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Original scientific paper

Analyzing the Impact of Industry 4.0 and the Internet of Things on Business Policy - The Case Study

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Abstract: The advent of Industry 4.0 as the research objectives integrated by the Internet of Things (IoT), which offers a transformative shift in sustainable business policies. As the World Economic Forum reported, it is steadily reshaping established business sustainability frameworks. This study divides the pivotal role that IoT-centric Industry 4.0 technologies play in shaping business policies, focusing keenly on their impacts on market share and business innovation - two key catalysts command the path of organizational sustainability, the hypothesis is presented by 10 items. Data from 289 Chinese enterprises are analyzed by Partial Least Squares Structural Equation Modeling (PLS-SEM), which reveals a significant development in business policy efficacy fostered by these emerging technologies. The finding shows that these innovations are central to enhancing sustainable business practices, primarily influencing pivotal aspects such as Product Quality, Customer Satisfaction, and Operational Efficiency. The maximum proportion of variation accounted for by an SF was 47.225%. MC test shows that the VIF values vary between 1.993 and 3.971. Importantly, the research underscores that environmentally aligned business strategies strengthen market share and fuel business innovation, resulting in heightened organizational performance. This study is a crucial proposal for integrating IoT-focused Industry 4.0 advancements into sustainable business policy frameworks, which will steer nations and corporations toward concurrently achieving economic and long-term sustainability objectives.

Keywords: business innovation; industry 4.0; internet of things; market share; sustainable business policy

1 INTRODUCTION

The emergence of Industry 4.0 and the widespread use of the Internet of Things (IoT) have initiated a change in basic assumptions in the global business landscape. Technological advancements (TAs) significantly influence firms' operational activities, customer interaction, and policy formulation, which leads to restructuring their practices (Çalık, 2021; Cirule & Uvarova, 2022). In the contemporary era characterized by extensive connectedness and reliance on information, firms must adjust to the dynamic and developing environment. According to Camana et al. (2021), integrating both the online and offline realms is altering the processes of product creation, manufacturing, sales, and customer engagement for organizations. Therefore, analyzing the effects of Industry 4.0 and the IoT on corporate policy is not only a theoretical endeavor but an essential requirement for companies seeking to maintain their competitiveness and drive innovation in the contemporary market. The present investigation aims to explore the diverse impacts of Industry 4.0 and the IoT on corporate policy in different industries. This study examines the impact of these advancements on strategic decision-making (DM), operating procedures, and customer interaction tactics. Furthermore, we shall examine the obstacles and prospects. Enterprises are faced to navigating through this era of digital transformation. The importance of this research cannot be overemphasized. According to Ding et al. (2020), Industry 4.0 innovations and the IoT can enhance efficiency and provide novel prospects across several sectors. However, this development also introduces intricate legislative and strategic decisions that enterprises must navigate. Enterprises must proactively adjust their policies in response to these Tasks, which maximize the advantages and minimize the potential hazards. This study aims to provide a detailed understanding on how Industry 4.0 and the IoT impact the corporate policy environment. To achieve this, we thoroughly analyzed practical examples and gathered insights from industry professionals. By doing so, we hope to offer a nuanced perspective on the subject matter (Baah et al., 2020; Hartley et al., 2020).

Upon the conclusion of this research, readers will gain significant knowledge regarding the tactics that prosperous firms are utilizing to utilize these technological advances effectively. Additionally, they will understand the critical lessons acquired from businesses that have encountered obstacles during the implementation process. The development of commercial models is a notable transition propelled by Industry 4.0 and the IoT. More adaptable and flexible alternatives replace the conventional paradigms rooted in linear manufacturing and delivery. The notion of "servitization" is increasingly acquiring popularity in contemporary business practices, whereby organizations are not just engaged in the sale of items but also extend their offerings to encompass a range of associated activities. General Electric (GE) and similar corporations have responded to this transition by introducing "Power by the Hour", which offers aviation propellers. IoT instruments integrated inside engines facilitate the transmission of up-to-date information on their efficiency and servicing requirements. Consequently, this enables airlines to adopt a payment model based on engine use instead of complete possession (Aggarwal et al., 2022; Cheng & Wang, 2021). The shift in the business paradigm discussed in the study above has significant consequences for many policies, including recognizing earnings, client agreements, and managing risks. Consequently, it becomes imperative to improve existing financial and legal regulations to accommodate these changes (Sharma et al., 2023). The advent of Industry 4.0 and the IoT has brought about a paradigm shift towards DM processes heavily reliant on data. The copious volume of data created by interconnected sensors and equipment presents firms with important information about their operational processes, consumer habits, and market dynamics. Statistical analysis is becoming more prevalent in enterprises to make well-informed choices at various levels within the firm. According to Vătămănescu et al. (2021), organizations that rely on data-driven approaches exhibit the 5% growth in productivity and a 6% rise in profitability compared to their counterparts. The adoption of information-centric DM has prompted the development of novel regulations about the management of data, privacy, and safety. Organizations are allocating resources toward the implementation of safeguarding procedures and compliance programs, which can guarantee the ethical use of information, while simultaneously dynamic regulatory structures conform to the General Data Protection Regulation (GDPR) in the European Union (EU).

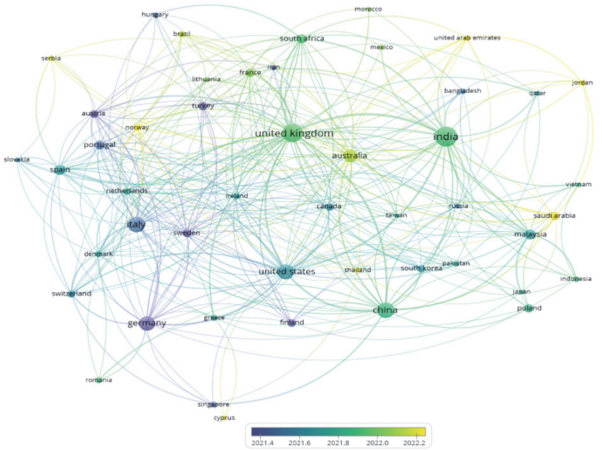

Figure 1 Engagement of authors working on IoT and industry 4.0 globally (2014-2023)

