and their levels

Factor codes	*Factors*	*Level*
C8	Sustainable Development Goals	I
C1	Technological infrastructure	II
C6	Public sector innovation skills	II
C2	Technological change	III
C4	Engagement of technological companies	III
C5	Technological alliances	III
C7	Innovation and technology transfer	III
C3	Responsive and adaptive regulation	V

Finally, the m-TISM model has been developed that shows the relationship between the factors according to their level. The transitive links that have no relationship in the existing literature have been eliminated from the model (see Figure 3).

Figure 3 m-TISM model (see online version for colours)



Note: ↑ – direct links; ⇡ – transitive links.

4 Results and discussion

Using a review of the literature, we were able to identify eight technological factors for this research study. It has been demonstrated that there is a direct link between identified factors and SDGs. The model was developed using a modified TISM approach. In the developed model, the responsive and adaptive regulations are depicted at the bottom level of the model (see Figure 3). When looking at the modified TISM hierarchical model, the most powerful driving force is found at the bottom of the model, where responsive and adaptive regulations (at the fourth level) are positioned. Responsive and adaptive regulations influence innovation and technology transfer, which impact public sector innovation skills. If the government is serious about implementing successful research policies, it will offer appropriate financing as well as support to technology and research organisations in order to achieve sustainable development. Level 3 includes technical changes, engagement of technological companies, technological alliances, and innovation and technology transfer. The responsive strategy also promotes the development of innovative capabilities in the public sector through invention, technology transfer, and training in the use of relevant technology. At the third level, technology alliances and engagement of technological companies impact each other. In order to solve global concerns outlined in the SDGs, technology collaborations and agreements will facilitate collaborative creativity, innovation, and knowledge integration. Scientists, researchers, and other organisations will be able to build a technological alliance to address challenges connected to sustainable development as a result of improved research policies and methods. In addition, technical infrastructure and public sector innovation skills are supported by innovation, technology collaboration, and technological change, which all contribute to the achievement of SDGs. Improved skills and technology infrastructure in developing nations will result in considerable improvements in income, technological innovation, and productivity in less developed countries. All stages of the modified TISM model contribute to the accomplishment of the SDGs. Policies and academics will need to pay close attention to the facts above if they are to achieve the SDGs by 2030. Thus, the suggested hierarchical m-TISM model provides a more realistic depiction of the technological factors that may help in the implementation of the SDGs. The model would facilitate a comprehensive understanding of the link between various technical aspects and the SDGs. In order to attain the SDGs, it is necessary to take into consideration the variables that have been highlighted.

5 Conclusions

The study contributes to the corpus of knowledge in a number of different ways. In this paper, we have shown that policymakers and institutions play a key role in ensuring sustainable development growth and economic development. All of the factors that have been identified are expected to have a substantial influence on the SDGs in a number of ways. In addition, we addressed the links and interactions that existed between the factors that were found. According to the findings of the study, policymakers will be better able to identify crucial areas of technological adoption on which they should concentrate their efforts to accomplish SDG. As a result, this research might be considered significant in technology management and the pursuit of sustainable development objectives.

6 Implications

The developed model is intended to assist policymakers and academics in accomplishing the SDGs using technological and innovative means. Innovative policies and regulations should be enacted by government institutions and policymakers in order to foster the advancement of science and technology. Implementing technological advances, increasing technical infrastructure, boosting the quality of their workforce's abilities, and building a long-term business climate should be the primary emphasis of their strategies. In developing nations, research, education, and innovation should be fostered more than they are currently (Porter, 2000; Bolton and Foxon, 2015).

7 Limitations and future research scope

Among the study's limitations was the absence of empirical validation for the suggested paradigm. An extensive survey of the literature served as the basis for our investigation. Consequently, the future focus of the research will be on the empirical validation of the proposed TISM model using PLS-SEM (Sharma et al., 2021a), which will be accomplished through expert opinion and a survey methodology.

References

Acemoglu, D. and Restrepo, P. (2018) 'The race between man and machine: implications of technology for growth, factor shares, and employment', *American Economic Review*, Vol. 108, No. 6, pp.1488–1542.

