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AI-Driven Product Development and Time-to-Market Acceleration in High-Tech SMEs

ABSTRACT

This study examines how AI adoption intensity, organizational readiness, and AI-enabled process integration influence product development efficiency and time-to-market acceleration in high-tech small and medium-sized enterprises. The research employed an applied, descriptive-analytical design using a cross-sectional survey of 210 high-tech SMEs across software, electronics, biomedical, and advanced manufacturing sectors. Data were gathered through a structured questionnaire assessing AI adoption, organizational readiness, process integration, and development outcomes, complemented by semi-structured interviews to contextualize quantitative findings. Statistical analyses included descriptive measures, correlation analysis, multiple regression models, and mediation testing using structural equation modeling to evaluate direct and indirect effects. Bootstrapped confidence intervals were applied to assess the significance of mediation pathways. AI adoption intensity demonstrated significant positive correlations with process integration ($r = .68$, $p < .001$), product development efficiency ($r = .52$, $p < .001$), and time-to-market reduction ($r = .47$, $p < .001$). Regression analyses revealed that AI adoption ($\beta = .39$, $p < .001$), organizational readiness ($\beta = .21$, $p = .003$), and process integration ($\beta = .27$, $p < .001$) significantly predicted time-to-market reduction, explaining 41% of its variance. Mediation analysis showed a significant indirect effect of AI adoption on time-to-market reduction via process integration (effect = 1.79, 95% CI: 0.94–2.80), indicating partial mediation. Group comparisons demonstrated that high AI adoption firms achieved substantially greater time-to-market reductions (23.41% vs. 9.74%, $p < .001$) and higher development efficiency than low adoption firms. AI adoption substantially enhances product development outcomes in high-tech SMEs, with process integration serving as a key mechanism through which these benefits materialize. Organizational readiness strengthens AI's impact, indicating that both technological and structural capabilities are essential for accelerating innovation cycles. Strengthening AI integration practices can therefore support SMEs in achieving faster and more efficient market delivery.

Keywords: Artificial intelligence; Product development; Time-to-market; High-tech SMEs; Process integration; Organizational readiness.

Introduction

The rapid advancement of artificial intelligence (AI) has transformed the competitive landscape for enterprises across global markets, reshaping innovation processes, product development cycles, and organizational performance models. High-tech small and medium-sized enterprises (SMEs), characterized by their agility, technological intensity, and dependence on rapid commercialization cycles, increasingly leverage AI to enhance decision-making, accelerate development timelines, and improve strategic responsiveness. AI technologies now permeate key operational domains such as ideation, prototyping, engineering design, demand forecasting, supply chain synchronization, and marketing analytics, thereby redefining how organizations structure and execute innovation-based growth strategies. Recent scholarship emphasizes the integration of digital intelligence capabilities as a central driver of renewed productivity and competitive differentiation, particularly

through the formation of new quality productive forces enabled by algorithmic tools, machine learning, and data-driven automation [1]. Within this evolving technological paradigm, AI adoption represents not merely a toolset but a transformation catalyst influencing enterprise performance, strategic positioning, and market entry dynamics.

High-tech SMEs increasingly operate within globalized and hypercompetitive ecosystems in which digital transformation has become a prerequisite for resilience and long-term viability. Research on multinational and technology-driven enterprises highlights the profound effects of AI and digital tools—including big data analytics, IoT, and machine learning—on process optimization and innovation efficiency across organizational functions [2]. This transformation is particularly evident in marketing, where AI-enabled precision targeting allows firms to derive deeper customer insights, predict market shifts, and tailor offerings more effectively [3]. In addition, AI plays a significant role in transforming enterprise business processes, enabling automation, reconfiguring workflow structures, and facilitating higher levels of operational intelligence [4]. These advances have major implications for SMEs seeking to reduce product development uncertainty, anticipate customer needs, and navigate resource constraints.

The techno-economic significance of AI is further illustrated in studies examining digital empowerment pathways within manufacturing and services, where AI accelerates industrial transformation and enhances the scalability of enterprise capabilities [5]. Scholars examining multinational enterprises demonstrate how AI affects governance, strategic adaptability, and investment decisions, particularly in high-tech corporations navigating complex innovation ecosystems [6]. Likewise, AI-driven demand forecasting models, especially within IoT-enabled smart infrastructure contexts, highlight how advanced analytics reduce forecasting errors and support more efficient product development planning [7]. Demand prediction accuracy has major implications for SMEs operating under resource limitations and compressed product lifecycle pressures.

