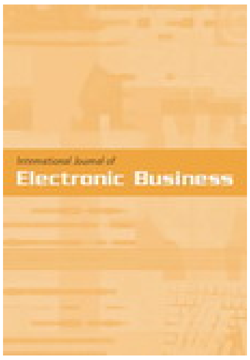

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Internet of things vs. factory of things: an evaluation of evolving technologies for corporate sustainable development

Lingya Zhang

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Internet of things vs. factory of things: an evaluation of evolving technologies for corporate sustainable development

Lingya Zhang

School of Digital Business and Intelligent Logistics,
Jiangsu Vocational College of Business,
Nantong 226011, Jiangsu, China
Email: wlzhang20230101@163.com

Abstract: Internet of things (IoT) and factory of things (FoT) both are evolving AI-based models that revolutionise efficiency, productivity, and decision making in various industrial sectors, worldwide. It is claimed that research on IoTs and FoTs is crucial to unlock the full potential across nations, especially in developing economies. This study aims to explore the nexus of both models in terms of the sustainable development of corporates. The first objective is to explore the connections between IoT and sustainable development (SD) from the perspective of the Chinese industrial sector. Second, the key aim is to investigate the relationship between FoT and sustainable development. In addition, the aim is to examine the directions of both models (i.e., IoT and FoT) toward subdimensions of SD such as economic, social, and environmental development. Using a structural approach with the support of SmartPLS, this research carried out the analysis to explore the outcomes as follows. The results confirmed a positive connection between IoTs and SD. Likewise, the outcomes assured a significant connection between FoT and SD. Multidimensional testing confirmed the positive relationships of IoTs and FoTs toward each dimension of SD such as economic, social, and environmental development.

Keywords: internet of things; IoT; factory of things; FoT; artificial intelligence; sustainable development; structural equation modelling.

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Biographical notes: Lingya Zhang studied in Nanjing University of Finance and Economics from 2000 to 2004 and received her Bachelor degree in 2004. Currently, she works in School of Digital Commerce and Intelligent Logistics, Jiangsu Vocational College of Business. Her research interests are included logistics and supply chain management.

1 Introduction

Artificial intelligence (AI)-based paradigms such as internet of things (IoT) and factory of things (FoT) have revolutionised industries by automating tasks, analysing vast datasets, and making informed decisions (Huynh-The et al., 2023; Wang and Shi, 2009).

AI is contributing to all sectors of human life to drive efficiency, innovation, and problem solving across various domains underscoring its transformative role in shaping the present and future. The IoT holds immense importance as it connects everyday objects to the internet, enabling them to collect and exchange data (Mohanta et al., 2022; Rose et al., 2015; Wen and Chen, 2010). This interconnected network enhances efficiency, convenience, and decision making in various sectors, including industrial sectors. IoT optimises processes, reduces costs, and enriches user experiences. It plays a pivotal role in environmental monitoring, energy conservation, and predictive maintenance. Since IoT continues to evolve, its ability to transform industries, enhance resource management, and improve overall quality of life underscores its significance in the modern technological landscape. However, the FoT is of paramount importance in modern manufacturing (Savazzi et al., 2014; Zuehlke, 2010). By integrating automation into the operations, FoTs enhance production efficiency, quality control, and resource utilisation. It enables real-time data analysis, predictive maintenance, and agile adaptation to market demands. The intelligent systems of FoTs reduce errors, streamline workflows, and guarantee economical operations, ultimately propelling economic expansion (Savazzi et al., 2014). Furthermore, its capacity to promote sustainable practices, reduce waste, and enhance worker safety aligns with global efforts towards environmentally responsible and socially conscious industrial development, solidifying its role as a catalyst for both technological advancement and sustainable progress (Zúñiga et al., 2017).

In order to balance environmental preservation with societal advancement, sustainable development, or SD, is essential (Holmberg and Sandbrook, 2019). It balances economic growth, social equity, and environmental conservation, ensuring a secure future for generations (Parris and Kates, 2003). China's industrial sector is of great global importance. Being the largest manufacturing hub in the world, it promotes global trade and develops industry best practices. China's industrial prowess contributes to its economic growth and technological advancement, playing a pivotal role in the global market (Lu et al., 2007; Wang and Shi, 2009). With its emphasis on innovation, infrastructure development, and strategic investments, China's industrial sector influences global trends and competitiveness (Weixin, 2006).

