LEX LOCALIS-JOURNAL OF LOCAL SELF-GOVERNMENT
ISSN:1581-5374 E-ISSN:1855-363X
VOL. 23, NO. 11(2025)

START-UPS IN THE ERA OF ARTIFICIAL INTELLIGENCE: TOWARDS SMARTER AND MORE INNOVATIVE BUSINESS PERFORMANCE

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Abstract
The study aims to analyze the impact of artificial intelligence components—such as machine learning, software engineering, and data analytics—on business intelligence elements including decision-making, human resources, and information systems, with a focus on startups that drive economic growth. The research gap centers on the lack of applied studies examining the relationship between artificial intelligence and business intelligence within the Algerian context, particularly regarding the integrated effect of these advanced technologies on institutional performance in startups. To address this gap, the study employed a quantitative methodology by designing a questionnaire distributed to a random sample of 345 startups in Algeria, with data analyzed using Smart PLS 4 software. The results revealed statistically significant positive effects of artificial intelligence components on business intelligence elements in Algerian startups, with varying effects from weak to moderate. Additionally, a strong and positive overall impact of artificial intelligence on business intelligence was confirmed with a value of 0.863, indicating a significant and robust relationship and the importance of AI in enhancing business intelligence performance in startups. The study recommends increasing investments in technical staff training, improving data infrastructure and information systems, and adopting comprehensive digital transformation strategies in startups. It also emphasizes the importance of future research focusing on the long-term impact of AI technologies across multiple sectors of the national economy to ensure sustainable development and foster innovation in the modern business environment**.**

Keywords: Artificial intelligence; Business intelligence; Machine learning; Software engineering; Data analytics; Decision-making; Human resources; Information systems.

1. Introduction

In recent years, the world has witnessed a revolution in the field of artificial intelligence, which has manifested its impact across most areas of life. Artificial intelligence plays a fundamental role in advancing progress, growth, and prosperity in the coming years. Researchers focus on both theory and application to develop systems that exhibit intelligent characteristics in human behavior, such as perception, problem-solving, planning, learning,

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adapting, acquiring knowledge, and interacting with the environment (Gheorghe, 2012, p. 2). Artificial intelligence holds great importance in organizing all aspects of political, economic, and cultural life, as it consists of autonomous programs capable of performing applications and solving problems independently, including skills like thinking, decision-making, and motivation based on self-determined principles (Havrda&Klocek, 2021, p. 2). It also refers to the ability of machines to imitate intelligent human behavior, including problem-solving and learning, which relates to the computer science field that studies how information systems learn, understand, and perceive (Mariani& al, 2023, pp. 1-2)(MILI & et al, 2025, p. p5). Researchers design and study intelligent agents that perceive their environment and take actions to enhance their chances of success (Bansla&Bansla, 2012, p. 1). As a critical part of decision-making processes in numerous fields, artificial intelligence rapidly reshapes the technological landscape and transforms many aspects of human life (Jennifer & Tamara, 2021, p. 11). It also contributes to transforming the business ecosystem and generating significant economic opportunities (Vijay Kumar & Harish, p. 1). Most institutions have shifted their trends from traditional management to modern administrations distinguished by technology use, employing artificial intelligence techniques and methods that substantially develop these institutions (Luo, 2018, p. 90). Furthermore, artificial intelligence in business has the ability to analyze problems precisely, confront them, and provide appropriate information depending on the situation to achieve high outcomes (Zhao & all, 2019, p. 45). Additionally, organizations can deploy artificial intelligence through applications available in all departments where tasks and inquiries are distributed via AI, which works to minimize errors to the lowest level, ensure speed and accuracy in accomplishing high-quality work, overcome difficulties, and monitor workflow (Hearst & Hirsh, 2017, p. 16).

The main problem of this study lies in exploring the impact of applying artificial intelligence (AI) technologies on enhancing business intelligence in startups in Algeria. The study aims to understand the extent to which AI contributes to developing institutional performance and improving decision-making processes. From this main problem, several sub-questions arise, focusing on the effect of machine learning on the decision-making process, the role of software engineering in improving human resource performance through AI applications, and the relationship between AI-supported data analytics and information systems within institutions. The study also investigates AI's impact on the quality and efficiency of decision support systems in the context of business intelligence, as well as how integrating these technologies increases institutional productivity and strengthens competitiveness. These questions reflect a keen interest in understanding AI's multifaceted effects, particularly its direct influence on various components of business intelligence. This opens the door to evaluating the effectiveness of intelligent systems in enhancing the performance of startups and achieving sustainable competitive advantages in today’s dynamic business environment..

2. Literature Review

Artificial intelligence (AI) refers to a well-known and reliable technology that enables machines (intelligent computer systems) to simulate human behavior and automatically solve problems (Albaity& all, 2023, p. 1). This technology achieves this by simulating cognitive functions related to human minds (Kok& al, 2009, p. 2). AI encompasses all mental processes, including creativity, motor control, sensory perception, and emotions (Blanchard, 2006, p. 4). It ranks among the most important technologies due to its significant technological breakthroughs (Korneeva& al, 2023, p. 1), such as generating new knowledge, tools, and ideas by simulating human intelligence, including machine learning, deep learning, neural techniques, networks, and reinforcement learning programmed to think and mimic human actions (Zahlan& al, 2023, p. 1). AI also represents a technology capable of achieving sustainable development goals (Pan &Rohit, 2023, p. 2), offering new opportunities and

posing major challenges as a new driver of future economic growth (Linhui& al, 2023, p. 1). It studies techniques for creating software agents capable of engaging in natural conversational interactions with humans.