Another domain profoundly influenced by AI is internationalization and global strategic expansion. Studies on multinational investment, localized advertising strategies, and glocal marketing models reveal that digital technologies support context-specific market engagement, reduce informational barriers, and enhance the fit between product design and local consumer expectations [8, 9]. This localization logic is increasingly visible in transnational corporations seeking to adapt offerings for culturally diverse marketplaces, as demonstrated in analyses of multinational retail and food-chain strategies in China [10, 11]. The capacity of AI to extract insights from large-scale consumer data, including social media text mining, further enhances multinational and SME competitiveness by guiding product innovation and improving satisfaction outcomes [12].

The strategic role of AI is equally important in emerging markets. AI-based tourism strategies emphasize the capability of intelligent systems to enhance service development, resource allocation, and consumer experience, contributing to broader economic growth in developing regions [13]. Research in Africa underscores how AI-supported precision marketing can generate economic uplift in low-income contexts by optimizing resource deployment and enhancing the effectiveness of SME marketing strategies [3]. These insights highlight the cross-contextual relevance of AI in supporting accelerated product development and market adaptation in resource-constrained environments.

The adoption of AI is also transforming competitive behaviors among enterprises, influencing investment strategies and reshaping labor markets. Analyses of emergent labor market transformations indicate that AI adoption leads to redefined workforce structures and dynamic skill requirements, presenting both opportunities and challenges as firms accelerate their innovation agendas [14]. Additional studies reveal that AI influences capital market behavior and financial performance,

particularly in industries encountering rapid digitization and industrial restructuring [15]. Such evidence underscores the multidimensional impact of AI on both internal enterprise systems and broader economic environments.

Digital transformation also intersects with crisis management, economic resilience, and enterprise sustainability. Research on anti-crisis management highlights the role of advanced technological systems in supporting strategic decision-making under conditions of uncertainty [16]. Related work examining innovation activities of multinational corporations in emerging economies suggests that AI-enabled operational intelligence plays a decisive role in sustaining competitiveness and facilitating adaptive responses to volatile market conditions [17]. These insights are particularly valuable for high-tech SMEs that typically operate under higher vulnerability to environmental turbulence and supply chain unpredictability.

AI-driven automation, particularly through robotic process automation (RPA), has gained traction as a method of enhancing operational efficiency and reducing repetitive workloads. Evidence from surveys of AI-based RPA applications demonstrates significant improvements in workflow optimization, accuracy, and organizational scalability, reinforcing the strategic value of deploying automated systems within SME environments [18]. Likewise, studies exploring capital input and output efficiency in AI enterprises show that strategic investment in AI technologies enhances resource utilization and output effectiveness [19]. These findings highlight the productivity gains potentially available to SMEs that integrate AI deeply into their development pipelines.

A complementary thread in the literature emphasizes the structural and economic environment within which AI-enabled enterprises operate. Investigations into globalization, the evolution of multinational enterprises, and cross-border production networks demonstrate that competitive advantage is increasingly contingent on digital capability maturity, innovation responsiveness, and technological integration [20, 21]. From capital-intensive manufacturing sectors to service-oriented firms, the role of AI continues to expand across product innovation frameworks, supply chain architectures, and customer engagement systems.

High-tech SMEs occupy a unique position in this landscape. Their size confers agility and adaptability, enabling faster integration of AI tools; yet resource constraints, skill shortages, and infrastructural limitations create significant barriers to full-scale transformation. Studies on integrated marketing communication and SaaS-based AI tools demonstrate that cloud-enabled intelligence can mitigate these constraints by offering scalable, low-cost AI solutions that align with SME innovation needs [22]. Meanwhile, localized marketing and economic strategies reinforce the importance of tailoring AI-enabled product development to the sociocultural and economic contexts of target markets [23, 24]. Such contextual understanding is essential for SMEs navigating internationalization while simultaneously accelerating development cycles.

