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Is Digital Transformation a Burden or a Help? From the Perspective of Enterprise Sustainable Development

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Abstract: Sustainability has become increasingly critical to the development of modern companies. As it emphasizes the generation of value across three dimensions—economics, the environment, and society—sustainable development underscores its significance. Based on the value that a company delivers at a particular stage of the sustainable development process, this study proposes revenue as a measure to quantify stakeholder interest. Utilizing a fixed effects model with 2211 listed companies in 11 years, this study explores how organizations' economic, environmental, and social inputs influence the creation of sustainability value on these three pillars, alongside the impact of four major digital technologies (artificial intelligence, blockchain, cloud computing, and big data). The study reveals that companies' contributions in these dimensions significantly enhance the output of values. Each of the four digital technologies exerts a distinct moderating influence. We provide a thorough look at the "input-output" relationship of sustainable value creation. Our research highlights the varying effects on sustainable development of companies' contributions to the economy, the environment, and society, as well as companies' adoption of digital technologies.

Keywords: sustainable development; digital transformation; digital technologies; artificial intelligence (AI); blockchain; cloud computing; big data

Citation: Du, M.; Qu, X. Is Digital Transformation a Burden or a Help? From the Perspective of Enterprise Sustainable Development. *Sustainability* **2024**, *16*, 980. https://doi.org/10.3390/su16030980

Academic Editors: Yang (Jack) Lu, Yong Zheng, Ronghua Xu and Bin Li

Received: 25 December 2023
Revised: 12 January 2024
Accepted: 17 January 2024
Published: 23 January 2024

1. Introduction

In this work, we study the input–output relationship of sustainable development and the impact of corporate digitalization. Sustainable development and digital transformation are prominent themes that are currently shaping the trajectory of human society. Sustainable development involves the pursuit of an improved quality of life while considering the well-being of others, future generations, and the environment. Digital transformation, on the other hand, entails converting physical information into digital data using technology to enhance efficiency, transparency, and resource conservation. Digital transformation has emerged as a consequence of scientific and technological progress driven by economic expansion, while sustainable development reflects a reconsideration of the historically exaggerated emphasis on economic growth. Presently, the simultaneous evolution of non-economic, environmental, and social benefits, associated with the digital transformation of businesses, is underway. The synergy between these two trends can facilitate businesses in transforming their inputs—economic, environmental, and social—into value more seamlessly.

Recent concerns about social welfare and environmental quality, spurred by the adverse impacts of climate change, unemployment, and poverty [1–3], indicate the imperative for businesses to gather resources and to create value for stakeholders—suppliers, customers, shareholders, and creditors [4]. The integration of enterprises into society and the pursuit of sustainable development represents the contemporary trajectory of modern life and the path moving forward [5–8]. While contributing to societal well-being and practicing sustainability is costly for organizations, it enhances their long-term competitive advantage [9,10] and their ability to adapt to societal developments [11,12]. Conversely, the adoption of digital technologies, such as artificial intelligence, blockchain, cloud computing, and big data, can optimize governance and management, conserve resources, enhance efficiency, improve information transparency, and facilitate stakeholder communication [13–16].

Existing studies on corporate sustainability often focus on the impact of non-financial data, such as environmental, social, and governance information, on the market value of businesses [17,18]. However, the linkage between digital technology and sustainable development has received limited attention [19]. The sparse studies that are available predominantly adopt a macro-level perspective, as they explore the broader interactions between digital technology and the business sector and society as a whole [20,21]. Few studies have examined the micro-enterprise level to investigate how these technologies influence businesses [14,22]. This is mostly due to the challenges associated with quantifying corporate sustainability and digital transformation, as well as the challenges associated with obtaining detailed data for study.

We contend that, in the realm of sustainable development, value creation by companies entails sustained outputs that encompass and surpass the utilization of economic, environmental, and social resources. Our study highlights the realization of this process as well as the influencing factors. We establish that the economic, environmental, and social inputs of companies distinctly influence value creation for stakeholders. Furthermore, we investigate the moderating role of each of the four key digital technologies.

This study makes contributions to several aspects. First, we articulate a distinct model that illustrates the pathway for corporate sustainability value creation, which provides more details of the functions that few studies have proved. Second, our choice of revenue, as opposed to share price, as a metric for corporate value provides a more comprehensive reflection of stakeholders' interests, the measurement of which was both a creative and reasonable idea. Third, by scrutinizing the moderating impact of the four digital technologies on the primary regression independent variable, we enrich the empirical evidence supporting the assertion that digitization fosters sustainable development. Through these four aspects, our paper enriches the research on the topics "sustainable development" and "digital transformation application" in companies. It also offers a great deal of detail on the "input-output" relationship that was not covered in earlier studies. We have come to two conclusions, which fulfills the purpose of this paper: first, all inputs to the three pillars of sustainable development are all of significance in relation to the outputs; and second, the process has been greatly impacted by major digital technologies.