Managing supply chains (SCs) experiences significant influence from Industry 4.0 and the IoT. Implementing real-time tracking and monitoring systems inside the SC has yielded several benefits, which includes the enhanced management of stock, decreased delays, and greater accuracy in demand forecasts. Corporations like Walmart have effectively utilized the IoT to establish an intelligent and technologically advanced SC system. RFID tags and IoT sensors are employed to monitor the motion and temperature of items, guaranteeing their freshness and mitigating wastage (Ahamad et al., 2022; Supardianto et al., 2019). Achieving such a high degree of openness and effectiveness requires modifications to SC rules, encompassing aspects such as supplier relations, contract administration, and controlling inventory. The utilization of Industry 4.0 and IoT innovations has forced firms to reassess their business design and labor administration procedures due to their enhanced flexibility and adaptability (F&A). In response to dynamic marketplaces and evolving client needs, businesses increasingly embrace flexible and adaptive organizational structures. The widespread use of agile approaches has grown increasingly prominent in software development. Teams from various departments engage in iterative collaboration to facilitate software development. Hence, swift responsiveness enables the client input. The transition above carries significant ramifications for human resource (HR) strategies, emphasizing the acquisition of individuals with a wide range of abilities and fostering environment. This encourages cooperation and ongoing education. The advent of Industry 4.0 and the IoT has also heightened attention on robustness and risk management (RM). The advent of enhanced connection has brought forth the possibility of cyberattacks, network malfunctions, and intrusions of data security. To address these risks effectively, organizations must implement comprehensive policies and procedures. According to a survey conducted by Centobelli et al. (2022), it was found that business disruption and cyber-attacks are among the foremost hazards encountered by firms in the contemporary business landscape. In reply, corporations are revising their insurance contracts, emergency preparedness strategies, and cybersecurity procedures. There is a growing emphasis on risk supervision by boards of directors, with RM now recognized as a crucial component of the planning process. Incorporating Industry 4.0 and the IoT has engendered social and moral deliberations for enterprises (Bag et al., 2021; Ghinoi et al., 2020). The increasing accumulation and examination of extensive data by corporations has brought out concerns about privacy, approval, and the ethical utilization of technology. For example, social media corporations such as Facebook have seen attention for their policies about the confidentiality of data.

Consequently, more stringent privacy regulations and heightened openness in data management have been adopted. Furthermore, corporations are integrating ethical principles into their procedures for developing technology, so they are acknowledging and responding to apprehensions around the presence of prejudice in artificial intelligence (AI) and algorithms. The significance of this paper is as follows. Firstly, the drive towards achieving ecological sustainability (ES) remains to impact company strategies within the framework of Industry 4.0 and the IoT. Secondly, organizations are under mounting demands to mitigate their carbon emissions (CO2E) and embrace environmentally sustainable strategies. IoT-enabled electrical networks are significantly transforming the energy sector by altering the delivery and use of energy. Finally, this transition necessitates the implementation of regulations, which facilitate the inclusion of renewable energy sources (RES), and ensure the electrical grid's dependability. This also provides rewards for adopting resource-efficient activities. The sustainability management concept has increasingly adopted as a standard procedure by firms, wherein they provide clients and investors with information regarding their environmental impact (EI) and initiatives to mitigate it. In summary, the influence of Industry 4.0 and the IoT on company policy is significant and extensive. The entities mentioned above actively contribute to globalization, promote cooperation among many stakeholders, which emphasize the significance of effectively managing risks and fulfilling social obligations. In the face of this revolutionary environment, organizations must consistently modify their policies to effectively tackle the issues and capitalize on the possibilities of Industry 4.0 and IoT. Organizations can effectively manage the delicate equilibrium amid fostering innovation and implementing accountable leadership, which will be most advantageous in navigating the current era of technological change (Belhadi et al., 2022). The future regulations will undoubtedly be influenced by the continuous advancement of innovation and the evolving demands of many stakeholders, including consumers, staff, and society. The structure of the manuscript is as follows. The first part introduced the research background and contribution of the influence of Industry 4.0 and the IoT on company policy. Section 2 presents the theoretical framework and hypothesis. Followed by it, Industry 4.0 and related business policy is shown in section 3; in this part, authors also make assumptions. Research methods and Data Analysis are given in section 4. In section 5, we can obtain the main findings and related hypothesis test. Section 6 presents the depth of discussion and the final summaries are shown in section 7.

2 THEORETICAL FRAMEWORK AND HYPOTHESIS

The correlation between ecological stewardship (EST) and economic growth (EG) is frequently controversial, with two distinct viewpoints being discussed. The initial viewpoint is frequently characterized as a "zero-sum" situation, wherein strategic decisions that entail environmental objectives (EOs) and economic ramifications are juxtaposed. In certain instances, these decisions can result in a mutually helpful outcome, commonly called a "win-win" scenario, wherein all parties engaged derive benefits. It is imperative to avoid perceiving this situation as a zero-sum contest but one that thoroughly examines potential avenues for mutual benefit among all parties (Zhao et al., 2019). Sure, environmental sustainability (ES) efforts have the potential to be economically advantageous and produce affordable outcomes, thereby establishing a mutually beneficial relationship. In the past few years, many scholars and specialists across diverse disciplines have examined how businesses can effectively incorporate environmental issues into their operational frameworks. The authors (Grafström & Aasma, 2021) have proposed various theoretical frameworks, such as ecological foot printing (EFP), the triple-bottom lines, business environment, and life cycle administration. These models offer valuable perspectives on how businesses can effectively tackle environmental, economic, and social concerns within their strategic approaches.

