

Review

Enhancing leadership effectiveness through artificial intelligence adoption: A literature review and exploratory research in the Egyptian manufacturing sector

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Abstract: Artificial Intelligence (AI) is increasingly shaping leadership effectiveness in manufacturing by enabling data-driven decision-making and enhancing collaboration with AI systems. In emerging economies such as Egypt, however, AI adoption remains uneven across organizational functions, limiting its potential to strengthen leadership practices. Empirical research on AI adoption in developing manufacturing contexts is scarce. This study addresses this gap through a literature review and exploratory research involving 60 senior leaders from 15 manufacturing firms across eight industries, including automotive, electronics, home appliances, glass and crystal, steel, chemicals, textiles, and food processing. Findings show that AI adoption is highest in strategic planning (21–25%) and customer analytics (16%), moderate in operational areas such as production, quality, and supply chain management (10–18%), and lowest in workforce analytics (3%) and innovation/R&D (2–5%), revealing a fragmented adoption landscape that limits leadership integration. Key barriers include legacy systems, limited data infrastructure, fragmented governance, and organizational resistance. To address these challenges, a structured brainstorming process engaged executives, managers, and AI experts to generate, refine, and prioritize initiatives, resulting in a phased, KPI-driven framework for AI-enabled leadership that integrates digital capabilities, organizational alignment, ethical practices, and strategic governance. The study demonstrates that cross-functional collaboration, ethical oversight, and iterative implementation can transform isolated AI initiatives into sustainable strategic enablers, enhancing leadership effectiveness, operational efficiency, workforce engagement, and long-term competitiveness. These findings provide actionable guidance for advancing AI adoption in manufacturing and highlight directions for future research.

Keywords: leadership effectiveness; artificial intelligence; AI adoption; egyptian manufacturing; digital transformation; AI governance

1. Introduction

The contemporary business environment is increasingly characterized by complexity, rapid technological change, and heightened market volatility. Organizations operate in dynamic ecosystems shaped by global competition, evolving customer expectations, and continuous innovation cycles. Digitalization has emerged as a transformative force, reshaping business models, operational structures, and strategic priorities across industries (Wilson et al., 2017; Vrontis et al., 2023). While digital transformation fosters innovation, efficiency, and connectivity, it also introduces challenges related to organizational agility, data governance, cybersecurity, and workforce adaptation. Organizations must therefore move beyond traditional management approaches and adopt adaptive, technology-enabled strategies capable of

responding effectively to these dynamic conditions (Duan et al., 2019; Rožman et al., 2023; Fullan et al., 2024; Dwivedi, 2025).

1.1. Leadership in the era of AI

Leadership, which is the ability to inspire, guide, and influence individuals toward shared objectives (Ransbotham et al., 2017; Iddagoda, 2021), is undergoing a profound transformation in the era of Artificial Intelligence (AI). Integrating AI into leadership practices enhances analytical capabilities, enables data-driven decision-making, and reshapes the management of people, processes, and performance (Manta, 2020; Connelly et al., 2021; Shahzad et al., 2023). In manufacturing contexts, where operational excellence, product quality, and sustainability are critical, leadership effectiveness increasingly relies on AI-enabled systems. Tools such as predictive analytics, digital twins, intelligent automation, and real-time monitoring provide leaders with actionable insights that support proactive decision-making, cross-functional collaboration, and continuous improvement (Peifer et al., 2022; Madanchian et al., 2024; Gomaa, 2025). Beyond operational efficiency, AI facilitates scenario planning, risk management, and strategic foresight, enabling leaders to anticipate disruptions, optimize resources, and accelerate innovation cycles (Mikalef et al., 2019; Adewale & Ndwandwe, 2025; Bollaert, 2025; Upreti et al., 2025).

1.2. Problem statement

The rapid advancement of AI necessitates evolving traditional leadership models to align with data-rich, technology-driven organizational environments. Leaders must cultivate competencies in digital literacy, algorithmic understanding, and ethical decision-making to leverage AI effectively while mitigating associated risks. Effective AI-enabled leadership integrates technical expertise with emotional intelligence, ensuring that human judgment complements machine intelligence (Chowdhury et al., 2023; Sposato, 2023). This human-machine synergy enhances foresight, innovation, and strategic agility but also introduces challenges related to transparency, accountability, bias, and fairness. Ethical governance, human-centered design, and participatory decision-making are essential to ensure responsible, equitable, and sustainable AI adoption within leadership practices (Smith & Green, 2018; Haenlein & Kaplan, 2019; Dissanayake & Keppetipola, 2024).

Despite growing scholarly interest, the relationship between AI adoption and leadership effectiveness remains underexplored, particularly in emerging economies. Most studies focus on technological or operational outcomes while overlooking behavioral, organizational, and cultural dimensions. Leadership effectiveness in the digital era depends not only on adopting advanced technologies but also on organizational readiness, strategic alignment, digital competence, and ethical governance (Maity, 2019; Titareva, 2021; Dissanayake & Keppetipola, 2024; Sposato, 2024). Understanding how these factors interact with AI adoption is critical for enhancing leadership performance, fostering innovation, and sustaining competitive advantage (Calp, 2020; Madanchian et al., 2024; Sposato, 2025; Fantoni et al., 2025).

In the Egyptian manufacturing context, AI adoption presents both opportunities and challenges. Firms exhibit varying levels of digital maturity, technological

capability, and organizational readiness, while leaders face constraints, such as outdated infrastructure, limited data governance, workforce resistance, and ethical concerns regarding transparency, accountability, and potential job displacement. Without strategic alignment and capability development, AI initiatives risk fragmentation and underutilization, reducing their impact on leadership effectiveness and overall organizational performance. Aligning AI-enabled leadership with national priorities, including Egypt Vision 2030 and the National Artificial Intelligence Strategy, requires coordinated efforts across government, academia, and industry, alongside investments in digital skills, institutional capacity, and robust governance frameworks. When managed effectively, AI adoption can strengthen strategic agility, enhance global competitiveness, and drive operational excellence in Egyptian manufacturing.