It is worth mentioning to conduct research on IoTs and FoTs in the context of sustainable development (SD) for several reasons, as follows. For example, this research helps optimise resource usage through smart systems, reducing waste and conserving energy and materials that eventually may contribute to SDGs by minimising ecological impact. IoTs and FoTs enable real-time environmental monitoring, aiding in pollution control, biodiversity preservation, and early detection of ecological threats which can improve organisational performance in terms of SD. It is also suggested that research on these variables may enhance the integration of renewable energy sources with IoTs and FoTs systems, promoting clean energy adoption and reducing greenhouse gas emissions. The research on IoTs and FoTs advances adaptive and lean manufacturing, aligning production with demand, minimising excess inventory, and reducing environmental footprint (Rose et al., 2015; Zúñiga et al., 2017; Zuehlke, 2010). It is also important to study IoTs and FoTs in terms of SD because it leads to novel solutions that address emerging sustainability challenges, fostering innovative approaches to global issues. Hence, research on IoTs and FoTs within the framework of SD is essential for harnessing the potential of these technologies to create a more sustainable, equitable, and prosperous future for both societies and the environment. To this end, we attempt to meet certain objectives through empirical investigation from the perspective of China, as follows.

First, the research examines the influence of IoT technology on sustainable development (SD). Secondly, it aims to uncover the impact of FoTs on SD. Thirdly, it seeks to expose the influence of IoTs and FoTs on the social aspects of SD. Fourthly, the objective is to examine how IoTs and FoTs influence the economic facet of SD. Finally, the main focus is to explore how IoTs and FoTs influence the environmental dimension of SD. This research is structured in the succeeding pinpoints. It provides a discussion of the theoretical framework and hypotheses relating to IoTs, FoTs, and SD. Consequently, the study provides details of research methods concerning the sampling process, data collection, and analysis procedure. Under discussion implications and discussion are pointed out accordingly. The concluding part addresses the study's limitations and paves the way toward potential future research opportunities for scholars globally.