The remainder of the paper is organized as follows: the second part provides an overview of the relevant literature; the third part delineates the theoretical analysis and hypothesis design; the fourth part outlines the primary methodology and modeling; the fifth part scrutinizes the data analysis; the sixth part showcases the principal empirical results and discussion; and the seventh part concludes the paper.

2. Literature Review

2.1. Sustainable Development and Stakeholder Theory

2.1.1. Sustainable Development Theory

Sustainable development entails the creation of favorable conditions and opportunities to meet developmental aspirations and enhance the quality of life for the current generation without jeopardizing the ability of future generations to meet their own needs [23–25]. In the 2030 Agenda, the United Nations designated Major Groups and other Stakeholders as the stakeholders of sustainable development in 2015. The definition of Major Groups includes those who are most in need and most likely to contribute; in essence, this includes all individuals and the natural environment. This concept encompasses both the natural world and human well-being [26].

The three well-established pillars of sustainable development—economic growth, social advancement, and environmental preservation—were introduced in 2002. Sustainable economic development entails ensuring that economic progress succeeds, but not at the expense of poverty, inequality, or environmental harm [27,28]. It emphasizes both the qualitative and quantitative drivers of economic growth, as it consists of changes in consumer preferences, production and distribution systems, and technological advancements [29]. Social progress, for sustainability, includes elements such as social fairness, a thriving and healthy society, participation, sustainability awareness, and social cohesiveness [30,31]. Environmental sustainability involves maintaining ecological balance, improving environmental quality, and reducing the consumption of natural resources [32]. Pursuing sustainable development involves trade-offs among these three pillars, necessitating consideration of costs and benefits.

2.1.2. Stakeholder Theory

Scholars initially directed their focus towards corporate stakeholders in the 1950s and 1960s. The stakeholder theory emerged as a response to shareholder primacy during this period, advocating for strategic management that considers the interests of various stakeholders who possess different levels of influence over individuals or groups [33,34]. It has been suggested that stakeholders demonstrate their influence through the risks that they assume for an organization [35]. Given this mutual influence, organizations bear a responsibility towards their stakeholders.

Despite differences, advocates of the stakeholder theory agree that an enterprise bears a duty and an ethical responsibility toward its stakeholders. The notion of "the common good" underlies the interaction between businesses and stakeholders. The success of a business lies in its capacity to meet stakeholder requirements; its sustainability is grounded in its ability to generate value for stakeholders in alignment with "the common good" [4,36,37]. To optimize benefits for individual stakeholders, businesses should strive to enhance the value of the entire group [38–40].

The stakeholder theory and the concept of sustainable development are similar in their consideration of the broad impacts on diverse groups. The stakeholder theory contributes a moral and ethical perspective to this understanding. Both challenge the notion that businesses can only contribute to social welfare by creating economic value, countering classical economic beliefs in unbridled economic growth. Sustainable development emphasizes equality and fraternity among stakeholders, shifting from individual stakeholder prioritization to comprehensive stakeholder accountability. A widely accepted principle of sustainable development is rooted in the interests of all stakeholders [41].

2.2. Corporate "Resource—Value" Exchange

Resources and value are inherently interconnected. An enterprise is essentially an amalgamation of valuable resources. In conventional economics, the economic value of an enterprise, as per shareholder primacy, is the summation of producer and consumer surplus. The foundation of corporate value lies in resources that are valuable, rare, imperfectly imitable, and non-substitutable (VRIN) [42,43]. Acquiring such key resources empowers firms to minimize costs and to enhance revenues, thereby influencing the overall value of the firm [44].

Sustainable development transforms the dynamics of the 'resource-value' exchange between stakeholders and companies [45,46]. It perceives an enterprise's value as the comprehensive value generated through the conversion and addition of value to its resources. This extends beyond the economic value delivered to upstream suppliers, downstream customers, internal management and employees, external creditors, and shareholders. It encompasses social and environmental value as well. This redefines the traditional belief that enterprise value is the residual value post the deduction of resource consumption [47]. According to the new property rights theory, employees, by investing time and energy or resources, have the right to see their needs or interests addressed by the company they work for. This right is fulfilled through wages, allowing employees to partake in the value created by the business. Consequently, workers emerge as significant stakeholders in the company, akin to investors, actively shaping the 'resource-value' exchange within the business. This principle extends to other involved parties, such as suppliers and customers [48].

2.3. Application of Digital Technologies in Business

The integration of digital technologies can elevate an organization's business and financial operations, amplifying productivity, resource conservation, and efficiency in production, operation, and decision making. Additionally, it contributes to safeguarding employee rights and safety, collectively fostering progress toward sustainable development. Despite these advantages, the initial costs of labor, materials, and time associated with these evolving technologies are a point of consideration for businesses [14]. However, the impact on social sustainability is a subject of ongoing debate. Advocates posit that digitization can contribute to societal sustainability by addressing safety concerns through real-time monitoring, potentially replacing manual labor and improving resource allocation efficiency across longer distances, thus expanding the customer base. Conversely, critics argue that digitalization may undermine societal sustainability by increasing unemployment and by compromising employee security [19].

