Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3, 2811-2827
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i3.5878

Conceptualizing intelligent system applications in the service economy: Aligning with sustainable development goals for a resilient future

Svetlana Bozhuk[1]*, Murat Akramovich Ikramov[2], Shaxnoza Djasurovna Ergashxodjayeva[3], Nilufar Muratovna Nabieva[4], Maksud Obitovich Kurolov[5], Yuri Malenkov[6], Mikhail Nogovitsyn[7], Victor Shishkin[8], Vladimir Bakharev[9], Viktor I. Shishkin[10], GalinaV. Kudriavtseva[11]
[1]Peter the Great St. Petersburg Polytechnic University, 195251, St. Petersburg, Russia; bojuk_svetlana@yandex.ru (S.B.).
[2,3,4,5]Marketing department, Tashkent State University of Economics, I. Karimov Str., 49, 100066, Tashkent, Republic of Uzbekistan; ikramov.m@mail.ru (M.A.I.) kurolovmaksud@tsue.uz (M.O.K.).
[6]Department of Management and Planning of Socio-Economic Processes, St Petersburg State University (SPbU), 7-9 Universitetskaya Embankment, 199034, St Petersburg, Russia; m800@list.ru (Y.M.).
[7]Department of Management and Planning of Socio-Economic Processes, St Petersburg State University (SPbU), 7-9 Universitetskaya Embankment, 199034, St Petersburg, Russia, 199034mikhail.nogovitsyn2015@yandex.ru (M.N.).
[8]Department of Functional Diagnostics, St Petersburg State University (SPbU), 7-9 Universitetskaya Embankment, 199034, St Petersburg, Russia; visvi@mail.ru (V.S.).
[9]Peter the Great St. Petersburg Polytechnic University, 195251, St. Petersburg, Russia; v50226@mail.ru (V.B.).
[10,11]St. Petersburg State University, 7-9, Universitetskaya nab., St. Petersburg, 199034, Russian Federation.

Abstract: This study aims to explore the relationship between intelligent system adoption and sustainability performance in the service economy, with a focus on aligning these technologies with the United Nations Sustainable Development Goals (SDGs). A quantitative research design was employed, utilizing survey data from 200 organizations across various service sectors. The data were analyzed using descriptive statistics, correlation analysis, and multiple regression to examine the impact of intelligent system adoption on sustainability outcomes, operational efficiency, and the barriers to SDG alignment. The findings show a significant positive relationship between intelligent system adoption and sustainability performance, indicating that organizations using intelligent systems report improved environmental and operational outcomes. Additionally, intelligent system adoption is positively correlated with SDG awareness and integration, while barriers such as financial constraints and lack of expertise negatively impact sustainability efforts. The study concludes that intelligent systems can play a critical role in driving sustainable business practices and enhancing organizational efficiency. However, overcoming barriers to SDG alignment requires targeted policy interventions and financial support. These findings provide practical insights for organizations seeking to leverage intelligent systems for sustainability and contribute to the broader discourse on the role of digital technologies in achieving global sustainability goals.

Keywords: *Digital transformation, Barriers to sustainability, Intelligent system adoption, Operational efficiency, SDG alignment, Service economy, Sustainability performance.*

1. Introduction

In recent years, the incorporation of intelligent systems in the service sector has become a key characteristic that has introduced change across sectors and new models of service delivery [1]. Starting from healthcare to education, from hospitality to finance, the concept of artificial intelligence (AI) and intelligent systems opened new doors of opportunity for creating efficiency, innovative customer experience, and growth [2]. Faced with the ongoing shift in focus towards service industries in world economies, mechanical and software systems have gained a crucial role in optimization of working processes, controlling the interaction with customers and offering support to business

History: Received: 15 January 2025; Revised: 14 March 2025; Accepted: 18 March 2025; Published: 29 March 2025
* Correspondence: bojuk_svetlana@yandex.ru

decisions. Still, the role of intelligent systems seems to be rather promising especially in terms of contributing to the United Nations Sustainable Development Goals (UNSDG; Figures 2 and 3) which are still being examined to a limited extent by researchers (among them Di Vaio, et al. [3]). This research aims at addressing this gap by developing a conceptual framework of how Intelligent System Applications can be related to the achievement of the SDGs with the end result being a better functioning and sustainable service economy for everyone.

The SDGs are the campaign works as a structural plan on which the whole globe need to perform to eliminate essential problems of poverty, inequality, climate change, and environmental depletion [4]. Whilst industries adopt intelligent systems each with its particular need as a result of changes in the market, applying intelligent systems in the service economy has to coincide with such primary objectives of the global community. Though intelligent systems are quickly developing in such diverse areas as manufacturing (SDG 9), responsible consumption and production (SDG 12), decent work and economic growth (SDG 8), and climate action (SDG 13) [5] the research on how they can support SDG achievement is limited. The potential of intelligent systems to transform industries makes it imperative to investigate ways in which these technologies can be used for the common good, leveraging energy efficient strategies, which address operational problems encountered in the service oriented sectors [6]. For instance, in case of intelligent system applications, AI driven solutions have made great strides in improving diagnostic accuracy, patient management and treatment planning [7]. Big data analytics and machine learning algorithms have been making intelligent systems that process big data such that it accelerates human errors and improves the whole patient outcomes. However, the difficulty here comes from making sure that such technological leaps to SDG 3 (Good Health and Well-being) is by making healthcare services more available and equitable for different populations. This highlights the opportunities intelligent systems have to support sustainable development by enabling several societal issues to be addressed, and at the same time enhance operational efficiency.

The first critical problem lies in this disconnect between the advances in intelligent systems technology and their compatibility with sustainability objectives. Despite leading to economic growth as well as service delivery, AI and intelligent systems do not address the bigger sustainability issues [8]. This study is motivated by the need to bridge this gap, to ensure that the development and application of intelligent systems within the service economy are concomitant with the SDGs. The challenge is not to let global economic growth take place at the expense of environmental and social well-being given that the service economy is an important driver of those aspects of global economic growth. Hence the main problem tackled in this research is how we can conceptualize intelligent system applications that enable sustainable development aligned to the SDGs [9]. Three most fundamental objectives are responsible for driving this study. In the first case, our attention is aimed at understanding how intelligent systems may help achieve specific SDGs within the service economy. It also sets out to construct a conceptual framework to merge intelligent systems with sustainability programs, so that technological progress helps meet the lasting objectives of society. The third contribution of the study is to identify the key challenges and opportunities for intelligent system application alignment with sustainable development objectives, useful for policymakers and industry leaders. To achieve these objectives, we will examine what case studies and industry examples tell us intelligent systems have successfully been applied, and where areas where existing practice lags as an impediment to progress towards sustainability [10].

The primary research question guiding this study is: What is the potential of ecological thinking to guide the conceptualization of intelligent system applications in the service economy towards, and within support of Sustainable Development Goals (SDGs)? Additional sub-questions include: More specifically, what are the central problems and opportunities in making intelligent systems conducive to achieving sustainability goals? and how can policy makers and business entities channel intelligent systems to create a more sustainable and resilient service economy? Through answering these questions, this study intends to offer a holistic analysis of the role of intelligent systems in fostering sustainability as well as participation in SDGs. This study was motivated by the increasing realization that technology can and should be a significant part of solutions to global ills. Intelligent systems, especially, will favor the service economy, which can improve processes, cut costs, and delight customers [11]. But the quick pace of tech development also threatens to be bad for society and the planet. Intelligent systems have the opportunity to either enhance or mitigate problems of inequality, resource depletion, and environmental degradation [7]. There is therefore an imperative to find how intelligent systems can help improve service delivery and still enable the achievement of global sustainability goals [12].