1.3. Research objectives and contributions

This study investigates the relationship between AI adoption and leadership effectiveness in Egyptian manufacturing firms, addressing a critical research gap in emerging economies. As shown in **Figure 1**, the study's objectives are to: (1) assess the extent and patterns of AI adoption across strategic and operational functions; (2) examine its influence on leadership practices, decision-making, and organizational performance; (3) identify barriers and enablers of AI integration; and (4) develop a practical, evidence-based framework for AI-enabled leadership to guide managers in leveraging AI strategically and responsibly.

By providing a multi-industry perspective, the study offers actionable insights for organizations in Egypt and other emerging economies aiming to use AI as a strategic enabler to enhance leadership effectiveness and organizational performance.

The paper is structured as follows: Section 2 reviews the literature on AI adoption and leadership effectiveness; Section 3 details the research methodology; Section 4 presents and discusses the findings; and Section 5 concludes with key insights and recommendations for future research and practice.

2. Literature review

Artificial Intelligence (AI) has emerged as a transformative force that is reshaping industries, redefining business models, and revolutionizing leadership paradigms. In manufacturing, AI is a cornerstone of digital transformation, driving improvements in productivity, operational efficiency, and strategic decision-making. By integrating predictive analytics, machine learning, and cognitive automation, AI enables leaders to make data-driven decisions, optimize operations, and strengthen collaboration between humans and intelligent systems. Consequently, leadership effectiveness is increasingly linked to the ability to leverage AI for strategic foresight, innovation, and sustainable performance (Malik et al., 2020; Madanchian et al., 2024; Bock & von der Oelsnitz, 2025). Despite its global momentum, AI adoption in emerging economies such as Egypt remains inconsistent and fragmented. Variations in digital infrastructure, organizational readiness, and workforce capabilities contribute to uneven outcomes, with many manufacturers facing challenges such as limited data governance, financial constraints, and resistance to change. While AI is widely acknowledged as a catalyst

for industrial competitiveness, its direct influence on leadership effectiveness in these contexts remains underexplored. Understanding how AI adoption shapes leadership capability and organizational transformation in Egyptian manufacturing is therefore critical (Rožman et al., 2022).

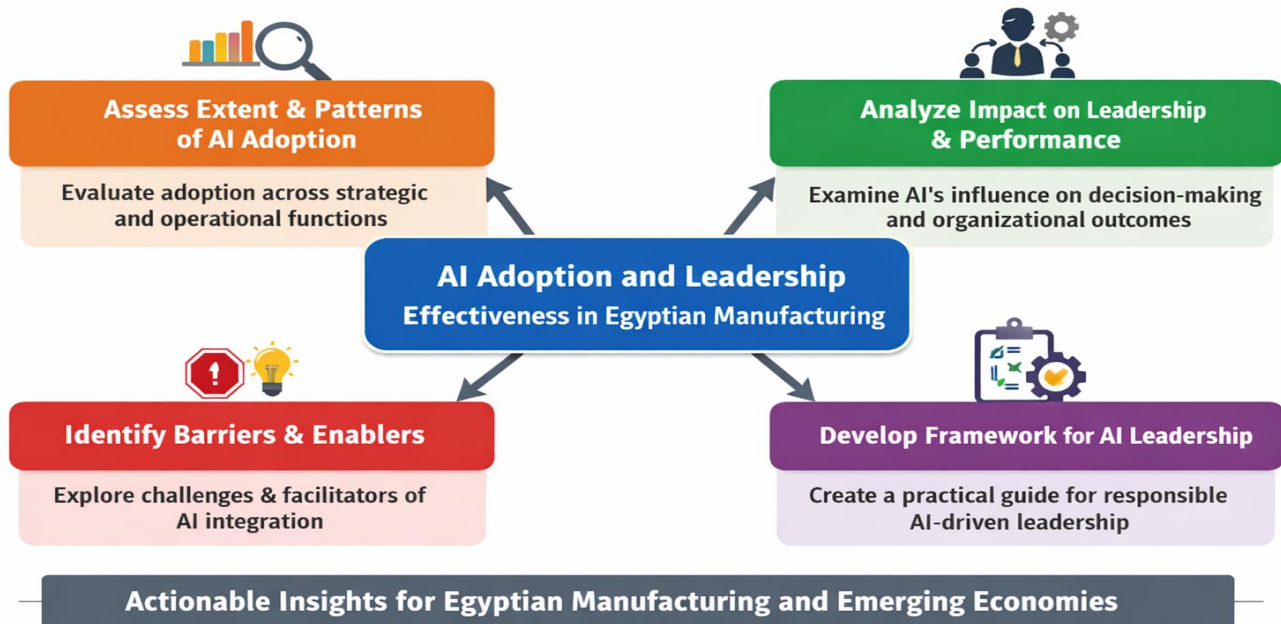


Figure 1. Research Objectives and Contributions.

To address this gap, this study employs a Systematic Literature Review (SLR) to synthesize global and regional research on AI adoption, digital transformation, and leadership development within manufacturing. Peer-reviewed publications from 2015–2026 were systematically retrieved from Scopus, Web of Science, and ScienceDirect using the keywords “Artificial Intelligence,” “Leadership,” “Manufacturing,” and “Digital Transformation.” The review followed a multi-stage protocol encompassing problem formulation, screening, eligibility assessment, data extraction, and thematic synthesis to ensure transparency and scholarly rigor. The reviewed studies collectively examine the relationships among AI technologies, organizational culture, human-centric and ethical dimensions, and governance mechanisms, providing an integrated understanding of how AI adoption enhances leadership effectiveness, particularly within emerging economies such as Egypt, where industrial growth intersects with cultural, institutional, and infrastructural constraints.

2.1. AI and the transformation of leadership

AI is redefining leadership by transforming decision-making, problem-solving, and strategy implementation. Traditional leadership models, often reliant on intuition and hierarchical authority, are evolving toward adaptive, participative, and data-driven paradigms. AI empowers leaders to extract insights from large datasets, anticipate outcomes, and align strategies with organizational objectives (Moldenhauer & Londt, 2018; Madanchian et al., 2024; Dwivedi, 2025). Fountaine et al. (2019) and Davenport & Ronanki (2018) highlight that AI enhances leadership agility by improving

forecasting, situational awareness, and evidence-based decision-making. In manufacturing, AI applications in predictive maintenance, quality control, and supply chain optimization have demonstrated measurable performance improvements. However, Canhoto & Clear (2020) observe that organizations often fail to realize these benefits due to weak leadership alignment, inadequate digital literacy, and fragmented strategy execution. Thus, effective AI-enabled leadership requires a balanced blend of technological competence, ethical judgment, adaptability, and inclusive change management.

