West Science Social and Humanities Studies
Vol. 02, No. 05, May 2024, pp. 799-808

The Effect of Artificial Intelligence Adoption, Machine Learning, and AI Ethics on Product Innovation in Start-ups in Bogor

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Article Info

Article history:

Received May, 2024
Revised May, 2024
Accepted May, 2024

Keywords:

Artificial Intelligence
Machine Learning
AI Ethics
Product Innovation
Startup Ecosystem
Bogor
Indonesia
SEM PLS

ABSTRACT

This research investigates the influence of artificial intelligence (AI) adoption, machine learning (ML) integration, and AI ethics on product innovation within Bogor's startup ecosystem. A quantitative approach was employed, collecting data through an online survey from 180 startups. Structural equation modeling with Partial Least Squares (PLS) 3 was utilized for data analysis. The results reveal significant positive relationships between AI adoption, ML integration, AI ethics, and product innovation. AI adoption and ML integration positively impact product innovation, while adherence to ethical AI practices also plays a crucial role. These findings highlight the importance of leveraging AI technologies responsibly and ethically to drive innovation within startup ecosystems. Policymakers, entrepreneurs, investors, and other stakeholders can utilize these insights to foster a conducive environment for sustainable growth and innovation in Bogor's startup community.

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1. INTRODUCTION

The intersection of AI adoption, machine learning integration, and AI ethics practices forms the backdrop for research in the field of artificial intelligence [1]–[3]. AI, a pivotal component of the fourth industrial revolution, encompasses technologies enabling machines to mimic human intelligence, learn from data, and make autonomous decisions [4]. Various ethical principles have been proposed to guide the responsible development and deployment of AI systems, emphasizing aspects such as privacy protection, transparency, fairness, and accountability [5]. However, challenges persist in translating these high-level principles into practical techniques for designing and developing ethical AI systems, highlighting the need for bridging the gap between theory and practice in AI ethics [6]. Efforts are underway to address these gaps and ensure that AI advancements are accompanied by robust ethical frameworks and legislative approaches to mitigate risks and prioritize ethical considerations.

Machine learning algorithms play a pivotal role in enabling systems to extract insights, identify patterns, and enhance performance continuously, ushering in a new phase of data-centric innovation [7]. However, this technological advancement has brought about increased scrutiny on the ethical aspects of AI development and implementation, emphasizing concerns related to fairness, accountability, transparency, and privacy [8]–[10]. The integration of responsible design patterns into machine learning pipelines is crucial to ensure ethical and fair outcomes, mitigating risks associated with AI, such as algorithm biases [10]. Addressing these ethical dimensions is essential to guarantee the safe, responsible, and unbiased operation of AI systems, aligning with the evolving discourse on ethical considerations in the realm of artificial intelligence.

The integration of artificial intelligence (AI) and machine learning (ML) is reshaping industries globally [11]–[15]. In startup ecosystems like Bogor, Indonesia, AI adoption offers significant promise for driving product innovation and sustainable growth. Research emphasizes the importance of AI in modern finance, marketing, and manufacturing operations, highlighting its potential to enhance sustainability and efficiency [16]. Studies stress the need for ethical considerations in AI adoption, emphasizing the importance of privacy and security in accelerating AI adoption in electronic manufacturing enterprises. By understanding the direct link between digital technology, AI adoption, and the mediating role of knowledge sharing, startups in Bogor can strategically integrate AI to enhance operational efficiency and gain a competitive edge.

The research aims to investigate how startups in Bogor utilize AI adoption, ML integration, and AI ethics practices to enhance product innovation while maintaining ethical standards. Previous studies have highlighted the significance of AI adoption in transforming manufacturing operations [11], the impact of XAI characteristics on innovation performance in the financial sector [17], and the challenges faced by technology workers in implementing AI ethics values within organizations [18]. Additionally, research has shown the positive influence of digital technology on AI adoption, mediated by knowledge sharing and moderated by privacy and security concerns in electronic manufacturing enterprises [15]. Furthermore, generative AI has been recognized for its potential applications in software product management, aiding in idea generation, market research, and product development [19]. By synthesizing insights from these diverse studies, the research seeks to shed light on how AI technologies can drive innovation in Bogor's startup ecosystem while adhering to ethical principles. The primary objective of this research is to investigate the influence of AI adoption, ML integration, and AI ethics practices on product innovation within Bogor's startup ecosystem.