2. Literature Review

Over the years integrating intelligent systems in the operation of the service economy has been given much concern due to improvements in the technology hence subsequent evolution of commercial activities in economies. AI particularly, has emerged as a source of innovation on how it can deliver an improved ways of services, enhanced customer experience, and a reduced level of complexity. Recent studies focus on different aspects of intelligent systems in various sectors including potential of I.S. to respond to the service economy as well as more global challenges such sustainability and inclusion [13]. However, the possibility of how these technologies may contribute, specifically in the region of United Nations Sustainable Development Goals (UN-SDG), such as decent work and economic growth (SDG 8), responsible consumption and production (SDG 12) and climate change (SDG 13), has not been explored by Kluczek, et al. [14].

New technologies such as Artificial Intelligence, machine learning and big data analytics have been a really big factor for intelligent systems. This has helped the corporate in the service sector well in managing organizational decision making processes, enhancing the customer's relationship and the overall market behavior forecasts [15]. Incorporating AI into recommendation system for instance has significantly improved on customer's satisfaction by utilizing personalized service and product recommendations from the recommendation system to base on individual preferences [16]. In the field of finance, intelligent systems have also facilitated complex task automation such as fraud detection, risk assessment and financial planning and thus improved and secure service delivery [17]. Much of the existing literature highlights operational benefits of intelligent systems, but awareness of growing importance of intelligent systems to the service economy is also growing. One example is that recent studies show that intelligent systems might foster new business opportunities and open new productivity potential through the development of emergent industries, such as AI based healthcare and education services [18, 19].

The transition to more sustainable business models is of increasing interest in the context of sustainability and how intelligent systems can support such a transition. This could be applied, for instance, to use of AI and machine learning algorithms for the optimization of the energy consumption, utilization of abundant resources and support of more sustainable supply chain practices [20]. Consequently, it is important for achieving DSG 12 (Responsible Consumption and Production) and DSG 13 (Climate Action). Intelligent systems in the logistics and transportation sectors have been adopted to enhance route planning and minimize fuel consumption (or environmental impact of service delivery) [21]. However, a number of scholars have observed that the sustainability benefits of intelligent systems can be fully realized only when these technologies are housed within larger corporate strategies supporting an environmental or social responsibility [6]. In the literature, a key theme is intelligent systems having a part to play in increasing inclusivity and diminishing inequality, albeit in the labor market. A worry with AI technologies — which are growing in prominence — is they precipitate displace workers, in low skill, repetitive and unskilled work [22]. On the contrary, there are other studies that take the view that smart systems can generate new avenues for employment through the development of new industries and improving the productivity of employees in the current sector [23-25].

Intelligent systems have also been shown to improve the resilience of their organization, especially due to external shocks to the organization that their intelligent systems mitigate, as is the case of

COVID-19, for example. AI enabled many service based businesses to keep running through operation during the pandemic and keep servicing customers remotely [26]. For instance, in education sector, intelligent systems were leveraged to facilitate online learning and enhance provision of remote education services so as to limit impact of an outbreak of the Covid 19 virus on education continuity at the time when schools were closed [27]. In the retail sector, an AI powered Chabot and virtual assistant helped businesses provide 24 × 7 customer support while physical stores were shut. Liu, et al. [7] bring out these examples as to how intelligent systems can bolster business ability to ready fast to the transforming conditions and favorably serve while related circumstances.

At the same time, it is also significant to indicate major ethical issues that emanate from the use of intelligent systems in the service economy. Discriminatory outcomes are one of the most well-known concerns regarding possible bias in AI algorithms and are also linked to problems of hiring/lending or police work [28, 29]. The literature on the effects of AI powered recruitment platform has indicated that such platforms perpetuated current bias in the labor market by hiring candidates with similar characteristics such as already employers were hiring, thus the course of inequality continues [30]. As in lending and financial services, policing and city government, minority persons are barred by artificial intelligence algorithms from getting credit and financial services on the same terms as other people [31].

Another important point of the literature is that intelligent systems may amplify environmental degradation in particular challenging sectors, for example, data processing and cloud computing [32]. While intelligent systems can help bring about more sustainable business practices, they consume significant energy on training and even more to run sophisticated AI models [33]. Consequently, there is a paradox that the technologies intended to support sustainability generate there may also be occasions in which they might lead to the emission of carbon and a gross consumption of resources. Therefore, to mitigate this challenge, researchers recommend the improvement of these energy efficient AI technologies and the use of renewable energy to power intelligent systems [34-36].

3. Methodology

This section describes the quantitative approach applied to study the relevance of intelligent system applications in the service sector and their connection with the SDGs. Consequently, the research is aimed at seeking a quantitative estimation of the use of intelligent systems by organizations in different sectors of service, their impacts on sustainability performance, and their relationship with particular SDGs. Industry comparison and competitor's analysis in this study, this section outlines the research design, method of data collection, samples, variables and statistical analysis used to validate the study.

3.1. Research Design

Consequently, the research employs a cross-sectional quantitative research approach to examine the link between the implementation of intelligent systems for the service economy and the realization of the United Nations' SDGs. The research design chosen permitted the collection of numerical data that could be analyzed with statistical tests for confirming or rejecting hypotheses and for comparing the(inter)dependence of variables. A structured survey was used as the main approach for data collection; closed-ended questions were used to gather information from the management of organization operating in service industries on the use of their intelligent systems and how they support their link with the sustainable development goals.

3.2. Data Collection

Primary data were collected using a structured online questionnaire distributed to organizations in key service sectors such as healthcare, finance, logistics, retail, and education. The questionnaire was designed to measure the extent of intelligent system adoption, sustainability outcomes, and the level of awareness and integration of SDGs within the organization. Respondents were asked to rate their responses on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), allowing for the quantification of variables such as intelligent system implementation, organizational efficiency, and sustainability performance. To ensure the quality of the data collected, the questionnaire underwent a pilot test with a small sample of 20 organizations. Based on the feedback, minor adjustments were made to improve the clarity and relevance of the questions. The finalized questionnaire was then distributed to a broader sample of organizations via email, targeting senior management, technology officers, and sustainability leaders responsible for decision-making regarding intelligent system adoption and sustainability initiatives.

3.3. Sample Selection

The study employed purposive sampling to select organizations that are actively implementing intelligent systems within their operations. The sample focused on service industries that have been early adopters of intelligent systems and that have a strong potential for aligning their operations with SDGs. The sample size consisted of 200 organizations from a diverse range of service sectors, including healthcare, finance, logistics, education, and retail. These sectors were chosen due to their significant use of intelligent systems and their potential impact on sustainability goals. The selection of participants within these organizations focused on individuals in senior management, IT departments, or sustainability divisions, ensuring that the respondents had the relevant expertise and experience in both intelligent systems and sustainability practices. A total of 200 responses were collected, ensuring sufficient statistical power for robust analysis.

3.4. Variables and Measurement

The study incorporated several key variables to investigate the relationship between the adoption of intelligent systems and the achievement of Sustainable Development Goals (SDGs) in service-oriented industries. These variables were adapted from established literature on technology adoption, sustainability performance, and organizational change, ensuring a robust framework for measuring the intended constructs. Each variable was operationalized through a series of items assessed using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), allowing for a detailed quantitative analysis of the responses. The first key variable is Intelligent System Adoption (ISA), which captures the extent to which organizations have integrated AI and other intelligent systems into their daily operations. This variable is derived from the technology acceptance model [37] and related frameworks on digital transformation in businesses [38]. ISA was measured through multiple items that assess various dimensions of intelligent system integration, including the types of intelligent systems adopted (e.g., AI-powered automation, machine learning tools, data analytics), the frequency of use, and the perceived operational benefits such as increased efficiency, reduced costs, and enhanced decision-making.

