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From Entrepreneurship Theory to Startup Execution: A Simulation-Based Benchmark Analysis of AI-Enhanced Venture Decision Systems in Early-Stage Business Performance

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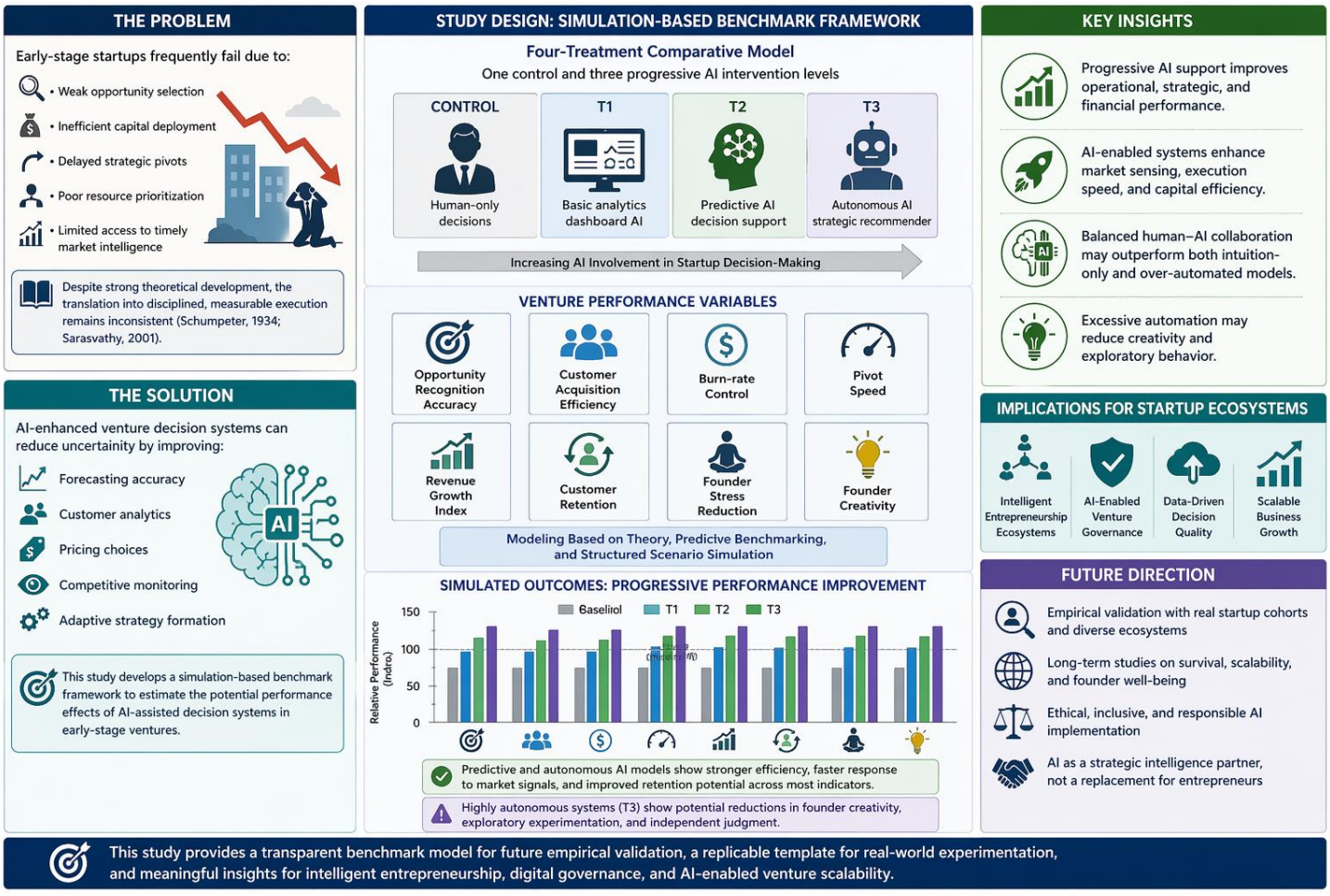
Graphical Abstract