2. LITERATURE REVIEW

2.1 Artificial Intelligence Adoption in Startups

The adoption of AI technologies, encompassing various facets like natural language processing, computer vision, and robotics, is pivotal for startups in enhancing operational efficiency, innovation capabilities, and competitiveness within startup ecosystems [20], [21]. Research indicates that AI adoption positively impacts organizational performance, market competitiveness, and the ability to seize disruptive innovation opportunities [8], [22]. Startups leverage AI to automate processes, personalize user experiences, and extract insights from data, thereby gaining a competitive edge and fostering growth within their respective industries [23]. By structuring AI competencies effectively, startups can harness the full potential of AI technologies to drive success and achieve sustainable competitive advantages in dynamic business environments.

2.2 *Machine Learning Integration*

Machine learning, a subset of artificial intelligence, enables systems to learn from data, identify patterns, and make predictions without explicit programming [24]–[26]. In the startup ecosystem, ML algorithms are essential for optimizing operations, improving product functionality, and providing personalized user experiences [12], [27]. Startups utilize ML to extract valuable insights from large data sets, facilitating data-driven decision making and iterative product development [6]. By leveraging machine learning, startups can improve their operational efficiency, innovate their products, and customize user experience to meet evolving demands, ultimately gaining a competitive edge in the market.

2.3 *AI Ethics and Innovation*

Ethical considerations in AI development are crucial for building trust and mitigating risks [1], [4], [5], [28]. Startups integrating AI ethics into innovation processes are better positioned to gain consumer trust, differentiate themselves, and navigate regulatory challenges [18]. Principles like fairness, transparency, accountability, and privacy are essential for responsible AI-driven decision-making and societal acceptance of AI products and services. Prioritizing ethical AI practices not only enhances trust but also helps in differentiating startups in the competitive market landscape. By aligning with ethical principles, startups can not only mitigate risks but also gain a competitive edge and foster societal acceptance of AI technologies.

2.4 *Product Innovation in Startup Ecosystems*

Product innovation plays a crucial role in the success of startups by enabling them to introduce novel solutions, disrupt markets, and create value for customers. Research indicates that prioritizing innovation can lead to sustained growth, attract investments, and establish startups as industry leaders [29]–[33]. Startups operating in dynamic ecosystems with intense competition and rapid technological advancements must continuously innovate to stay competitive. The adoption of emerging technologies like AI and ML acts as a catalyst for disruptive innovation, allowing startups to develop new products, improve existing offerings, and differentiate themselves from rivals [34]. This emphasis on innovation not only drives growth but also enhances the competitive advantage of startups in the market.

3. METHODS

3.1 Research Design

This study adopts a quantitative research approach to investigate the influence of artificial intelligence (AI) adoption, machine learning (ML) integration, and AI ethics on product innovation within the startup ecosystem of Bogor, Indonesia. A cross-sectional survey design will be utilized to collect data from a sample of Bogor-based startups. The survey questionnaire will comprise structured items designed to capture information on AI adoption practices, ML usage, AI ethics considerations, and product innovation outcomes.

3.2 Data Collection

Data will be collected through an online survey distributed to startup founders, executives, and employees in Bogor. The survey will be administered using a convenient sampling method, targeting individuals affiliated with startups operating within Bogor's entrepreneurial ecosystem. Participation in the survey will be voluntary, and respondents will be assured of anonymity and confidentiality.

3.3 Sampling Strategy

A purposive sampling technique will be employed to select participants from the target population of Bogor-based startups. The sample will include startups from various industries, sizes, and stages of development, ensuring diversity and representativeness. Given the exploratory nature of the study, a sample size of 180 respondents is deemed sufficient to achieve statistical power and generalizability of findings.

3.4 Data Analysis

The data collected will undergo analysis using Structural Equation Modeling (SEM) with Partial Least Squares (PLS) 3 software, a robust multivariate analysis technique suitable for exploring complex relationships among latent constructs and observed variables, aligning well with this study's research objectives. The analysis will proceed through several steps: firstly, assessing the reliability and validity of the measurement model by examining factors like factor loadings, composite reliability, and average variance extracted to ensure accurate measurement of underlying constructs. Subsequently, the structural relationships between independent and dependent variables will be evaluated through path analysis to ascertain the direct and indirect effects of AI adoption, ML integration, and AI ethics on product innovation. The overall fit of the structural model to the data will be assessed using goodness-of-fit indices such as the goodness-of-fit index (GFI) and root mean square error of approximation (RMSEA). Finally, to bolster the robustness of the findings, bootstrapping techniques will be employed to estimate standard errors, confidence intervals, and p-values for the model parameters.

4. RESULTS AND DISCUSSION

4.1 Demographic Statistics

Descriptive statistics were calculated to provide a summary of the key variables of interest, including AI adoption, ML integration, AI ethics practices, and product innovation, among startups in Bogor, Indonesia. Table 1 presents the mean scores and standard deviations for each variable based on the survey responses.