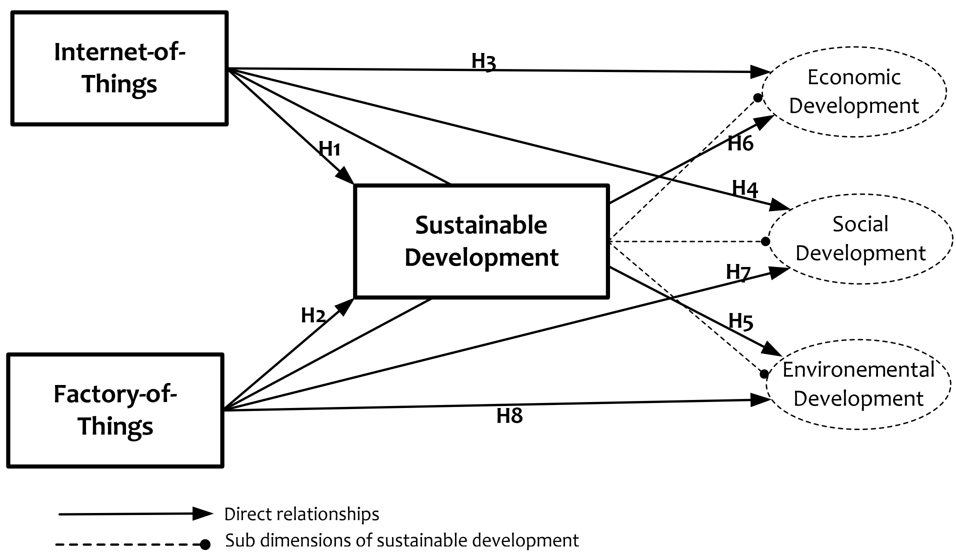
2 Literature review

Resource-based view (RBV) is a strategic management theory emphasising a firm's unique internal resources as sources of competitive advantage (Finney et al., 2008; Madhani, 2010). It posits that a company's distinctive capabilities, like valuable assets, skills, and knowledge, drive its success. RBV suggests that sustained competitive advantage stems from resources that are rare, hard to imitate, non-substitutable, and aligned with strategic goals (Finney et al., 2008). By focusing on internal strengths rather than industry conditions, RBV guides firms in identifying, developing, and leveraging their core competencies to outperform rivals (Kraaijenbrink et al., 2010). This theory underpins effective resource allocation, innovation, and long-term profitability in dynamic business landscapes (Madhani, 2010; Sila, 2015). RBV asserts that companies should build upon and exploit their unique resource base which leads to achieving competitive differentiation (Sharma et al., 2022; Wang, 2006). This theory aids firms in achieving success by adapting effectively to changing market dynamics and emphasising evolving tools over time such as AI-based models like IoTs and FoTs. It is advocated by the researchers that the research on IoTs and FoTs stems from the rapid integration of technology into various industries. With the rise of interconnected devices and automation, IoT emerged as a transformative force. FoT extends this concept, integrating IoT, AI, and automation in manufacturing. This research seeks to explore their implications for sustainable development as shown in the figure and explained in a subsequent section.

2.1 Internet of things and sustainable development

It is claimed that hypothesised relationships between IoT and SD are multifaceted as IoT has the potential to significantly impact various dimensions of SD. While the exact outcomes may depend on technological advancements, policy decisions, and societal choices (Ma et al., 2019; Rose et al., 2015). For example, IoT-enabled smart grids, buildings, and transportation systems could optimise energy consumption and reduce waste, which eventually help to bring sustainable development (Abir et al., 2021). IoT devices can collect real-time data on air and water quality, helping governments and organisations make informed decisions to tackle pollution-related information which indeed supports SD (Fatimah et al., 2020; Zarei et al., 2016). IoT can enhance energy management by monitoring energy usage in real time (Liu et al., 2019). This can lead to more precise energy distribution, load balancing, and the integration of renewable energy sources into the grid, promoting cleaner and more sustainable energy practices (Rose et al., 2015). IoT-enabled operations such as supply chains can enhance traceability and transparency, reducing waste, improving inventory management, and minimising transportation inefficiencies. This can contribute to more sustainable production and distribution processes (Pan et al., 2018). IoT can support the transition to a circular economy by enabling better product lifecycle tracking, facilitating product reuse and refurbishment, and promoting the sharing economy (Rejeb et al., 2022). These relationships highlight the potential of IoT to contribute significantly to various dimensions of sustainable development (Rejeb et al., 2022). However, it's important to note that realising these benefits also requires addressing challenges related to data privacy, security, interoperability, and the environmental impact of manufacturing and disposing of IoT devices (Imteaj et al., 2021).

Figure 1 Research model



Furthermore, IoT holds immense potential for driving SD such as real-time data collection and analysis, IoT can optimise resource utilisation, enhance energy efficiency, and enable smart urban planning (Liu et al., 2019). It facilitates informed decision making, promotes eco-friendly practices in numerous sectors such as agriculture, supply chains, and waste management, and empowers individuals to monitor their health and reduce commuting through telecommuting (Fatimah et al., 2020). IoT bolsters community engagement, fostering awareness and participation in sustainable initiatives. While these synergies offer a promising path toward SD goals, challenges such as data security and device sustainability must be tackled for a holistic and impactful integration of IoT in the journey toward a more sustainable future (Fatimah et al., 2020). From a corporate perspective, the research on IoT has widely been carried out by scholars to uncover the influence of IoT in different perspectives and domains across the world (Abir et al., 2021; Fatimah et al., 2020; Liu et al., 2019; Zarei et al., 2016). For example, researchers have revealed the influence of IoT in terms of the social dimension of SD, the economic dimension of SD, and the environmental dimension of SD (Maksimovic, 2018).

On the other hand, RBV theory aids research on IoT and SD by focusing on unique, valuable, and immobile resources that drive competitive advantage (Madhani, 2010; Samaranayake et al., 2022). It helps identify strategic IoT applications, their complementarity with sustainability goals, and how they create value (Samaranayake et al., 2022). RBV's helps to evaluate sustainability benefits, while dynamic capabilities assess adaptability (Foltean and Glovaţchi, 2021). It guides understanding of barriers to imitation and how organisations leverage IoT for lasting, distinctive sustainable outcomes (Madhani, 2010). Applying RBV to IoT and SD research enhances comprehension of resource-driven strategies, aiding in uncovering key factors that foster successful integration of IoT technologies in SD contexts. Based on the massive significance of IoT in terms of SD and supporting arguments of RBV, we currently assumed the following propositions to empirically validate the outcomes from China.

H1 IoT has a positive relationship with sustainable development (SD).