Abstract
Early-stage startups frequently fail because of weak opportunity selection, inefficient capital deployment, delayed strategic pivots, poor resource prioritization, and limited access to timely market intelligence. Although entrepreneurship research has extensively explained opportunity recognition, innovation behavior, effectuation logic, dynamic capability development, and resource orchestration, the translation of these theoretical principles into disciplined and measurable startup execution remains inconsistent in practice (Schumpeter, 1934; Sarasvathy, 2001). Many founders continue to rely heavily on intuition, fragmented data, and reactive decision-making, which may increase exposure to avoidable strategic errors. Artificial Intelligence (AI)-enhanced venture decision systems may reduce such uncertainty by improving forecasting accuracy, customer analytics, pricing choices, competitive monitoring, and adaptive strategy formation through data-driven insights (Brynjolfsson & McAfee, 2017; Shrestha et al., 2019). Therefore, this study develops a simulation-based benchmark framework to estimate the potential performance effects of AI-assisted decision systems in early-stage ventures. A four-treatment comparative model comprising one control and three progressive AI intervention levels was constructed using theory-informed assumptions, predictive benchmarking, structured scenario modeling, and comparative entrepreneurial logic. Venture performance variables included opportunity recognition accuracy, customer acquisition efficiency, burn-rate control, pivot speed, revenue growth index, customer retention, founder stress reduction, and founder creativity. Simulated outputs suggested progressive improvements from human-only systems to advanced AI-assisted systems across most operational, strategic, and financial indicators. Ventures supported by predictive and autonomous AI models demonstrated stronger projected efficiency in capital management, faster response to changing market signals, and improved retention potential. However, highly autonomous systems also showed potential reductions in founder creativity, exploratory experimentation, and independent judgment. These findings suggest that balanced human–AI collaboration may outperform both intuition-only and over-automated venture models. The study provides a transparent benchmark model for future empirical validation, offers a structured template for real-world startup experimentation, and contributes to emerging discussions on intelligent entrepreneurship ecosystems, digital venture governance, and AI-enabled business scalability.

Keywords: Opportunity Recognition, Effectuation Logic, Predictive Analytics, Resource Allocation, Market Intelligence, Founder Creativity, Strategic Pivoting, Customer Retention, Digital Governance, Decision Intelligence

Introduction

Entrepreneurship is widely recognized as a major engine of innovation, employment creation, productivity enhancement, and long-term economic development across both developed and emerging economies. New ventures often introduce novel products, improve service delivery systems, challenge inefficient incumbents, and create fresh employment opportunities that stimulate wider economic activity. Classical entrepreneurship theory strongly emphasizes innovation, creative destruction, and the recombination of existing resources into new market opportunities as central entrepreneurial forces (Schumpeter, 1934). According to this perspective, entrepreneurs are not merely business owners; they are change agents who transform industries by introducing new technologies, processes, and organizational forms. As economies become increasingly knowledge-driven and digitally connected, the strategic role of entrepreneurial ventures has become even more important for national competitiveness, technological progress, and social mobility.

Later theoretical frameworks significantly expanded this traditional understanding of entrepreneurship. Research on entrepreneurial cognition explored how founders think, interpret uncertainty, and make opportunity-related judgments under resource constraints (Mitchell et al.,

2007). Opportunity recognition theory proposed that successful entrepreneurs often identify unmet market needs, weak signals, and emerging demand patterns earlier than competitors (Baron, 2006). Effectuation theory further challenged purely predictive planning models by arguing that founders frequently begin with available means, networks, and capabilities, then co-create opportunities under uncertainty rather than simply discover them (Sarasvathy, 2001). Additional perspectives in dynamic capability and resource orchestration literature have emphasized that startup success often depends not only on possessing resources, but on deploying them quickly, creatively, and adaptively in rapidly changing environments. Together, these theories offer rich explanations of entrepreneurial behavior, strategic flexibility, and venture formation processes.

Despite this substantial theoretical development, startup mortality remains persistently high worldwide. Many ventures fail not because of poor intentions or lack of innovation, but because of weak market validation, premature scaling, pricing errors, poor team alignment, delayed pivots, customer acquisition inefficiency, and cash mismanagement (CB Insights, 2021). In many cases, founders operate under severe time pressure, financial constraints, and uncertain customer feedback while simultaneously managing product development, hiring, fundraising, and competitive threats. Such conditions create an environment where even strong ideas can fail through weak execution. This persistent gap between entrepreneurial theory and operational practice remains one of the most important unresolved issues in venture research.