2.2. Perspectives on AI-enabled leadership

Scholars present diverse views on how AI reshapes leadership roles and competencies. Quaquebeke & Gerpott (2023) challenge the assumption that leadership is exclusively human, arguing that AI systems may assume functions such as motivation, support, and feedback more consistently than humans. Bock & von der Oelsnitz (2025) identify 24 competencies, divided equally between skills and personality traits, necessary for leaders in the AI era, including communication, collaboration, and ethical awareness. Vargas Portillo (2025) emphasizes that integrating AI into leadership development requires strategic planning, awareness of ethical risks, and continuous adaptation. Rasool (2025) similarly highlights that leadership is often overlooked in AI research, particularly in education and training contexts where guidance and ethical oversight are vital. Collectively, these studies stress the importance of developing leaders who can combine technological fluency with human empathy and moral responsibility.

2.3. Core dimensions of AI-enabled leadership

Four interrelated dimensions underpin AI-enabled leadership effectiveness: Digital and Data-Driven Capabilities—the analytical capacity to interpret and apply data insights for informed decision-making; Organizational and Cultural Readiness—the extent to which an organization’s culture supports innovation, learning, and collaboration; Human-Centric and Ethical Orientation—the commitment to fairness, transparency, and accountability in AI applications; and Strategic Governance and Investment—the leadership structures and resources that guide AI implementation and align initiatives with long-term organizational objectives (Raisch & Krakowski, 2021; Bughin et al., 2018; Dwivedi et al., 2021; Fountaine et al., 2019). These dimensions collectively define the capabilities, culture, ethics, and governance structures necessary for effective AI-enabled leadership.

2.4. AI in manufacturing: Global and Egyptian perspectives

Manufacturing is among the most AI-intensive sectors, with applications spanning predictive maintenance, intelligent inspection, process optimization, digital twins, and real-time monitoring. These technologies enable proactive decision-making, reduce downtime, improve product quality, and enhance operational efficiency. Globally, AI adoption has shifted manufacturing from reactive to predictive and adaptive approaches, increasing resilience, productivity, and competitiveness (Brougham & Haar, 2018). The effectiveness of these technologies depends heavily

on leadership's ability to integrate AI into strategic planning, workforce development, and operational processes, ensuring alignment between technological capabilities and organizational goals. In Egypt, AI adoption is gradually advancing, with large firms in the automotive, steel, and chemical industries implementing AI to optimize production, quality management, and supply chain operations. Small and medium-sized enterprises (SMEs), however, face barriers including limited financial resources, insufficient digital infrastructure, and gaps in human capital. Leadership effectiveness in this context is contingent upon mobilizing resources, enhancing digital capabilities, and aligning AI initiatives with both organizational strategy and national priorities (Azab et al., 2025). Badawy (2025) evaluates Egypt's 2024 National Strategy on Ethical AI, recognizing its focus on transparency, accountability, and privacy, but noting that enforcement is limited, sector-specific guidance is insufficient, and public engagement remains minimal. Drawing on international frameworks (UNESCO, EU AI Act, Canada) and regional examples (UAE, Saudi Arabia, South Africa), twelve governance gaps are identified, including the absence of enforceable legal mandates, insufficient attention to informal sectors, limited data sovereignty, and a lack of gender-responsive AI auditing. A healthcare case study demonstrates the practical consequences of these gaps, emphasizing the need for reforms such as an independent AI ethics regulator, sector-specific ethical toolkits, and integration of AI ethics into Vision 2030 and national education programs. These insights highlight that effective AI-enabled leadership in Egypt must address technological, cultural, and governance challenges while supporting ethical, responsible, and sustainable AI adoption.

2.5. Challenges in AI-driven leadership

Despite its transformative potential, AI adoption in manufacturing presents several interrelated challenges that can impede leadership effectiveness. Technical constraints such as poor data quality, fragmented systems, and a lack of integration reduce the accuracy, reliability, and interpretability of AI outputs, limiting their utility for decision-making. Organizational resistance remains a major barrier, as employees may perceive AI as a threat to job security, and managers may be hesitant to modify established routines (Westerman et al., 2019). Overcoming these obstacles requires transparent communication, participatory leadership, and continuous reskilling programs that empower employees to work alongside AI tools. Ethical and governance challenges further complicate adoption. Data privacy, algorithmic bias, and accountability concerns necessitate robust ethical frameworks, monitoring mechanisms, and clear standards for responsible AI use (Zeeshan et al., 2024). In emerging economies, capability gaps, limited regulatory oversight, and weak institutional support amplify these challenges, highlighting the need for leaders with both technical literacy and ethical foresight. Furthermore, AI initiatives may fail to deliver expected benefits if not aligned with organizational culture, human capital readiness, and long-term strategic objectives. Effective leadership must therefore combine technological competence, human-centered management, and ethical decision-making to ensure AI adoption produces measurable improvements in operational performance, workforce engagement, and strategic outcomes.

3. Research methodology

This study employs an exploratory, mixed-methods design to investigate AI adoption and its impact on leadership effectiveness in Egypt's manufacturing sector. AI is recognized as a strategic enabler that enhances data-driven decision-making, operational efficiency, workforce productivity, and innovation. In emerging economies like Egypt, adoption remains uneven, often concentrated in specific functions and constrained by challenges such as limited technological infrastructure, legacy systems, fragmented governance, and workforce skill gaps. This study systematically examines adoption patterns, functional barriers, and leadership outcomes, addressing a critical empirical gap and providing actionable insights for managers, policymakers, and researchers. **Figure 2** illustrates the comprehensive methodology applied.