Alonso, A.D. and Kok, S. (2018) 'Entrepreneurial action in the context of firms and managers operating internationally: an empirical study', *Journal for International Business and Entrepreneurship Development*, Vol. 11, No. 4, pp.343–362.

Amalia, R.T. and Korflesch, H.F.V. (2021) 'Entrepreneurship education in European and American higher education: a systematic literature review', *Journal for International Business and Entrepreneurship Development*, Vol. 13, Nos. 3–4, pp.311–349.

Baumers, M., Dickens, P., Tuck, C. and Hague, R. (2016) 'The cost of additive manufacturing: machine productivity, economies of scale and technology-push', *Technological Forecasting and Social Change*, Vol. 102, No. 2016, pp.193–201.

Ben Amara, D. and Chen, H. (2021) 'Evidence for the mediating effects of eco-innovation and the impact of driving factors on sustainable business growth of agribusiness', *Global Journal of Flexible Systems Management*, Vol. 22, No. 3, pp.251–266.

Bloom, D.E., McKenna, M. and Prettner, K. (2018) *Demography, Unemployment, Automation, and Digitalisation: Implications for the Creation of (Decent) Jobs, 2010–2030*, No. w24835, National Bureau of Economic Research.

Bolton, R. and Foxon, T.J. (2015) 'Infrastructure transformation as a socio-technical process – implications for the governance of energy distribution networks in the UK', *Technological Forecasting and Social Change*, Vol. 90, No. 2015, pp.538–550.

Bozeman, B. (2000) 'Technology transfer and public policy: a review of research and theory', *Research Policy*, Vol. 29, Nos. 4–5, pp.627–655.

Cash, D.W., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Guston, D.H., Jäger, J. and Mitchell, R.B. (2003) 'Knowledge systems for sustainable development', *Proceedings of the National Academy of Sciences*, Vol. 100, No. 14, pp.8086–8091.

Chen, Y., Vanhaverbeke, W. and Du, J. (2016) 'The interaction between internal R&D and different types of external knowledge sourcing: an empirical study of Chinese innovative firms', *R&D Management*, Vol. 46, No. S3, pp.1006–1023.

Colombo, M.G., Cumming, D.J. and Vismara, S. (2016) 'Governmental venture capital for innovative young firms', *The Journal of Technology Transfer*, Vol. 41, No. 1, pp.10–24.

Crush, J.S. and Frayne, G.B. (2011) 'Urban food insecurity and the new international food security agenda', *Development Southern Africa*, Vol. 28, No. 4, pp.527–544.

Darling-Hammond, L. (2016) 'Research on teaching and teacher education and its influences on policy and practice', *Educational Researcher*, Vol. 45, No. 2, pp.83–91.

Deb, S., Mukherjee, A. and Mathews, B. (2011) 'Aggression in sexually abused trafficked girls and efficacy of intervention', *Journal of Interpersonal Violence*, Vol. 26, No. 4, pp.745–768.

Dhir, S. and Dhir, S. (2020) 'Modeling of strategic thinking enablers: a modified total interpretive structural modeling (TISM) and MICMAC approach', *International Journal of System Assurance Engineering and Management*, Vol. 11, No. 1, pp.175–188.

Dhir, S. and Sushil (2017) 'Flexibility in modification and termination of cross-border joint ventures', *Global Journal of Flexible Systems Management*, Vol. 18, No. 2, pp.139–151.

Dhir, S., Ongsakul, V., Ahmed, Z.U. and Rajan, R. (2020) 'Integration of knowledge and enhancing competitiveness: a case of acquisition of Zain by Bharti Airtel', *Journal of Business Research*, Vol. 119, No. 2020, pp.674–684.

Dhir, S., Rajan, R., Ongsakul, V., Owusu, R.A. and Ahmed, Z.U. (2021) 'Critical success factors determining performance of cross-border acquisition: evidence from the African telecom market', *Thunderbird International Business Review*, Vol. 63, No. 1, pp.43–61.