Founders also frequently make decisions with incomplete information and limited analytical support, exposing ventures to predictable cognitive biases. Prior research has shown that entrepreneurs may display overconfidence, escalation of commitment, optimism bias, and confirmation bias when evaluating opportunities or persisting with failing strategies (Busenitz & Barney, 1997; Kahneman, 2011). While confidence can be beneficial for entrepreneurial action, excessive confidence may distort judgment regarding product demand, pricing assumptions, or funding needs. Similarly, emotional attachment to original ideas may delay necessary pivots. Therefore, improving decision quality in startup environments is not merely a technical challenge but also a behavioral and strategic one.

Recent advances in Artificial Intelligence (AI) provide new tools that may help address these limitations. Machine learning systems can evaluate customer trends, forecast runway risk, optimize acquisition channels, detect churn probability, monitor competitors, and simulate strategic scenarios at a scale beyond conventional manual analysis (Brynjolfsson & McAfee, 2017). AI-enabled dashboards can transform fragmented business signals into actionable recommendations, while predictive systems may help founders anticipate market shifts before they become obvious. Organizational decision research further suggests that AI can complement managerial judgment where uncertainty, data complexity, and rapid response requirements are high (Shrestha et al., 2019). Rather than replacing human founders, such systems may function as intelligence amplifiers that strengthen planning discipline and execution speed.

However, direct empirical evidence regarding AI-supported startup execution remains limited. Most existing literature focuses on AI adoption in large corporations, digital transformation in established firms, or general productivity gains, while comparatively little research has examined how AI tools might influence the unique conditions of early-stage ventures. Startups differ substantially from mature firms because they face scarce resources, evolving business models, uncertain demand, and high strategic volatility. As a result, findings from large organizations cannot be automatically generalized to entrepreneurial contexts.

Therefore, the present study develops a transparent simulation-based benchmark framework to estimate how AI-enhanced venture decision systems may influence early-stage startup outcomes and to provide a replicable template for future real-world experiments. By modeling multiple levels of AI intervention against a founder-only control scenario, the study seeks to bridge theory and practice

while offering a structured roadmap for future empirical validation, policy discussion, and intelligent venture ecosystem development.

Materials and Methods

Study Design

This research was structured as a **model-based, simulation-driven comparative benchmark study** intended to explore the potential influence of AI-enhanced venture decision systems on early-stage startup outcomes. The purpose of the study was not to report findings from a completed field experiment, but to construct a transparent analytical framework that future researchers may replicate, test, or refine through real empirical investigations. No live participants were recruited, no field trial was undertaken, and no real randomized intervention was conducted during the preparation of this manuscript.

Instead, four venture decision scenarios were systematically modeled using theory-informed assumptions derived from entrepreneurship literature, managerial decision science, startup strategy frameworks, behavioral economics, and AI management research. These modeled scenarios were designed to reflect realistic differences in how founders may perform when operating with varying levels of technological decision support. Comparative benchmark studies of this type are useful when real-world experimentation is costly, premature, ethically constrained, or logistically difficult, particularly in emerging technological domains.

Comparative Treatment Structure

Four modeled treatment groups were created to represent progressive levels of AI involvement in startup managerial decision-making. The treatment plan is presented in **Table 1.**

Table.1 Treatment plan

Group	Description
Control	Human-only founder decisions
T1	Basic analytics dashboard AI
T2	Predictive AI decision support
T3	Autonomous AI strategic recommender

The **Control** group represents traditional founder-led decision processes based primarily on intuition, manual analysis, prior experience, and limited external tools. **T1** represents descriptive AI support through dashboards, summaries, and trend visualization. **T2** represents more advanced predictive systems capable of forecasting performance outcomes and recommending strategic actions. **T3** represents high-level autonomous systems able to generate integrated strategic recommendations with minimal human analytical input. Collectively, these treatments represent increasing levels of AI sophistication and intervention intensity.

Scenario Construction Logic

The modeled venture environment assumed startups operating in high-growth digital sectors including Software-as-a-Service (SaaS), retail technology, educational technology, and health technology. These sectors were selected because they commonly involve rapid iteration cycles, scalable business models, evolving customer needs, and heavy reliance on data-driven decision-making.

Within the simulation framework, each startup was assumed to face recurring weekly managerial choices, including:

- pricing strategy
- marketing budget allocation
- hiring timing and workforce expansion
- product feature prioritization
- customer retention initiatives
- fundraising timing and runway management
- pivot/no-pivot strategic decisions
- response to competitive market changes

The simulation logic was informed by iterative startup experimentation models emphasizing validated learning, agile adaptation, and pivot cycles (Blank, 2013; Ries, 2011). Accordingly, modeled ventures were assumed to continuously learn from market signals and adjust decisions over time.