H2 IoT has a positive relationship with the social dimension of SD.

H3 IoT has a positive relationship with the economic dimension of SD.

H4 IoT has a positive relationship with the environmental dimension of SD.

2.2 Factory of things and sustainable development

FoT denotes an evolved form of the industrial internet of things (Odważny et al., 2018), where interconnected devices, machinery, and systems in a manufacturing setting collaborate autonomously. FoT optimises production, automates tasks, and enables real-time data analysis, fostering intelligent and adaptable factories for enhanced efficiency and productivity (Shariatzadeh et al., 2016; Zuehlke, 2010). It is stated that the hypothesised relationship between the FoT and SD is complex and multifaceted, as FoT has the potential to both contribute to and be influenced by SD goals (de Villiers et al., 2021; Hozdić, 2015). FoT can lead to more efficient utilisation of resources such as energy, water, and raw materials within manufacturing facilities (Lucke et al., 2008). For example, smart sensors and data analytics can optimise processes, minimising waste and reducing the environmental footprint, which aligns with SDGs of responsible consumption and production (Sajadieh et al., 2022). FoTs can enable better integration of renewable energy sources into manufacturing processes (Meng et al., 2018). FoT can assist the shift to green manufacturing activities by permitting real-time observing of the emissions (Lucke et al., 2008). It is claimed that by assisting factories to adhere to environmental guidelines and upgrade the quality of the air and water, this supports the SDGs for clean water and air quality (Meng et al., 2018). Moreover, by permitting predictive maintenance, decreasing downtime, and ultimately extending the life of machinery, FoT improves to maximise resource efficiency and prevent the need for excessive replacements. This urges innovation, industry, and infrastructure growth (Pech et al., 2021). Several SDGs can be joined together and global climate change can be mitigated with the use of FoT that could support corporations' sustainable growth (Sajadieh et al., 2022; Zuehlke, 2010). Furthermore, there are lots of opportunities and troubles associated with the connection between FoT and SD (de Villiers et al., 2021; Hozdić, 2015). Thus, FoT enables altering industrial processes, optimising resource usage, and promoting innovation (Rao, 2021). It is also highlighted that scholars elucidated that through the employment of IoT capabilities, FoT can incentivise industries to accept conscientious practices (Lucke et al., 2008; Rao, 2021; Zuehlke, 2010). To that end, the collaboration between FoTs and SD confines an idea of a more sustainable future whereby technology fosters progress while preserving the environment, society as well as financial success (Lucke et al., 2008). FoTs regarding SD liaison capture an idealised world in which technology aligns with sustainable principles, supporting a future in which advancements align with environmental sustainability, social justice, and long-term economic viability (Hozdić, 2015). RBV theory emphasises that a firm's unique resources and capabilities drive competitive advantage (Joyce and Winch, 2005). Therefore, based on the massive significance of FoT concerning sustainable development along with supporting arguments of RBV, we currently assumed the following directions to empirically validate the outcomes.

H5 FoT has a positive relationship with sustainable development (SD).

H6 FoT has a positive relationship with the social dimension of SD.

H7 FoT has a positive relationship with the economic dimension of SD.

H8 FoT has a positive relationship with the environmental dimension of SD.

3 Methodologies

3.1 Data gathering and sampling

In this study, about 1,000 questionnaires were carefully circulated among participants in the market of China. In the process of data collection, a few methods were utilised such as online distribution through WeChat and e-mails. Besides, personal visits had been planned to Chinese respondents. We are presently concentrating on the Chinese market to gather more tangible data regarding how the addition of such technologies can significantly impact sustainable development. The managers were solely requested to participate in surveys and received 980 responses successfully. In short, 893 opinion polls were contemplated for data analysis after having scrutiny and analysis of improperly filled information and other crucial issues such as incomplete responses in order to ensure the authenticity of the feedback. The utilisation of a seven-point Likert scale was used which is inspired by previous studies conducted by scholars (Omer et al., 2016; Shahid et al., 2021; Waheed et al., 2018). Furthermore, the main survey comprised thirty questions, and respondents' profiles were assessed based on five specific characteristics (see Table 1).

3.2 Pilot analysis

In addition, it is significant to tackle pilot testing prior to performing a survey on a huge scale to assess fruitful and better results (Thabane et al., 2010). For this intention, about 45 opinion polls (n = 45) were tackled for the said purpose and the final results were judged on behalf of specific criteria of data analysts (Black and Babin, 2019; Hair, 2011).