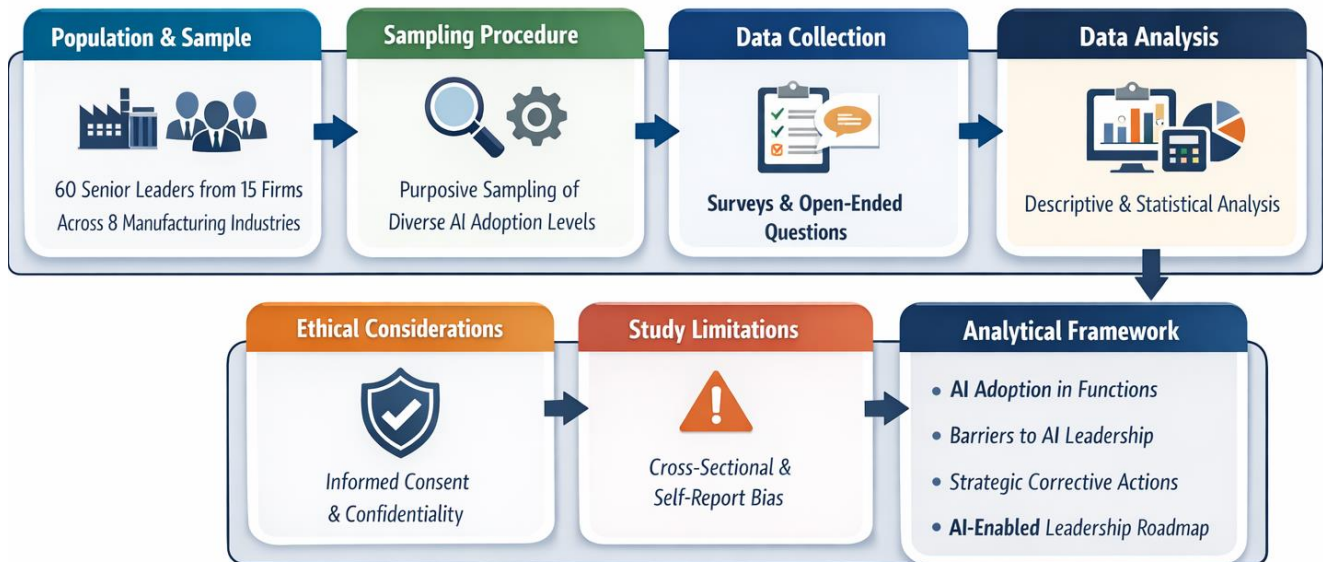


Figure 2. Research Methodology Framework for AI Adoption and Leadership Effectiveness.

- (1) **Population and Sample:** The study focused on senior leaders and decision-makers across eight key manufacturing sectors in Egypt: automotive, electronics, home appliances, glass and crystal, steel, chemicals, textiles, and food processing. These industries were chosen for their economic significance and technological diversity. A total of 60 leaders from 15 firms participated, representing a range of organizational sizes, operational scales, and digital maturity levels. Participants were directly involved in strategic planning, operations, and innovation initiatives, offering a cross-functional and cross-industry perspective on AI adoption and leadership practices.
- (2) **Sampling Procedure:** A purposive sampling strategy was applied to select organizations with varying levels of AI adoption and digital readiness. Participants were drawn from IT, operations, HR, and R&D departments to ensure diverse functional perspectives. The inclusion of multinational subsidiaries and medium-scale local manufacturers provided a broad spectrum of adoption experiences, organizational challenges, and leadership impacts.

- (3) **Data Collection and Instrumentation:** Data were collected using a structured survey based on validated constructs of AI adoption and leadership effectiveness. The survey assessed AI integration across strategic, operational, and support functions, organizational readiness, perceived leadership effectiveness, and implementation challenges. Open-ended questions captured qualitative insights into barriers, strategic priorities, and lessons learned, adding depth to quantitative findings. The instrument was reviewed by experts and pretested to ensure clarity, relevance, and validity.
- (4) **Data Analysis:** Quantitative data were analyzed using descriptive statistics, including percentages, mean Likert-scale ratings, standard deviations (SD), coefficients of variation (CV), and severity classifications. Leaders' Perception (%) reflected the proportion of respondents identifying a barrier as significant; Mean (1–5 Likert) indicated average agreement; SD measured variability; CV (%) captured relative dispersion; and Severity classified barriers as High (Mean ≥ 3.6), Moderate (3.3–3.5), or Low (≤ 3.2), highlighting priority areas for intervention. Qualitative data were thematically analyzed and triangulated with quantitative results to provide a comprehensive understanding of AI adoption patterns, functional barriers, and leadership implications.
- (5) **Ethical Considerations:** Participation was voluntary, and informed consent was obtained from all respondents. Anonymity of participants and organizations was maintained, and sensitive data were securely stored. Ethical oversight ensured compliance with international research standards, safeguarding participants' rights and promoting candid responses.
- (6) **Study Limitations and Mitigation:** The cross-sectional design captures a single point in time, limiting insights into temporal dynamics; longitudinal studies are recommended for future research. Although the sample size is modest, purposive selection across industries, organizational scales, and functional roles enhances representativeness. Self-reported data may introduce bias, mitigated through triangulation with organizational records and cross-functional perspectives. While focused on manufacturing, the methodology and analytical framework apply to other industrial contexts in emerging economies pursuing strategic AI adoption.
- (7) **Analytical Framework:** The methodology integrates four interrelated lenses:
 - **AI Adoption Across Business Functions:** Evaluates the scope, depth, and maturity of AI integration across strategic, operational, and support functions, highlighting strengths, gaps, and implications for decision-making, efficiency, and innovation.
 - **Barriers to AI-Enabled Leadership:** Identifies technological, organizational, human, ethical, and governance constraints, highlighting significance, variability, and priority areas for intervention.
 - **Strategic Corrective Actions:** Proposes targeted interventions in digital capabilities, organizational culture, human-centric practices, and governance mechanisms to enhance AI adoption and leadership outcomes.

- **AI-Enabled Leadership Roadmap:** Translates findings into a phased, actionable framework with defined responsibilities and measurable KPIs, ensuring sustainable adoption and strategic alignment.

In summary, this methodology provides a rigorous, ethically grounded, and empirically robust framework for exploring AI adoption and leadership effectiveness in Egypt's manufacturing sector. By integrating mixed methods, cross-functional perspectives, and quantitative–qualitative triangulation, it delivers actionable insights for managers, organizational leaders, and policymakers, addressing critical research gaps and guiding context-aware AI adoption to enhance leadership, performance, and innovation outcomes.

3.1. AI adoption across business functions

AI adoption in Egypt's manufacturing sector displays marked functional asymmetry, reflecting differences in digital maturity, resource allocation, and strategic priorities. As shown in **Table 1**, adoption is uneven across six core business functions, indicating a pattern of selective deployment rather than enterprise-wide integration.