Additionally, several studies demonstrate how AI supports decision-making in investment-intensive sectors, including infrastructure, logistics, and manufacturing, highlighting its ability to enhance forecasting accuracy, reduce operational inefficiencies, and support strategic resource planning [15, 25]. This is complemented by research in environmental and sustainability-driven marketing strategies, where AI-based systems contribute to greener branding and more sustainable business models [26]. Together, these perspectives illustrate the diverse utility of AI in supporting product development across technological, organizational, and market dimensions.

The literature also underscores the role of AI in shaping organizational governance and cross-border risk environments. Studies exploring intellectual property risks, tax strategies, and international expansion dynamics reveal that AI introduces new complexities into enterprise regulatory landscapes while also offering tools to enhance compliance and reduce risk

exposure [23, 27, 28]. These regulatory dynamics influence product development timelines, especially when firms operate across multiple jurisdictions and must ensure alignment with international standards.

Despite the breadth of research on AI within multinational and large enterprise contexts, fewer studies have examined how AI directly influences product development speed and time-to-market acceleration in high-tech SMEs, particularly through mediating mechanisms such as process integration, digital readiness, and workflow automation. Much of the existing literature documents the macroeconomic, managerial, or sector-level impacts of AI adoption rather than investigating the micro-level operational processes that determine how quickly SMEs can convert ideas into market-ready products. As global competition intensifies and product life cycles shorten, understanding how AI can be leveraged to accelerate innovation has become a strategic imperative for high-tech SMEs.

Therefore, the aim of this study is to investigate how AI adoption intensity, organizational readiness, and AI-enabled process integration influence product development efficiency and time-to-market acceleration in high-tech SMEs.

Methodology

The study adopted an applied, descriptive-analytical research design aimed at examining how artificial intelligence capabilities contribute to product development efficiency and reductions in time-to-market within high-tech small and medium-sized enterprises. Given the complexity of AI integration in innovation workflows, the design relied on a cross-sectional approach that enabled the assessment of firms operating at different stages of technological maturity. Participants were selected from high-tech SMEs active in sectors such as electronics, software, biomedical engineering, and advanced manufacturing. These firms were chosen because of their strategic dependence on rapid innovation cycles and their increasing adoption of AI-enabled tools. Inclusion criteria required that participating firms have an active R&D unit, demonstrable engagement with AI applications in at least one stage of product development, and a minimum operational history of three years. Senior managers, R&D directors, AI specialists, and product development engineers constituted the core respondent group, as these individuals possessed direct knowledge of decision-making processes, innovation pipelines, and AI-enabled operational mechanisms. Sampling relied on a combination of purposive and criterion-based strategies to ensure that only firms with relevant technological integration were included, thereby enhancing the validity of data related to AI-driven innovation outcomes.

Data collection was conducted through a structured questionnaire complemented by semi-structured interviews. The questionnaire was designed to assess three primary domains: the level of AI adoption across product development stages, perceived improvements in development speed and process efficiency, and organizational readiness factors that influence time-to-market acceleration. Items were developed after a thorough review of contemporary AI innovation frameworks, digital transformation models, and product lifecycle management literature. Respondents were asked to provide ratings on a five-point Likert scale that captured both the depth and breadth of AI application within their firms. The semi-structured interviews were conducted with a subset of participants to generate richer qualitative insights that could contextualize the survey findings. These interviews explored themes such as the integration of AI into ideation and prototyping, algorithmic decision support in design and testing, workflow automation, cross-functional collaboration enabled by AI tools, and managerial perceptions of AI-mediated efficiency. This mixed-instrument approach ensured that both quantitative and qualitative dimensions of AI-driven product development were comprehensively captured.

The analysis followed a sequential explanatory strategy in which quantitative data were first processed and interpreted, followed by qualitative contextualization. Quantitative survey responses were analyzed using statistical software to compute descriptive measures, evaluate construct validity, and test hypothesized relationships. Reliability analyses were performed to confirm internal consistency across instrument dimensions. Inferential analyses, including regression modeling and structural equation modeling, were employed to examine the impact of AI adoption intensity on time-to-market acceleration and to identify the mediating role of organizational readiness and process integration. The qualitative interview data were analyzed through thematic content analysis to identify recurring concepts and experiential patterns. Coding proceeded through open, axial, and selective stages to extract themes related to AI-enabled decision-making, innovation speed, workflow optimization, and organizational enablers or barriers. The qualitative findings were then integrated with quantitative results to provide a comprehensive interpretation of how AI contributes to product development efficiency in high-tech SMEs. This analytical framework enabled the study to derive robust, triangulated insights into the mechanisms through which AI accelerates innovation cycles and enhances competitiveness in technology-driven markets.