Figure 2 Research Model

These frameworks are not substitutes for one another. Instead, they provide distinct viewpoints on the identical matter. To effectively address stewardship across social, economic, and ecological realms, adopting a broader and comprehensive strategy is imperative. The research follows two established theoretical frameworks, which are environmental modernization theories (EMT) (Kahupi et al., 2021) and practice-based perspective theories (PBV) (Hull et al., 2021). This viewpoint regards EST as a potential advantage rather than a challenge, endorsing notions such as the "integration of ecological principles into economic systems" and the "efficient utilization of ecological resources" (de Morais et al., 2021; Sulich & Sołoducho-Pelc, 2022). Consistent with this perspective, the Public Benefiting Corporation advocates implementing SC strategies prioritizing environmental sustainability (Su & Urban, 2021). The PBV concept introduced by Yu et al. (2022), represents an expanded iteration of the widely recognized resource-based view theories (RBV). According to Yumei et al. (2022), the efficiency of a firm is influenced by the adoption of recognized procedures that are executed uniquely by other companies. A structural equation modeling (SEM) paradigm has been devised to establish an extensive structure incorporating various eco-environmental activities, which include circular buying, operational efficiency, and product quality. This structure is grounded in the theoretical underpinnings of ecological transition and the RBV, with an emphasis on the IoT within the framework of Industry 4.0. These methods will eventually have an impact on the general efficiency of a company. Tab. 1 presents descriptions and concepts about the procedures above, while Fig. 1 illustrates the conceptual framework.

Table 1 Definition of the variables

Implementation of Internet of Things (IoT) and Industry 4.0 technologies (IoT&I4.0T)	Implementing the Internet of Things (IoT) and Industry 4.0 technologies requires incorporating intelligent devices and data processing into industrial processes to improve automation, performance, and production.
Operational Efficiency (OE)	Operational Efficiency (OE) is the degree to which a company uses its resources to generate or deliver products or services while reducing waste and expenses.
Product Quality (PQ)	Product Quality (PQ) refers to a product's overarching standard and features, such as its dependability, durability, performance, and conformity to requirements and consumer demands.
Customer Satisfaction (CS)	Customer Satisfaction (CS) is a metric that measures how satisfied and delighted consumers are with an item, service, or general experience, indicating their level of satisfaction with the services a business has offered.
Market Share (MS)	Market Share (MS) is the amount or proportion of a market's or sector's overall earnings or sales that a specific business or product possesses; it is frequently used to indicate its ability to compete in that market.
Business Innovation (BI)	Business Innovation (BI) introduces novel concepts, methods, offerings, or services within a company to enhance its competitive advantage, operational efficiency, or consumer value idea, fostering development and adaptation within an ever-changing business climate.
Business Sustainability (BS)	Business Sustainability (BS) incorporates a company's dedication to performing its business affairs in a socially responsible, sustainable, and economically feasible manner, seeking to meet present requirements without compromising the capacity of future generations to satisfy their demands.

3 INDUSTRY 4.0 AND THE BUSINESS POLICY

Industry 4.0 is commonly known as the 4th industrial revolution (IR), which signifies a paradigmatic transformation in production and corporate operations. The integration of sophisticated technologies, including the Internet of Things (IoT), artificial intelligence (AI), big data analytics (BDA), and digitization, is the primary catalyst for this approach to change across diverse industries. According to Alkhuzaim et al. (2021), the implementation of these advances allows organizations to establish manufacturing processes that are both more effective and adaptable, resulting in heightened output and enhanced profitability. For example, IoT sensors enable the acquisition of instantaneous data about machine efficiency and product quality (PQ), which enables enterprises to enhance their operational efficiency and minimize periods of inactivity. Incorporating technology into production procedures significantly impacts business policy (BP). Considering the potential and difficulties presented by the advent of Industry 4.0, enterprises must formulate and adjust their policies in a commensurate manner. A crucial element is implementing strategic planning towards adopting and allocating technology resources. According to Huang et al. (2021), organizations must thoroughly evaluate technologies aligning with their business objectives and organizational capacities. The strategic coherence establishment is necessary to guarantee that investments made in Industry 4.0 innovations are profitable and do not result in excessive financial burdens. Furthermore, organizations must consider the ramifications of data confidentiality and safety. This is particularly crucial due to the increasing prevalence of interconnected devices and information-sharing ecosystems, which bring about novel threats and need compliance with legal obligations.

Moreover, the advent of Industry 4.0 calls for a reassessing personnel policy. The use of automation and AI systems can significantly influence the characteristics of employment and the competencies demanded of workers. Based on a report published by the World Economic Forum (WEF) in 2018, organizations allocate resources by implementing training and upskilling initiatives. The objective is to provide employees with the digital competencies required for success in the context of the 4th IR. BPs ought to demonstrate a solid dedication to the growth and welfare of employees, therefore cultivating an environment that promotes ongoing learning and flexibility. In summary, Industry 4.0 impacts on the BP environment. Companies necessitated proactively adopting technological advancements, and addressing apprehensions regarding information safety, which allocates resources towards the growth of human capital (HC) to maintain competitiveness in the digital age.

3.1 IoT and BP

The IoT has evolved as a disruptive technology phenomenon with significant consequences for BP. IoT pertains to a system of interrelated equipment and items that can gather, trade, and send data on the Internet. As organizations progressively incorporate the IoT into their operational frameworks, it becomes imperative to develop strategic BPs, which leverages its capabilities while effectively addressing the accompanying problems. Elavarasan et al. (2021) suggest Internet of Things (IoT) technology to allow organizations to get immediate and up-to-date knowledge, better their DM capabilities, which optimizes operating effectiveness. In the context of the manufacturing industry, IoT sensors enable the monitoring machinery health and facilitate the optimization of scheduled repairs. This results in a reduction of both downtime and expenses. These prospects require an anticipatory approach to BP. Administration of data and confidentiality are fundamental components of corporate policies about the IoT. The increasing prevalence of interconnected gadgets has led organizations to amass substantial amounts of data, frequently encompassing confidential client data. According to Mohammadi et al. (2021), enterprises must establish comprehensive data management policies to safeguard data storage, transport, and exploitation effectively. Adherence to privacy standards, the General Data Protection Regulation (GDPR) in Europe mitigate potential litigation and reputational hazards.