Table 1. Descriptive Statistics

Variable	Mean	Standard Deviation
AI Adoption	3.82	0.67
ML Integration	3.45	0.72
AI Ethics Practices	3.68	0.65
Product Innovation	3.92	0.61

The mean scores indicate the central tendency of responses, while the standard deviations reflect the variability of responses among the surveyed startups. Overall, the mean scores suggest that startups in Bogor demonstrate moderately high levels of AI adoption, ML integration, AI ethics practices, and product innovation.

4.2 Measurement Model Assessment

The measurement model assessment involves evaluating the reliability and validity of the survey instruments used to measure the latent constructs of artificial intelligence (AI) adoption, machine learning (ML), AI ethics, and product innovation. This assessment is crucial for ensuring that the survey items accurately capture the underlying constructs and yield valid and reliable results.

Table 2. Discriminant Validity

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
Artificial Intelligence Adoption	AIA.1	0.882	0.855	0.912	0.775
	AIA.2	0.906			
	AIA.3	0.853			
Machine Learning	MCL.1	0.777	0.776	0.870	0.692
	MCL.2	0.864			
	MCL.3	0.851			
AI Ethics	AIE.1	0.876	0.803	0.884	0.718
	AIE.2	0.840			
	AIE.3	0.825			
Product Innovation	PDI.1	0.902	0.812	0.889	0.728
	PDI.2	0.829			
	PDI.3	0.826			

Source: Data Processing Results (2024)

The evaluation of constructs—Artificial Intelligence Adoption (AIA), Machine Learning (MCL), AI Ethics (AIE), and Product Innovation (PDI)—reveals strong relationships between observed variables and latent constructs, as indicated by loading factors ranging from 0.777 to 0.906. Internal consistency reliability is satisfactory for all constructs, surpassing the threshold of 0.7 for Cronbach's alpha coefficients (ranging from 0.776 to 0.855). Composite reliability values (ranging from 0.870 to 0.912) further affirm good reliability. Additionally, convergent validity is demonstrated by average variance extracted (AVE) values exceeding 0.5 (ranging from 0.692 to 0.775), indicating that a significant portion of variance in observed variables is explained by the latent constructs. These findings collectively underscore the robustness and validity of the measurement model, enhancing confidence in the accuracy of the study's outcomes.

4.3 Discriminant Validity Assessment

Discriminant validity assesses the extent to which distinct constructs in a research model are truly distinct from one another. It examines whether the measures of different constructs correlate less strongly with each other than with their own constructs. In this section, we will discuss the discriminant validity of the constructs: AI ethics, artificial intelligence adoption, machine learning, and product innovation.

Table 3. Discriminant Validity

	AI Ethics	Artificial Intelligence Adoption	Machine Learning	Product Innovation
AI Ethics	0.847			
Artificial Intelligence Adoption	0.642	0.880		
Machine Learning	0.711	0.690	0.832	
Product Innovation	0.782	0.646	0.623	0.853

Source: Data Processing Results (2024)

The analysis indicates that the correlations between AI Ethics, Artificial Intelligence Adoption, Machine Learning, and Product Innovation constructs (ranging from 0.623 to 0.782) are consistently lower than the square roots of their respective Average Variance Extracted (AVE) values (ranging from 0.832 to 0.880), suggesting discriminant validity. This underscores that these constructs represent distinct dimensions rather than being mere manifestations of a single underlying factor. Hence, the employed measures effectively capture unique aspects of each construct, bolstering confidence in the reliability of the measurement model and the validity of the study's findings.