Findings and Results

In line with the objectives of the study, descriptive and inferential analyses were conducted to characterize the participating firms and to examine the relationships between AI adoption, product development efficiency, and time-to-market outcomes. Table 1 presents the demographic and structural characteristics of the high-tech SMEs included in the analysis.

Table 1

Demographic and Structural Characteristics of Participating High-Tech SMEs (N = 210)

Characteristic	Category	n	%
Sector	Software/IT	74	35.2
	Electronics	58	27.6
	Biomedical	36	17.1
	Advanced manufacturing	42	20.0
Firm size (employees)	10–49	92	43.8
	50–99	76	36.2
	100–249	42	20.0
Years in operation	3–5 years	69	32.9
	6–10 years	87	41.4
	More than 10 years	54	25.7

The sample was broadly distributed across key high-tech sectors, with software and IT firms forming the largest group, followed by electronics, advanced manufacturing, and biomedical enterprises. Most firms fell within the smaller end of the SME spectrum, with nearly two thirds employing fewer than 100 staff, reflecting the lean and agile nature of high-tech SMEs. In terms of maturity, a substantial portion of firms had been operating between 6 and 10 years, indicating that the majority had already passed their initial start-up phase and had established product development routines within which AI tools could be meaningfully deployed.

Table 2

Descriptive Statistics and Correlations for Main Study Variables (N = 210)

Variable	M	SD	1	2	3	4	5
1. AI adoption intensity	3.62	0.71	—				
2. Process integration	3.48	0.76	0.68***	—			
3. Time-to-market reduction (%)	17.35	8.92	0.47***	0.55***	—		
4. Product development efficiency	3.89	0.68	0.52***	0.49***	0.46***	—	
5. Organizational readiness	3.74	0.73	0.44***	0.41***	0.33***	0.38***	—

Note. Time-to-market reduction is expressed as a perceived percentage decrease in development cycle duration over the last three years. *** $p < .001$.

The descriptive results indicate that, on average, firms reported moderate to high levels of AI adoption intensity and process integration, with mean scores above the scale midpoint. On average, respondents perceived a 17.35% reduction in time-to-market over the preceding three years, suggesting that the sample consists of organizations that have already experienced tangible cycle-time benefits. AI adoption intensity showed strong positive correlations with process integration and product development efficiency, and a moderate positive association with both time-to-market reduction and organizational readiness. Process integration itself was strongly related to time-to-market reduction, indicating that the way AI is embedded in workflows is at least as important as its mere presence. The pattern of correlations supports the hypothesized view that AI capabilities, when coupled with adequate readiness and integration, are associated with accelerated development cycles and more efficient product pipelines.

Table 3

Multiple Regression Predicting Time-to-Market Reduction from AI-Related Predictors (N = 210)

Predictor	B	SE B	β	t	p
Constant	4.12	3.21	—	1.28	.203
Firm size (log employees)	1.47	0.81	0.11	1.81	.072
Firm age (years)	0.09	0.06	0.08	1.50	.136
Software/IT sector (1/0)	1.96	1.12	0.10	1.75	.081
AI adoption intensity	3.21	0.52	0.39	6.17	< .001
Organizational readiness	1.48	0.49	0.21	3.02	.003
Process integration	2.07	0.58	0.27	3.57	< .001

Model statistics: $R^2 = .41$, Adjusted $R^2 = .39$, $F(6, 203) = 23.46$, $p < .001$.

The regression results demonstrate that AI-related variables make a substantial and statistically significant contribution to explaining differences in perceived time-to-market reduction across firms, above and beyond basic structural characteristics. While firm size, firm age, and sectoral membership display only marginal or non-significant effects, AI adoption intensity, organizational readiness, and process integration all positively and significantly predict greater time-to-market reduction. In particular, AI adoption intensity exhibits the strongest standardized effect, indicating that each one-unit increase in adoption intensity is associated with an estimated 3.21 percentage point increase in time-to-market reduction. Process integration also has a robust effect, suggesting that firms which more systematically embed AI into their workflows achieve additional acceleration benefits. Organizational readiness shows a moderate but significant contribution, implying that supportive structures, skills, and culture help to translate AI capabilities into concrete cycle-time improvements. Overall, the model explains about 41% of the variance in time-to-market reduction, underscoring the central role of AI-related factors in shaping speed-to-market outcomes in high-tech SMEs.