According to the recommended criteria, the current values were normal and stood higher than 0.7 (Hair, 2011).

Table 1 Descriptive findings (N = 893)

	Male		*Female*	
	Freq.	*%*	*Freq.*	*%*
Gender	488	54.64	405	45.36
Qualification				
Bachelor	116	23.77	065	16.05
Master	129	26.43	141	34.81
PhD	148	30.33	120	29.63
Others	095	19.47	079	19.51
Age in years				
17–20	120	24.59	070	17.28
21–23	130	26.64	140	34.57
24–27	140	28.69	144	35.56
>28	098	20.08	051	12.59
Work experience in years				
<3 years	078	15.98	068	16.79
4–8 years	155	31.76	150	37.04
9–13 years	145	29.71	130	32.10
>14 years	110	22.54	057	14.07

3.3 Measures/scales

All the measurement scales used in the study were taken from previous research. To measure big data, a six-item originally developed by Kim and Wang (2019) was employed. The evaluation of IoT involved 12 items which were adapted from a previous study conducted by Jarašūnienė et al. (2023). Likewise, the assessment of the factory of things (FoT) was based on a 5-item scale derived from (Zuehlke, 2010). Sustainable development was analysed from three perspectives; social, economic, and environmental development using a total of 15 items as referenced from (Bansal, 2005).

3.3 Analysis tools and techniques

First of all, a descriptive analysis tool was applied to analyse the core statistics about the profiles of the respondents. Secondly, in order to understand the association among variables of the research, a correlation testing approach was implemented. Thirdly, we examined validity on the basis of two approaches Fornell and Larcker and HTMT methods (Ab Hamid et al., 2017; Fornell and Larcker, 1981a). Similarly, the validity procedure was done on behalf of the proposed strategy such as loadings, AVEs, and reliability assessment using composite reliability (Russell, 1978). SEM using SmartPLS software was finally applied to establish the directional relationships among the variables (Ramayah et al., 2018). It was essential to compute the NFI and SRMR values to ensure the model's validity in SEM (Hu and Bentler, 1999). For loading and AVEs outcomes, values should be upper 0.5 in line with the guidelines by Hu and Bentler (1999). Reliability values should exceed 0.7, as recommended by Hair (2011). Values should be less than 0.9 in HTMT (Henseler et al., 2015). The results of the square roots of AVEs should surpass the interrelationships in discriminant validity as outlined by Henseler et al. (2015). NFI values should be above 0.9 according to Hu and Bentler (1999). Lastly, the outcomes of SRMR should be less than 0.08 aligning with the criteria established by Hair (2011) and Hu and Bentler (1999).

4 Results and findings

4.1 Validity and reliability

Table 2 provides affirmation of the validity and reliability values with the rest of the statistical reports of means and standard variations. As previously stated, it is essential to ensure that loadings and AVE outcomes should be below 0.5 and reliability values should be above 0.7 as recommended by Hair (2011).

Table 2 Validity process

	Items	*Mean*	*SD*	*Loadings*	*AVE*	*Reliability*
Internet of things (IoT)					0.780	0.801
	IoT-F1	4.982	1.540	0.633		
	IoT-F2	5.134	1.351	0.554		
	IoT-F3	4.982	1.021	0.634		
	IoT-F4	4.982	1.540	0.555		
	IoT-F5	5.134	1.540	0.633		
	IoT-F6	4.982	1.351	0.634		
	IoT-F7	4.982	1.021	0.633		
	IoT-F8	5.134	1.540	0.554		
	IoT-F9	4.982	1.540	0.634		
	IoT-F10	4.982	1.351	0.555		
	IoT-F9	5.134	1.021	0.633		
	IoT-F10	4.982	1.540	0.634		
Factory of things (FoT)					0.758	0.808
	FoT-F1	4.982	1.540	0.633		
	FoT-F2	5.134	1.351	0.554		
	FoT-F3	4.982	1.021	0.634		
	FoT-F4	4.982	1.540	0.555		
	FoT-F5	5.134	1.540	0.633		

Notes: *Items removed having <0.5 AVEs and loadings.
IoT – internet of things; FoT – factory of things; SD – sustainable development;
SoSD – social perspective of SD; EcSD – economic perspective of SD;
EnSD – environmental perspective of SD.