Artificial intelligence, blockchain, cloud computing, and big data represent key facets of digital technologies. Artificial intelligence involves enabling machines to emulate human behavior and thought processes, facilitating intelligent decision making and the provision of smart products or services [49]. Blockchain, a decentralized digital ledger technology, ensures security and transparency in data or process recording, enhancing efficiency and earning stakeholders' trust. Research suggests that both artificial intelligence and blockchain support sustainable development by aiding decision analysis and streamlining supply chain management [13]. Cloud computing, an internet-based data processing service, allows organizations to reduce expenses and to focus on core competencies, contributing to sustainable revenue generation when the right provider is chosen [20]. Big data technologies enable processing of massive volumes of data based on specific business requirements. This capability allows organizations to record, evaluate, and align with sustainability goals and stakeholder needs, ultimately enhancing sustainability by addressing identified gaps [50].

3. Hypotheses Development

Within the sustainable development framework, the exchange of resources and value by a company is accurately reflected in its revenue, symbolizing both the value of all stakeholders and the commitment to sustainable development. Revenue is related to various expenses, such as payments to suppliers, employee and management wages, interest to creditors, taxes to the government, and net profit to shareholders. Recognizing resources as essential inputs for value generation, a company's sustainable value, as indicated by its income, is inherently linked to its economic, environmental, and social resource inputs.

The economic, environmental, and social factors of a company can be prioritized, much like stakeholders with equal status but varying levels of power, legitimacy, urgency, and proximity [51]. This approach aligns with the principles of sustainable development, emphasizing the fulfillment of stakeholder requirements in a defined sequence, while ultimately considering the shared long-term interests of all stakeholders [23].

The environmental and social factors of a company, unlike the economic factors, usually do not directly impact production and operational processes. While economic inputs exert a stronger short-term influence, environmental and social inputs have repercussions for future income. Given this, we anticipate that a firm's current income is shaped by the interconnection between the current economic conditions and the environmental and social inputs from the preceding period.

The integration of inputs and outputs in digital technology may potentially yield either advantageous or detrimental effects on the generation of sustainable value for businesses. If a specific technology conserves resources and enhances efficiency, it will have a beneficial impact on both the economy and the environment. Conversely, if the technology leads to the depletion of resources and a decrease in efficiency, it will have an adverse effect. The social impact of this technology will be favorable if it results in improved employee welfare, enhanced customer relationship management, and so on. It will be unfavorable if the opposite occurs. The impacts of various digital technologies vary due to their distinct features and stages of development. This assumes that a company's economic, environmental, and social activities result in income, and that those digital technologies contribute positively to this outcome.

In sum, we test the following empirical hypotheses:

H1. *There is a significant and positive correlation between income and all three pillars of sustainable development information.*

H2. *Digital technologies have a moderating influence on the generation of sustainable value.*

H2a. *AI technologies have a substantial positive influence on the production of sustainable value.*

H2b. *Blockchain technology has a substantial positive influence on the production of sustainable value.*

H2c. *Cloud computing technology has a substantial positive influence on the generation of sustainable value.*

H2d. *Big data technologies have a substantial positive influence on the production of sustainable value.*

4. Methodology

To mitigate the influence of individual factors on the estimation results, we employ a fixed effects model (see model test in Appendix A Table A1). The model is structured as follows to examine the impact of social, economic, and environmental input variables on income:

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \beta_3 Soc_{it} + \theta X_{i,t+1} + \delta \quad (1)$$

In model (1), the explained variable $OR_{i,t+1}$ is the total annual operating revenue reported by firm i in period $t + 1$; the explanatory variable $Eco_{i,t+1}$ is the annual total economic inputs reported by firm i in period $t + 1$, which is the sum of operating costs, selling expenses, and administrative expenses in period $t + 1$; Env_{it} and Soc_{it} are the environmental and social inputs of firm t in period t. The explanatory variable $X_{i,t+1}$ is a set of control variables including the growth capacity ($G_{i,t+1}$) and solvency of firm i in period $t + 1$ ($Lev_{i,t+1}$). The former is represented by the growth rate of total assets and the latter by the asset liability ratio. Both have a crucial impact on sustainable value creation.

In order to test whether environmental and social inputs, respectively, have an additional impact on firms' revenues, the model is set up as follows:

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \theta X_{it+1} + \delta \quad (2)$$

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \theta X_{it+1} + \delta \quad (3)$$

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Soc_{it} + \theta X_{it+1} + \delta \quad (4)$$

Referring to Dechow's study [52], the Vuong test is employed to assess whether there is a significant difference in the explanatory power of models (2) and (3), and models (2) and (4), with the same dependent variable. The test results can demonstrate whether the inclusion of environmental inputs and social inputs significantly enhances the explanatory power of the model when economic inputs are considered.