Table 4

Mediation Analysis of Process Integration in the Relationship Between AI Adoption Intensity and Time-to-Market Reduction (N = 210)

Path / Effect	B	SE	95% CI Lower	95% CI Upper
AI adoption → Process integration (a)	0.72	0.06	0.60	0.84
Process integration → Time-to-market (b)	2.48	0.51	1.48	3.46
AI adoption → Time-to-market (direct, c′)	1.42	0.49	0.45	2.35
Indirect effect (a × b)	1.79	0.48	0.94	2.80
Total effect (c = c′ + a × b)	3.21	0.52	2.19	4.24

Note. Time-to-market refers to the percentage reduction in development cycle duration. Indirect effect confidence intervals are based on bootstrapping with 5,000 resamples.

The mediation analysis indicates that process integration constitutes a significant pathway through which AI adoption intensity contributes to reductions in time-to-market. AI adoption intensity is strongly associated with higher levels of process integration, and process integration in turn significantly predicts increased time-to-market reduction. The indirect effect of AI via process integration is positive and statistically significant, as its bootstrapped confidence interval does not include zero, demonstrating that part of the influence of AI adoption on cycle-time acceleration operates through the way AI is embedded in development workflows. At the same time, the direct effect of AI adoption intensity on time-to-market reduction remains significant after accounting for process integration, suggesting partial rather than full mediation. This pattern implies that AI contributes to acceleration both by enabling more integrated, data-driven processes and by exerting direct influences, such as improved decision quality, enhanced forecasting, or automated experimentation, that are not fully captured by the process integration construct.

Table 5

Comparison of Time-to-Market and Process Outcomes Between Low and High AI Adoption Groups (Upper and Lower Tertiles; n = 70 per group)

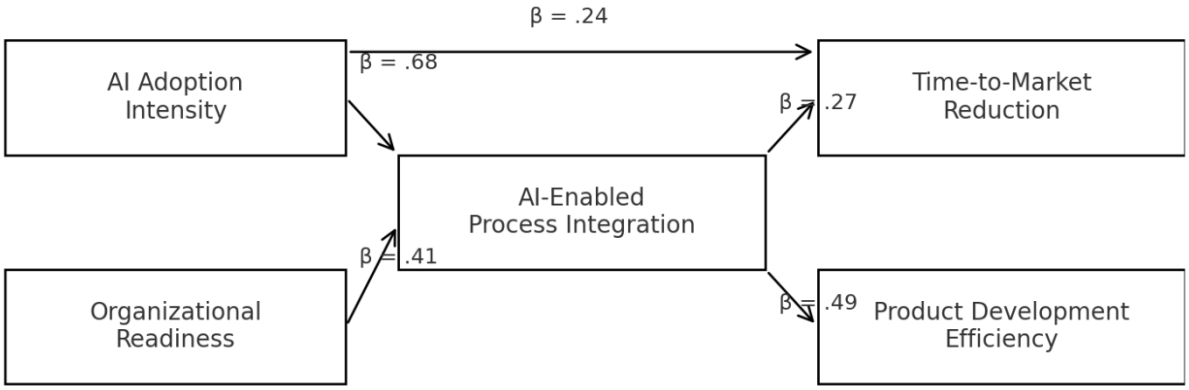
Outcome variable	Low AI adoption M (SD)	High AI adoption M (SD)	t	p
Time-to-market reduction (%)	9.74 (5.86)	23.41 (7.92)	11.84	< .001
Product development efficiency	3.41 (0.59)	4.32 (0.52)	9.20	< .001
Process integration	2.86 (0.63)	4.09 (0.55)	11.01	< .001

Note. Groups were formed based on the lower and upper tertiles of the AI adoption intensity scale.