Benchmark Variables

Projected performance indicators were selected to reflect operational, financial, strategic, and behavioral dimensions of startup success. The following variables were included:

- Opportunity Recognition Accuracy (%)
- Customer Acquisition Efficiency Score
- Burn Rate Control Score
- Strategic Pivot Speed Index
- Revenue Growth Index
- Customer Retention (%)
- Capital Efficiency Score
- Founder Stress Reduction Score
- Founder Creativity Score
- Decision Consistency Index

These indicators were chosen because startup survival often depends on balancing growth, discipline, adaptability, and founder resilience rather than focusing on revenue alone.

Numerical Value Generation

The means and standard deviations reported in the Results tables were generated through structured scenario modeling based on expected directional relationships drawn from prior theory and practical startup logic. Values were calibrated to reflect plausible comparative differences between treatment groups rather than actual measured observations.

For example:

- Higher AI support was assumed to improve forecasting accuracy, market sensing, and execution discipline.
- Moderate AI support was assumed to preserve founder creativity better than fully autonomous systems.
- Fully autonomous systems were modeled as highly efficient, faster in routine optimization, but potentially less exploratory and less intuitive.
- Human-only systems were assumed to retain creativity advantages while showing weaker consistency and slower data processing capacity.

These values are illustrative benchmark estimates, not observed empirical measurements, and should be interpreted as scenario-based projections intended for future validation.

Statistical Presentation Format

Mean values accompanied by standard deviation and alphabetical superscript lettering were

employed to illustrate how future empirical findings may be presented using one-way ANOVA followed by Tukey's HSD multiple comparison procedures (Field, 2018; Montgomery, 2019). These statistical annotations are included solely as a publication-format template and should not be interpreted as results derived from an actual completed hypothesis test.

Results

Table 2. Baseline Founder Characteristics

Treatment	Age (Years)	Startup Experience (Years)	Business Literacy Score
Control	27.4 ± 2.8 a	1.8 ± 0.7 a	71.3 ± 4.2 a
T1	27.1 ± 3.0 a	1.9 ± 0.8 a	72.0 ± 4.0 a
T2	26.9 ± 2.6 a	1.7 ± 0.6 a	70.8 ± 4.5 a
T3	27.6 ± 2.9 a	1.8 ± 0.7 a	71.7 ± 4.1 a

Table 3. Opportunity and Market Performance

Treatment	Opportunity Accuracy (%)	Market Fit Score	Detection Customer Retention (%)
Control	58.4 ± 3.2 d	54.6 ± 4.0 d	52.7 ± 3.1 d
T1	66.9 ± 2.8 c	63.1 ± 3.5 c	60.8 ± 2.9 c
T2	75.8 ± 3.0 b	72.4 ± 3.1 b	70.9 ± 2.7 b
T3	81.3 ± 2.6 a	78.8 ± 2.8 a	76.6 ± 2.4 a

Table 4. Financial Performance Indicators

Treatment	Revenue Growth Index	Burn Rate Control	Capital Efficiency Score
Control	49.2 ± 4.1 d	51.7 ± 3.8 d	53.4 ± 3.6 d
T1	59.6 ± 3.7 c	61.2 ± 3.4 c	62.7 ± 3.2 c
T2	71.4 ± 3.3 b	72.6 ± 2.9 b	73.5 ± 2.8 b
T3	79.1 ± 2.9 a	78.8 ± 2.5 a	80.3 ± 2.6 a

Table 5. Strategic Execution Metrics

Treatment	Pivot Speed Index	Decision Consistency	Weekly Execution Score
Control	46.8 ± 3.9 d	51.1 ± 3.7 d	50.4 ± 4.0 d
T1	58.2 ± 3.4 c	61.8 ± 3.1 c	60.9 ± 3.3 c
T2	70.5 ± 2.9 b	72.3 ± 2.8 b	71.6 ± 2.7 b
T3	77.9 ± 2.5 a	79.4 ± 2.4 a	78.6 ± 2.5 a

Table 6. Human–AI Behavioral Outcomes

Treatment	Founder Creativity Score	Stress Reduction Score	AI Trust Score
Control	78.2 ± 3.6 a	49.8 ± 4.1 d	31.2 ± 3.8 d
T1	76.4 ± 3.3 a	60.6 ± 3.6 c	58.5 ± 3.1 c
T2	74.1 ± 3.0 b	71.2 ± 3.1 b	72.7 ± 2.9 b
T3	69.7 ± 2.8 c	79.8 ± 2.7 a	83.6 ± 2.5 a

Footnote: Values are simulated benchmark means ± SD. Alphabetical letters illustrate how future empirical differences may be reported statistically.