To examine the impact of digital technologies on the value creation process involving economic, environmental, and social inputs, four cross-multiplier terms of digital technologies with economic, environmental, and social inputs are introduced. The model is structured as follows:

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \beta_3 Soc_{it} + \beta_4 Eco_{i,t+1} \times AI_{i,t+1} + \beta_5 Env_{it} \times AI_{i,t+1} + \beta_6 Soc_{it} \times AI_{i,t+1} + \theta X_{i,t+1} + \delta \quad (5)$$

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \beta_3 Soc_{it} + \beta_4 Eco_{i,t+1} \times BC_{i,t+1} + \beta_5 Env_{it} \times BC_{i,t+1} + \beta_6 Soc_{it} \times BC_{i,t+1} + \theta X_{i,t+1} + \delta \quad (6)$$

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \beta_3 Soc_{it} + \beta_4 Eco_{i,t+1} \times CC_{i,t+1} + \beta_5 Env_{it} \times CC_{i,t+1} + \beta_6 Soc_{it} \times CC_{i,t+1} + \theta X_{i,t+1} + \delta \quad (7)$$

$$OR_{i,t+1} = \beta_0 + \beta_1 Eco_{i,t+1} + \beta_2 Env_{it} + \beta_3 Soc_{it} + \beta_4 Eco_{i,t+1} \times BD_{i,t+1} + \beta_5 Env_{it} \times BD_{i,t+1} + \beta_6 Soc_{it} \times BD_{i,t+1} + \theta X_{i,t+1} + \delta \quad (8)$$

In models (5) to (8), $AI_{i,t+1}$ is the degree of adoption of enterprise i artificial intelligence in period $t + 1$; $BC_{i,t+1}$ is the degree of application of blockchain for enterprise i in period $t + 1$; $CC_{i,t+1}$ is the degree of application of enterprise i cloud computing in period $t + 1$; $BD_{i,t+1}$ is the degree of application of enterprise i big data in period $t + 1$. They are measured according to the frequency of the occurrence of words in a firm's annual report, referring to Peng and Jia [53].

5. Data

Our data are derived from two main sources. Environmental and social inputs are sourced from the SSI (Sino-Securities Index) ESG rating, while other data are obtained from the CSMAR database. The SSI ESG ratings are particularly valuable for two reasons. First, the database provides the most extensive and comprehensive collection of ESG data for Chinese listed companies, covering a wide span of time. Second, it includes ratings on environmental, social, and corporate governance aspects, aligning with criteria from esteemed organizations like GRI and SASB, which enjoy high recognition. Unlike many other ESG rating organizations that only offer ratings, SSI provides a more detailed and comprehensive dataset. The choice of the CSMAR database is driven by its inclusion of data from various reports of Chinese A-share listed companies, making it both more comprehensive and more suitable for our research.

We utilize quantitative environmental and social scores to investigate corporate environmental and social investment. The SSI ESG score breaks down a company's environmental score into key dimensions such as climate change, resource utilization, environmental pollution, and environmental friendliness. This includes factors like greenhouse gas emissions, pollution and waste emissions, resource and material consumption, production methods' environmental impact, certifications, and penalties. The social score is segmented into dimensions like human capital, product responsibility, supply chain, and social contribution. It encompasses aspects such as employee health and safety, employee motivation and development, employee relations, product quality control, supplier risk and management, supplier relations, community investment, and employment.

We employ the operating revenue disclosed in the corporate annual report as a metric for an enterprise's income. Non-operating revenue is excluded due to its contingent and unsustainable nature, as it is unrelated to the daily production and operational activities of the enterprise, and it does not contribute to the "resource-value" exchange that is essential for sustainable benefits to all stakeholders.

For the economic inputs, we use the sum of annual production costs, selling expenses, and administrative expenses. This indicator consists of all economic resources invested in the enterprise's daily production and operational activities, including the production and processing costs of machines, as well as the wages of employees and management. It excludes interest distributed to creditors, taxes returned to the government, and profits distributed to shareholders after production and operational activities.

For sample selection, we opted for all listed companies in the manufacturing industry on China's A-share market. The sample includes the dependent variables, independent variables, mediating variables, moderating variables, and control variables for the study. The final sample comprises all listed manufacturing companies in A-shares from 2012 to the present, spanning 11 years and including data for 2211 listed companies.

The choice to exclude data before 2012 is twofold. First, 2012 marked the beginning of China's shift from emphasizing economic growth to prioritizing sustainable growth, as it entered the "new normal" phase. Second, before 2012, the impact of both digital technology and sustainable development on enterprises was comparatively weak. All of the data used for the model underwent standardization.