The comparison of firms in the lowest and highest tertiles of AI adoption intensity reveals substantial and statistically significant performance differences. High-adoption firms report more than double the perceived time-to-market reduction compared to low-adoption firms, highlighting the magnitude of acceleration associated with advanced AI use. These firms also exhibit markedly higher product development efficiency scores, indicating smoother workflows, fewer rework cycles, or more effective resource utilization in their innovation processes. Similarly, process integration scores are significantly higher among high-adoption firms, consistent with the view that these organizations have moved beyond experimental or isolated AI pilots to more systematic, end-to-end integration of AI tools across the product development pipeline. The large effect sizes reflected in the t-statistics support the conclusion that higher levels of AI adoption are strongly associated with both structural improvements in development processes and tangible gains in time-to-market performance in high-tech SMEs.

Figure 1

Final Model of the Study



Discussion and Conclusion

The findings of this study provide strong evidence that AI adoption intensity, organizational readiness, and AI-enabled process integration jointly contribute to improved product development efficiency and accelerated time-to-market in high-tech SMEs. The statistical results demonstrate clear relationships between these constructs, showing that AI adoption exerts both direct and indirect effects on development outcomes. The significant mediation pathway through AI-enabled process integration suggests that the mechanisms by which AI creates value are deeply embedded in internal workflow structures rather than confined to surface-level automation. These results align with the growing body of research on AI-driven transformation across enterprise systems, which collectively emphasizes that the value of AI arises not merely from accessing advanced technologies but from integrating them meaningfully into organizational decision-making and operational routines.

The strong association between AI adoption intensity and process integration corresponds closely with arguments made in the literature regarding digital empowerment and new quality productive forces in enterprises [1]. Studies exploring the transformation of enterprise business processes similarly argue that AI reshapes core activities by improving real-time data utilization, facilitating forecasting, and enhancing coordination across functional areas [4]. This underscores the interpretation that process integration acts as a conduit through which AI capabilities are operationalized within SMEs. The positive relationship found between organizational readiness and integration mirrors findings from multinational enterprise research, where readiness in terms of skills, culture, and infrastructural maturity conditions the effectiveness of AI-enabled transformation [29]. SMEs with more developed readiness capabilities may thus be better positioned to capture the value associated with AI adoption, particularly in environments characterized by rapid technological shifts.

The direct and indirect contributions of AI adoption to time-to-market reduction reflect the broader trend of AI-enabled efficiency observed across diverse sectors. In studies examining internationalized and technology-intensive enterprises, AI tools have been shown to accelerate planning cycles, reduce uncertainty, and improve responsiveness to environmental volatility [17]. The observed acceleration in high-tech SME development cycles also aligns with research highlighting the predictive capabilities of AI-driven demand forecasting, particularly in IoT-enabled smart environments [7]. With more accurate projections, firms can reduce rework, avoid misallocation of resources, and synchronize production with market

needs more effectively. This supports the argument that AI does not merely speed up discrete tasks but improves the entire temporal structure of innovation workflows.

Similarly, the results indicating enhanced product development efficiency among firms with higher AI integration find strong support in research exploring AI-driven process automation. Studies show that robotic process automation reduces repetitive workloads, increases accuracy, and allows human workers to shift attention toward higher-value tasks [18]. These improvements naturally translate into more streamlined development cycles and reduced operational friction. Moreover, empirical studies on the efficiency of AI enterprises reveal that investment in AI capabilities correlates with more productive resource utilization across development and production stages [19]. The present findings thus reinforce existing evidence that AI integration strengthens development efficiency not only through automation but also through improved analytical, design, and decision-making capacities.

Another major implication of the findings relates to the importance of strategic and organizational context in shaping AI-driven development outcomes. International studies on globalization and multinational enterprise strategy emphasize that digital adoption interacts dynamically with organizational structures, governance practices, and market conditions [20]. The significance of organizational readiness in this study supports the theoretical claim that AI benefits are contingent on foundational capabilities such as human capital, technological infrastructure, and adaptive culture. Firms with higher readiness appear to capture a greater portion of AI's potential value, echoing research that stresses the importance of supportive organizational climates for digital innovation [11]. Moreover, findings from integrated marketing communication and SaaS-based AI deployment studies suggest that scalable, modular AI architectures can reduce barriers associated with resource constraints often faced by SMEs [22]. These observations point to the possibility that differences in readiness may explain heterogeneous adoption outcomes among SMEs in this study.