AI investigates how to enable computers to simulate information processes instead of humans, allowing them to rapidly search databases and extract information efficiently and rationally (Zhisheng, 2023, p. 5). It employs automated algorithms, robots, or mechanical devices that mimic human cognitive functions using human minds to perform various tasks (Yang3 & al, 2023, p. 3). AI supports organizations throughout all four stages of innovation: idea generation, idea examination, experimentation, and finally development and marketing. It influences manufacturing through intelligent agents, specialized systems, and big data analytics (Dwivedi& al, 2023, p. 2).(zighed&mekimah, 2023, p. 4) Moreover, using deep learning creates new job opportunities and boosts productivity, functioning as an intangible capital asset that organizations can invest in and use to generate outputs through the production function (Czarnitzki& al, 2023, p. 1). Its applications often provide actionable insights to improve the decision-making process (Dwivedi& al, 2023, p. 1).

Artificial intelligence (AI) holds increasing importance in daily life and social relationships, which raises expectations about its ability to enhance human well-being, alongside concerns about risks to human autonomy and safety. AI helps address complexities by improving decision-making processes and managing resources (Koutou, 2018, pp. 26-27). It aims to accelerate information analysis and produce more accurate and reliable data outputs, enabling employees to perform high-level tasks that provide sustainable competitive advantages to organizations and facilitate cognitive computing (Fares & al, 2023, p. 2). AI classifies into two types: weak AI, which focuses on a narrow set of specific tasks, and strong AI, also known as Artificial General Intelligence, capable of performing most cognitive functions that humans possess and applying intelligence across multiple problems. This field explores new technology theories, techniques, application systems, and the expansion and enhancement of human intelligence (Ma &Siau, 2018). AI employs several technologies, notably machine learning, referring to the process through which computers identify patterns or regularities from sets of habits or behaviors (Valerie & et al, 2022, p. 1). Software engineering encompasses the design of complete software systems, including their technical functions and internal structures at all levels. It operates as a system composed of units interacting through executable processes (Denert, 2020, p. 2). Data analytics involves examining data to detect errors and omissions and correcting them when possible, entailing detailed data analysis to ensure data accuracy (Dibekulu, 2020, p. 1).

Artificial intelligence (AI) is an advanced technology aimed at simulating human capabilities in perception, problem-solving, and learning, enabling computer systems to perform tasks intelligently and independently. Thanks to these capabilities, AI has become a pivotal element in transforming traditional business models within organizations by allowing the processing and analysis of vast amounts of data quickly and accurately. This ability forms a strong foundation for developing business intelligence systems. Business intelligence relies on data analysis and transforming data into meaningful information that supports strategic and operational decision-making, enhancing the competitive capability of organizations by leveraging AI outcomes to improve performance, organize resources, and make decisions based on precise insights. Consequently, AI constitutes a critical technological foundation that boosts the effectiveness of business intelligence systems and advances them toward higher levels of institutional intelligence.

Business intelligence is defined as a set of methodologies for improving decision-making in business through reality-based support systems. It assists in analyzing data extracted from internal or external sources and presenting it as information. It can also

provide accurate and specialized information within a vast amount of diverse data (Effy, 2009, p. 215). (mekimah& et al, 2024, p. 3) It also represents a collection of approaches, processes, and techniques that convert raw data into final information used to support strategic, tactical, and operational planning and decision-making within organizations. This facilitates access to information, discovery, transformation, and development of understanding, leading to improved decision-making approaches (Kimball & al, 2009, p. 20). The advantages of decision support systems include the ability to choose the largest number of alternatives and analyze the impact of each alternative on the problem under study. The possibility to analyze the anticipated consequences of decisions made, enabling the avoidance of problems that may arise in the future because of these decisions, responding quickly to unexpected situations, and experimenting with multiple different policies for solutions. A decision support system can try several policies or perspectives to reach a solution and assess the impact of each on the outcome (Turban &Volonino, 2011, p. 105).