Table 2 Validity process (continued)

	Items	*Mean*	*SD*	*Loadings*	*AVE*	*Reliability*
Social dimension of SD (SoSD)					0.722	0.808
	SoSD-F1	4.982	1.540	0.633		
	SoSD-F2	5.134	1.351	0.554		
	SoSD-F3	4.982	1.021	0.634		
	SoSD-F4	4.982	1.540	0.555		
Economic dimension of SD (EcSD)					0.743	0.801
	EcSD-F1	4.982	1.540	0.633		
	EcSD-F2	5.134	1.351	0.554		
	EcSD-F3	4.982	1.021	0.634		
	EcSD-F4	4.982	1.540	0.555		
	EcSD-F5	5.134	1.540	0.633		
	EcSD-F6	4.982	1.351	0.634		
Environmental dimension of SD (EnSD)					0.698	0.780
	EnSD-F1	4.982	1.540	0.633		
	EnSD-F2	5.134	1.351	0.554		
	EnSD-F3	4.982	1.021	0.634		
	EnSD-F4	4.982	1.540	0.555		
	EnSD-F5	5.134	1.540	0.633		

Notes: *Items removed having <0.5 AVEs and loadings.
IoT – internet of things; FoT – factory of things; SD – sustainable development; SoSD – social perspective of SD; EcSD – economic perspective of SD; EnSD – environmental perspective of SD.

4.2 *Analysis of Pearson's correlation*

Table 3 shows the correlation analysis that confirms the connection among variables discussed in this research. It is important to note that these values should fall within the range of –1 to +1. Negative values indicate a negative connection while lower values signify a weaker connection and higher values indicate a stronger connection as demonstrated by Fornell and Larcker (1981a) and Hair (2011). The specific results are as shown in Table 3.

Table 3 Pearson correlation

	IoT	*FoT*	*SD*	*SoSD*	*EcSD*	*EnSD*
IoT	1.00					
FoT	0.24	1.00				
SoSD	0.17	0.27	1.00			
EcSD	0.30	0.33	0.28	1.00		
EnSD	0.22	0.20	0.29	0.40	1.00	
SD	0.18	0.21	0.30	0.15	0.39	1.00

Notes: Values should be between –1 to +1 in Pearson testing (Hair, 2011). IoT – internet of things; FoT – factory of things; SD – sustainable development; SoSD – social perspective of SD; EcSD – economic perspective of SD; EnSD – environmental perspective of SD.

4.3 Model of discriminant validity

Table 4 displays the results of the discriminant assessment used for the data verification process. These criteria have been recommended by researchers. For instance, it is expected that the square roots of AVEs should exceed the interrelationships in discriminant validity as directed by Fornell and Larcker's (2081b) guidelines. The square roots of AVEs are highlighted in bold in the first row of each column, while the other values represent the interrelationships.

Table 4 Model of discriminant validity

	IoT	*FoT*	*SD*	*SoSD*	*EcSD*	*EnSD*
IoT	**0.84**					
FoT	0.34	**0.75**				
SoSD	0.44	0.26	**0.88**			
EcSD	0.36	0.25	0.38	**0.84**		
EnSD	0.24	0.29	0.30	0.33	**0.74**	
SD	0.40	0.46	0.24	0.19	0.22	**0.86**

Notes: Bold values are AVEs square roots and rest values are interrelationships.
IoT – internet of things; FoT – factory of things; SD – sustainable development;
SoSD – social perspective of SD; EcSD – economic perspective of SD;
EnSD – environmental perspective of SD.

4.4 Heterotrait-monotrait

Apart from the analysis conducted by Fornell and Larcker in 1981b, an alternative technique known as HTMT is utilised to validate the data by surveying its analogies. According to the endorsement provided by Henseler et al. in 2015, HTMT values should not exceed 0.9. Therefore, the present results validate the data's HTMT accuracy based on the obtained results.

Table 5 HTMT

	IoT	*FoT*	*SD*	*SoSD*	*EcSD*	*EnSD*
IoT						
FoT	0.26					
SoSD	0.23	0.29				
EcSD	0.36	0.37	0.29			
EnSD	0.20	0.20	0.36	0.29		
SD	0.22	0.22	0.20	0.32	0.34	

Notes: The values should be <0.9.
IoT = internet of things; FoT – factory of things; SD – sustainable development;
SoSD – social perspective of SD; EcSD – economic perspective of SD;
EnSD – environmental perspective of SD.