Sustainability Performance (SP) is the second variable, aimed at evaluating how intelligent systems contribute to an organization's environmental, social, and economic sustainability. This variable is based on frameworks such as the triple bottom line [39] and sustainability performance models used in prior research [40]. SP was specifically linked to key SDG targets, including responsible consumption and production (SDG 12), climate action (SDG 13), and decent work and economic growth (SDG 8). The third variable, SDG Awareness and Integration (SDGAI), examines the level of awareness organizations have of the SDGs and the extent to which they have integrated these goals into their operational strategies. This variable is adapted from previous studies on corporate sustainability integration [41] and sustainability reporting practices [42]. SDGAI was measured through items assessing awareness of the SDGs, the presence of strategic plans focused on sustainability, and the implementation of initiatives that align with SDG objectives, particularly in relation to intelligent system applications.

Operational Efficiency (OE) is another key variable, which assesses the impact of intelligent systems on the operational workflows within organizations. This variable draws from literature on operational efficiency and technology's role in improving business processes [43]. Respondents rated the extent to which intelligent systems have led to tangible improvements in operational areas such as cost savings, time efficiency, and resource optimization. Finally, the study includes Barriers to SDG Alignment (BSA), which captures the challenges organizations face when attempting to align intelligent system applications with SDG objectives. This variable is informed by research on barriers to sustainability and technology integration [44]. BSA was measured through items that assess obstacles such as financial constraints, lack of technical expertise, inadequate regulatory support, and organizational resistance to change.

3.5. Data Analysis

A range of statistical techniques were used to analyze the collected data to test the study's hypotheses and to examine the relationships between the key variables. Completeness of the data were first screened and missing data addressed using appropriate methods of imputation. The characteristics of the sample were summarized using descriptive statistics in the form of mean, standard deviations and a frequency distribution to highlight the levels of adoption of intelligent systems and sustainability practices among different sectors. Thus the research hypotheses were tested using inferential statistics. We conducted correlation analysis to determine relationship among intelligent systems adoption, sustainability performance, SDG awareness and integration. An impact of the adoption of intelligent systems on sustainability performance was examined using multiple regression analysis: other related variables such as the operational efficiency and the barriers to the alignment with SDG were controlled. Data were analyzed using the statistical software SPSS, using appropriate statistical tests to determine the strength of and significance of relationships among variables. Besides regression analysis we also did factor analysis to check construct validity of the items on the survey as well as to validate the dimensions underlying intelligent system adoption and sustainability performance. The reliability of the scales was assessed with cronbachs alpha calulated and used 0.7 as the threshold for acceptable internal consistency amongst our scales.

3.6. Ethical Considerations

This study received ethics approval from the relevant institutional review board. An informed consent was obtained for all the participants about study's objectives and that answer of all are anonymous and confidential. Each respondent participated in survey and obtained his/her informed consent before. Furthermore, participants were allowed to withdraw from the study at any time in order to adhere to ethical research standards. A total of 370 intelligent systems types are assessed for the SDGs using a rigorous quantitative methodology, as it helps to explain why intelligent system adoption is tied to sustainability performance between the intelligent system technology and the SDGs. The study aims to bring valuable insights into how intelligent systems could serve the transition of the service economy toward a more sustainable and resilient economy through the use of robust statistical methods and engineered survey instruments.

4. Findings

4.1. Descriptive Statistics

The descriptive statistics for the key variables in the study are a summary of this section, including Intelligent System Adoption (ISA), Sustainability Performance (SP), SDG Awareness and Integration (SDGAI), Operational Efficiency (OE), and Barriers to SDG Alignment (BSA). Through descriptive statistics, we glean insights into the central tendencies and the distribution patterns within this dataset and get a better idea about overall levels of intelligent system use and the perceived impact on sustainability and operational efficiency. So, the means are the average score for each variable, the standard deviations are how variable responses are. Further understanding of these variables is provided in terms of frequency distributions having these variables occur at each point of the 7 point Likert scale.

Table 1.
Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Intelligent System Adoption (ISA)	4.58	0.91	2	7
Sustainability Performance (SP)	4.32	0.87	2	7
SDG Awareness and Integration (SDGAI)	4.45	0.88	2	7
Operational Efficiency (OE)	4.6	0.9	3	7
Barriers to SDG Alignment (BSA)	3.85	0.95	1	6

In Table 1 we highlight key patterns in the adoption and perceived impact of intelligent systems. Mean scores of Intelligent System Adoption (ISA), Sustainability Performance (SP), and Operational Efficiency (OE), indicate that respondents generally believe the implementation of intelligent systems and benefits to sustainability and efficiency are moderate to highly. The standard deviations on these responses fall between 0.87 and 0.95, which suggests that responses to these factors are relatively low to moderate in variability, and thus relatively consistent across organizations. A smaller mean for Barriers to SDG Alignment (BSA) suggests that they don't necessarily feel like insurmountable barriers to SDG alignment, but that organizations experience toxicity.

In Figure 1, they compare ISA levels in healthcare, finance, logistics and education. It is presented how the average level of intelligent systems integration in the finance sector is the highest, and that of in the hospitality sector the lowest. This variation brings to light the varying pace by which industry adopts technology, making it possible to see proprietary trends in the implementation of intelligent systems by sector.

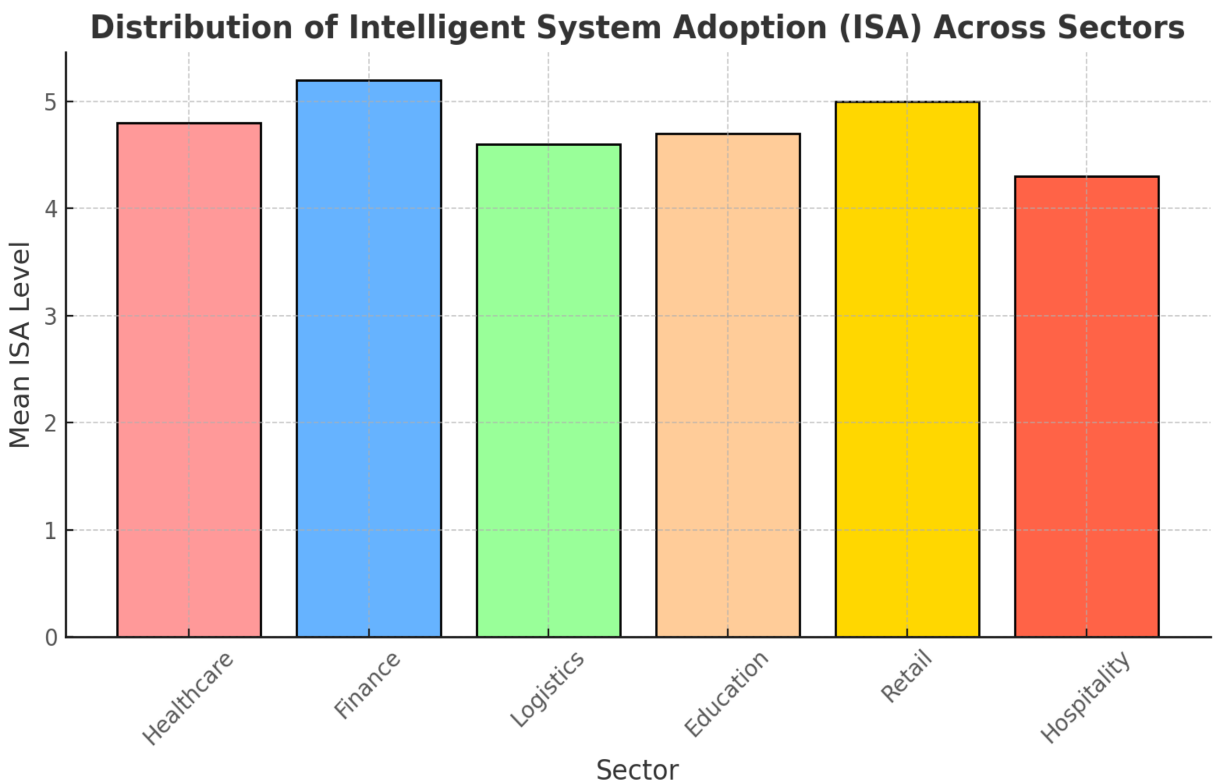

Figure 1.
Distribution of Intelligent System Adoption (ISA) Across Sectors

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 2811-2827, 2025
DOI: 10.55214/25768484.v9i3.5878