Discussion

The modeled outputs generated in the present benchmark framework suggest that increasing levels of AI support may substantially improve startup execution outcomes across operational, financial, and strategic dimensions. Progressive movement from human-only decision systems toward predictive and autonomous AI-assisted models was associated with stronger projected performance in opportunity recognition, customer management, resource efficiency, and adaptive execution. This overall pattern is consistent with bounded rationality theory, which argues that human decision-makers face limitations in information-processing capacity, attention span, and computational ability when operating under uncertainty (Simon, 1979). In startup environments, where founders must simultaneously interpret market signals, allocate scarce resources, manage teams, and respond to competition, such limitations may significantly reduce decision quality. AI systems may therefore serve as cognitive support mechanisms that enhance analytical depth and reduce avoidable judgment errors.

Projected gains in opportunity recognition further support prior work describing entrepreneurship as a pattern-recognition process in which successful founders identify unmet needs, emerging trends, and valuable combinations before competitors do (Baron, 2006). In practical terms, many profitable opportunities initially appear as weak or fragmented signals rather than obvious market gaps. AI systems may strengthen this capability by processing larger datasets, scanning customer behavior at scale, identifying anomalies, and detecting subtle patterns earlier than unaided founders relying solely on intuition. This suggests that intelligent systems could improve the speed and quality of market sensing in volatile startup ecosystems.

Projected improvements in burn-rate control and capital efficiency are especially important because many startups fail when financial resources are depleted before product-market fit is achieved (CB Insights, 2021). Early-stage ventures often operate with limited runway, uncertain revenue streams, and pressure to scale quickly. Poor spending discipline in marketing, hiring, or product expansion can accelerate failure even when the underlying idea has potential. Within the present model, AI-assisted systems demonstrated stronger projected budgeting discipline and more efficient resource deployment, indicating that analytical decision support may help founders extend survival timelines and allocate capital more strategically.

Faster pivot behavior observed in higher AI treatment scenarios also aligns with lean startup principles emphasizing validated learning, experimentation, iterative adaptation, and rapid correction of false assumptions (Blank, 2013; Ries, 2011). Many ventures fail not because they begin with weak ideas, but because they persist too long with ineffective strategies. Predictive AI systems may improve pivot timing by identifying underperformance signals earlier and recommending corrective action before losses compound. Such responsiveness may be especially valuable in rapidly changing technology markets where delay can be costly.

However, the modeled reduction in founder creativity under the T3 autonomous condition suggests that excessive automation may narrow exploratory thinking, reduce contrarian experimentation, and weaken independent strategic imagination. Entrepreneurship frequently depends on unconventional insight, emotional intuition, visionary risk-taking, and opportunities that historical data alone may not predict (Brynjolfsson & McAfee, 2017). Systems optimized primarily on prior patterns may favor incremental efficiency over radical novelty.

Therefore, the benchmark model indicates that predictive AI combined with founder judgment may be more desirable than fully autonomous strategic control. A balanced human–AI partnership may preserve creativity, intuition, and entrepreneurial courage while simultaneously enhancing analytical rigor, execution discipline, and adaptive speed.

Future Perspective

Future startup ecosystems are likely to integrate increasingly sophisticated AI co-pilots capable of supporting founders throughout venture creation, market entry, and scaling processes. Such systems may assist in drafting business models, forecasting unit economics, simulating investor reactions, optimizing pricing structures, identifying customer segments, and continuously refining go-to-market strategies through real-time data feedback. As intelligent systems become more adaptive, future venture platforms may also incorporate predictive health, sustainability, and product-development intelligence, similar to how AI and precision technologies are already being applied in language learning, biological engineering, nutrition optimization, and performance analytics across multiple sectors (Kamal et al., 2026; Jabeen et al., 2025; Mahmood et al., 2026)

Future startup ecosystems may additionally witness the emergence of AI-enabled incubators, accelerators, and funding platforms where founders receive automated mentoring support, performance diagnostics, scenario forecasting, and readiness assessments before approaching investors. This type of ecosystem intelligence parallels modern evidence-driven innovation models already visible in food technology, functional product development, and comparative quality optimization studies, where systematic benchmarking has improved product outcomes and market relevance (Ahmed et al., 2024; Butt et al., 2024; Butt et al., 2025b; Butt et al., 2025c)