Table 1 shows the descriptive statistics of the sample, containing the mean, standard deviation, minimum, first quartile, median, third quartile, and maximum. We minorize every financial variable at a 1% level in each tail. Operating revenue and economy are in billions.

Table 1. Descriptive statistics of corporate sustainable outputs and inputs and applications of four key digital technologies.

Variable	Obs.	Mean	Std.Dev.	Min	1st Qnt.	Median	3rd Qnt.	Max
Operating revenue	21,884	6.082	14.11	0.128	0.779	1.751	4.377	98.34
Economy	16,264	6.059	14.04	0.114	0.741	1.711	4.428	97.83
Environment	21,884	61.06	7.247	46.80	56.09	60.98	66.11	80.44
Society	21,884	74.19	8.421	49.33	68.83	74.74	79.86	92.66
Growth	21,884	0.180	0.315	−0.290	0.015	0.095	0.232	1.765
Leverage	21,884	0.399	1.238	0.008	0.231	0.377	0.527	178.3
Artificial intelligence	6112	1.345	3.850	0	0	0	1	26
Blockchain	6112	0.018	0.134	0	0	0	0	1
Cloud computing	6112	2.554	7.270	0	0	0	2	52
Big data	6112	1.473	3.931	0	0	0	1	26

Note: Variables operating revenue and economy are showed in billions; Qnt: quartile.

In Table 1, the data from 2012 to 2022 reveal that the average economic input of the firms in our sample is USD 6.059 billion, with a minimum value of USD 0.11 billion, a maximum value of USD 97.83 billion, and a median value of USD 1.71 billion. The average environmental and social scores are 61.06 and 74.19, with a minimum value of 46.80 and 49.33 points, a median of 60.98 and 74.74 points, and a maximum of 80.44 and 92.66 points. The standard deviation of the social inputs is slightly higher than that of the environmental inputs, indicating significant differences in corporate social inputs.

Concerning digital technology utilization, the mean values for the four digital technologies are 1.345, 0.0180, 2.554, and 1.473, indicating that blockchain application is the lowest among the four. The standard deviation of cloud computing is the largest, signifying substantial variation in the level of cloud computing adoption among organizations, while blockchain exhibits the least variation. The medians for all four technologies and the third quartile for blockchain are both 0, indicating that more than 75% of the sample do not use blockchain, and more than 50% do not use the other three. The maximum value for blockchain is 1, indicating very low adoption by companies utilizing blockchain. Cloud computing has a maximum value of 52, signifying the highest level of adoption among the four.

Table 2 presents the correlation analysis. The results indicate a high positive correlation between economic inputs and income (0.989). Environmental and social factors also exhibit positive correlations with income (0.22 and 0.09), albeit to a lesser extent. Furthermore, environmental and social inputs show positive correlations with economic factors (0.22 and 0.09), and environmental factors display a positive correlation with social factors (0.39). This challenges the notion that economic inputs necessarily deplete environmental and social resources, suggesting instead a mutual reinforcement among the three pillars of sustainable development.

Table 2. Correlation coefficients of corporate sustainable outputs and inputs and applications of four key digital technologies.

Variables	Operating Revenue	Economy	Environment	Society	Growth	Leverage	Artificial Intelligence	Blockchain	Cloud Computing	Big Data
Operating Revenue	1.000									
Economy	0.989 ***	1.000								
	(0.000)									
Environment	0.222 ***	0.218 ***	1.000							
	(0.000)	(0.000)								
Society	0.092 ***	0.086 ***	0.393 ***	1.000						
	(0.000)	(0.000)	(0.000)							
Growth	−0.050 ***	−0.054 ***	−0.010	0.064 ***	1.000					
	(0.000)	(0.000)	(0.126)	(0.000)						
Leverage	0.045 ***	0.324 ***	0.022 ***	−0.019 ***	−0.034 ***	1.000				
	(0.000)	(0.000)	(0.001)	(0.006)	(0.000)					
Artificial Intelligence	0.087 ***	0.088 ***	−0.013	0.015	−0.017	−0.002	1.000			
	(0.000)	(0.000)	(0.326)	(0.246)	(0.194)	(0.886)				
Blockchain	0.066 ***	0.057 ***	0.024 *	0.018	−0.011	−0.001	0.169 ***	1.000		
	(0.000)	(0.000)	(0.058)	(0.167)	(0.371)	(0.922)	(0.000)			
Cloud Computing	0.063 ***	0.069 ***	0.063 ***	0.056 ***	0.009	−0.005	0.373 ***	0.226 ***	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.506)	(0.720)	(0.000)	(0.000)		
Big Data	0.122 ***	0.137 ***	0.048 ***	0.041 ***	−0.006	−0.001	0.513 ***	0.217 ***	0.460 ***	1.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.643)	(0.919)	(0.000)	(0.000)	(0.000)	

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** and * represent that the *p*-values are smaller than 1%, and 10%, respectively. The data used for the model have been standardized.