Furthermore, establishing and maintaining confidence with consumers and partners is contingent upon the criticality of openness in data management methods. The IoT also presents cybersecurity challenges since networked gadgets might serve as potential vulnerabilities for hackers. According to Asgari and Asgari (2021), BP must include comprehensive cybersecurity solutions, including device authorization, encryption, and detection of breaches. To successfully reduce these hazards, businesses must develop event response strategies and provide resources for cybersecurity instruction for their staff. In summary, corporate strategy must change to effectively harness the benefits of IoT, address concerns regarding data security and confidentiality, and guarantee adherence to pertinent legislation. This adaptation is crucial for fostering long-term development and maintaining efficiency in many industries.

H1: The IoT has a significant and favorable impact on customer satisfaction (CS)

H2: The IoT has a significant and favorable impact on operational efficiency (OE).

H3: The IoT significantly and favorably impacts product quality (PD).

The IoT has changed the game for organizations, significantly impacting operations and BP and market share (MS). Applications of IoT in BP have the power to alter market trends and give an advantage. Market evaluation and planning are two critical areas wherein IoT influences BP. Companies may collect customer preferences and PQ information via IoT devices, including intelligent sensors and linked items. According to Zając and Avdiushchenko (2020), this abundance of data enables firms to make better-educated choices regarding product creation, marketing tactics, and pricing practices. Businesses may increase their MS by gaining a deeper grasp of market dynamics and customer habits by incorporating IoT data into their BP. IoT applications also directly affect logistics and SC management, which affects corporate strategy. According to Chen et al. (2020), IoT-enabled SCs provides the improved transparency and accountability, resulting in more effective inventory control and lower operating costs. This effectiveness helps businesses to create business plans that improve SC tactics, reorganize distribution systems, and quickly adapt to changes in consumer demand. Businesses may gain an economic edge by assuring the availability of goods and prompt delivery, which will eventually increase their MS by integrating IoT into their SC strategies. IoT may also transform client interaction and assistance, a crucial component of corporate strategy. Thanks to IoT devices like smart watches and automated home appliances, businesses may offer proactive consumer service and personalized services. According to Al-Awlaqi and Aamer (2022), organizations may customize their goods and services to match specific client demands by integrating IoT information into client retention strategies. Greater loyalty may result from this customer-centered strategy, which may ultimately spur MS expansion. From information-driven market evaluation and SC efficiency to customized consumer interaction techniques, IoT applications can influence BP in various ways. Businesses have a more substantial chance to gain a more excellent MS and maintain their competitiveness in today's changing business environment when they adopt IoT technology and incorporate it into their strategies.

H4: PQ has a favorable impact on the MS of the company.

H5: OE has a favorable impact on the MS of the company.

H6: CS has a favorable impact on the MS of the company.

3.2 IoT Application in BP and Business Innovation (BI)

By offering a favorable environment for revolutionary BP applications, the IoT is accelerating BI. The capacity of IoT to influence plans, expedite procedures, and promote innovation inside enterprises stands out as one area where it has a significant effect on BI. Data-driven DM is a key area where IoT affects corporate strategy and BI. According to Gupta et al. (2021), IoT gadgets provide unparalleled immediate information, allowing organizations to create data-centric strategies that support well-informed strategic decisions. To develop a culture of information-driven innovation, businesses may leverage IoT data to uncover market developments, customer behavior, and operational shortcomings. IoT is essential for streamlining corporate operations and developing fresh sources of income. According to Soo et al. (2021), organizations may monitor stock levels, track deliveries, and boost logistics by integrating IoT technology into SC administration, saving money and increasing operational effectiveness. IoT implementations can also result in innovative industries like product-as-a-service and automated upkeep, which can upend established sectors and support BI. Companies must modify their policies to accept these innovative concepts and investigate new options for money if they want to stay relevant.

Furthermore, IoT promotes the innovation of corporate policies by enhancing consumer involvement and PQ. According to Mavroudi et al. (2022), IoT-enabled gadgets, like smart devices and smartwatches, offer valuable insights into user behavior and choices, allowing businesses to customize their goods and services appropriately. Businesses may develop novel goods and services that better suit consumer demands by combining IoT data into client-centric policies, eventually promoting BI. Focusing on the consumer's needs may boost MS growth, build client devotion, and provide new income opportunities. Because of changing business practices, allowing data-driven DM, streamlining workflows, and promoting customer-centered inventiveness, IoT implementations are advancing business intelligence. In a continuously interconnected world, businesses that effectively incorporate IoT into their strategies may take advantage of new possibilities, boost their productivity, and stay at the top of their respective sectors.

H7: PQ has a favorable impact on the BI of the company.

H8: OE has a favorable impact on the BI of the company.

H9: CS has a favorable impact on the BI of the company.

3.3 IoT Application in BP and Business Sustainability (BS)

With an emphasis on encouraging BS, the IoT plays a crucial role in establishing BP. Organizations now prioritize sustainability, and IoT systems provide practical tools for coordinating everyday activities with goals related to social accountability and the ecosystem. IoT helps businesses to be more sustainable by facilitating more effective utilization of resources, lowering waste, and fostering ethical SC procedures. Resource management (RM0 is one of the primary methods by which IoT influences BP regarding sustainability. According to Hopkins (2021), IoT sensors and gadgets can instantaneously track resource utilization, including water, electricity, and resources. Companies can create policies that promote resource-effective activities using this data. IoT, for example, may assist companies in measuring energy consumption in the production industry, enabling them to put in place regulations that lower operating expenses and energy wastage. Companies may reduce their EI and support a sustainable future through improving RM. IoT also makes it easier to implement ethical SC procedures, which are essential for long-term corporate viability. According to Singhai and Sushil (2023), IoT-enabled surveillance and tracking systems guarantee ethical and sustainable procurement by enabling accountability and tracking across the SC. Businesses might establish guidelines that favor vendors who follow legal labor procedures and ecological norms. This complies with CSR objectives and reduces SC hazards from unsafe procedures. IoT additionally promotes company sustainability by measures for decreased waste and BP. Makhdoom et al. (2023) state that IoT devices may measure product use, gather information on deterioration, and enable automated repair. Companies may create guidelines that promote long-lasting, repairable, and recyclable products. Businesses may lessen their influence on the ecosystem and help to create an environmentally friendly future by prolonging the lifespan of their goods and cutting waste. IoT applications optimize RM, enable ethical SC procedures, and decrease waste, all of which help to shape company policies that support sustainability. Businesses that use IoT in their sustainability strategy improve their image and performance in a market that is becoming more environmentally sensitive while positively impacting the earth.