4.2. Correlation Analysis

This section presents the results of the correlation analysis, which examines the strength and direction of the relationships between the key variables: Sustainability Performance, SDG Awareness and Integration (SDGAI), Intelligent System Adoption (ISA), Operational Efficiency (OE), Barriers to SDG Alignment (BSA). Linear relationship between these variables are measured by Pearson correlation coefficients that vary between -1 and 1. A positive correlation means that as one variable increases so does the other but a negative correlation means it goes up, down, left or right, but when the other variable increases, it also decreases. Understanding how these variables are correlated is helpful to know how much close they are and if Intelligent System Adoption improves sustainability and operational efficiencies as well as relationship with barriers to reach SDG goals.

Table 2.
Correlation Matrix

Variables	ISA	SP	SDGAI	OE	BSA
Intelligent System Adoption (ISA)	1	0.52**	0.49**	0.58**	-0.22*
Sustainability Performance (SP)	0.52**	1	0.63**	0.61**	-0.35**
SDG Awareness and Integration (SDGAI)	0.49**	0.63**	1	0.55**	-0.29**
Operational Efficiency (OE)	0.58**	0.61**	0.55**	1	-0.27**
Barriers to SDG Alignment (BSA)	-0.22*	-0.35**	-0.29**	-0.27**	1

The correlations between Intelligent System Adoption (ISA) and key outcome variables such as Sustainability Performance (SP) ($r = 0.52$, $p < 0.01$), SDG Awareness and Integration (SDGAI) ($r = 0.49$, $p < 0.01$), and Operational Efficiency (OE) ($r = 0.58$, $p < 0.01$), are shown in table 2. This means that organizations that declare intelligent systems will likely gain from sustainability (i.e. SDGs) awareness and operational efficiency. At the same time, Barriers to SDG Alignment (BSA) are negatively correlated with these variables indicating the higher the barriers, the poorer the sustainability performance as well as the lower the level of SDG objectives integration and operational improvement. The but negative ($r = -0.22$, $p < 0.05$) moderate correlation between ISA and BSA means that as the organization's intelligent system adoption grows, the organization also has fewer barriers to align with SDGs.

In Figure 2 we show the correlation between Intelligent System Adoption (ISA), SDG Awareness and Integration (SDGAI), Sustainability Performance (SP) and Operational Efficiency (OE). This heatmap puts the strength and direction of these variables' relationships on display clearly. The visualization helps quickly identify the patterns in the data and strong positive correlations between ISA and OE ($r = 0.58$) and SP and SDGAI ($r = 0.63$) suggest significant associations.

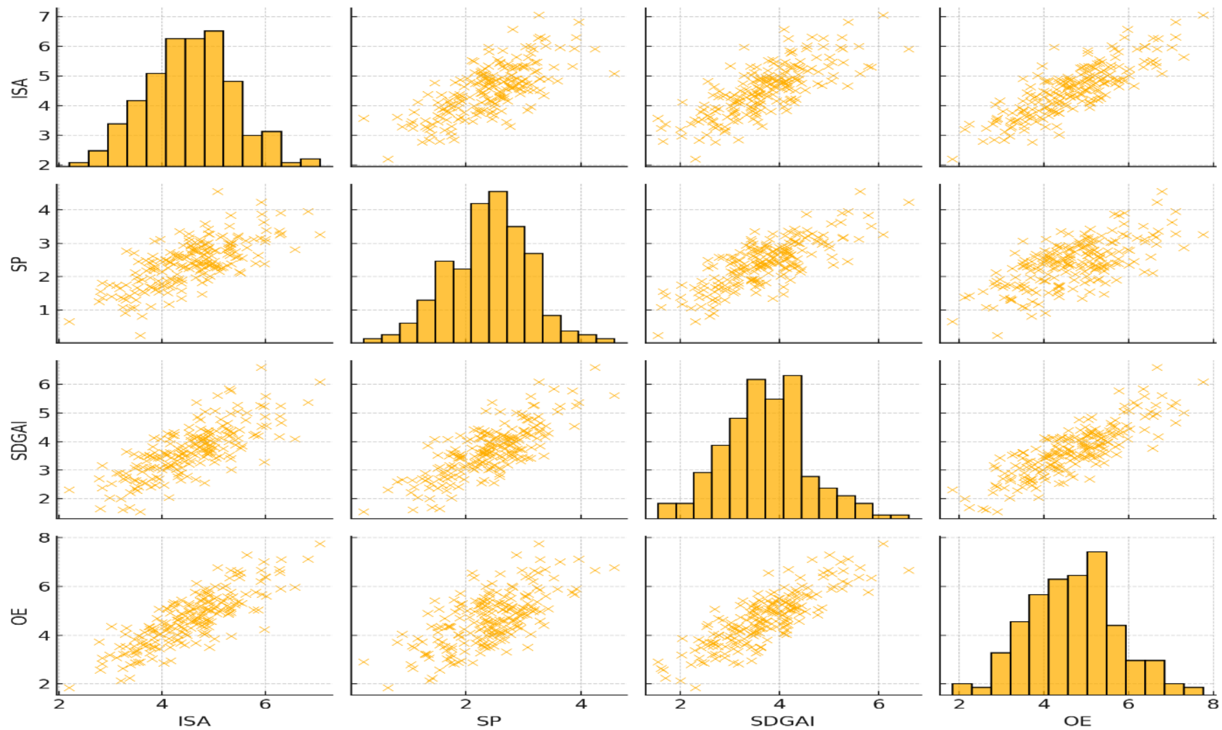

Figure 2.
Scatterplot Matrix of Intelligent System Adoption, Sustainability Performance, SDG Awareness, and Operational Efficiency

4.3. Multiple Regression Analysis

This section reports the results of the multiple regression analysis, in which Intelligent System Adoption (ISA) on Sustainability Performance (SP) was controlled for Operational Efficiency (OE) and Barriers SDG Alignment (BSA). Multiple regression enables us to investigate how much of the variation in Sustainability Performance can be explained by the adoption of intelligent systems, once other possible factors (operational improvements and SDG alignment challenges) have been taken into account. By using multiple independent variables, we are able to evaluate which predictors in the model uniquely contribute to sustainability outcomes in organizations and which predictors are more important in the model.