4.5 Path relationships using SEM

Table 6 shows the directional pathways evaluated based on beta values within a structural equation model (Zarei et al., 2016). To assess the authenticity of the SEM model, it is recommended to scrutinise the NFI and SRMR values. According to the criteria outlined by Hu and Bentler in 1999, the NFI value should exceed 0.9 and the SRMR value should be lower than 0.08. The present results adhere to these approvals with an NFI of 0.9210 and an SRMR of 0.0352 signifying a strong model fit.

Table 6 SEM model results

Directions	*E.D.*	*Direct*	*Sig.*	*S.E.*	*Decision*
H1: IoT→SD	±	0.244***	0.001	0.081	Supported
H2: FoT→SD	±	0.18***	0.000	0.024	Supported
H3: IoT→SoSD	±	0.198***	0.002	0.030	Supported
H4: IoT→EcSD	±	0.22***	0.000	0.082	Supported
H5: IoT→EnSD	±	0.390***	0.002	0.018	Supported
H6: FoT→SoSD	±	0.288***	0.000	0.030	Supported
H7: FoT→EcSD	±	0.41***	0.000	0.088	Supported
H8: FoT→EnSD	±	0.307***	0.000	0.014	Supported
		Model fitness	*Suggested*	*Current*	
		NFI	>0.9	0.9210	
		SRMR	<0.08	0.0352	
AGE			--	--	
SIZE			--	--	

Notes: ***Sig at 0.05.
ES – expected signs; S.E. – standard errors; E.D. – expected direction.
DE – direct paths effect; IoT – internet of things; FoT – factory of things;
SD – sustainable development; SoSD – social perspective of SD;
EcSD – economic perspective of SD; EnSD – environmental perspective of SD.

5 Discussion and implications

A total of eight hypotheses were proposed to explore the nexus of IoT, FoT, SD, SoSD, EcSD, and EnSD. First, it was assumed in H1 that IoT is positively linked with SD. The results after SEM implementation have shown a positive connection between IoT and SD at (β = 0.244***; p = 0.001). Based on such calculations and findings, H1 is accepted. It was assumed in H2 that IoT is positively linked with SoSD dimension of SD. The results after SEM implementation have shown a positive connection between IoT and SoSD at (β = 0.198***; p = 0.002). Based on such calculations and findings, H2 is accepted. Third, it was assumed in H3 that IoT is positively linked with EcSD dimension of SD. The results after SEM implementation have shown a positive connection between IoT and ECSD at (β = 0.198***; p = 0.002). Based on such calculations and findings, H3 is accepted. Fourth, it was assumed in H4 that IoT is positively linked with EnSD dimension of SD. The results after SEM implementation have shown a positive connection between IoT and EnSD at (β = 0.22***; p = 0.000). Based on such calculations and findings, H4 is accepted. In addition, the outcomes support past studies in which experts suggested the immense significance of IoT from numerous perspectives, worldwide (Abir et al., 2021; Fatimah et al., 2020; Liu et al., 2019; Lucke et al., 2008; Maksimovic, 2018; Rejeb et al., 2022; Zúñiga et al., 2017; Samaranayake et al., 2022; Zarei et al., 2016)

However, it was assumed in H5 that FoT is positively linked with SD. The results after SEM implementation have shown a positive connection between FoT and SD at (β = 0.18***; p = 0.000). Based on such calculations and findings, H5 is accepted. It was assumed in H6 that FoT is positively linked with SoSD dimension of SD. The results after SEM implementation have shown a positive connection between SoSD and SD at (β = 0.288***; p = 0.000). Based on such calculations and findings, H6 is accepted. Similarly, it was assumed in H7 that FoT is positively linked with EcSD dimension of SD. The results after SEM implementation have shown a positive connection between EcSD and SD at (β = 0.41***; p = 0.000). Based on such calculations and findings, H7 is accepted. Finally, it was assumed in H8 that FoT is positively linked with the EnSD dimension of SD. The results after SEM implementation have shown a positive connection between EnSD and SD at (β = 0.307***; p = 0.000). Based on such calculations and findings, H8 is accepted. On the other hand, the present outcomes support some past studies in which experts suggested the immense significance of FoT from numerous perspectives, worldwide (Fatimah et al., 2020; Hozdić, 2015; Lucke et al., 2008; Meng et al., 2018; Mitlin, 1992; Odważny et al., 2018; Sajadieh et al., 2022; Shariatzadeh et al., 2016; Zuehlke, 2010).