H10: MS has a favorable impact on the BS of the company.

H11: BI has a favorable impact on the BS of the company.

4 RESEARCH METHODOLOGY AND DATA

4.1 Research Methods

This portion of the study presents a detailed account of our methodology for investigating the associations amid observable and fundamental factors. Our strategy involved the utilization of a survey methodology and the application of an analytical method known as structural equation modeling (SQM). Initially, the present study focuses on elucidating the intricacies of the study instrument's approach, followed by a comprehensive exposition of the pertinent characteristics of our sampling size. Subsequently, we elucidate the methodology employed to conduct the survey. Our data evaluation utilized the partial least squares structural equations modeling (PLS-SEM) program, specifically version 6.0. This software is recognized for its capacity to effectively handle a wide range of immediate and moderating impacts, as shown in research conducted by Domenech et al. (2019). To evaluate the five fundamental principles of interest, we developed a questionnaire employing proven measuring scales that operationalize these factors.

The themes in this discussion pertain to BI, MS, BS, and the IoT in the context of Industry 4.0, PQ, OE, and CS. The data was obtained from Chinese food businesses. To collect first-hand information, a standardized questionnaire was distributed. A 5-point Likert scale was included in constructing our questionnaire, allowing participants to indicate their level of consent with a range of topics. The scale encompassed a range of values, with 1 representing "Strongly Disagree" and 5 representing "Strongly Agree". Fig. 2 represents the theoretical framework of our investigation.

The investigators employed data from Chinese enterprises over the summer of 2019 to merge IoT and Industry 4.0 apps with ideas derived from BP to augment business effectiveness. The study's main aim was to examine the potential enhancements in a firm's efficiency resulting from implementing Industry 4.0 technology and adopting BP concepts. The data collection procedure for the present research was conducted as follows. Table 2 provides a comprehensive overview of the socioeconomic position of the people in the questionnaire. During the summer of 2021, a comprehensive distribution of 600 surveys was conducted. Out of the total sample size, 447 responses were received. However, upon closer examination, it was determined that 38 of these responses were inadequate. Hence, they were not included in the subsequent study. As a result, the entirety of the 409 leftover replies were included in the sample for the intent of conducting additional study. While the adequacy of the sampling size for implementing PLS-SEM to examine the study's hypotheses was acknowledged, it is noteworthy to mention that the survey garnered a response rate of merely 67% from the respondents first approached, as reported by Bag et al. in 2021. Tab. 2 displays the demographic features of the individuals who participated in the survey.

Table 2 Demographic profile of the participants

Characteristics Title	*N*	%
Vice president	14	3.42
General manager	54	13.20
Plant manager	64	15.65
Procurement manager	34	8.31
Logistics manager	65	15.89
Operation manager	82	20.05
Information system manager	96	23.47
Work experience		
< 5	76	18.58
5-10	128	31.30
10-15	86	21.03
15-20	47	11.49
20-35	43	10.51
> 35	29	7.09

4.2 Data Analysis

The data supplied by the survey responders was analyzed using the analytical software program SPSS 25 in combination with AMOS 24. In the domain of SEM, it is noteworthy to mention that a minimum sample size of 200 is recommended by Sharma et al. (2021). The population size of our research, consisting of 409 individuals, exceeds the required threshold, suggesting that our dataset is substantial enough for conducting SEM evaluation. In addition, we adopted the maximal probability estimations, a frequently applied approach in SEM, known for its suitability in handling datasets, including over 300 observations.

5 RESULTS ANALYSIS AND FINDINGS

5.1 Descriptive Stats

Tab. 3 displays a range of statistical metrics, encompassing the average, variability, and correlation factors. After collecting demographic information, our investigation thoroughly evaluated the measurement framework and polling tool to establish convergence validity (CV), reliability, and discriminant validity (DV). We employed the variance inflation factor (VIF) to identify convergence amongst factors. The F-square figures were calculated to assess the relevance of every component in the framework. These values indicate the percentage of variability described by every independent variable (INDV). Before doing the SEM evaluation, we performed resampling and carefully examined the postulated correlations created in the measuring framework. The CV assessment assumed that theoretical measurements should demonstrate statistically essential associations. CV measures the degree to which two factors are expected to correlate positively. Tab. 3 presents pertinent measures, including Cronbach's alpha (CA), average extracted variance (AVE), and composite reliability (CR). The criteria employed in the present investigation indicate that the reliability and validity of our findings are consistent with recognized benchmarks.

Table 3 Descriptive stats of data

Variables	Observations	Mean	SD	(CV)
BI	399	3.891	0.546	0.157
MS	399	2.986	1.659	0.618
BS	399	3.549	0.274	0.088
PQ	399	4.202	0.521	0.138
OE	399	2.863	0.612	0.237
CS	399	2.867	0.611	0.239
IoT & I4.0T	399	3.197	1.826	0.633

The Fornell and Larcher criteria is a widely utilized approach for evaluating the DV of constructs in empirical studies. The process entails the analysis of a tabular representation of data, where higher numbers along the diagonal signify a more robust indication of DV. If the square root (SR) of the AVE, which indicates the extent to which structures are distinguishable from one another, exceeds the SR of other inter-construct correlations, it confirms that the components are separate. This differentiation increases our level of assurance in the associations amid entities and their related conceptual frameworks, showing that these associations are more robust and dependable than those with alternative frameworks.