Adoption is most advanced in strategic planning, where 21–25% of leaders report using predictive analytics, dashboards, and CRM systems. This concentration suggests that firms prioritize decision-support applications that deliver immediate value with relatively low integration complexity. However, the limited use of AI for market intelligence (4%) reveals a constrained external orientation, potentially weakening responsiveness to competitive and market dynamics.

Operational functions exhibit moderate but uneven adoption. While performance monitoring (18%) and production planning (11%) are increasingly used to enhance efficiency, more transformative applications, such as process automation (7%) and energy optimization (8%), remain limited. This indicates a predominantly incremental approach to AI adoption, with firms focusing on optimization rather than systemic transformation.

In quality and safety, AI is more widely applied to quality control and defect detection (14%) than to predictive safety (6%). This imbalance reflects a reactive approach to risk management, where AI is used to address issues post-occurrence rather than to anticipate and prevent them.

Supply chain and inventory functions follow a similar pattern. Although AI supports optimization (12%) and demand forecasting (10%), its limited use in supplier performance evaluation (4%) constrains visibility into upstream risks and reduces supply chain resilience.

A clear divergence is observed between external and internal analytics. Customer analytics shows relatively higher adoption (16%), indicating a focus on market-facing capabilities. In contrast, workforce analytics remains minimal (3%), suggesting that AI-driven human capital management is not yet a strategic priority. This imbalance may limit long-term productivity and organizational alignment.

Table 1. AI Adoption Across Business Functions in Egypt's Manufacturing Sector.

Category/function	AI application area	Strategic objective	% of leaders utilizing AI	Adoption level
Strategic Planning	Predictive analytics, dashboards, CRM tools	Facilitate data-driven decision-making and enhance customer insights	25%	High
	Strategic planning tools	Optimize resource allocation and support long-term strategy	21%	High
	Market trend & competitive intelligence	Monitor competitors and anticipate market changes	4%	Low
Operations & Production	Operational performance monitoring	Improve efficiency and minimize downtime	18%	Medium
	Production scheduling & maintenance planning	Maximize throughput and prevent bottlenecks	11%	Medium
	Energy management & efficiency optimization	Reduce energy costs and improve operational sustainability	8%	Low
	Process automation & robotics	Automate workflows and scale production	7%	Low
Quality & Safety	Quality control & defect detection	Ensure consistent product quality and reduce defects	14%	Medium
	Safety monitoring & hazard prediction	Prevent workplace accidents and enhance safety compliance	6%	Low
Supply Chain & Inventory	Supply chain optimization	Streamline logistics and improve delivery reliability	12%	Medium
	Inventory management & demand forecasting	Align supply with demand and reduce stock discrepancies	10%	Medium
	Supplier performance evaluation	Strengthen supplier reliability and mitigate supply chain risks	4%	Low
Customer & HR Analytics	Customer insights	Personalize engagement and enhance retention	16%	Medium-High
	Workforce productivity & HR analytics	Optimize workforce performance and support talent management	3%	Low
Innovation & Design	Product design & simulation	Accelerate product development and improve design quality	5%	Low
	Research & Development (R&D)	Drive innovation and shorten development cycles	2%	Very Low

The lowest adoption levels are found in innovation and product development. AI applications in product design (5%) and R&D (2%) remain marginal, indicating that firms largely deploy AI to improve existing processes rather than to drive innovation. This reflects a short-term, efficiency-oriented orientation that may constrain future competitiveness.

Overall, AI adoption is concentrated in strategic and customer-facing functions, moderate in operational domains, and limited in workforce and innovation areas. These patterns point to a fragmented and functionally siloed adoption model. Advancing toward a more integrated and balanced approach, particularly by strengthening capabilities in workforce analytics, innovation, and external intelligence, will be essential for enhancing leadership effectiveness and sustaining competitive advantage in an increasingly digital industrial environment.

3.2. Barriers to effective AI-enabled leadership

Leadership effectiveness in Egypt's manufacturing sector is shaped by a complex interplay of technological, organizational, human, ethical, and strategic factors. While AI adoption is gradually expanding across multiple business functions, its potential remains constrained by interrelated barriers that limit leaders' ability to leverage data-driven insights, optimize operations, enhance workforce performance, and drive innovation. These constraints directly affect organizational responsiveness, strategic agility, and long-term competitiveness, making it essential to systematically identify and address them.

Barriers were analyzed across six functional domains, namely, Strategic & Planning, Operations & Production, Quality & Safety, Supply Chain & Inventory, Customer & HR Analytics, and Innovation & Design, to provide a comprehensive perspective on AI adoption gaps and their impact on leadership practices. In Strategic & Planning, predictive analytics, dashboards, and CRM tools were underutilized due to weak AI leadership, poor data quality, and limited executive support. Strategic planning tools often failed to align with organizational objectives, and market intelligence initiatives revealed low awareness of emerging trends and competitor activity. **Table 2** highlights these gaps, emphasizing fragmented alignment, resistance to AI, and insufficient integration of AI into strategic decision-making, which restricts leaders' capacity for informed long-term planning.

In Operations & Production, applications such as performance monitoring, production scheduling, energy management, and robotics were constrained by legacy systems, siloed structures, and underdeveloped digital infrastructure. Limited access to real-time analytics and inefficient scheduling further restricted leaders' ability to make timely, data-driven operational decisions. Similarly, Quality & Safety functions, including defect detection and hazard prediction, showed low adoption due to limited human-AI collaboration, algorithmic bias, and workforce anxiety about job displacement, negatively affecting operational efficiency and safety outcomes.

Supply Chain & Inventory processes were hindered by fragmented visibility, misaligned initiatives, and weak digital culture, resulting in suboptimal demand forecasting and limited supplier oversight. In Customer & HR Analytics, low trust in AI, resistance to change, and workforce displacement concerns constrained analytics' effectiveness in personalizing customer engagement, improving workforce productivity, and optimizing skill alignment. Finally, Innovation & Design, including AI-enabled product simulation and R&D, was slowed by short-term investment priorities, weak digital culture, and underdeveloped infrastructure, limiting innovation cycles and competitive differentiation.