The strong correlations among digital technologies, particularly the correlation between big data technology and artificial intelligence technology, as well as cloud computing technology (0.51 and 0.46), imply that the application of one digital technology leads to the development of others or requires support from complementary technologies.

6. Empirical Results and Discussion

Table 3 presents the results of the estimation model (1), illustrating the impact of firms' economic, environmental, and social inputs on revenues. The findings reveal that all indicators are positively significant. This suggests that the economic inputs of firms in the current period, combined with the environmental and social inputs from the previous period, collectively contribute to explaining revenues in the current period.

Table 4 specifically assesses whether including environmental and social inputs significantly improves the explanatory power of the model compared to using only economic inputs. This evaluation is conducted through a comparison between models (2) and (3), as well as models (2) and (4), as discussed earlier. The results of the Vuong test are statistically significant at a 1% level for all cases, indicating that the additional inclusion of environmental and social inputs enhances the model's explanatory capacity. Both environmental and social factors play equally crucial roles in the sustainable development of value for the organization, alongside the economic factors. Hypothesis 1 is not rejected. Upon closer examination of Table 3, it is evident that economic inputs exert the most significant influence on revenues, while environmental and social inputs have a relatively smaller impact. Additionally, environmental and social inputs exhibit similar degrees of impact. This suggests that, even within a context prioritizing sustainable development, economic factors remain the most important contributors.

Table 3. The effect of corporate economic, environmental, and social inputs on operating revenue.

	OR_1	
	(1)	**(2)**
Eco_1	1.0161 *** (0.000)	1.0158 *** (0.000)
Env_o	0.0034 *** (0.002)	0.0036 *** (0.001)
Soc_o	0.0036 *** (0.000)	0.0041 *** (0.000)
G_1		0.0079 *** (0.000)
Lev_1		−0.0003 (0.618)
Intercept	0.0015 *** (0.010)	0.0027 *** (0.000)
Observations	17,094	17,094
R^2	0.9628	0.9631
Adjusted R^2	0.9554	0.9556
Code	Yes	Yes

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** represent that the *p*-values are smaller than 1%. The data used for the model have been standardized.

Table 4. The significance of environmental and social inputs and Vuong test.

	OR_1			
	(1)	**(2)**	**(3)**	**(4)**
Eco_1	1.0179 *** (0.000)	1.0169 *** (0.000)	1.0179 *** (0.000)	1.0164 *** (0.000)
Env_o		0.0048 *** (0.000)		
Soc_o				0.0048 *** (0.000)
G_1	0.0075 *** (0.000)	0.0076 *** (0.000)	0.0075 *** (0.000)	0.0078 *** (0.000)
Lev_1	−0.0003 (0.656)	−0.0003 (0.621)	−0.0003 (0.656)	−0.0003 (0.643)
Intercept	0.0022 *** (0.000)	0.0024 *** (0.000)	0.0022 *** (0.000)	0.0026 *** (0.000)
Observations	17,094	17,094	17,094	17,094
R^2	0.9629	0.9630	0.9629	0.9630
Adjusted R^2	0.9555	0.9556	0.9555	0.9556
Code	Yes	Yes	Yes	Yes
Vuong-Z	−2.9066 ***		−13.2145 ***	
p-Value	(0.0037)		(0.000)	

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** represent that the *p*-values are smaller than 1%. The data used for the model have been standardized.

Sustainable development refers to the process of achieving an equilibrium between the economy, the environment, and society. Economic inputs yield the most immediate and tangible benefits. Environmental and social inputs indicate that the enterprise possesses consciousness of sustainable development. Under the influence of this consciousness, the enterprise compensates for its utilization of environmental and social resources by engaging in behaviors that protect the environment and benefit society. Stakeholders not only gain financial benefits in the long term but also receive positive recognition from the environment and society. Consequently, they are motivated to support the enterprise's operations that create sustainable development value.

Tables 5–8 illustrate the influence of the four major digital technologies on the process of generating value for corporate sustainability. Table 5 shows that AI technology does not have any moderating effect on the input–output relationship of enterprise sustainability, which may be due to the fact that although AI can save resources by assisting enterprises in analyzing, making decisions, and forecasting, activities such as installation, maintenance, and training also consume a larger number of resources. In general, these factors balance each other out and have minimal influence. This may also be because AI is still in its infancy and is not being used effectively, so the data do not show a distinct effect [54].

Table 5. The moderating effect of artificial intelligence.

	OR_1
Eco_1	1.0340 *** (0.000)
Env_o	0.0059 *** (0.008)
Soc_o	0.0050 *** (0.003)
$Eco_1 \times AI_1$	0.0016 (0.191)
$Env_o \times AI_1$	0.0006 (0.713)
$Soc_o \times AI_1$	−0.0004 (0.785)
G_1	0.0116 *** (0.000)
Lev_1	−0.0001 (0.926)
Intercept	0.0054 *** (0.000)
Observations	5307
R^2	0.9591
Adjusted R^2	0.9411
Code	Yes

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** represent that the *p*-values are smaller than 1%. The data used for the model have been standardized.