Dinesh, K.K. and Sushil (2019) 'Strategic innovation factors in startups: results of a cross-case analysis of Indian startups', *Journal for Global Business Advancement*, Vol. 12, No. 3, pp.449–470.

Dinesh, K.K. and Sushil (2021) 'Strategic innovation and entrepreneurial ownership: an analysis using GEM data and fuzzy simulation', *Benchmarking: An International Journal*, Vol. 28, No. 10, pp.2896–2915.

Donou-Adonsou, F., Lim, S. and Mathey, S.A. (2016) 'Technological progress and economic growth in Sub-Saharan Africa: evidence from telecommunications infrastructure', *International Advances in Economic Research*, Vol. 22, No. 1, pp.65–75.

Edler, J. and Fagerberg, J. (2017) 'Innovation policy: what, why, and how', *Oxford Review of Economic Policy*, Vol. 33, No. 1, pp.2–23.

Edward, P. and Sumner, A. (2014) 'Estimating the scale and geography of global poverty now and in the future: how much difference do method and assumptions make?', *World Development*, Vol. 58, No. 2014, pp.67–82.

Farzanegan, M.R. and Witthuhn, S. (2017) 'Corruption and political stability: does the youth bulge matter?', *European Journal of Political Economy*, Vol. 49, No. 2017, pp.47–70.

Franco, M. and Haase, H. (2015) 'University-industry cooperation: researchers' motivations and interaction channels', *Journal of Engineering and Technology Management*, Vol. 36, No. 2015, pp.41–51.

Freeman, R.B. (2015) 'Immigration, international collaboration, and innovation: science and technology policy in the global economy', *Innovation Policy and the Economy*, Vol. 15, No. 1, pp.153–175.

Frey, C.B. and Osborne, M.A. (2017) 'The future of employment: how susceptible are jobs to computerisation?', *Technological Forecasting and Social Change*, Vol. 114, No. 2017, pp.254–280.

Gani, M.O., Takahashi, Y., Faroque, A.R., Mortazavi, S. and Alam, M.Z. (2021) 'Virtual trade show: past assessment, present status, and future prospects', *Journal for International Business and Entrepreneurship Development*, Vol. 13, Nos. 3–4, pp.286–310.

Gherheș, V. and Obrad, C. (2018) 'Technical and humanities students' perspectives on the development and sustainability of artificial intelligence (AI)', *Sustainability*, Vol. 10, No. 9, p.3066.

Gilg, A., Barr, S. and Ford, N. (2005) 'Green consumption or sustainable lifestyles? Identifying the sustainable consumer', *Futures*, Vol. 37, No. 6, pp.481–504.

Gold, A.H., Malhotra, A. and Segars, A.H. (2001) 'Knowledge management: an organisational capabilities perspective', *Journal of Management Information Systems*, Vol. 18, No. 1, pp.185–214.

Graham, H. (2002) 'Building an inter-disciplinary science of health inequalities: the example of lifecourse research', *Social Science & Medicine*, Vol. 55, No. 11, pp.2005–2016.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N. and Noble, I. (2013) 'Sustainable development goals for people and planet', *Nature*, Vol. 495, No. 7441, pp.305–307.

Guan, J. and Yam, R.C. (2015) 'Effects of government financial incentives on firms' innovation performance in China: evidences from Beijing in the 1990s', *Research Policy*, Vol. 44, No. 1, pp.273–282.

Gunasekaran, A., Dubey, R. and Singh, S.P. (2016) 'Flexible sustainable supply chain network design: current trends, opportunities and future', *Global Journal of Flexible Systems Management*, Vol. 17, No. 2, pp.109–112.

Hanjra, M.A. and Qureshi, M.E. (2010) 'Global water crisis and future food security in an era of climate change', *Food Policy*, Vol. 35, No. 5, pp.365–377.

Hodder, A.J. and Hodder, A. (2016) 'FAO support to date palm development around the world: 70 years of activity', *Emirates Journal of Food and Agriculture*, Vol. 28, No. 1, pp.1–11.