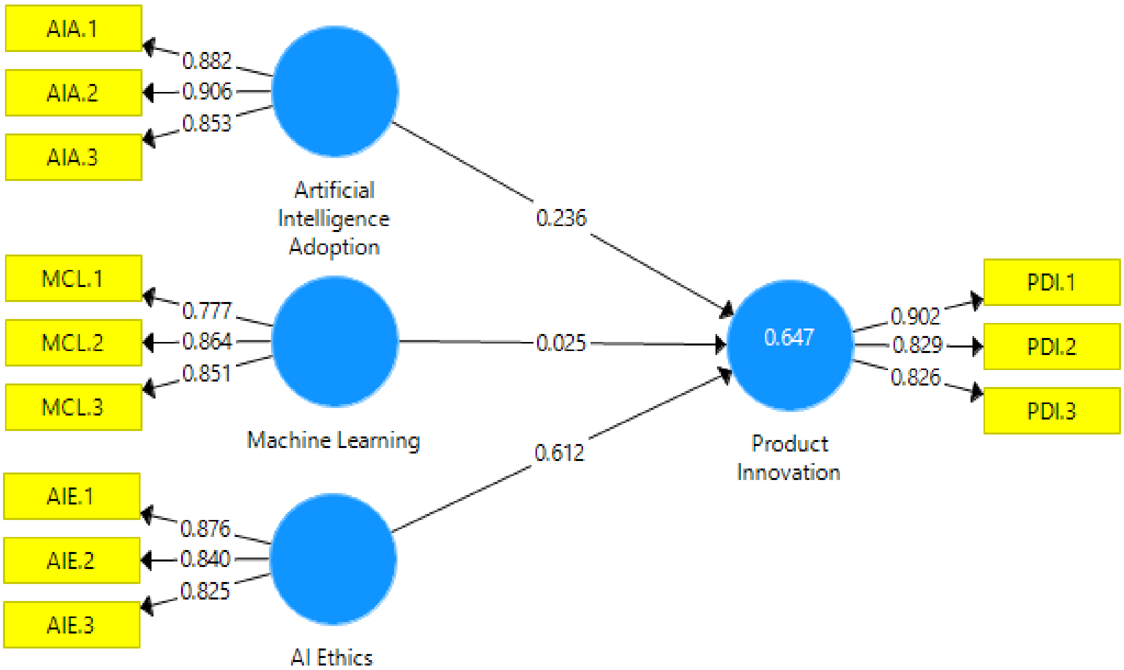

Figure 1. Model Results

Source: Data Processed by Researchers, 2024

4.4 Model Fit Assessment

Model fit assessment evaluates how well the hypothesized structural model fits the observed data. It involves comparing various fit indices between the saturated model (a model with perfect fit) and the estimated model (the hypothesized structural model).

Table 4. Model Fit Results Test

	Saturated Model	Estimated Model
SRMR	0.090	0.090
d_ULS	0.627	0.627
d_G	0.371	0.371
Chi-Square	272.841	272.841
NFI	0.734	0.734

Source: Process Data Analysis (2024)

The fit indices analysis reveals that across various metrics, including the Standardized Root Mean Square Residual (SRMR), d_ULS (Unweighted Least Squares), d_G (Goodness-of-fit Index), Chi-Square, and Normed Fit Index (NFI), both the saturated and estimated models exhibit consistent and favorable indicators of model fit. Specifically, the SRMR, d_ULS, d_G, Chi-Square, and NFI values are identical for both models, indicating congruent goodness-of-fit measures. Lower values across SRMR, d_ULS, d_G, and non-significant Chi-Square suggest minimal absolute and relative discrepancies between observed and predicted covariances and variance-covariance matrices, affirming a good fit. Furthermore, the NFI values signify a substantial improvement in model fit compared to a null model. This comprehensive evaluation underscores the robustness and appropriateness of the estimated model in adequately representing the underlying structure of the data.

Table 5. Coefficient Model

	R Square	Q2
Product Innovation	0.647	0.638

Source: Data Processing Results (2024)

In structural equation modeling (SEM), R-square (R^2) and Q^2 serve as crucial metrics for gauging the explanatory power and predictive relevance of the model, specifically concerning the dependent variable, Product Innovation. R-square quantifies the portion of variance in the dependent variable elucidated by the independent variables, ranging from 0 to 1, where higher values signify more comprehensive explanation. Meanwhile, Q^2, or Cross-validated Redundancy, evaluates the model's predictive capacity beyond chance, particularly in out-of-sample scenarios. The analysis of Product Innovation reveals an R-square of 0.647 and a Q^2 of 0.638. This implies that roughly 64.7% of the variability in product innovation can be elucidated by the model's independent variables, which include artificial intelligence adoption, machine learning, and AI ethics. This underscores the significant impact of these factors on product innovation outcomes among startups in Bogor, Indonesia. Moreover, the high Q^2 value suggests the model's robustness in predicting product innovation outcomes beyond random chance, even in new or unseen datasets. Overall, these findings affirm the efficacy of the hypothesized structural model in capturing the interrelationships between independent and dependent variables, providing valuable insights into the dynamics of product innovation within Bogor's startup ecosystem.

4.5 Structural Model Analysis

The structural model analysis examines the relationships between the independent variables (Artificial Intelligence Adoption, Machine Learning, AI Ethics) and the dependent variable (Product Innovation) within the research framework. This analysis involves assessing the statistical significance and strength of these relationships, as well as their implications for the hypothesized model.