Business intelligence systems offer many benefits to organizations; they enable rapid responses to economic conditions and changes, and they improve overall organizational performance (Ranjan, 2009, p. 64). Their importance lies in the ability to manage information presentation effectively, measured by how meaningfully this information is displayed to the beneficiaries. Additionally, their significance includes optimal time investment, contributing to performance system integration and connectivity, providing required coordination, and reducing reliance on individuals in administrative processes, especially in decision-making, to strengthen the organization's business intelligence system (Ballard, 2006, p. 55). They also play an important role in risk reduction and support planning and its processes to adapt to different conditions and events that affect organizational activities and operations (Loshin, 2003, p. 4). The success factors of business intelligence lie in its ability to deliver remarkable results if implemented correctly; however, such projects often face challenges (Adamala&Cridrin, 2011, p. 1). Furthermore, the critical success factors for any work are the results—if they are satisfactory, the work proceeds in the right direction. Thus, there must be continuous and careful attention from management, as implementation is not an easy task. Despite awareness of the potentially great value from integrating business intelligence into the organization's activities and operations, many constraints may reduce the benefits of applying business intelligence, such as the high initial project cost, widespread system upgrading and maintenance, lack of qualified staff, and running queries on business intelligence affecting the end user's time (Albawaleez, 2014, p. 21). Business intelligence consists of several elements, the most important being decision-making, which is one step in problem-solving and can be applied in various fields, ranging from personal situations to organizational management. It is a process that starts from a specific point and leads to a result (Taherdoost&Madanchian, 2023, p. 4). Information systems represent a crucial field where organizations compete to innovate new technologies and capabilities to support them, with information considered the core of these systems, as data provides a solid foundation for supporting decision-making operations concerning the necessary information (Forat, 2018, p. 1). Human resources refer to human ingenuity and their pursuit of innovation to develop intelligent machines and their capabilities in shaping the future of technology and decision-making to meet individual needs, interests, and goals (Schubert & Knecht, 2020, p. 3).

Artificial intelligence revolutionizes business management as well as the economy and society as a whole by changing the interactions and relationships among stakeholders. It impacts customers, organizations, and stakeholders in the business world (Bharadiya& al, 2023, p. 86). Advances in artificial intelligence have enabled the improvement of many practices by creating new forms considered significant competitive advantages. This rapidly evolving technology allows businesses to offer brand services and even new forms of commercial

interactions with employees. Organizations have confirmed the simultaneous digitization of artificial intelligence that they require, focusing on their current strategies while routinely and proactively seeking new market opportunities. This transformation affects not only business management but also various industrial sectors (Bharadiya& al, 2023, p. 85).

Organizations greatly benefit from integrating artificial intelligence into their operations and strategic information technology as AI helps them create new revenue streams, make decisions, and gain competitive advantages. Artificial intelligence significantly influences commercial decision-making by changing how organizations make decisions, leading to increased efficiency, effectiveness, and competitiveness in the continuously evolving business field (Rajakrishnan, 2023, p. 687).

Deep learning complements human intelligence and improves decision-making capabilities. It enhances the relationship between humans and machines as a promising path to achieving higher efficiency and productivity. It highlights ongoing efforts to surpass the limits of what smart machines can achieve and represents the realization of science fiction through human ingenuity and ambition to innovate and develop smart machines. Deep learning has the potential to shape the future of technology and decision-making processes (socorromarquez, 2024, p. 2).

Information systems rely on computer data integrated with other procedures to provide timely and efficient information to support decision-making and other functions. They handle massive amounts of information, and efficient decision-making only occurs if the necessary information is fast, accurate, and of high quality. Inefficiency results from the lack of good information systems (Berisha-Shaqir, 2014, p. 1). Software engineering techniques regularly support decision-making by using search methods such as genetic algorithms effectively to solve problems and make successful decisions. Each stage of development requires similar high-level decisions, and software engineering assists organizations in making developmental decisions (Gay &Heimdahl, 2013, p. 2).

This research constitutes an important scientific contribution in management and technology by highlighting the role of artificial intelligence in enhancing business intelligence within Algerian startups. It keeps pace with modern technological advancements that have fundamentally changed the business environment by improving decision quality, raising efficiency and productivity levels, and providing innovative solutions that contribute to sustainable growth and increased competitiveness.

The study aims to analyze the impact of artificial intelligence applications on different business intelligence components, such as decision-making, human resources, information systems, and data analysis. It also evaluates the effectiveness of employing AI to improve administrative and operational performance. Furthermore, the research explores the digital transformation opportunities offered by this technology to Algerian startups while identifying the main challenges that might hinder optimal utilization.

The research offers practical recommendations based on its findings to support decision-makers in developing digital transformation and administrative innovation strategies. These efforts contribute to transforming Algerian startups into smart entities capable of competing in rapidly changing markets and achieving sustainable success. It also provides a scientific framework to support the development of work environments, enhance integration between humans and machines in decision-making, and realize the anticipated economic efficiency.

3. Research Methodology

To test the study hypotheses and reach results regarding the impact of applying artificial intelligence (AI) technologies on enhancing business intelligence in startups, we studied Algerian start-ups as a case study.

3.1.Study Population and Sample

We estimated the study population to include approximately 5,000 start-ups in Algeria (ALGERIA PRESS SERVICE, 2024). A simple random sample was selected with a size calculated using Stephen Thompson's formula, amounting to 357 enterprises (Thompson, 2012).Using the Thompson sampling formula, as follows:

$$n = \frac{N \times p(1-p)}{\left[[N-1 \times (d^2 \div z^2)] + p(1-p)\right]}$$

N: population size,
z: standard score corresponding to the significance level of 0.95, which equalled 1.96,
d: margin of error, which equalled 0.05,
p: proportion of the characteristic's presence and neutrality = 0.50.

$$n = \frac{5.000 \times 0.05(1-0.05)}{\left[[1{,}300{,}000-1 \times (0.50^2 \div 1.96^2)] + 0.05(1-0.05)\right]} \approx 357$$

A total of 345analyzable start-ups were retrieved, resulting in a response rate of 96.63%.

3.2.Measurement

To test the relationships among the study variables and to construct a structural model while ensuring its validity, a questionnaire was developed.