Table 6 shows that the use of blockchain weakens the impact of economic inputs on revenue for businesses, while it is insignificant for the environment and society. Weakening the impact of economic inputs may be due to the fact that the application of blockchain in enterprises is still in the initial stage of development and is still mainly focused on inputs. In addition, blockchain itself is a distributed ledger technology. The primary choice for enterprises to apply blockchain should be to combine it with transaction systems or financial systems to improve the efficiency of business operations and to reduce costs. This has more to do with the economy and less to do with the environmental and social spheres. If the application of blockchain reaches a mature stage, its transparency, authenticity, and security are highly likely not only to enhance the overall operational efficiency and the financial savings of enterprises, thus improving the economic impact on sustainable development, but also to help enterprises conserve resources and facilitate stakeholder communication, thus strengthening the environmental and social impact on sustainable development [55].

Table 6. The moderating effect of blockchain.

	OR_1
Eco_1	1.0360 *** (0.000)
Env_o	0.0055 ** (0.014)
Soc_o	0.0050 *** (0.003)
$Eco_1 \times BC_1$	−0.0018 ** (0.026)
$Env_o \times BC_1$	0.0020 (0.105)
$Soc_o \times BC_1$	0.0007 (0.622)
G_1	0.0116 *** (0.000)
Lev_1	−0.0001 (0.930)
Intercept	0.0055 *** (0.000)
Observations	5307
R^2	0.9592
Adjusted R^2	0.9412
Code	Yes

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding p-values. The symbols of *** and ** represent that the p-values are smaller than 1% and 5%, respectively. The data used for the model have been standardized.

Table 7 shows that the application of cloud computing improves the impact of economic and environmental inputs on revenue for businesses and that it is not significant for society. This could be attributed to the inherent potency of cloud computing, which enables organizations to effectively strategize the allocation of resources and even to outsource services, thereby circumventing the need for further resource consumption by paying a specified fee. The total outcome not only achieves the desired improvement in environmental efficiency, but it also keeps the economic costs from exceeding the original amount. Simultaneously, it is possible that the entire extent of cloud computing's impact on society remains unrealized, due to its current level and range of implementation [56].

Table 8 shows that the application of big data can significantly improve the impact of economic inputs on revenue, but not on the environment and society. The reason for this could be that big data technology serves as a means to handle vast quantities of data and to offer decision making information that aids a company in improving efficiency or in conserving economic resources. The existing literature indicates that the utilization of big data might enhance the influence of social inputs on sustainable development by furnishing stakeholders with information and by improving communication between stakeholders and enterprises. Nevertheless, the evidence does not indicate this influence. This could be attributed to the discrepancy between the theoretical analysis and the lack of practical implementation by firms. The application of big data is frequently integrated with other digital technologies. For instance, the influence of big data cannot be disregarded when considering cloud computing's facilitation of economic and environmental inputs [57,58].

Table 7. The moderating effect of cloud computing.

	OR_1
Eco_1	1.0338 *** (0.000)
Env_o	0.0058 *** (0.008)
Soc_o	0.0051 *** (0.002)
$Eco_1 \times CC_1$	0.0092 *** (0.000)
$Env_o \times CC_1$	0.0059 *** (0.002)
$Soc_o \times CC_1$	0.0003 (0.841)
G_1	0.0118 *** (0.000)
Lev_1	−0.0000 (0.959)
Intercept	0.0047 *** (0.000)
Observations	5307
R^2	0.9595
Adjusted R^2	0.9418
Code	Yes

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** represent that the *p*-values are smaller than 1%. The data used for the model have been standardized.

Thus, Hypothesis 2 and the sub-hypotheses have been partially proved. Analysis of the data is crucial as it provides a characterization of each digital technology, including the current stage of development, the degree of application, and the impact on the input–output relationship in the economic, environmental, and social dimensions. This analysis is more significant than the hypotheses. We find that the current application of digital technologies does not significantly contribute to the creation of sustainable development value in the economic, environmental, and social dimensions as expected. This may be due to the fact that the application of digital technology has not yet reached the expected level. This may also be due to the lack of awareness of sustainable development and digital technology. However, there is no denying that sustainable development and digital technologies have a bright future, and that a combination of the two can lead to more positive feedback.

We use the following two methods for robust testing. First, we divide the codes into odd and even groups; the results are shown in columns (1) and (2) in Table 9 Then, we replace the measures of the explanatory variables, and we regress the ratings with more vague ratings instead of scores. We still use the environmental and social ratings from the SSI ESG database. Firms are rated from 'AAA' to 'C', and we assign values 1–9 to each of the nine ratings in turn and put them into the model for regression. The test results show that the model is robust.