Table 2. Strategic Gaps and Key Barriers for AI-Enabled Leadership.

Category	AI Application area	Strategic gaps	Key barriers
Strategic & Planning	Predictive analytics, dashboards, CRM	Limited use of data for informed decision-making	Weak AI leadership; poor data quality
	Strategic planning tools	Misalignment with organizational objectives	Lack of unified AI strategy; limited executive support
	Market trend & competitive intelligence	Low awareness of emerging trends and competitors	Resistance to AI adoption; fragmented initiatives
Operations & Production	Performance monitoring	Limited real-time visibility of production	Legacy systems; underdeveloped digital infrastructure
	Production scheduling & maintenance	Inefficient resource utilization	Limited access to real-time analytics
	Energy management & efficiency	Underutilized optimization opportunities	Perceived financial risk; low prioritization
Quality & Safety	Process automation & robotics	Slow adoption and scaling	Siloed structures; insufficient digital capabilities
	Quality control & defect detection	Inconsistent product quality monitoring	Limited human–AI collaboration; inadequate integration
	Safety monitoring & hazard prediction	Low adoption of predictive safety systems	Algorithmic bias; workforce anxiety
Supply Chain & Inventory	Supply chain optimization	Fragmented visibility and responsiveness	Misaligned initiatives; weak digital culture
	Inventory management & demand forecasting	Inaccurate demand planning	Poor data quality; limited real-time analytics
	Supplier performance evaluation	Limited oversight of suppliers	Siloed structures; regulatory ambiguity
Customer & HR Analytics	Customer insights	Weak personalization and engagement	Low trust in AI; resistance to change
	Workforce productivity & HR analytics	Suboptimal workforce alignment	Job displacement concerns; weak AI leadership
Innovation & Design	Product design & simulation	Slow product innovation	Short-term investment focus; weak digital culture
	Research & Development (R&D)	Limited AI-enabled R&D capacity	Absence of AI strategy; underdeveloped infrastructure

These functional challenges are consolidated into four interrelated dimensions, as summarized in **Table 3**: Digital & Data Capabilities, Cultural & Organizational Change, Human-Centric & Ethical Concerns, and Strategic Governance & Investment. Digital & Data Capabilities include poor data quality, weak governance, insufficient leadership skills, underdeveloped infrastructure, and limited real-time analytics access. Cultural & Organizational Change covers resistance to AI-driven transformation, siloed structures, limited change management maturity, and a weak digital-learning culture. Human-Centric & Ethical Concerns encompass fairness, transparency, accountability, low trust, and workforce anxiety, while Strategic Governance & Investment includes the absence of a unified AI strategy, misalignment with business priorities, regulatory ambiguity, financial risks, and short-term focus.

Table 3. Key Barriers to Effective AI-Enabled Leadership.

Barrier category	Code	Leadership constraint	Comments
Digital & Data Capabilities	A1	Poor data quality & governance	Limits analytics reliability
	A2	Insufficient AI/digital leadership skills	Hinders adoption
	A3	Difficulty integrating AI with legacy systems	Delays deployment
	A4	Underdeveloped digital/automation infrastructure	Reduces efficiency
	A5	Limited access to real-time analytics	Slows decision-making
Cultural & Organizational Change	B1	Resistance to AI-driven transformation	Slows adoption
	B2	Lack of sustained executive sponsorship	Reduces prioritization
	B3	Limited change management maturity	Hinders adaptation
	B4	Siloed structures restricting collaboration	Limits cross-functional work
	B5	Weak digital-learning culture	Reduces adaptability
Human-Centric & Ethical Concerns	C1	Concerns over fairness, transparency, and bias	Reduces trust
	C2	Anxiety over job displacement	Lowers engagement
	C3	Unclear accountability for responsible AI use	Limits ethical use
	C4	Limited human–AI collaboration	Reduces AI impact
	C5	Low organizational trust in AI	Slows adoption
Strategic Governance & Investment	D1	Absence of a unified AI strategy	Limits long-term planning
	D2	High perceived financial risks	Reduces investment
	D3	Misalignment with business priorities	Fragments adoption
	D4	Regulatory ambiguity	Creates uncertainty
	D5	Short-term focus limits long-term investments	Reduces sustainability

The perceived significance of these barriers is quantified in **Table 4**, which reports five metrics for each barrier: Leaders’ Perception (%), indicating the proportion of respondents identifying the barrier as significant; Mean (1–5 Likert), showing average agreement; Standard Deviation (SD), reflecting response variability; Coefficient of Variation (CV, %), capturing relative dispersion; and Severity, classified as High (Mean ≥ 3.6), Moderate (3.3–3.5), or Low (≤ 3.2). These metrics provide both quantitative and comparative insights, enabling prioritization of barriers across functions and firms.

Among the four dimensions, Digital & Data Capabilities emerged as the most critical. Poor data quality and weak governance (A1, 48%) and insufficient AI and digital leadership skills (A2, 46%) were consistently identified as pressing challenges. Limitations in integrating AI with legacy systems (A3), underdeveloped infrastructure (A4), and restricted access to real-time analytics (A5) further constrain leaders’ ability to make informed, timely decisions.

Barriers associated with Cultural & Organizational Change, including resistance to AI-driven transformation (B1, 36%) and limited executive sponsorship (B2, 31%), highlight the importance of organizational culture and leadership engagement. Human-Centric and Ethical Concerns (C1–C2) underscore the need for trust, accountability, and effective human–AI collaboration. Strategic Governance & Investment barriers, such as the absence of a unified AI strategy (D1, 32%) and

perceived financial risks (D2, 29%), emphasize the importance of long-term planning, strategic alignment, and targeted investment to sustain AI adoption.

Table 4. Quantification of Leadership Barriers.