In developing the questionnaire, the research team consulted with experts in the field, comprising academics specializing in artificial intelligence and business intelligence, industry practitioners with experience in startups and business management, and potentially, experts in survey design and psychometrics. These experts provided valuable feedback on the questionnaire's content and design, ensuring it addressed relevant aspects of the topic and reflected both theoretical rigor and practical relevance. Their input helped to refine the questionnaire items, enhancing its validity and reliability for the study.

We conducted a pilot test of the questionnaire by distributing it to a small exploratory sample of small and medium-sized enterprises. This pilot test enabled us to enhance the quality of the questions and improve participants' understanding of them, and we utilized the results to refine the questions and increase their clarity.

To test the relationships between the study variables and build a structural model with confirmed validity, a questionnaire was designed consisting of 21 questions divided into two sections. The first section focused on artificial intelligence, covering questions 1 to 15, while the second section addressed business intelligence, covering questions 16 to 21.

Table 1. Descriptive statistics for the variables.

Item code	Statement	Mean	**Standard Deviation**	R	Saturation coefficient	P value
m1	Our company relies on machine learning techniques to analyze data and improve the performance of products and services.	3.65	0.705	0.455	0.809	0.000
m2	We use machine-learning models to predict market trends and customer behavior.	3.43	0.643	0.366	0.751	0.000

m3	Machine learning algorithms contribute to automating processes and enhancing the accuracy of decision-making.	4.12	1.032	0.325	0.861	0.000
m4	We train machine-learning models using company data to achieve continuous performance improvement.	3.90	0.572	0.487	0.783	0.000
S1	We apply software engineering principles to develop integrated artificial intelligence solutions that meet our company's needs.	3.56	1.003	0.523	0.742	0.000
S2	Our development teams depend on artificial intelligence techniques to improve software quality and reduce errors.	3.44	0.987	0.366	0.786	0.000
S3	We implement modern software engineering methodologies to facilitate the integration of artificial intelligence into our products.	3.98	1.043	0.359	0.775	0.000
S4	We use software engineering tools to support the effective development and maintenance of artificial intelligence systems.	3.50	1.078	0.346	0.832	0.000
S5	We ensure regular updating of our software engineering team's skills to keep pace with advancements	3.72	1.456	0.456	0.657	0.000

	in artificial intelligence. .					
d1	We rely on AI-supported data analysis techniques to extract accurate insights from big data. .	3.44	1.003	0.378	0.880	0.000
d2	Our company uses data analysis tools to enhance understanding of customer behavior and make strategic decisions.	3.85	0.124	0.438	0.862	0.000
d3	Data analysis techniques contribute to early detection of problems and opportunities within our operations.	4.10	0.753	0.466	0.830	0.000
de1	AI-powered business intelligence systems help us improve the quality of our managerial and strategic decisions.	3.77	0.874	0.388	0.913	0.000
de2	We depend on business intelligence analytics to make informed decisions based on accurate and up-to-date data.	3.97	0.234	0.488	0.870	0.000
de3	Business intelligence tools assist in reducing risks associated with commercial decision-making.	3.33	1.039	0.312	0.772	0.000
h1	Integrating artificial	3.66	0.835	0.344	0.797	0.000

	intelligence into our systems enhances employee interaction with technology and increases their productivity.					
h2	We believe that collaboration between humans and artificial intelligence achieves the best results in the work environment.	4.01	1.057	0.238	0.826	0.000
h3	Artificial intelligence technologies provide employees with the necessary support to make faster and more accurate decisions.	4.12	0.193	0.299	0.879	0.000
i1	Our company relies on advanced AI-supported information systems to improve data and information management.	3.77	0.746	0.345	0.894	0.000
i2	Smart information systems facilitate efficient information flow between different departments.	3.55	0.355	0.340	0.849	0.000
i3	We use business intelligence solutions to analyze data from information systems and convert it into actionable insights.	3.80	0.389	0.569	0.860	0.000

Source: Prepared by researchers using Smart PLS 4.

This table demonstrates robust and statistically significant results across all items, evidenced by P values consistently at 0.000, indicating strong confidence in the findings. The saturation coefficients are generally high (mostly above 0.7), which reflects the strong reliability and validity of the measured constructs related to artificial intelligence and business intelligence applications. The R-values vary moderately, suggesting different degrees of correlation strength for each statement within the model. Standard deviations show variability in responses, yet means mostly stay above neutral (above 3), implying generally positive agreement from respondents on the effectiveness and integration of AI technologies in their companies. Overall, the data solidly supports the positive impact of AI components like

machine learning, software engineering, and data analytics on organizational practices and decision-making processes.