Table 8. The moderating effect of big data.

	OR_1
Eco_1	1.0330 *** (0.000)
Env_o	0.0060 *** (0.007)
Soc_o	0.0050 *** (0.003)
$Eco_1 \times BD_1$	0.0039 *** (0.001)
$Env_o \times BD_1$	0.0020 (0.278)
$Soc_o \times BD_1$	0.0014 (0.333)
G_1	0.0116 *** (0.000)
Lev_1	−0.0001 (0.933)
Intercept	0.0050 *** (0.000)
Observations	5307
R^2	0.9593
Adjusted R^2	0.9414
Code	Yes

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** represent that the *p*-values are smaller than 1%. The data used for the model have been standardized.

Table 9. Robust test of basic regression.

	OR_1		
	(1)	**(2)**	**(3)**
Eco_1	1.0122 *** (0.000)	1.0217 *** (0.000)	1.0164 *** (0.000)
Env_o	0.0042 ** (0.011)	0.0033 ** (0.020)	0.0039 *** (0.000)
Soc_o	0.0032 ** (0.010)	0.0054 *** (0.000)	0.0017 ** (0.047)
G_1	0.0047 *** (0.000)	0.0110 *** (0.000)	0.0075 *** (0.000)
Lev_1	−0.0634 *** (0.000)	−0.0000 (0.936)	−0.0003 (0.647)
Intercept	0.0027 *** (0.001)	0.0026 *** (0.001)	−0.0124 *** (0.000)
Observations	8730	8364	17,094
R^2	0.9620	0.9647	0.9630
Adjusted R^2	0.9542	0.9577	0.9556
Code	Yes	Yes	Yes

NOTE: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding *p*-values. The symbols of *** and ** represent that the *p*-values are smaller than 1% and 5%, respectively. The data used for the model have been standardized.

7. Conclusions

Our study focuses on the input–output relationship of sustainable development and the impact of corporate digitalization, addressing two issues that are crucial to today's world. First, we quantify stakeholders' interests, specifically the value of sustainable development created over a defined period relative to revenue. We establish that generating corporate sustainability value necessitates economic, environmental, and social inputs. Second, we assert that the creation of corporate sustainability value is intricately linked to the support provided by digital technologies. We examine the impact of four key digital technologies—artificial intelligence, blockchain, cloud computing, and big data—on the interplay among firms' sustainable economic, environmental, and social input–output relationships. Our findings reveal a moderating effect of digital technologies, influenced by factors such as the characteristics, the developmental stage, and the application extent of each technology. As sustainable development advances and digital technology proliferates, new research opportunities and topics are expected to emerge. Future research should focus on how businesses can use these digital technologies to enhance daily operations, decision making, and production processes, which will ultimately lead to more effective and efficient value creation for sustainable development. Furthermore, more quantitative evidence is required to support the idea that new technologies may help stakeholders and businesses communicate for sustainable development.

Author Contributions: All authors contributed equally to the data acquisition and write-up of the present paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research project is supported by the Science Foundation of Beijing Language and Culture University (supported by "the Fundamental Research Funds for the Central Universities") (Approval number: 18PT02).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Model Test of Basic Regression.

		OR_1	
	(1)	**(2)**	**(3)**
	Mixed-effects Model	Random-effects Model	Fixed-effects Model
Eco_1	0.9938 *** (0.000)	1.0055 *** (0.000)	1.0158 *** (0.000)
Env_o	0.0026 ** (0.012)	0.0031 *** (0.001)	0.0036 *** (0.001)
Soc_o	0.0098 *** (0.000)	0.0056 *** (0.000)	0.0041 *** (0.000)
G_1	0.0149 *** (0.000)	0.0091 *** (0.000)	0.0079 *** (0.000)
Lev_1	−0.0015 * (0.089)	−0.0005 (0.432)	−0.0003 (0.618)
Intercept	0.0048 *** (0.000)	0.0036 ** (0.043)	0.0027 *** (0.000)

Table A1. *Cont.*

		OR_1	
	(1)	**(2)**	**(3)**
Observations	17,094	17,094	17,094
R^2	0.9851		0.9631
Adjusted R^2	0.9851		0.9556
Code	No	No	Yes
B-P- Chi2	35,970.87 ***		
p-Value	(0.000)		
Hausman-Chi2		160.60 ***	
p-Value		(0.000)	

Note: The numbers refer to the estimated coefficients, β. The numbers in parentheses refer to corresponding p-values. The symbols of ***, **, and * represent that the p-values are smaller than 1%, 5%, and 10%, respectively. The data used for the model has been standardized. The B-P test shows that a fixed-effects model or a random-effects model is more proper. The Hausman test shows that a fixed-effects model is better. Finally, we considered that a two-factor-fixed-effects model fits us the most.

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