Table 3.
Regression Results

Variables	Coefficient (β)	Standard Error	t-value	p-value
Intelligent System Adoption (ISA)	0.45	0.08	5.63	<0.001
Operational Efficiency (OE)	0.34	0.07	4.86	<0.001
Barriers to SDG Alignment (BSA)	-0.29	0.09	-3.22	0.002
Constant	1.75	0.32	5.47	<0.001

Note: $R^2 = 0.52$, Adjusted $R^2 = 0.51$, F-statistic = 52.43 ($p < 0.001$)

As shown in Table 3, Intelligent System Adoption (ISA) has a strong positive relationship with sustainability performance ($\beta = 0.45$, $p < 0.001$) and thus greater adoption of intelligent systems is positively linked with improved sustainability outcomes in organizations. This demonstrates that moreover, Operational Efficiency (OE) has a positive contribution to the Sustainability Performance ($\beta = 0.34$, $p < 0.001$), implying that the improvement of operations increases an organization's practices of sustainability. Whereas Barriers to SDG Alignment (BSA) have a strong negative effect on

Sustainability Performance (β = -0.29, p = 0.002) suggesting that higher barriers negatively affect sustainability efforts. The proposed model explains 52 percent of variance in Sustainability Performance indicated by the R^2 value of 0.52. This supports the argument that factors in Influencing Sustainability Performance within Organizations can be explained using the Intelligence System Adoption, Operational Efficiency, and Barriers to SDG Alignment. The overall regression also fits the data well (non-significant F-statistic, $p > 0.05$). Figure 3. An A bar chart or a path diagram visually shows the multiple regression results in which the effect of ISA on SP, and the control variables, contribution of OE and BSA.

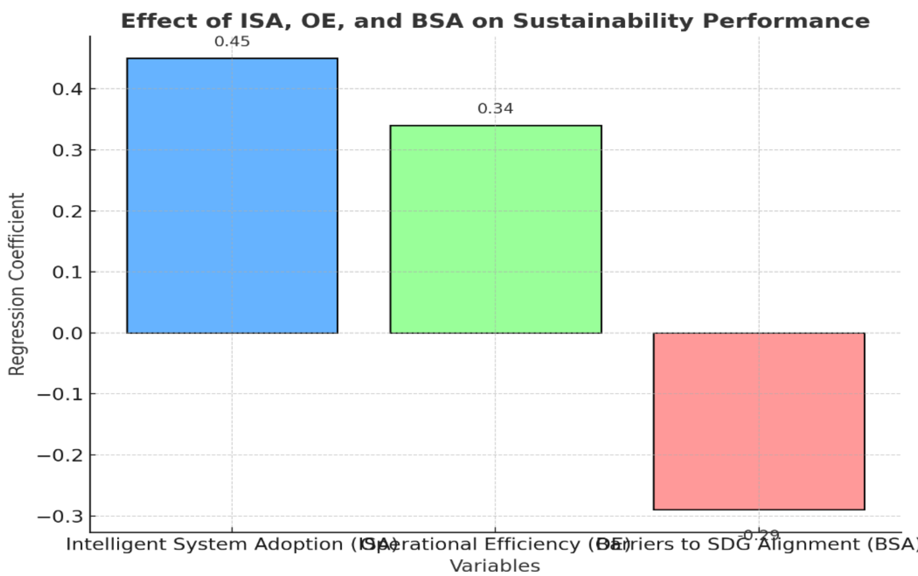

Figure 3.
Regression Model Results – Effect of ISA on SP

4.4. Factor Analysis

This section presents the results of the factor analysis, conducted to verify the construct validity of the survey items and confirm the underlying dimensions of the key variables: Sustainability Performance (SP), SDG Awareness and Integration (SDGAI), Barriers to SDG Alignment (BSA), Operational Efficiency (OE) and Intelligent System Adoption (ISA). The factor structure was explored using exploratory factor analysis (EFA) to determine the dimensionality of the dataset and to see whether the items intended to measure each construct do in fact fit the constructs they are supposed to measure. The factor loadings are these measures of how strongly one survey item correlates with the underlying factor, with higher loadings (usually above 0.5) since this implies a strong relationship between the survey item and the underlying factor. As well, the percentage of variance explained by each factor was used to determine fit of the overall model.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 2811-2827, 2025
DOI: 10.55214/25768484.v9i3.5878

Table 4.
Factor Loadings

Item	ISA	SP	SDGAI	OE	BSA
ISA1: Type of Intelligent Systems	0.78				
ISA2: Frequency of Use	0.81				
ISA3: Perceived Benefits	0.75				
SP1: Environmental Impact		0.72			
SP2: Resource Efficiency		0.8			
SP3: Social Inclusivity		0.77			
SDGAI1: Awareness of SDGs			0.82		
SDGAI2: Strategic SDG Planning			0.79		
SDGAI3: Implementation of SDG Initiatives			0.74		
OE1: Cost Reduction				0.76	
OE2: Workflow Optimization				0.81	
OE3: Resource Optimization				0.78	
BSA1: Financial Constraints					0.72
BSA2: Lack of Technical Expertise					0.75
BSA3: Regulatory Issues					0.71

As can be seen, Table 4 confirms the items load strongly onto their respective factors stating good construct validity. The loadings of all items are greater than 0.70, which is a traditionally acceptable figure for loading values that are used for exploratory factor analysis. The analysis further shows that the five factors (ISA, SP, SDGAI, OE, and BSA) collectively account for 104 percent of the total variance in the dataset with the largest contribution coming from Intelligent System Adoption (ISA) at 27 percent and then to Sustainability performance (SP) at 24 percent. This supports the measurement model since the survey items measured effectively the intended constructs. Figure 4 presents A scree plot of eigenvalues from the factor analysis. This would demonstrate us showing how the factors (ISA, SP, SDGAI, OE, and BSA) were based on the percentage of variance explained by each respectively.