The following figure illustrates the modified model of the study after removing the previously mentioned indicators:

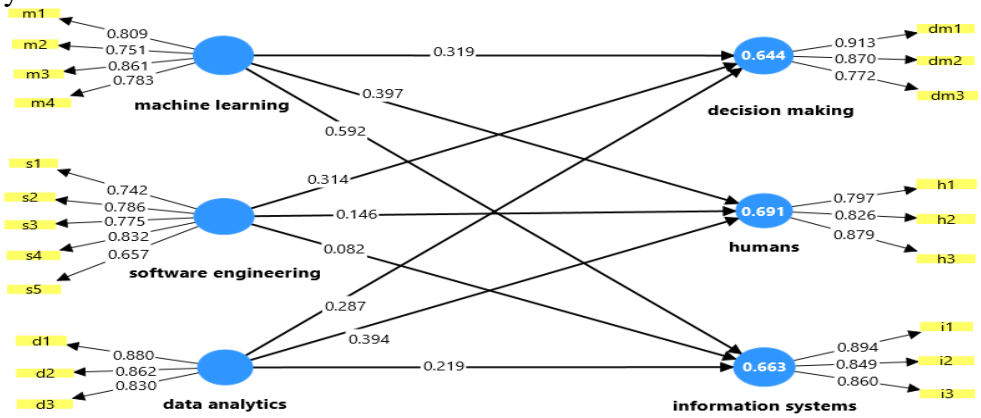

Figure1. Standard Study Model for the Relationship Between Study Variables.

Source: prepared researches using smart pls4.

3.3.Evaluation of Reliability

We utilized Cronbach's alpha to measure the stability of the study tool and reinforced it with the Composite Reliability (CR) index, we present the results in the table below:

Table 3. Value of Cronbach's Alpha Index and RHO Index

Variables	Cronbach's Alpha	Composite Reliability	RHO Index	Convergent Validity AVE
Machine Learning	0.814	0.878	0.820	0.643
Software Engineering	0.848	0.872	0.979	0.578
Data Analysis	0.820	0.893	0.823	0.736
DecisionMaking	0.812	0.889	0.832	0.729
Humans	0.782	0.873	0.793	0.697
Information Systems	0.836	0.901	0.841	0.753

Source: prepared researches using smart pls4.

From the previous table, it is observed that all Cronbach's alpha coefficients are high, being greater than 0.7, and the RHO values are also high, exceeding 0.70, indicating that the questionnaire used is reliable. Additionally, the Composite Reliability (CR) index is greater than 0.7 across all dimensions, which supports the conclusion that the study instrument possesses stability. It is also noted that the Average Variance Extracted (AVE) values are greater than 0.50, which are statistically acceptable, signifying good convergence among the questions.

3.4. The Fornell-Larcker Criterion

This criterion is used to assess the discriminant validity of latent variables, also known as the degree of overlap between dimensions, where the value of the correlation between a latent variable and itself should be greater than its correlation with other latent variables.

The study results based on the Fornell-Larcker criterion are presented in the following matrix:

Table. 4 Measurement of Fornell-Larcker Criterion

	Data	DecisionMak	HumanResou	Informati	Machi	Software

	Analysis	ing	rces	on Systems	ne Learning	Engineering
Data Analysis	0.858					
DecisionMaking	0.706	0.940				
HumanResources	0.759	0.854	0.835			
Information Systems	0.675	0.648	0.709	0.868		
Machine Learning	0.683	0.704	0.754	0.791	0.802	
Software Engineering	0.642	0.690	0.638	0.579	0.603	0.760

Source: prepared by researches using smart pls4.

We observe from the table that all latent variables, the value of the correlation with itself is greater than its correlation with the other latent variables. Therefore, the latent variables are independent.

3.5.The HTMT Criterion

This criterion measures the ratio of between-trait correlations to within-trait correlations. The structural model should not include a value greater than 0.90; if it does, this indicates a high theoretical similarity between constructs. The study results according to the HTMT criterion are as follows:

Table. 5 Measurement of HTMT Criterion

	Data Analysis	DecisionMaking	HumanResources	Information Systems	Machine Learning	Software Engineering
Data Analysis						
DecisionMaking	0.864					
HumanResources	0.838	0.795				
Information Systems	0.818	0.791	0.871			
Machine Learning	0.832	0.861	0.732	0.652		
Software Engineering	0.661	0.593	0.581	0.607	0.617	

Source: prepared by researches using smart pls4.

From the above table, all the values are not close to 1 and ranged between 0.581 and 0.871, thus meeting the criterion. Therefore, there are no constructs with theoretical similarity

3.6.Endogeneitytest

The Gaussian Copula test is a statistical tool used to examine the dependence between variables and can help check for endogeneity issues in the data.

Table 6. Gaussian Copula Test

Variables	Original sample (O)	Samplemean (M)	Standard deviation (STDEV)	T statistics(|O/STDEV|)	P values
intelligent systems and processes→ market intelligence	0.427	0.394	0.339	1.260	0.208
intelligent systems and processes → competitive intelligence	0.326	0.300	0.281	1.159	0.246
intelligent systems and processes → competitive advantage	-0.192	-0.184	0.274	0.702	0.483
Market intelligence → competitive intelligence	0.591	0.276	.0.361	1.636	0.102
Competitive intelligence→competitiveadvantage	0.342	0.290	0.273	1.252	0.211
Market intelligence→competitiveadvantage	-0.248	-0.041	0.414	0.600	0.549

Source: Prepared by researchers using Smart PLS 4

The table shows that the path coefficient (O) between machine learning and decision making reached -0.308, indicating a negative relationship with a mean of -0.275 and a standard deviation of 0.088. The calculated T-value reached 3.489 at a significance level of 0.576, which indicates that the relationship between machine learning and decision making is not statistically significant. The relationship between software engineering and decision making had a path coefficient of -0.256, indicating a negative relationship with a mean of -0.223 and a standard deviation of 0.073. The calculated T-value reached 3.497 at a significance level of 0.300, meaning this relationship is also not statistically significant. The path coefficient between data analytics and decision making was 0.167, indicating a positive relationship with a mean of 0.158 and a standard deviation of 0.098. The calculated T-value was 1.697 at a significance level of 0.090, which also shows a non-significant relationship.