Table 4 Results of Discriminant Validity

Variable	IoT & I4.0T	PQ	OE	CS	BI	MS	BS
IoT & I4.0T	0.8534						
PQ	0.5722	0.7690					
OE	0.6672	0.6845	0.7565				
CS	0.6192	0.6240	0.6864	0.7987			
BI	0.5779	0.6566	0.5866	0.5184	0.7315		
MS	0.4080	0.7133	0.6432	.6298	.6240	0.8054	
BS	0.7190	0.6854	0.7027	0.5971	0.6163	0.7056	0.8266

5.2 Explanatory Factor Analysis (EFA)

EFA has frequently been employed in prior studies investigating the intersection between Industry 4.0 and SC administration. The EFA is a statistically significant approach that is highly beneficial in identifying and exploring the latent links among numerous factors. The present research reveals that Tab. 5 provides information on the Kaiser-Meyer-Olkin (KMO) value, demonstrating a figure of 0.87. This value is above the specified minimal criterion of 0.60, as proposed by Stich et al. (2020). Furthermore, Bartlett's Test of Sphericity results yielded a statistically relevant conclusion, suggesting that the dataset gathered for this study is appropriate for EFA. Tab. 6 offers valuable insights into the rotating component grid following the implementation of rotating procedures. The data presented illustrates the categorization of 25 various substances into seven separate groups. Significantly, all component loadings above the threshold of 0.50% suggest robust associations amid the factors and their corresponding classes. Additionally, every eigenvalue was equivalent to or above 1.00, showing the strength of the component structure revealed using EFA.

Table 5 KMO and Bartlett's test

Bartlett's Test of Sphericity	5275.472	5273.498
	259.63	259.621
	0.001	0.001

Table 6 Cronbach's alpha results

Variables	Items	Standard loadings	Cronbach's α	CR
IoT & I4.0T			0.903	0.925
	IoT1	0.634		
	IoT2	0.841		
	IoT3	0.802		
	IoT4	0.869		
PQ			0.832	0.893
	PQ1	0.851		
	PQ2	0.736		
	PQ3	0.661		
	PQ4	0.914		
OE			0.923	0.932
	CS1	0.837		
	CS2	0.801		
	CS3	0.853		
BI			0.813	0.807
	BI1	0.737		
	BI2	0.802		
	BI3	0.92		
	BI4	0.866		
MS			0.916	0.935
	ENP1	0.719		
	ENP2	0.731		
	ENP3	0.731		
	ENP4	0.675		
BS			0.91	0.915
	BS1	0.88		
	BS2	0.959		
	BS3	0.709		

5.3 Multi-Collinearity Testing

The VIF is a commonly employed measure for assessing the presence of multi-collinearity (MC), or excessive correlation, amongst INDVs in a numerical investigation. In research done by Liu (2020), it is suggested that a Variance Inflation Factor (VIF) score under 5.0 may be evidence that MC does not pose a substantial issue amongst the INDVs. Tab. 7 presents the outcomes of the MC testing, whereby the VIF values vary between 1.993 and 3.971. The obtained scores are well within the allowed limit for VIF ratings, indicating no significant problem of MC amongst the INDVs under investigation.

Table 7 Multi-collinearity test

Variable list	Unstandardized Coefficients		Standardized			Collinearity	
	B	SE	Beta	t	Sig.	Tolerance	VIF
(Constant)	0.071	0.205	0.000	0.362	0.799	0.000	0.000
IoT & I4.0T	0.148	0.055	0.147	2.965	0.007	0.569	2.012
PQ	0.023	0.062	0.022	0.365	0.795	0.482	2.419
OE	0.052	0.056	0.058	0.945	0.410	0.405	2.850
CS	0.108	0.061	0.116	1.866	0.089	0.381	3.055
BI	0.122	0.073	0.125	1.762	0.112	0.290	4.015
MS	0.257	0.059	0.267	4.656	0.001	0.428	2.702
BS	0.248	0.065	0.242	4.207	0.001	0.414	2.781

5.4 Common Method (CM) Bias

To assess the potential presence of CM bias in the framework, a Harman's single-factor (SF) analysis was conducted. The study performed with the SPSS program, employing an un-rotated factor approach with a limitation of an SF.

Table 8 Total explained variance

	Initial eigenvalues			Extraction sums of squared loadings		
Components	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	13.46	44.864	44.864	13.460	44.864	44.864
2	2.63	8.765	53.628	2.630	8.765	53.628
3	1.202	4.006	57.635	1.202	4.006	57.635
4	1.022	3.409	61.043	1.022	3.409	61.043
5	0.851	2.837	63.88	0.851	2.837	63.880
6	0.783	2.611	66.491	0.783	2.611	66.491
7	0.687	2.29	68.78	0.687	2.290	68.780
8	0.624	2.081	70.861	0.624	2.081	70.861
9	0.603	2.012	72.874	0.603	2.012	72.874
10	0.532	1.775	74.648			
11	0.501	1.668	76.316			
12	0.485	1.619	77.935			
13	0.426	1.419	79.354			
14	0.4	1.332	80.686			
15	0.376	1.255	81.941			
16	0.367	1.223	83.164			
17	0.356	1.188	84.351			
18	0.345	1.15	85.501			
19	0.318	1.06	86.561			
20	0.3	0.999	87.562			
21	0.286	0.952	88.513			
22	0.271	0.902	89.415			
23	0.265	0.884	90.298			
24	0.239	0.799	91.097			
25	0.238	0.792	91.89			

According to the findings presented in Tab. 8, the maximum proportion of variation accounted for by an SF was 47.225%. The observed proportion is lower than the widely acknowledged criterion of 50%, indicating no substantial worry over CM bias in the framework.

5.5 Analysis of Factor Loadings (FLs)

To evaluate the CV of the research, an analysis was conducted on the FLs and cross-loadings (CLs) of the survey responses, which are presented in Tab. 9. According to the recommendations put forward by Hair et al. (2012), FLs should preferably be equivalent to or greater than 0.5. Any questionnaire responses that did not meet the predetermined criteria were excluded from the research. Consequently, a total of 23 survey items were retained, each of which exhibited satisfactory degrees of validity. The set of kept items together explained 76.709% of the variation in the reliant concept, suggesting a high level of CV.

Table 9 Factor analysis

Variable	IoT & I4.0T	PQ	OE	CS	BI	MS	BS
IoT & I4.0T 1	0.801						
IoT & I4.0T 2	0.792						
IoT & I4.0T 3	0.768						
IoT & I4.0T 4	0.694						
PQ 3		0.784					
PQ 4		0.788					
PQ 2		0.779					
OE 2			0.798				
OE 1			0.793				
OE 3			0.789				
CS 1				0.830			
CS 4				0.828			
CS 2				0.823			
CS 3				0.820			
BI 2					0.810		
BI 3					0.805		
BI 1					0.798		
MS 3						0.838	
MS 4						0.832	
MS 2						0.827	
MS 1						0.819	
BS 1							0.798
BS 2							0.823
BS 3							0.832

Note: Variable cross-loadings are in bold.