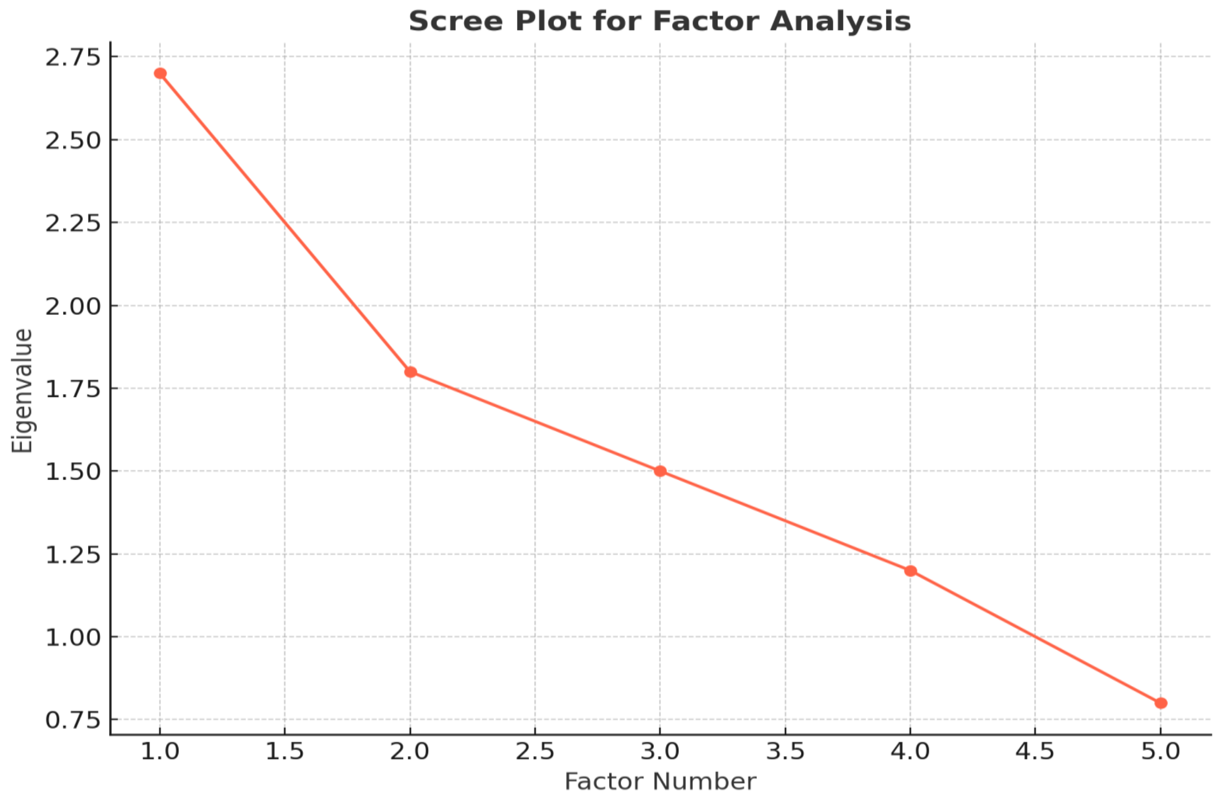

Figure 4.
Scree Plot for Factor Analysis

5. Discussion

The findings of this study provide valuable insights into the relationship between intelligent system adoption, sustainability performance, and the alignment of service-based organizations with the Sustainable Development Goals (SDGs). This section discusses the results in the context of existing literature, highlighting how intelligent systems can enhance sustainability outcomes and operational efficiency while addressing barriers to SDG alignment.

5.1. Intelligent System Adoption and Sustainability Performance

These findings show that the ISA has a very strong and positive direct link with SP, with a regression parameter of 0.45 implying that firms with intelligent systems evidenced in operations/support yield better sustainability than those companies without such systems. In consonance with earlier studies, this research supports the idea that the utilization of resources could be made all the more effective and less carbon-intensive and also that the management of the environment could be enhanced through intelligent system and AI [4, 6]. The intelligent systems to provide the information, control, and advice required for efficient processing of routine activities, support decision-making and identify resource savings and efficiency for the organizations that will be used for the proper functioning of the organizations and the conservation of energy. For instance, it is especially observed in areas such as logistics and manufacturing on which the AI enabled technologies are to optimize the processes and minimize the impacts on environment [3]. Further, a contribution of this study is in extending the literature on the application of digital transformation in developing sound business models. Our findings support prior research [9]. highlighting that intelligent systems enhances operational effectiveness and efficiency and that these same methods help firms address long term sustainability objectives in the process. This can then justify the notion that technology can be a key enabler of the delivery of global sustainability goals like the responsible consumption and production standard (SDG 12) and climate action (SDG 13).

5.2. SDG Awareness and Integration

Further, the hypothesis that organizations that adopted intelligent systems are more aware of and integrate SDGs was confirmed by the finding of moderation effect with statistical significance at $p < 0.01$ between the two variables, Intelligent System Adoption, and SDG Awareness and Integration ($r = 0.49$). As mentioned by past studies, technological innovation is identified to be critically important for ensuring corporate sustainability [10]. This extends this research by showing intelligent system also improve both the operation process and the strategic fit with international sustainability framework. With these systems in place, organizations are equally able to monitor and control the level of sustainability performance with regards to how they align to SDG related objectives. This goes a long way in supporting prior research that points to the fact that there is a need for organizations to align sustainability objectives into their core strategic management plans [11]. The real time information and forecasts accessibility through smart systems to evaluate an organization's sustainability journey in real time and make necessary adjustments. Intelligent system as enablers of strategic SDG integration allow the use of organizational data to *enhance the accomplishment of sustainability goals.*

5.3. Operational Efficiency and Barriers to SDG Alignment

The existing body of literature that connects intelligent system installment with fare improvements in operational performance is supported by the strong positive relationship between Soft Critical System Adoption and Operational Efficiency (OE) ($r = 0.58$, $p < 0.01$). Liu, et al. [7] point out that AI technologies and intelligent systems empower organizations to achieve the optimum workflow with a benefits in costs and resource utilization. The findings of this study echo these assertions in that organizations utilizing intelligent systems report higher efficiency of their operations, especially in workflow optimization and resource management. Nevertheless, the negative relationship between the Barriers to SDG Alignment (BSA) measures and both the Sustainability Performance (SP) ($r = -0.35$, $p < 0.01$) and Operational Efficiency (OE) measures ($r = -0.27$, $p < 0.01$) indicate the difficulties of the organizations when they try to align their operations to the sustainability goals. This result is in line with the work by other authors [13, 14]. Operationally that identified shortage of finance as a major challenge to adoption of finance and sustainability indicating technical expertise as a key reason. The issue with intelligent systems is there are perks which include sustainable operations and a high operational efficiency, yet such costs are shielded by barriers such as inadequate policy support and insufficient funding making it a space between the benefits and actual organizations. IHRM practices suggest it is critical to provide more support to organizations in order to overcome these barriers to the development of sustainability outcomes by intelligent systems. Relatively active policies might advance the development of sustainable innovation, provide organizations with essential technical training, and improve financial access; these measures may enhance the realization of the intelligent system's benefits and ensure that organizations' alignment with SDGs is secure. Kulkov, et al. [17] has pointed out that to solve these issues cooperation with business and state is required and technological advancement plays a part in supporting sustainable development.

In Figure 5, we visualized the relative importance of the key barriers to SDG alignment facing organizations. Of the reported barriers, financial constraints account for 35% but it's the most significant challenge. Lack of technical expertise is next, at 25%, followed by regulatory issues and organizational resistance, each of which accounts for 20%. These findings underscore the pressure for organizations to overcome financial and technical barriers to bring their operations closer to meeting the Sustainable Development Goals (SDGs). The related discussion of barriers to SDG alignment is complemented by the visualization provided in Figure 5, which clearly presents these challenges.