The table also shows that the path coefficient (O) between software engineering and decision making was 0.084, indicating a positive relationship with a mean of 0.056 and a standard deviation of 0.098. The calculated T-value was 0.848 at a significance level of 0.396, indicating a non-significant relationship. The relationship between software engineering and human resources had a path coefficient of 0.141, showing a positive relationship with a mean of 0.120 and a standard deviation of 0.073. The calculated T-value was 1.932 at a significance level of 0.053, indicating non-significance. The path coefficient between software engineering and information systems was -0.111, indicating a negative relationship with a mean of -0.105 and a standard deviation of 0.042. The T-value was 2.657 at a significance level of 0.149, also non-significant.

Additionally, the path coefficient (O) between data analytics and decision making reached 0.320, indicating a positive relationship with a mean of 0.220 and a standard deviation of

0.056. The calculated T-value was 3.165 at a significance level of 0.239, showing a non-significant relationship. The relationship between data analytics and human resources had a path coefficient of 0.099, a positive relationship with a mean of 0.083 and a standard deviation of 0.073. The T-value was 1.342 at a significance level of 0.180, also non-significant. The path coefficient between data analytics and information systems reached 0.235, indicating a positive relationship with a mean of 0.223 and a standard deviation of 0.057. The calculated T-value was 4.094 at a significance level of 0.125, which remains non-significant.

From these results, all P-values for the study variables are greater than 0.05, indicating no statistical significance. Therefore, we can conclude that the study model does not suffer from critical endogeneity issues affecting regression results (Malevergne&Sornette, 2010).

3.7.Normality Test

To assess the fairness and absence of bias in the study model, a Cramér-Von Mises test was conducted to judge whether the data follow a normal distribution or not, along with a CMB test to determine if the data are biased or not. Table below presents results:

Table 7. Normality Test (Cramér-Von Mises)

Variables	Cramér-Von Mises	P Value
Artificial Intelligence	0.490	0.120
Business Intelligence	2.350	0.098

Source: prepared researches using smart pls4.

Since the P values are greater than 0.05, the null hypothesis of normal distribution is accepted. Thus, all questionnaire domains are normally distributed, allowing the study to proceed with statistical testing.

4. Results

Researchers verify the significance of the paths using the Bootstrapping technique by generating 500 partial samples.

4.1.Sub-Hypotheses Testing

The Structural Model Paths Related to the Sub-Hypotheses, The results are shown in the following figure:

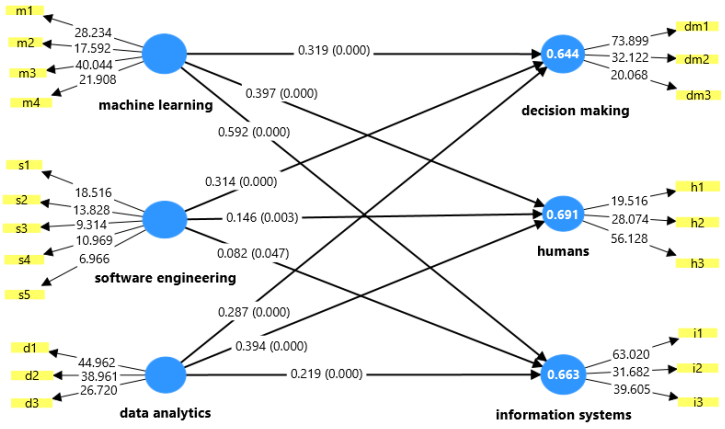

Figure 2. Statistical Significance of Structural Model Paths Related to Sub-Hypotheses

Source: prepared researches using smart pls4.

The hypothesis testing aims to determine the effect of artificial intelligence elements on business intelligence elements in Algerian startups.

Table 7. Structural Model Analysis for Sub-Hypotheses

Relationship	Path Coefficient	T Value	P Value
Machine Learning → DecisionMaking	0.319	4.532	0.000
Machine Learning → HumanResources	0.397	5.570	0.000
Machine Learning → Information Systems	0.592	12.418	0.000
Software Engineering → DecisionMaking	0.314	4.798	0.000
Software Engineering → HumanResources	0.146	3.012	0.000
Software Engineering → Information Systems	0.082	1.987	0.000
Data Analytics → DecisionMaking	0.287	4.361	0.000
Data Analytics → HumanResources	0.394	5.740	0.000
Data Analytics → Information Systems	0.219	3.891	0.000

Source: prepared researches using smart pls4.

The table shows that the relationship between machine learning and decision making in startups is statistically significant at the 0.05 level, with a p-value of 0.000 and a calculated T-value of 4.532, which is greater than the critical T-value of 1.948. The path coefficient (O) of 0.319 indicates a positive but weak effect, meaning machine learning has a weak positive impact on decision making in startups.