Abbreviations: IoT&I4.0T: Implementation of IoT and Industry 4.0 Technologies; PQ: Product Quality; OE: Operational Efficiency; CS: Customer Satisfaction; BI: Business Innovation; MS: Market Share; BS: Business Sustainability.

5.6 SEM

The study framework provided in the paper was evaluated using SPSS AMOS 24 software. Various metrics of quality-of-fit were employed to assess the adequacy of the model's fit to the information. These metrics encompassed df/Chi-square, quality-of-fit, modified quality of fit, the root-mean-square error of estimation, relative fit gauge, Tucker Lewis gauge, and standardized fit index. As depicted in Tab. 10, the findings demonstrate that all quality-of-fit indices fall inside their permissible thresholds. This implies that the study model offered has high effectiveness and accuracy in fitting the data, displaying a robust total fit.

Table 10 Models' fitness indices

Indices of Fit	Required Threshold	Achieved Threshold
(Chi/df)	≤ 3.00	1.287
(GOF)	≥ 0.90	0.992
(AGOF)	≥ 0.80	0.953
(RMSEA)	≤ 0.05	0.028
(CFI)	≥ 0.93	0.997
(TLI)	≥ 0.90	0.991
(NFI)	≥ 0.90	0.993

5.7 Hypothesis Test

The research's features of the causative links, particularly the standardized path coefficients, are presented in Tab. 11 and Fig. 3.

Table 11 The results of hypothesis testing

Hypothesis	Hypothesis Testing	b-Value	f-Value	Result
1	IoT and I4.0 technologies → Product Quality	0.301**	147.60	Accepted
2	IoT and I4.0 technologies → Customer Satisfaction	0.455***	155.43	Accepted
3	IoT and I4.0 technologies → Operational Efficiency	0.371***	198.18	Accepted
4	Product Quality → Market Share	0.318**	238.91	Accepted
5	Customer Satisfaction → Market Share	0.339***	184.73	Accepted
6	Operational Efficiency → Market Share	0.132**	230.48	Accepted
7	Product Quality → Business Innovation	0.077**	141.51	Accepted
8	Customer Satisfaction → Business Innovation	0.292**	143.95	Accepted
9	Operational efficiency → Business Innovation	0.221***	153.72	Accepted
10	Business Innovation → Business Sustainability	0.341***	143.89	Accepted
11	Market Share → Business Sustainability	0.119***	125.36	Accepted

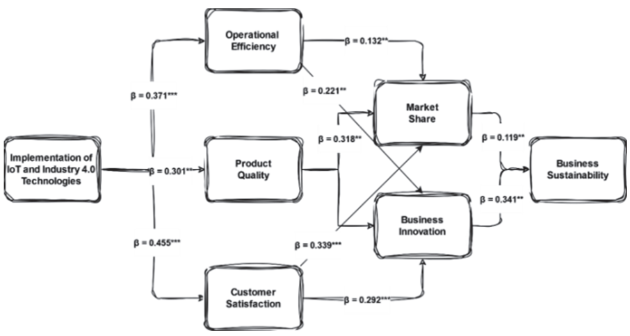

Figure 3 Path diagram

6 DISCUSSIONS

The Fourth Industrial Revolution, often known as Industry 4.0, signifies a dramatic change in how organizations conduct their operations. With the aid of a thorough case study, this debate explores how Industry 4.0 and the IoT influence BP. The paper investigates how these revolutionary innovations are altering corporate practices and regulations. IoT, AI, big data analytics (BDA), and digitalization are just a few of the innovative technologies, which make up Industry 4.0. These technologies' incorporation has evolved into a key change agent for various sectors. This connection allows businesses to create flexible, efficient production procedures that boost productivity and profitability. The report emphasizes the critical necessity for organizations to allocate resources toward the adoption of Industry 4.0 technology strategically. The relevance of assessing technologies that align with organizational capabilities and commercial objectives is emphasized by Awad (2023). Strategic consistency is essential for investments in Industry 4.0 developments to be successful and not place undue financial constraints. Organizations must make essential data privacy and security decisions when adopting Industry 4.0 and IoT. The report emphasizes the expanding use of smart devices and information-sharing environments, which pose new security risks and need adherence to regulatory requirements. Firms must prioritize strong information management procedures and technological safeguards to protect private information.

Industry 4.0's incorporation of AI and automation technologies can change employment positions and put new demands on workers' skill capabilities. The World Economic Forum (WEF) 2018 suggested funding projects for worker retraining and upskilling to provide them with the digital skills they need to succeed in the 4th IR. Our research highlights how crucial it is to create an atmosphere that encourages continual learning and adaptability to respond to these shifts. It is clear from the results that Industry 4.0 is drastically altering corporate strategies. To remain successful in the digital era, organizations must consciously accept technology innovations, manage data protection issues, and invest in the growth of their human resources. Business practices must be developed to show a solid dedication to workers' development and well-being, helping foster an atmosphere that encourages adaptability and continuing development.

Our research examines the IoT as a competitive technology and an essential element of Industry 4.0. IoT allows businesses to collect real-time data, improving operating effectiveness and decision-making capacity. It is used in maintaining mechanical health, streamlining repair plans, and lowering costs and unavailability. Our research shows the need for strong data administration and safety rules in IoT adoption. IoT gadgets must conform to security laws like GDPR to reduce legal and reputational concerns since they gather enormous volumes of data, particularly private consumer information. Accurate data administration procedures and all-encompassing cybersecurity systems are essential for establishing confidence with customers and business associates. According to the report, IoT promotes sustainability by promoting effective resource utilization, wastage reduction, and moral SC practices. Businesses can develop rules encouraging asset-efficient operations with the aid of RM, which includes monitoring water, power, and resources. IoT-enabled monitoring and monitoring solutions may ensure ethical SC practices align with corporate social responsibility (CSR) goals. Business intelligence (BI) is improved by incorporating IoT information into corporate policy, which allows data-driven DM procedures. Organizations may use IoT to identify operating inefficiencies, market dynamics, and consumer behavior to guide strategic choices. As a result, processes are streamlined, new income streams are created, and a culture of data-driven invention is fostered. The investigation emphasizes that Industry 4.0 and IoT are changing corporate policies and goals in various industries in its ending. Businesses need to take the initiative to embrace these game-changing technologies, solve data safety and privacy issues, and engage in training their personnel. The report also emphasizes the possibilities for BI, sustainability, and competitive advantages by the efficient use of IoT data in corporate strategies. Companies must adjust and update their policies to accept these technical improvements properly if they want to be relevant and nimble in the digital era.