5.1 Implications

5.1.1 Theoretical and managerial implications

Theoretically, this study donates the current body of knowledge concerning the internet of things (Odważny et al.), the concept of the factory of things (FoT), sustainable development (SD), and its sub-dimensions like social development (SoSD), economic development (EcSD), and environmental development (EnSD). This study expands upon established theories and literature by providing empirical evidence. Notably, it reveals a previously overlooked positive correlation between IoT and economic development (ED), grounded in the RBV theory and practical observations. The study shows a positive connection between FoT and SD. The study adds to the literature by showing the importance of IoT on SD along with sub-dimensions of SD such as SoSD, EcSD, and EnSD. Likewise, the study adds to the literature by showing the importance of FoT on SD along with sub-dimensions of SD such as SoSD, EcSD, and EnSD, respectively. Hence, it provides a novel and interesting contribution based on empirical analysis of the Chinese market.

From a managerial perspective, the study suggests several interesting and fruitful implications in both ways such as considering IoTs and FoTs to optimise their sustainable performance (SD) within three major streams social, economic, and environmental perspectives. For instance, managers are suggested by embracing IoT technologies and integrating them strategically into business practices, managers can play a pivotal role in advancing SD goals, contributing to resource conservation, environmental preservation, and a more responsible approach to various business operations. Managers are suggested to focus on IoT since it generates vast amounts of real-time data related to energy consumption, resource utilisation, and operational efficiency. Using this data, managers can make well-informed decisions that minimise waste and maximise resource utilization, meeting the sustainable development goals. On the other hand, managers can reduce their environmental impact, identify inefficiencies, and reduce consumption by using this data. It is suggested to management that IoT can support the execution of circular economy by pursuing the lifecycles of products and by assisting competent recycling and refurbishment procedures. Managers are additionally advised to focus on IoT and FoT to increase the sustainable growth. FoT can support the managers to create intelligent factories that can better control quality, optimise production schedules, and react in real time varying conditions. Managers must understand the significance of FoT since it can predict both equipment and machinery failure and also can prevent costly accidental downtime. By doing this, operational efficiency could be increased while resource waste and environmental impact could be minimised. FoT-generated data can support management in precisely computing emissions and environmental impact which ultimately help to win over the market.

6 Conclusions

It is concluded that IoTs and FoTs play a major role in enabling corporate sustainable development in today's business environment. These technologies offer unprecedented opportunities to enhance visibility, optimise operations, mitigate risks, and deliver superior experiences for corporate stakeholders. IoTs and FoTs technologies are pivotal for sustainable development, offering real-time insights, efficient resource management, and predictive maintenance. Both models may empower industries to reduce waste, enhance operations, and drive circular practices, advancing environmental, social, and economic responsibility. Hence, these variables have immense importance as currently revealed the nexus from emerging nations like China. It is concluded that there is a positive connection between IoTs and sustainable development within three streams, i.e., social, economic, and environmental perspectives of sustainable development. Likewise, the study summarised a positive connection between FoTs toward sustainable development. Finally, it is concluded that there is a positive connection between FoTs and sustainable development within three streams, i.e., social, economic, and environmental perspectives of sustainable development which summarised a massive significance of both industrial models for sustainable development of the Chinese industrial sector.

7 Limitations and research avenues

The study keeps absolute limitations that may provide valuable insights for future researchers in the fields of the IoT, FoT, and sustainable development (SD) along with sub-dimensions like social development (SoSD), economic development (EcSD), and environmental development (EnSD). Firstly, the study's applicability is constrained by the relatively small sample size. Secondly, the research focused exclusively on one developing country, namely China. Thirdly, the study did not explore the potential influence of moderation or mediation variables. Additionally, data collection was limited to three main provinces in China which may not fully represent the entire country. For future research, it is recommended that longitudinal studies can employ larger sample sizes not only within the Chinese context but also across various global economies. Furthermore, researchers should consider incorporating mediating and moderating factors to gain a deeper understanding of the relationships among the IoT, FoT, and SD together with sub-dimensions of SD, including social development, economic development, and environmental development.

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