Code	Leaders' perception (%)	Mean (1–5)	SD	CV (%)	Severity
A1	48%	4.2	0.8	19.0	High
A2	46%	4.1	0.9	22.0	High
A3	34%	3.7	0.9	24.3	Moderate
A4	28%	3.4	0.8	23.5	Moderate
A5	27%	3.3	0.7	21.2	Moderate
B1	36%	3.7	0.9	24.3	Moderate
B2	31%	3.5	0.8	22.9	Moderate
B3	30%	3.4	0.7	20.6	Moderate
B4	24%	3.1	0.8	25.8	Low
B5	22%	3.0	0.7	23.3	Low
C1	35%	3.6	0.9	25.0	Moderate
C2	25%	3.2	0.8	25.0	Low
C3	27%	3.3	0.7	21.2	Low
C4	23%	3.1	0.7	22.6	Low
C5	21%	3.0	0.7	23.3	Low
D1	32%	3.5	0.8	22.9	Moderate
D2	29%	3.4	0.8	23.5	Moderate
D3	26%	3.2	0.7	21.9	Low
D4	27%	3.3	0.7	21.2	Low
D5	24%	3.1	0.7	22.6	Low

Severity classification: High (≥ 4.0), Moderate (3.3–3.9), Low (≤ 3.2).

The coefficients of variation (19–25%) indicate variability in perceptions across firms and functions, reflecting differences in digital maturity, AI readiness, and leadership preparedness. These findings support a phased, multi-dimensional approach: first, strengthen digital capabilities and leadership skills; second, implement targeted organizational change and ethical safeguards; and third, establish strategic governance and investment mechanisms. Systematically addressing these dimensions allows leaders to maximize AI's impact on decision-making, operational efficiency, workforce performance, and innovation, thereby enhancing competitiveness and resilience.

In conclusion, effective AI-enabled leadership in Egypt's manufacturing sector requires a holistic strategy integrating technological readiness, organizational culture, human-centered practices, and strategic governance. By identifying, quantifying, and prioritizing barriers, this study provides actionable insights for managers and policymakers to allocate resources, implement targeted interventions, and foster sustainable AI adoption. Addressing these barriers enables leaders to leverage AI for improved decision-making, operational excellence, workforce optimization, and innovation, strengthening competitive advantage in an increasingly digital industrial landscape.

3.3. Strategic corrective actions

Overcoming barriers to effective AI-enabled leadership in Egypt's manufacturing sector requires a systematic, multidimensional strategy, anchored in a structured brainstorming approach. This approach convened executives, managers, IT specialists, HR professionals, operational leads, and AI experts in interactive workshops, enabling participants to generate diverse ideas, evaluate feasibility, refine solutions iteratively, and build consensus. By relying on brainstorming, corrective actions were developed to be practical, contextually relevant, and strategically aligned, ensuring AI adoption avoids fragmentation or underutilization. The sessions guided initiatives across four interrelated dimensions, forming an integrated AI ecosystem where technology, culture, ethics, and governance reinforce one another to drive operational efficiency, leadership effectiveness, workforce engagement, and long-term competitiveness.

- (1) **Digital & Data Capabilities:** Digital and data infrastructure form the foundation of AI-enabled leadership. Brainstorming sessions identified poor data quality, fragmented legacy systems, and limited real-time insights as key barriers. Participants co-designed robust data governance frameworks, specifying ownership, stewardship, quality standards, and monitoring mechanisms to ensure accurate, actionable information. They also recommended modernizing legacy systems and deploying AI-ready middleware to integrate AI across production, operations, and supply chains, emphasizing advanced analytics and automation initiatives, including IoT deployment and predictive dashboards, to enable real-time, proactive decision-making. Finally, executive and managerial AI upskilling programs were highlighted to improve the interpretation of AI insights and strategic decision-making. Collectively, these measures ensure AI adoption delivers operational efficiency, predictive capability, and strategic value beyond isolated technology projects.
- (2) **Cultural & Organizational Change:** Organizational culture is critical for embedding AI into operations. Brainstorming revealed resistance to change, siloed structures, and weak learning cultures as major obstacles. Collaborative ideation led to structured change management programs, combining training, guidance, and feedback loops to actively engage employees. Executive sponsorship and AI champions were recommended to signal strategic commitment and accountability. To enhance knowledge sharing and consistent application of AI insights, cross-functional teams and integrated workflows were emphasized. Additionally, continuous learning and experimentation initiatives were designed to foster adaptability, innovation, and proactive engagement with emerging AI technologies. Iterative refinement during brainstorming ensured these interventions are practical, effective, and tailored to organizational needs.
- (3) **Human-Centric & Ethical Concerns:** Sustainable AI adoption depends on workforce trust, transparency, and ethical accountability. Brainstorming sessions highlighted employee concerns over job displacement, algorithmic bias, and limited human–AI collaboration. Participants co-developed ethical AI governance frameworks, including bias audits, explainable AI, and accountability mechanisms. They also recommended reskilling programs and workforce communication strategies to present AI as augmentation rather than

replacement, reducing anxiety and enabling effective collaboration. Furthermore, monitoring mechanisms and clear accountability structures were emphasized to ensure responsible AI use, mitigate operational and reputational risks, and promote ethical decision-making. These measures, derived directly from brainstorming, strengthen workforce trust, increase adoption, and enable reliable AI integration.

- (4) **Strategic Governance & Investment:** Governance and strategic oversight are essential to prevent fragmented initiatives, misaligned priorities, and inefficient resource use. Brainstorming workshops revealed gaps in strategic alignment and regulatory compliance. Stakeholders co-designed a unified AI roadmap to sequence initiatives, align projects with organizational objectives, and optimize resource allocation. Steering committees and alignment reviews were recommended to maintain oversight, ROI-based project prioritization to allocate resources to high-impact initiatives, and regulatory and compliance monitoring to ensure adherence to legal and ethical standards. These governance measures, informed by brainstorming, transform AI adoption into sustainable, high-value investments aligned with organizational strategy.
- (5) **Integrated Implementation and Strategic Impact:** The brainstorming approach not only generated corrective actions but also guided their sequencing, prioritization, and integration across all dimensions. When implemented cohesively, organizations achieve operational efficiency through automation and predictive analytics; enhanced leadership effectiveness as executives gain AI expertise; accelerated adoption supported by cultural engagement and cross-functional collaboration; improved workforce trust and engagement via ethical governance and reskilling; and sustainable strategic alignment through unified roadmaps and multi-year planning. **Table 5** summarizes these Strategic Corrective Actions, mapping each measure to priority, expected impact, and responsible units. High-priority actions, such as data governance, executive AI training, and ethical AI frameworks, address critical constraints identified in brainstorming sessions, while medium-priority actions strengthen operational scalability, collaboration, and workforce adaptability.