The comparative results showing significant performance differences between low and high AI adoption groups further illustrate the transformative potential of AI. Empirical research on AI's impact on market competition and productivity in globalized industries demonstrates that firms with deeper digital integration achieve superior performance outcomes compared to lagging competitors [14]. Similarly, analyses of digital economy environments reveal that AI adoption accelerates industrial restructuring processes by enhancing operational intelligence and reducing frictions in complex workflows [5]. The results of the present study mirror these findings, showing that SMEs that adopt AI more intensively experience substantially higher efficiency and shorter time-to-market cycles, thereby gaining competitive advantages in innovation-driven sectors.

Another notable alignment arises with literature addressing the role of AI in multinational and cross-border business environments. Research on international market strategies reveals that AI enhances firms' abilities to localize offerings, tailor development pathways, and respond quickly to cultural and market-specific insights [8, 24]. As SMEs increasingly expand participation in global technology markets, accelerated time-to-market becomes essential for capturing emerging opportunities and responding to competitive pressures. Likewise, text-mining studies examining consumer preferences in fast-moving industries demonstrate that AI-supported analysis improves the alignment between product features and customer expectations [12]. Such capabilities may contribute to the cycle-time advantages observed among high-adoption SMEs in this study.

In addition, the literature shows that AI adoption supports dynamic strategic decision-making across diverse enterprise forms. For example, research on capital market perspectives argues that AI strengthens investment decision-making by

increasing predictive precision and reducing uncertainty [15]. Similarly, studies examining sustainability-oriented marketing strategies find that AI contributes to environmental branding and resource efficiency [26]. These insights suggest that the acceleration observed in this study may not only be a technical artifact but also derive from improved strategic clarity and alignment across development phases.

While the results of this study resonate strongly with global research trends, they also contribute unique insights by focusing specifically on high-tech SMEs—an area that has received comparatively limited empirical attention. Much of the existing literature addresses AI in the context of multinational or large-scale enterprises, emphasizing macroeconomic effects, corporate governance implications, or large-scale industrial transformation [6, 21]. The present findings extend this body of knowledge by demonstrating that AI can yield measurable performance improvements even in smaller, resource-constrained firms—provided that organizational readiness and process integration conditions are met. This supports emerging perspectives suggesting that digital tools democratize innovation capability across firm sizes, enabling SMEs to compete in domains previously dominated by larger enterprises [2].

Collectively, the findings indicate that AI adoption in high-tech SMEs is most effective when supported by organizational readiness and embedded within integrated development processes. The model validated in this study highlights the multi-layered nature of AI value creation, showing that direct technological effects are amplified when internal systems are prepared to absorb and operationalize AI-driven insights. This aligns with research on the spatial spillover effects of AI adoption in enterprise ecosystems, which show that AI benefits extend beyond isolated tasks to alter the structural composition of enterprise capabilities [1]. The implication is that SMEs seeking accelerated development must not only acquire AI tools but also cultivate the internal conditions necessary to translate technology into performance.

This study, while comprehensive in its analytical scope, is subject to several limitations. The cross-sectional design limits causal inference, and although statistical associations were strong, longitudinal data would provide deeper insight into how AI influences development cycles over time. The reliance on self-reported measures introduces potential bias, particularly in the perception of efficiency gains and time-to-market improvements. The sample, while diverse across high-tech sectors, may not capture the full variability of SMEs in other regions or industries. Finally, the study does not differentiate between specific types of AI tools, which may vary significantly in their developmental impact.

Future studies should incorporate longitudinal or panel data methods to validate causal pathways and assess how AI-driven transformation unfolds across multiple development cycles. Comparative studies across different national contexts or regulatory environments would provide insights into how external conditions shape AI adoption outcomes. Further research should also differentiate between types of AI applications—such as generative design tools, predictive analytics, and automated testing platforms—to understand their unique contributions to development acceleration. Mixed-methods studies would provide richer interpretive depth into how organizational culture and managerial attitudes influence AI integration and utilization.

High-tech SMEs should prioritize strategic investments in AI-enabled process integration rather than solely acquiring digital tools. Strengthening organizational readiness through skill development, infrastructure enhancement, and cultural alignment will significantly amplify the benefits of AI. Managers should view AI not as a standalone technology but as a catalyst for broader workflow redesign, enabling faster innovation cycles and stronger competitive positioning. Firms that invest early in

AI integration and readiness-building are likely to achieve substantial advantages in product development speed and market responsiveness.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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