6.1 Theoretical and Policy Implications

The findings have significant theoretical ramifications illuminating the pressing need for Industry 4.0 to include innovative technologies like the IoT, AI, BDA, and digitalization. This points to an essential field for theoretical investigation, where academics may dive more deeply into the complex processes of these innovations and their significant influence on organizational transformation and policy creation. The report also highlights the strategic component of resource allocation (RA) and exhorts organizations to do so wisely, following their unique goals and capacities. This element calls for theoretical research into how RA decisions are made, especially in the complicated environment of Industry 4.0. The report also highlights the rising significance of privacy and data anonymity in the era of connected gadgets and information-sharing environments, especially in IoT and Industry 4.0. The pressing need for robust theoretical frameworks cannot be overstated, as they are essential in guiding organizations to address privacy concerns effectively. These frameworks must ensure compliance with legal regulations while promoting stakeholder trust and confidence.

A theoretical investigation of the patterns of labor policy, skill development, and flexibility in the context of technical shocks is also necessary, given the changing nature of workers, which is characterized by the incorporation of automation and AI algorithms. Research in this field can clarify the theoretical underpinnings of successful personnel policies and tactics for fostering staff development and satisfaction in the technological era. The research's consequences on the policy front provide insightful advice for decision-makers. This advice includes a range of policy suggestions meant to promote sustainability, productivity, and safety in the digital era. To guarantee efficient planning and spending on Industry 4.0 technologies, policy makers are urged to support strategic RA and management while promoting cooperation among the public, private, and academic sectors. The report also emphasizes how crucial it is to provide clear policy frameworks for information management and security to uphold data privacy regulations and encourage openness in data processing. The need for governments to actively assist workforce development activities is also emphasized. This includes sponsoring training programs and encouraging improving initiatives to provide employees with the requisite digital capabilities. Policy frameworks could also give organizations direction for flexible business policies that put employee growth, adaptability, and health first.

Lastly, the research emphasizes sustainability and ethical practices inside organizations, and policymakers are urged to support these practices through regulations. This involves promoting waste minimization practices, moral SC management, and resource-effective operations. These conclusions offer an in-depth plan for theoretical study and pragmatic policies, highlighting the critical role that flexibility and proactive involvement with changing technology trends play in the setting of Industry 4.0 and IoT.

6.2 Research Limitations and Directions for Future Research

This study significantly contributes to understanding the effects of Industry 4.0 and the IoT on BP. However, it is essential to acknowledge the presence of some constraints within this study. The research's dependence on a case study may restrict the broader relevance of its conclusions across many businesses and circumstances. The inclusion of cross-industry comparable research has the potential to improve the generalizability of findings. Furthermore, the research mainly uses quantitative data analysis, which may overlook qualitative intricacies. Future research endeavors may consider using qualitative methodologies to have a comprehensive picture.

Furthermore, it is essential to note that the study makes certain assumptions on the general applicability of its policy implications. However, it is crucial to recognize that the effectiveness of these implications may differ depending on the specific regulatory and socio-cultural environments in which they are implemented. Examining contextual elements that impact policy implementation might provide advantageous outcomes. Moreover, the research does not extensively explore the possible obstacles associated with implementation, indicating the necessity for comprehensive investigations. Potential areas for future research encompass cross-industry comparisons aimed at comprehending the distinctive dynamics within various sectors, qualitative examinations that offer more comprehensive insights, examination of contextualized factors that influence the subject matter, recognizing obstacles and ways to mitigate barriers, long-term research to monitor the evolution of policies, comparable worldwide studies to identify best practices in policy implementation and examinations into the moral and social ramifications associated with the implementation of Industry 4.0 and IoT. These channels will offer a more thorough comprehension of the intricate correlation amid the implementation of technological advances and the formation of policies, enabling the formulation of policy proposals that are better informed and tailored to specific contexts.

7 CONCLUSION

Compared with the past work, FLs should preferably be equivalent to or greater than 0.5. VIF values vary between 1.993 and 3.971. The obtained scores are well within the allowed limit for VIF ratings, no significant problem of MC amongst the INDVs under investigation. This paper emphasizes the critical necessity for organizations to allocate resources toward the adoption of Industry 4.0 technology. In conclusion, our research has shed light on the profound influence of Industry 4.0 and the IoT on BP. After conducting a thorough analysis of the research, the incorporation of innovative technology, smart distribution of resources, effective data governance, well-defined personnel policies, and flexible BPs play a crucial role in successfully navigating the era of digitalization. Theoretical implications underscore the necessity for more investigation to explore the complex processes of these technologies and their impact on organizational transformation. Policymakers are provided with recommendations to encourage the allocation of resources, implement comprehensive legislation for the oversight of data and safety, and facilitate the growth of the workforce. They offer flexible guidelines for company policies, and advocate for sustainability and moral practices. Nevertheless, it is essential to acknowledge the limits of this study, which encompass its narrow scope of a single case study and its dependence on quantitative research. Future study directions include making cross-industry contrasts, conducting qualitative studies, exploring contextual variables, identifying execution obstacles, conducting longitudinal research, comparing overseas policies, and examining ethical and societal elements. These instructions will facilitate a more comprehensive and situation-specific comprehension of the interaction amid Industry 4.0, IoT, and BP, eventually guiding organizations in developing adaptable strategies within a constantly shifting digital environment.

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