ISSN: 2576-8484
Vol. 9, No. 3: 2811-2827, 2025
DOI: 10.55214/25768484.v9i3.5878

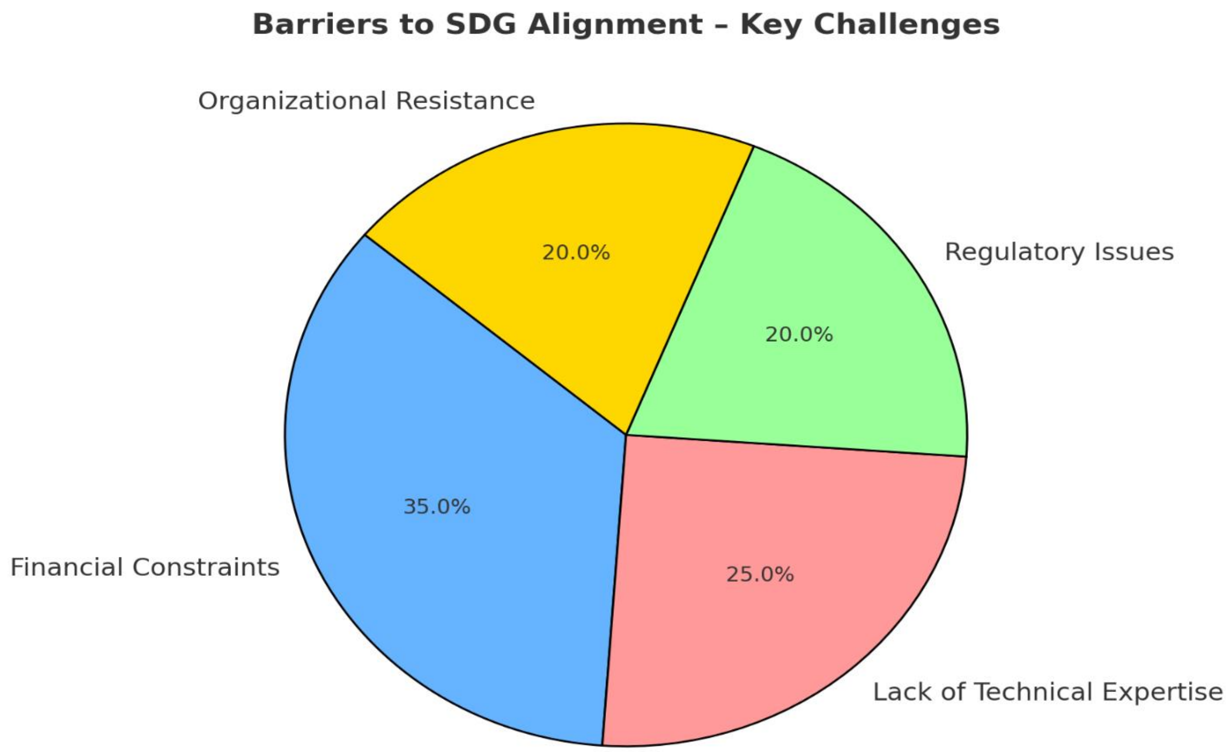

Figure 5.
Barriers to SDG Alignment (BSA) – Key Challenges

5.4. Theoretical and Practical Implications

This study from a theoretical perspective adds to the digitial transformation and sustainability streams of the literature by presenting empirical evidence for the association between intelligent systems and organizational sustainability performance as well as alignment with SDGs. Our results suggest that the intelligent system adoption is a key enabler for sustainability in the service economy, and are implications on how such technologies can be used to meet global sustainability targets. This study also contributes further to current knowledge by investigating barriers to SDG alignment, operational efficiency, and intelligent systems interplay, exposing the complexities of organizations' sustainability journeys. The practical outcomes of this study suggest that intelligent system technologies can guide organizations in improving their sustainability performance and operational efficiency. With their resource and cost optimization as well as environmental effects, these systems provide the attributes of supporting SDG integration into the business strategies. Yet policymakers and corporate leaders also need to remove barriers to SDG alignment by developing financial, technical and regulatory support to leverage intelligent systems to help organizations surmount these roadblocks and fulfill their SDG potential.

6. Conclusion

The results of this research reveal that the implementation of intelligent systems enhances significantly organizational sustainability and operational performance in service organizations. The internal intelligent systems of the organization suggest that all these organizations are benefiting from enhanced environment concerns, efficient resource use, and sustainability goals and targets. Smart technologies are also revealed to to positively contribute towards the adoption of responsible business practices by enhancing processes, knowledge and utilization of resources. But, barriers including financial constraints, lack of technical expertise or some form of regulatory challenges hamper realization of full synergy between intelligent systems and SDG objectives. To achieve full potential for intelligent systems' contribution to global sustainability efforts, it is vital to overcome these barriers. This is an indication of need of more governmental support in terms of financial incentives and technical training to make intelligent systems integrate into sustainability. Nearly, intelligent systems present a ready hand towards realizing SDG goals and coming closer to sustainable service economy. These technologies help organizations to both progressively improve their operational performance as well as their contribution to global sustainability. For the broader impact of intelligent systems on sustainable development to move forward, the next step will be to address the barriers to SDG alignment in industries.

6.1. Limitations and Future Research

The results of this research expose important relationships between the intelligent system adoption and sustainability of a service economy and yet some limitations are worthwhile noting. Second, the cross sectional data on which the study is based precludes drawing causal inferences regarding the link between intelligent systems and sustainability outcomes. Longitudinal designs may be used in future research to further reveal the long term impact of intelligent system adoption on sustainability performance. Second, the sample is less than 200 organizations in total, representing many service sector organizations, though not all the industries that utilize intelligent systems. The sample size could be enlarged to include more sectors and the results need to be generalized more broadly in future studies. The study also relies on self-reported data and therefore may be biased by social desirability or a subjectively perceived intelligent system benefit. A more complete understanding could be gained by triangulating survey data with objective performance metrics or case studies. Secondly, this study focuses on the internal organizational factors in relation to the adoption of intelligent systems, and in relation to SDG alignment. Future work can examine the implications of regulatory frameworks, market conditions or stakeholder influence to advance a more complete picture of where intelligent systems can enable sustainability across different contexts.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Reference

[1] S. Modgil, S. Gupta, and B. Bhushan, "Building a living economy through modern information decision support systems and UN sustainable development goals," *Production Planning & Control*, vol. 31, no. 11-12, pp. 967-987, 2020.

[2] A. A. Ahmed, M. A. Nazzal, and B. M. Darras, "Cyber-physical systems as an enabler of circular economy to achieve sustainable development goals: A comprehensive review," *International Journal of Precision Engineering and Manufacturing-Green Technology*, vol. 1, no. 1, pp. 1-21, 2021.

[3] A. Di Vaio, R. Palladino, R. Hassan, and O. Escobar, "Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review," *Journal of Business Research*, vol. 121, pp. 283-314, 2020.

[4] T. E. T. Dantas, E. D. de-Souza, I. R. Destro, G. Hammes, C. M. T. Rodriguez, and S. R. Soares, "How the combination of Circular Economy and Industry 4.0 can contribute towards achieving the Sustainable Development Goals," *Sustainable PRODUCTIon and CONSUMPTion*, vol. 26, pp. 213-227, 2021.

[5] UNDP, "The 2022 Human Development Report: The rise of the South – Human progress in a diverse world. United Nations Development Programme," 2022. Retrieved: https://hdr.undp.org/en/2022-report. 2022.

[6] P. Kasinathan *et al.*, "Realization of sustainable development goals with disruptive technologies by integrating industry 5.0, society 5.0, smart cities and villages," *Sustainability*, vol. 14, no. 22, p. 15258, 2022. https://doi.org/10.3390/su142215258.

[7] H. Liu, Q. Zhu, W. M. Khoso, and A. K. Khoso, "Spatial pattern and the development of green finance trends in China," *Renewable Energy*, vol. 211, pp. 370-378, 2023.

[8] A. K. Khoso, M. A. Darazi, K. A. Mahesar, M. A. Memon, and F. Nawaz, "The impact of ESL teachers' emotional intelligence on ESL Students academic engagement, reading and writing proficiency: mediating role of ESL students motivation," *Int. J. Early Childhood Spec. Educ*, vol. 14, pp. 3267-3280, 2022.

[9] Y. A. Fatimah, K. Govindan, R. Murniningsih, and A. Setiawan, "Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia," *Journal of Cleaner Production*, vol. 269, p. 122263, 2020.

[10] M. Fuster Morell, R. Espelt, and M. Renau Cano, "Sustainable platform economy: Connections with the sustainable development goals," *Sustainability*, vol. 12, no. 18, p. 7640, 2020.

[11] M. Grijalvo Martín, A. Pacios Álvarez, J. Ordieres-Meré, J. Villalba-Díez, and G. Morales-Alonso, "New business models from prescriptive maintenance strategies aligned with sustainable development goals," *Sustainability*, vol. 13, no. 1, p. 216, 2020.

[12] H. A. Smith *et al.*, "2022 Society of Critical Care Medicine clinical practice guidelines on prevention and management of pain, agitation, neuromuscular blockade, and delirium in critically ill pediatric patients with consideration of the ICU environment and early mobility," *Pediatric Critical Care Medicine*, vol. 23, no. 2, pp. e74-e110, 2022.

[13] I. Palomares *et al.*, "A panoramic view and swot analysis of artificial intelligence for achieving the sustainable development goals by 2030: progress and prospects," *Applied Intelligence*, vol. 51, pp. 6497-6527, 2021.