Ikram, M. (2021) 'Models for predicting non-renewable energy competing with renewable source for sustainable energy development: case of Asia and Oceania region', *Global Journal of Flexible Systems Management*, Vol. 22, No. 2, pp.133–160.

Jin, B. (2019) 'Country-level technological disparities, market feedback, and scientists' choice of technologies', *Research Policy*, Vol. 48, No. 1, pp.385–400.

Kamath, R. (2018) 'Blockchain for women next generation for Sustainable Development Goal 5', *Asian Development Perspectives*, Vol. 9, No. 1, pp.88–109.

Kaul, R. (2001) 'Accessing primary education: going beyond the classroom', *Economic and Political Weekly*, Vol. 36, No. 2, pp.155–162.

Ketata, I., Sofka, W. and Grimpe, C. (2015) 'The role of internal capabilities and firms' environment for sustainable innovation: evidence for Germany', *R&D Management*, Vol. 45, No. 1, pp.60–75.

Kramer, B. (2014) 'Dementia caregivers in Germany and their acceptance of new technologies for care: the information gap', *Public Policy & Aging Report*, Vol. 24, No. 1, pp.32–34.

Lamba, H.K., Meena, A., Srivastava, S. and Khoa, T.T. (2020) 'Unboxing Hulu: a tale of strategic alliance to survive in the sharing world', *Journal for Global Business Advancement*, Vol. 13, No. 3, pp.296–320.

Le Blanc, D. (2015) 'Towards integration at last? The sustainable development goals as a network of targets', *Sustainable Development*, Vol. 23, No. 3, pp.176–187.

Liu, J., Kauffman, R.J. and Ma, D. (2015) 'Competition, cooperation, and regulation: understanding the evolution of the mobile payments technology ecosystem', *Electronic Commerce Research and Applications*, Vol. 14, No. 5, pp.372–391.

Lu, Y., Nakicenovic, N., Visbeck, M. and Stevance, A.S. (2015) 'Policy: five priorities for the UN sustainable development goals', *Nature*, Vol. 520, No. 7548, pp.432–433.

Malhi, Y., Roberts, J.T., Betts, R.A., Killeen, T.J., Li, W. and Nobre, C.A. (2008) 'Climate change, deforestation, and the fate of the Amazon', *Science*, Vol. 319, No. 5860, pp.169–172.

Marsal-Llacuna, M.L., Colomer-Llinàs, J. and Meléndez-Frigola, J. (2015) 'Lessons in urban monitoring taken from sustainable and livable cities to better address the smart cities initiative', *Technological Forecasting and Social Change*, Vol. 90, No. 2015, pp.611–622.

Mazzucato, M. and Semieniuk, G. (2018) 'Financing renewable energy: who is financing what and why it matters', *Technological Forecasting and Social Change*, Vol. 127, No. 2018, pp.8–22.

Mendiara, T., García-Labiano, F., Abad, A., Gayán, P., de Diego, L.F., Izquierdo, M.T. and Adánez, J. (2018) 'Negative CO_2 emissions through the use of biofuels in chemical looping technology: a review', *Applied Energy*, Vol. 232, No. 2018, pp.657–684.

Munesue, Y., Masui, T. and Fushima, T. (2015) 'The effects of reducing food losses and food waste on global food insecurity, natural resources, and greenhouse gas emissions', *Environmental Economics and Policy Studies*, Vol. 17, No. 1, pp.43–77.

Nair, S., Shams, R., Siachou, E. and Vrontis, D. (2021) 'The behavioural perspective of cause-related marketing: a conceptual framework of behavioural antecedents and outcomes', *Journal for Global Business Advancement*, Vol. 14, No. 4, pp.500–519.

Nilsson, M., Griggs, D. and Visbeck, M. (2016) 'Policy: map the interactions between Sustainable Development Goals', *Nature*, Vol. 534, No. 7607, pp.320–322.

Parmesan, C. and Yohe, G. (2003) 'A globally coherent fingerprint of climate change impacts across natural systems', *Nature*, Vol. 421, No. 6918, pp.37–42.