The relationship between machine learning and human resources in startups is also statistically significant at the 0.05 level, with a p-value of 0.000 and a T-value of 5.570 exceeding 1.948. The path coefficient of 0.397 shows a positive and moderate effect, indicating machine learning moderately positively influences human resources.

For machine learning and information systems, the relationship is statistically significant at the 0.05 level with a p-value of 0.000 and a T-value of 12.418 greater than 1.948. The path coefficient of 0.592 indicates a positive and moderate effect on information systems.

The effect of software engineering on decision making in startups is statistically significant (p=0.000, T=4.798 > 1.948) with a positive but weak path coefficient of 0.314, showing a weak positive impact.

Software engineering positively and weakly affects human resources with statistical significance (p=0.000, T=3.012 > 1.948) and a path coefficient of 0.146.

Software engineering also positively but weakly influences information systems, with a significant p-value of 0.000 and T-value of 1.987, and a path coefficient of 0.082.

Data analytics positively and weakly affects decision making (p=0.000, T=4.361 > 1.948) with a path coefficient of 0.287.

Data analytics positively and moderately influences human resources (p=0.000, T=5.740 > 1.948) with a path coefficient of 0.394.

Finally, data analytics positively and weakly affects information systems with statistical significance (p=0.000, T=3.891 > 1.948) and a path coefficient of 0.219.

Overall, all these relationships are statistically significant, and all path coefficients indicate positive effects ranging from weak to moderate among the AI elements and business intelligence components in startups.

4.2.Main Hypothesis Testing:

The Structural Model Paths Related to the Sub-Hypotheses, The results are shown in the following figure:

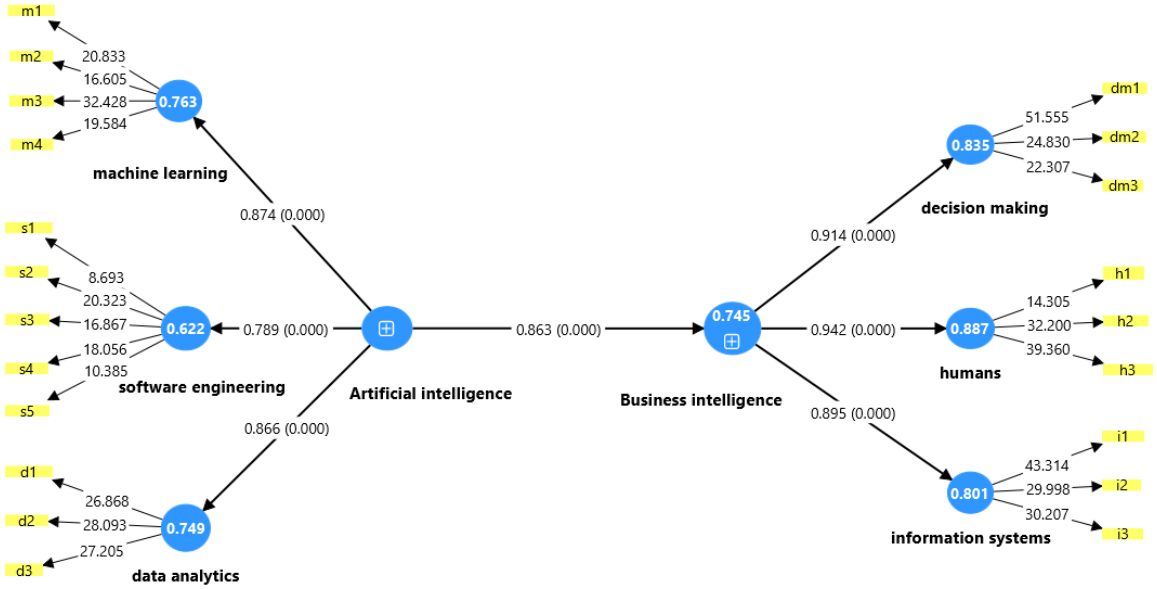

Figure 3. Statistical Significance of Structural Model Paths Related toMain Hypotheses

Source: prepared researches using smart pls4.

The hypothesis testing aims to determine the effect of artificial intelligence on business intelligence in Algerian startups.

Table 8. Structural Model Analysis for the Main Hypothesis

	Pls-sem		
Structural Model			
Relationship	**Path Coefficient**	**T Value**	**P Value**
Artificial Intelligence → Business Intelligence	0.863	30.875	0.000

Source: Prepared researches using Smart PLS 4.

From the table, it is noted that the correlation coefficient between the two variables is 0.863, indicating a strong positive relationship between them. This correlation is statistically significant at a p-value of 0.000, which is less than 0.05. The computed T-value is 30.875, which is greater than the critical T-value of 1.984. Therefore, the hypothesis is accepted, stating that there is a statistically significant positive effect of artificial intelligence on business intelligence in startups in Algeria.

5. Discussion

Business intelligence is considered a process that reduces the time required to obtain and enable critical business data and enhances efficiency in the administrative decision-making process, allowing for organizational dynamism and the presentation of institutional information, as reported by Heang& Mohan (2017, p. 2). This is attributed to the pivotal role played by business intelligence in every institution, where various tasks can be completed in a timely manner. It is also evaluated as one of the most important technological investments and a key factor in helping organizations achieve sustainability. Moreover, it is regarded as a disciplinary strategy that assists innovative small and medium enterprises in adapting to environmental changes and handling disruptions, enabling them to gain a better understanding of the business environment and continuously learn about corporate strategies and competitive business practices, as stated in the study by YazdiRamezaniMojarad et al. (2014, p. 2).