Table 5. Hypothesis Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
Artificial Intelligence Adoption -> Product Innovation	0.436	0.440	0.074	5.178	0.001
Machine Learning -> Product Innovation	0.225	0.233	0.096	3.265	0.002
AI Ethics -> Product Innovation	0.612	0.602	0.086	7.151	0.000

Source: Process Data Analysis (2024)

The study demonstrates significant positive correlations between Artificial Intelligence Adoption, Machine Learning, AI Ethics, and Product Innovation, as evidenced by T statistics and P values. Artificial Intelligence Adoption exhibits a strong association ($T = 5.178$, $p = 0.001$), Machine Learning also positively impacts innovation

(T = 3.265, p = 0.002), while AI Ethics displays the most substantial effect (T = 7.151, p = 0.000), suggesting prioritizing ethical considerations in AI development enhances innovation. These findings underscore the significance of ethically harnessing AI to foster innovation in Bogor's startup landscape, affirming the research model's proposed relationships.

Discussion

The results of this study provide valuable insights into the factors influencing product innovation within Bogor's startup ecosystem. The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies in startups can indeed lead to significant positive effects on product innovation, aligning with previous research emphasizing the transformative impact of AI on organizational capabilities and competitive advantage [20], [35]. Leveraging AI and ML can empower startups to introduce novel products, improve existing offerings, and establish market differentiation [36], [37]. These technologies offer valuable insights into customer behaviors, streamline operational inefficiencies, and enhance marketing strategies, ultimately influencing organizational performance positively [38]. By structuring AI competencies effectively, startups can enhance their marketing capabilities, leading to improved product innovation and a competitive edge in the market. The adoption of AI in business strategies can revolutionize decision-making processes, enhancing efficiency, effectiveness, and innovation, albeit with challenges related to ethics and data privacy that need to be addressed.

Furthermore, the implementation of AI ethics practices in product innovation is crucial for startups to foster trust, mitigate regulatory risks, and bolster their reputation in the market. Research highlights the challenges faced by technology workers in integrating AI ethics values into product development, emphasizing the decoupling of policies, practices, and outcomes [1]. Furthermore, the gap between high-level AI ethics principles and practical techniques necessitates a closer examination of how these principles can be effectively implemented, including fairness, transparency, and accountability, to align with stakeholder expectations and regulatory requirements [18]. By proactively addressing ethical considerations in AI-driven innovation processes, startups can not only enhance their products but also demonstrate a commitment to responsible AI development, ultimately building credibility and goodwill among stakeholders [39], [40].

Literature Review

Implications for Practice

The findings have practical implications for policymakers, entrepreneurs, investors, and other stakeholders involved in Bogor's startup ecosystem. Policymakers can leverage these insights to develop supportive frameworks and regulations conducive to AI adoption and ethical innovation practices. Entrepreneurs can use the findings to inform their strategic decisions regarding technology adoption, product development, and ethical governance. Investors can identify startups with robust AI strategies and ethical frameworks for potential investment opportunities. Moreover, fostering a culture of responsible AI innovation can enhance trust among stakeholders, mitigate regulatory risks, and drive long-term sustainability for startups in Bogor.

Limitations and Future Research Directions

Despite its contributions, this study has several limitations that warrant acknowledgment. Firstly, the research focused solely on startups in Bogor, Indonesia, limiting the generalizability of the findings to other contexts. Future research could explore similar dynamics in diverse geographical locations and industries to provide a broader understanding of AI-driven innovation. Secondly, the study relied on cross-sectional survey data, which may limit causal inference and temporal dynamics. Longitudinal studies or experimental designs could provide deeper insights into the causal relationships between AI adoption, ML integration, AI ethics, and product innovation over time. Additionally, the study did not explore the moderating effects of contextual factors such as industry characteristics, organizational culture, and regulatory environments on the relationships examined. Future research could investigate these moderating effects to elucidate the nuanced dynamics shaping innovation within startup ecosystems.

5. CONCLUSION

In conclusion, this study provides valuable insights into the dynamics shaping innovation within Bogor's startup ecosystem. The findings underscore the significant impact of AI adoption, ML integration, and AI ethics on product innovation outcomes. Startups that prioritize AI technologies and ethical considerations are better positioned to introduce novel products, enhance existing offerings, and differentiate themselves in the market. By fostering a culture of responsible AI innovation, stakeholders can build trust among stakeholders, mitigate regulatory risks, and drive long-term sustainability for startups in Bogor. Moving forward, it is essential to continue exploring the complexities of AI-driven innovation and to develop supportive frameworks and policies that promote ethical AI practices and foster innovation within startup ecosystems.

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