Pisano, U., Lange, L., Berger, G. and Hametner, M. (2015) *The Sustainable Development Goals (SDGs) and Their Impact on the European SD Governance Framework Vienna University of Economic and Business*, pp.5–6, ESDN Quarterly Report 35, European Sustainable Development Network, Austria.

Porter, M.E. (2000) 'Location, competition, and economic development: local clusters in a global economy', *Economic Development Quarterly*, Vol. 14, No. 1, pp.15–34.

Rajan, R., Dhir, S. and Sushil (2020a) 'Alliance termination research: a bibliometric review and research agenda', *Journal of Strategy and Management*, Vol. 13, No. 3, pp.351–375.

Rajan, R., Dhir, S. and Sushil (2020b) 'Technology management for innovation in organisations: an argumentation-based modified TISM approach', *Benchmarking: An International Journal*, Vol. 28, No. 6, pp.1959–1986.

Rajan, R., Dhir, S. and Sushil (2021a) 'Determinants of alliance productivity and performance: evidence from the automobile industry', *International Journal of Productivity and Performance Management*, Vol. 63, No. 1, pp.43–61.

Rajan, R., Rana, N.P., Parameswar, N., Dhir, S., Sushil and Dwivedi, Y.K. (2021b) 'Developing a modified total interpretive structural model (M-TISM) for organisational strategic cybersecurity management', *Technological Forecasting and Social Change*, Vol. 170, No. 2021, p.120872.

Rayna, T. and Striukova, L. (2016) 'From rapid prototyping to home fabrication: how 3D printing is changing business model innovation', *Technological Forecasting and Social Change*, Vol. 102, No. 2016, pp.214–224.

Requejo, J.H. and Bhutta, Z.A. (2015) 'The post-2015 agenda: staying the course in maternal and child survival', *Archives of Disease in Childhood*, Vol. 100, No. 1, pp.S76–S81.

Riahi, K., Kriegler, E., Johnson, N., Bertram, C., Den Elzen, M., Eom, J., Schaeffer, M., Edmonds, J., Isaac, M., Krey, V. and Longden, T. (2015) 'Locked into Copenhagen pledges – implications of short-term emission targets for the cost and feasibility of long-term climate goals', *Technological Forecasting and Social Change*, Vol. 90, No. 2015, pp.8–23.

Rogge, K.S. and Reichardt, K. (2016) 'Policy mixes for sustainability transitions: an extended concept and framework for analysis', *Research Policy*, Vol. 45, No. 8, pp.1620–1635.

Safa, N.S., Von Solms, R. and Furnell, S. (2016) 'Information security policy compliance model in organisations', *Computers & Security*, Vol. 56, No. 2016, pp.70–82.

Salami, R. and Soltanzadeh, J. (2012) 'Comparative analysis for science, technology and innovation policy; lessons learned from some selected countries (Brazil, India, China, South Korea and South Africa) for other LdCs like Iran', *Journal of Technology Management & Innovation*, Vol. 7, No. 1, pp.211–227.

Sanlier, N. (2009) 'The knowledge and practice of food safety by young and adult consumers', *Food Control*, Vol. 20, No. 6, pp.538–542.

Sharma, D., Paul, J., Dhir, S. and Taggar, R. (2021a) 'Deciphering the impact of responsiveness on customer satisfaction, cross-buying behaviour, revisit intention and referral behaviour', *Asia Pacific Journal of Marketing and Logistics*, DOI: 10.1108/APJML-07-2021-0465.

Sharma, K., Jain, M. and Dhir, S. (2021b) 'Analysing the impact of artificial intelligence on the competitiveness of tourism firms: a modified total interpretive structural modeling (m-TISM) approach', *International Journal of Emerging Markets*, DOI: 10.1108/IJOEM-05-2021-0810.

Shi, H., Chertow, M. and Song, Y. (2010) 'Developing country experience with eco-industrial parks: a case study of the Tianjin economic-technological development area in China', *Journal of Cleaner Production*, Vol. 18, No. 3, pp.191–199.