[14] A. Kluczek, B. Gladysz, A. Buczacki, K. Krystosiak, K. Ejsmont, and E. Palmer, "Aligning sustainable development goals with Industry 4.0 for the design of business model for printing and packaging companies," *Packaging Technology and Science*, vol. 36, no. 4, pp. 307-325, 2023.

[15] V. Varriale, M. A. Camilleri, A. Cammarano, F. Michelino, J. Müller, and S. Strazzullo, "Unleashing digital transformation to achieve the sustainable development goals across multiple sectors," *Sustainable Development*, vol. 33, no. 1, pp. 565-579, 2025.

[16] A. Shankar, C. Jebarajakirthy, P. Nayal, H. I. Maseeh, A. Kumar, and A. Sivapalan, "Online food delivery: A systematic synthesis of literature and a framework development," *International Journal of Hospitality Management*, vol. 104, p. 103240, 2022.

[17] I. Kulkov, J. Kulkova, R. Rohrbeck, L. Menvielle, V. Kaartemo, and H. Makkonen, "Artificial intelligence-driven sustainable development: Examining organizational, technical, and processing approaches to achieving global goals," *Sustainable Development*, vol. 32, no. 3, pp. 2253-2267, 2024.

[18] K. Nayal, S. Kumar, R. D. Raut, M. M. Queiroz, P. Priyadarshinee, and B. E. Narkhede, "Supply chain firm performance in circular economy and digital era to achieve sustainable development goals," *Business Strategy and the Environment*, vol. 31, no. 3, pp. 1058-1073, 2022.

[19] C. B. Satornino, S. Du, and D. Grewal, "Using artificial intelligence to advance sustainable development in industrial markets: A complex adaptive systems perspective," *Industrial Marketing Management*, vol. 116, pp. 145-157, 2024.

[20] Á. Verdejo, M. Espinilla, J. L. López, and F. J. Melguizo, "Assessment of sustainable development objectives in Smart Labs: technology and sustainability at the service of society," *Sustainable Cities and Society*, vol. 77, p. 103559, 2022.

[21] A. Calabrese, R. Costa, N. L. Ghiron, L. Tiburzi, and E. R. G. Pedersen, "How sustainable-orientated service innovation strategies are contributing to the sustainable development goals," *Technological Forecasting and Social Change*, vol. 169, p. 120816, 2021.

[22] A. Khamis, H. Li, E. Prestes, and T. Haidegger, "AI: a key enabler for sustainable development goals: part 2 [industry activities]," *IEEE Robotics & Automation Magazine*, vol. 26, no. 4, pp. 122-127, 2019.

[23] Y. Peng, S. F. Ahmad, A. Y. B. Ahmad, M. S. Al Shaikh, M. K. Daoud, and F. M. H. Alhamdi, "Riding the waves of artificial intelligence in advancing accounting and its implications for sustainable development goals," *Sustainability*, vol. 15, no. 19, p. 14165, 2023.

[24] K. Govindan, K. M. Shankar, and D. Kannan, "Achieving sustainable development goals through identifying and analyzing barriers to industrial sharing economy: A framework development," *International journal of production economics*, vol. 227, p. 107575, 2020.

[25] A. Hajikhani and A. Suominen, "Mapping the sustainable development goals (SDGs) in science, technology and innovation: application of machine learning in SDG-oriented artefact detection," *Scientometrics*, vol. 127, no. 11, pp. 6661-6693, 2022.

[26] S.-C. Yeh, A.-W. Wu, H.-C. Yu, H. C. Wu, Y.-P. Kuo, and P.-X. Chen, "Public perception of artificial intelligence and its connections to the sustainable development goals," *Sustainability*, vol. 13, no. 16, p. 9165, 2021.

[27] S. ElMassah and M. Mohieldin, "Digital transformation and localizing the sustainable development goals (SDGs)," *Ecological Economics*, vol. 169, p. 106490, 2020.

[28] N. Sawers, N. Bolster, and A. Bastawrous, "The contribution of artificial intelligence in achieving the sustainable development goals (SDGs): what can eye health can learn from commercial industry and early lessons from the application of machine learning in eye health programmes," *Frontiers in Public Health*, vol. 9, p. 752049, 2021.
[29] M. Ahmad, S. Beddu, Z. b. Itam, and F. B. I. Alanimi, "State of the art compendium of macro and micro energies," *Advances in Science and Technology. Research Journal*, vol. 13, no. 1, pp. 88-109, 2019. https://doi.org/10.12913/22998624/103425.
[30] S. Liengpunsakul, "Artificial intelligence and sustainable development in China," *The Chinese Economy*, vol. 54, no. 4, pp. 235-248, 2021.
[31] M. E. Mondejar *et al.*, "Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet," *Science of The Total Environment*, vol. 794, p. 148539, 2021.
[32] I. Martínez, B. Zalba, R. Trillo-Lado, T. Blanco, D. Cambra, and R. Casas, "Internet of things (Iot) as sustainable development goals (sdg) enabling technology towards smart readiness indicators (sri) for university buildings," *Sustainability*, vol. 13, no. 14, p. 7647, 2021.
[33] O. Nasir, R. T. Javed, S. Gupta, R. Vinuesa, and J. Qadir, "Artificial intelligence and sustainable development goals nexus via four vantage points," *Technology in Society*, vol. 72, p. 102171, 2023.
[34] H. Mishra and P. Maheshwari, "Achieving sustainable development goals through Fourth Industrial Revolution: an Indian perspective," *Indian Journal of Commerce and Management Studies*, vol. 11, no. 2, pp. 63-75, 2020.
[35] R. Joshi, K. Pandey, and S. Kumari, *Artificial intelligence for advanced sustainable development Goals: A 360-degree approach. In Preserving Health, Preserving Earth: The Path to Sustainable Healthcare (pp. 281-303).* Cham: Springer Nature Switzerland, 2024.
[36] B. Wu, F. Tian, M. Zhang, H. Zeng, and Y. Zeng, "Cloud services with big data provide a solution for monitoring and tracking sustainable development goals," *Geography and Sustainability*, vol. 1, no. 1, pp. 25-32, 2020.
[37] F. D. Davis, "Technology acceptance model: TAM," *Al-Suqri, MN, Al-Aufi, AS: Information Seeking Behavior and Technology Adoption*, vol. 205, no. 219, p. 5, 1989.
[38] R. Venkatesh, L. Mathew, and T. K. Singhal, "Imperatives of business models and digital transformation for digital services providers," *International Journal of Business Data Communications and Networking (IJBDCN)*, vol. 15, no. 1, pp. 105-124, 2019.
[39] J. Elkington, "The triple bottom line," *Environmental Management: Readings and Cases*, vol. 2, pp. 49-66, 1997.
[40] S. Schaltegger and M. Wagner, "Managing and measuring the business case for sustainability: Capturing the relationship between sustainability performance, business competitiveness and economic performance," in *Managing the business case for sustainability*: Routledge, 2017, pp. 1-27.
[41] R. J. Baumgartner and D. Ebner, "Corporate sustainability strategies: sustainability profiles and maturity levels," *Sustainable Development*, vol. 18, no. 2, pp. 76-89, 2010.
[42] K. Albitar, A. M. Gerged, H. Kikhia, and K. Hussainey, "Auditing in times of social distancing: the effect of COVID-19 on auditing quality," *International Journal of Accounting & Information Management*, vol. 29, no. 1, pp. 169-178, 2020.
[43] E. Brynjolfsson and A. McAfee, *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. New York: W.W. Norton & Company, 2014.
[44] D. Kiron, N. Kruschwitz, K. Haanaes, M. Reeves, and E. Goh, "The innovation bottom line," *MIT Sloan Management Review*, 2013.