This is due to the fact that strategic planning is supported by business intelligence to help organizations achieve competitive advantage through various methods such as providing

intelligent estimates, assessments, market insights, and information about the measures taken by competitors and the organization itself. This aspect was also addressed in the study by Valjevae et al. (2018, p. 5). Business intelligence is further credited with enabling current decision-making and facilitating future achievements by identifying anticipated future events and activities associated with changes in the system and environment.

Artificial intelligence is recognized as broad and diverse, with numerous applications in various fields, including economic sectors. It encompasses all technological developments that enable machines and computers to analyze and infer. Its applications are considered essential to all organizations, regardless of their activity type, as indicated by Kizzy (2019), who reported that artificial intelligence includes a wide range of diverse and frequently used applications capable of performing most cognitive functions that humans may have. Furthermore, artificial intelligence applies across multiple problems as a new technological science that explores theory, technique, application systems, and the expansion and enhancement of human intelligence.

Analytics on decision-making in startups in Algeria. This can be attributed to the fact that these institutions do not sufficiently filter and select stored information to make optimal decisions and achieve success. This finding contrasts with the study by Socorro Marquez (2024), which highlights the significant contribution of machine learning in improving decision-making by expanding the capabilities of intelligent machines and human ingenuity. It also contrasts with Ali Mohammed (2020), who found a strong impact of software engineering on decision-making, driving digital transformation, resilience, data insights, and infrastructure development. Similarly, it differs from Riaz et al. (2022), who emphasized the critical role of data analytics in organizational success through effective interaction between decision-making and data analysis.

There is a positive and moderate effect of machine learning and data analytics on human resources in startups, alongside a weak positive effect of software engineering. This is due to institutions collecting and ethically analyzing information about competitors, market trends, and business environments, then using this information for competitive decision-making. This aligns with Herpita&Heliana (2024), who showed that data analytics enhances hiring efficiency, employee selection accuracy, and development, ultimately improving overall organizational performance. It also contrasts with Kumar et al. (2024), who demonstrated a significant impact of machine learning on human resource functions like performance prediction, attrition analysis, and workforce planning.

Machine learning has a positive and moderate impact on information systems in startups, with a weak positive effect from software engineering and data analytics. This is explained by the limited discovery of previously unknown relationships in large data sets used for pattern recognition. This finding differs from Laato et al., who point to advances in hardware and software where machine-learning solutions are vital components of many information systems, requiring further research on integration and evaluation practices. It also contrasts with Tonmoy&Sunanda (2024), who reported that integrating data and information analytics in the service industry leads to significant improvements in operational efficiency, risk management, and customer satisfaction through fraud reduction, claims processing simplification, and personalized service enhancement.

There is a strong positive effect of artificial intelligence on business intelligence in startups, indicating that these institutions can learn, infer, think, make decisions, solve problems, and perform tasks independently. This confirms the findings of Deepak (2024), which showed AI's strong impact on business intelligence reflected in advanced analytics, predictive capabilities, and actionable insights extraction from complex data sets. However, it

also highlights challenges related to bias, transparency, and ethical considerations brought by AI integration.

These results provide insights into how AI components influence various aspects of business intelligence in Algerian startups, highlighting both the potential benefits and current limitations faced by these institutions in adopting AI technologies.

6. Conclusion

This research concludes by emphasizing the significant role artificial intelligence plays as a pivotal factor in developing and enhancing institutional performance and enabling startups in Algeria to adapt to the rapidly changing modern business environment. The study's results reveal a strong positive impact of artificial intelligence on business intelligence, demonstrating the ability of institutions to leverage smart technologies to enhance decision-making processes, improve human resource management, develop information systems, and refine data analytics for more accurate and effective decisions.

Based on these findings, the study recommends increasing investment in technical infrastructure and targeted training programs to develop the skills of teams in artificial intelligence and software engineering. It also stresses the importance of improving data quality and updating information systems to support more precise analysis and decision-making. Furthermore, the study proposes adopting comprehensive digital transformation strategies that utilize artificial intelligence applications to boost the competitiveness of startups, enabling them to create new income sources and expand innovation opportunities.

Moreover, the study calls for addressing ethical challenges related to artificial intelligence, such as transparency and bias, and ensuring a balance between relying on intelligent systems and preserving the vital human role in decision-making. It highlights the necessity of continuous institutional and administrative support to guarantee successful AI implementations and advocates for flexible decision support systems that allow experimenting with multiple alternatives to manage changing conditions. Finally, the study urges conducting more applied research focused on evaluating the long-term impact of artificial intelligence technologies in other sectors of the national economy, thereby building an integrated knowledge base that keeps pace with the digital revolution and contributes effectively to sustainable development through smart technology investments.

Funding

The authors gratefully acknowledge financial support from the Deanship of Scientific Research, King Faisal University (KFU) in Saudi Arabia. Grant Number (**KFU253568**)

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