Smith, A., Kern, F., Raven, R. and Verhees, B. (2014) 'Spaces for sustainable innovation: solar photovoltaic electricity in the UK', *Technological Forecasting and Social Change*, Vol. 81, No. 2014, pp.115–130.

Spickermann, A., Grienitz, V. and Heiko, A. (2014) 'Heading towards a multimodal city of the future?: Multi-stakeholder scenarios for urban mobility', *Technological Forecasting and Social Change*, Vol. 89, No. 2014, pp.201–221.

Stirling, A. (2007) 'A general framework for analysing diversity in science, technology and society', *Journal of the Royal Society Interface*, Vol. 4, No. 15, pp.707–719.

Stratigea, A., Papadopoulou, C.A. and Panagiotopoulou, M. (2015) 'Tools and technologies for planning the development of smart cities', *Journal of Urban Technology*, Vol. 22, No. 2, pp.43–62.

Sushil (2012) 'Interpreting the interpretive structural model', *Global Journal of Flexible Systems Management*, Vol. 13, No. 2, pp.87–106.

Sushil (2017) 'Modified ISM/TISM process with simultaneous transitivity checks for reduced direct pair comparisons', *Global Journal of Flexible Systems Management*, Vol. 18, No. 4, pp.331–351.

Sushil (2019) *Structured Literature Review with TISM Leading to an Argumentation Based Conceptual Model*, Working Paper, IIT Delhi.

Terama, E., Milligan, B., Jiménez-Aybar, R., Mace, G.M. and Ekins, P. (2016) 'Accounting for the environment as an economic asset: global progress and realising the 2030 Agenda for Sustainable Development', *Sustainability Science*, Vol. 11, No. 6, pp.945–950.

Thoben, K.D., Wiesner, S. and Wuest, T. (2017) '"Industrie 4.0" and smart manufacturing – a review of research issues and application examples', *International Journal of Automation Technology*, Vol. 11, No. 1, pp.4–16.

Vásquez-Urriago, Á.R., Barge-Gil, A. and Rico, A.M. (2016) 'Science and technology parks and cooperation for innovation: empirical evidence from Spain', *Research Policy*, Vol. 45, No. 1, pp.137–147.

Vincent, L.A., Peterson, T.C., Barros, V.R., Marino, M.B., Rusticucci, M., Carrasco, G., Ramirez, E., Alves, L.M., Ambrizzi, T., Berlato, M.A. and Grimm, A.M. (2005) 'Observed trends in indices of daily temperature extremes in South America 1960–2000', *Journal of Climate*, Vol. 18, No. 23, pp.5011–5023.

Appendix

Interpretive logic

Links	*Interpretation*	*Literature*
C1-C8	Provides ICT structure, transportation networks, product-testing facilities, standard organisations, research institutions arrangements and skills	Jin (2019), Porter (2000)
C2-C1	Continuous expansion in technology needs proper technological infrastructure	Jin (2019), Chen et al. (2016)
C3-C2	Helps in the development of new knowledge and enhances advance technical capabilities	Chen et al. (2016), Vásquez-Urriago et al. (2016)
C3-C4	Provide funding and involve technology firms to find solutions to national level problems	Ketata et al. (2015)
C3-C5	New research policies and systems will support the technology alliance between scientists, researchers, and various organisation to address issues related to sustainable development	Lu et al. (2015), Freeman (2015)
C3-C7	Investment in research and innovation for long-run economic development	Lu et al. (2015)
C4-C1	Provides technical capabilities	Vásquez-Urriago et al. (2016)
C4-C5	Provides technical capabilities for innovation and research	Thoben et al. (2017), Freeman (2015)
C5-C4	Create research capability, provides technology sharing and ability to increase agricultural productivity	Franco and Haase (2015)
C5-C6	Better access to information and produces knowledge globally	Stratigea et al. (2015), Acemoglu and Restrepo (2018)
C6-C8	Increases the growth of society and supports research and innovation	Rogge and Reichardt (2016)
C7-C6	Eliminating the technological and information gap and improve awareness of new technologies	Kramer (2014)