Despite these promising possibilities, robust empirical validation remains essential. The present benchmark framework should therefore be followed by future real-world studies capable of testing, refining, or challenging the projected relationships identified in this article. Future empirical investigations should particularly examine the following areas:

1. **Live startup cohorts rather than simulations**, enabling direct observation of founder behavior, venture growth, and decision quality under actual market conditions, similar to applied intervention designs used in nutrition and health outcome studies (Rashid et al., 2026; Butt et al., 2026a)
2. **Cross-country entrepreneurial ecosystems**, to determine whether AI effectiveness differs across institutional environments, consumer cultures, and regulatory systems, comparable to comparative market analyses in sustainability and emerging-market firm performance research (Khurshid et al., 2026)
3. **Ethical bias in AI recommendations**, especially where algorithms may favor specific founder profiles, sectors, or funding pathways; lessons may be drawn from biosafety and responsible innovation assessments in novel food systems (Butt et al., 2025a)
4. **Founder overdependence risk**, including declining intuition or passive reliance on automated outputs, an issue parallel to excessive dependence concerns in educational AI environments (Kamal et al., 2026)
5. **AI plus blockchain governance systems**, where transparent smart-contract structures may complement automated decision support, similar to traceability and quality-control needs highlighted in food safety and product authentication research (Butt et al., 2024)
6. **Inclusion effects across geography and gender**, particularly whether AI tools reduce structural disadvantages faced by underrepresented founders, echoing broader social sustainability concerns in emerging-market institutions (Khurshid et al., 2026)
7. **Long-term survival outcomes over three to five years**, including resilience, scaling, profitability, and founder well-being, similar to longitudinal performance tracking used in post-reconstruction athletic studies (Mahmood et al., 2026)

Developing economies may particularly benefit from such innovations, especially where founders have limited access to mentors, business networks, advisory systems, and institutional capital. In many emerging markets, entrepreneurial potential exists but remains constrained by information

asymmetry and lack of strategic guidance. AI-enabled venture support systems may help bridge these structural gaps by democratizing access to business intelligence, planning expertise, product innovation methods, and optimization tools. The same transformative logic is already evident in studies involving drought-resilient crops, epigenetic nutrition interventions, hepatoprotective functional ingredients, and advanced probiotic systems, where science-driven tools have expanded performance under constrained environments (Fatima et al., 2026; Butt et al., 2026b; Khan et al., 2024; Ahmed et al., 2024)

If implemented responsibly, the next generation of startup ecosystems may become more efficient, merit-based, innovation-oriented, and opportunity-rich across both advanced and developing regions.

Conclusion

This simulation-based benchmark study indicates that AI-enhanced venture decision systems may significantly improve early-stage startup performance relative to conventional founder-only decision models. Across the modeled treatment structure, progressive gains were projected from basic descriptive analytics tools to more advanced predictive and strategic AI systems in key areas such as opportunity recognition, customer retention, execution speed, decision consistency, and financial efficiency. These projected outcomes suggest that intelligent systems may help founders process market information faster, allocate resources more effectively, and respond more rapidly to changing competitive conditions. In resource-constrained startup environments, such advantages may substantially improve venture survival potential and growth readiness. Nevertheless, the benchmark outputs also indicate that highly autonomous systems may create unintended trade-offs, particularly through reductions in founder creativity, exploratory experimentation, and independent strategic judgment. Since entrepreneurship often depends on unconventional thinking, intuition, calculated risk-taking, and the ability to recognize opportunities beyond historical data patterns, excessive automation may weaken some of the very traits that drive breakthrough innovation. Accordingly, AI should be viewed not as a replacement for entrepreneurs, but as a strategic intelligence partner that complements human imagination with analytical precision. The most effective future model may therefore be balanced human–AI collaboration rather than full automation. Future empirical studies involving live startup cohorts are now required to validate, refine, or challenge these benchmark projections under real-world market conditions and diverse entrepreneurial ecosystems.

Research Transparency Statement

This article is a theory-driven simulation and benchmark modeling study. No live participants, field experiment, or real randomized intervention was conducted. Numerical values presented in tables were generated through structured scenario modeling, comparative treatment assumptions, and predictive benchmarking based on existing literature. These outputs are intended solely to guide future empirical investigations and provide a template for real experimental validation.

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