In conclusion, the brainstorming approach was central to developing these strategic corrective actions. By engaging diverse stakeholders in collaborative ideation, iterative refinement, and consensus-building, Egyptian manufacturers can ensure AI adoption evolves from isolated projects into an integrated, strategic enabler of operational performance, leadership effectiveness, workforce engagement, and sustainable competitiveness. The outputs captured in **Table 5** reflect both the practical and innovative dimensions of this methodology, providing a clear, actionable roadmap for implementation and long-term impact.

Table 5. Strategic Corrective Actions for Overcoming AI-Enabled Leadership Barriers.

Code	Corrective actions	Priority	Expected impact	Implementation focus
A1	Establish robust data governance, assign stewardship	High	Improved decision-making, reduced errors	IT & Data Management
A2	Executive AI upskilling programs and workshops	High	Stronger AI-driven decision-making	HR & Leadership
A3	Modernize systems, implement middleware	Medium	Streamlined operations	IT Infrastructure
A4	Expand IoT and automation	Medium	Operational scalability	Operations & IT
A5	Deploy dashboards and predictive analytics	High	Faster, accurate decisions	IT & Business Intelligence
B1	Structured change management, employee involvement	High	Higher AI adoption	Change Management
B2	Secure executive commitment, appoint AI champions	High	Sustained AI initiatives	Executive Management
B3	Train managers, standardize processes	Medium	Consistent adoption	Leadership & HR
B4	Promote cross-functional teams, collaborative tools	Medium	Knowledge sharing, accelerated AI adoption	Operations & IT
B5	Continuous learning programs, reward experimentation	Medium	Enhanced adaptability	HR & Innovation
C1	Ethical AI governance, bias audits, explainable AI	High	Increased trust	Governance & AI Teams
C2	Communicate AI augmentation, reskilling programs	High	Reduced resistance, workforce engagement	HR & Change Management
C3	Define accountability structures, monitoring	Medium	Responsible AI use	Governance & Risk
C4	Train employees, integrate AI support	Medium	Improved productivity	HR & Operations
C5	Promote transparency, share success stories	Medium	Smoother adoption	Change Management & IT
D1	Develop AI roadmap, align initiatives	High	Cohesive adoption, long-term competitiveness	Executive Management
D2	Conduct ROI analysis, prioritize high-impact projects	High	Cost-effective deployment	Finance & Strategy
D3	Establish AI steering committees, review alignment	Medium	Optimized strategic impact	Executive Management
D4	Monitor regulations, compliance frameworks	Medium	Reduced compliance risk	Legal & Governance
D5	Develop multi-year AI plans, balance short-term wins	Medium	Sustainable transformation	Strategy & Finance

3.4. AI-enabled leadership roadmap

AI-enabled leadership in Egypt's manufacturing sector represents a strategic transformation that goes far beyond technology deployment. It integrates digital capabilities, workforce development, organizational culture, ethical governance, and strategic investment to drive operational efficiency, innovation, and sustainable competitiveness. AI adoption is not merely a technical upgrade; it is a leadership imperative, requiring strategic oversight, human-centered decision-making, ethical responsibility, and measurable outcomes aligned with both organizational objectives and Egypt Vision 2030.

To develop this roadmap, a structured brainstorming approach was applied, engaging executives, managers, IT specialists, HR professionals, operational leaders, and AI experts. This collaborative process ensured that diverse perspectives were captured, identifying challenges and opportunities across technology, operations, workforce, and governance. IT specialists highlighted fragmented legacy systems and poor data quality, HR professionals emphasized workforce readiness and cultural

alignment, operational leaders contributed insights on process inefficiencies, and AI experts provided guidance on emerging technologies and ethical standards. The resulting roadmap is directly anchored in the **Table 6** initiatives, making it a structured, measurable, and actionable plan. The roadmap is organized around four interdependent dimensions, each integrating initiatives, codes, phases, responsibilities, and targets.

Table 6. AI-Enabled Leadership Roadmap.

Dimension	Code	Initiative	Phase	Responsible unit	Target
Digital & Data Capabilities	A1	Establish comprehensive data governance	Short-term	IT & Data Management	100% of critical data assets are governed
	A2	Deliver AI upskilling for executives	Short-term	HR & Leadership	90% of executives trained & certified
	A3	Modernize legacy systems & deploy AI-ready middleware	Medium-term	IT Infrastructure	80% of legacy systems upgraded & integrated
	A4	Expand IoT infrastructure & automate operations	Long-term	Operations & IT	70% of production lines are IoT-enabled & automated
	A5	Deploy predictive analytics dashboards	Medium-term	IT & Business Intelligence	95% adoption in key business units
Cultural & Organizational Change	B1	Implement structured change management & engagement	Short-term	Change Management	80% workforce participation
	B2	Appoint executive sponsors & AI champions	Short-term	Executive Management	Sponsors assigned to 100% of key units
	B3	Train managers & standardize AI adoption processes	Medium-term	Leadership & HR	90% of managers trained & certified
	B4	Foster cross-functional collaboration & AI-driven teams	Medium-term	Operations & IT	75% of projects executed cross-functionally
	B5	Promote continuous learning, innovation & experimentation	Long-term	HR & Innovation	80% workforce is engaged in learning programs
Human-Centric & Ethical Leadership	C1	Establish ethical AI governance & conduct bias audits	Short-term	Governance & AI Teams	100% of AI projects are ethically reviewed
	C2	Communicate AI augmentation & reskilling initiatives	Short-term	HR & Change Management	85% employee awareness & participation
	C3	Define accountability structures & monitoring	Short-term	Governance & Risk	100% of AI initiatives with clear accountability
	C4	Train employees & integrate AI into workflows	Medium-term	HR & Operations	90% of the relevant workforce trained & AI-enabled
	C5	Promote transparency through success stories & knowledge sharing	Medium-term	Change Management & IT	70% of teams share AI success stories
Strategic Governance & Investment	D1	Develop unified AI roadmap aligned with strategy	Short-term	Executive Management	100% initiatives aligned with strategy
	D2	Conduct ROI analysis & prioritize high-impact projects	Medium-term	Finance & Strategy	80% of projects prioritized by ROI
	D3	Operationalize AI steering committees & alignment reviews	Medium-term	Executive Management	Quarterly reviews for all initiatives
	D4	Monitor regulations & enforce compliance	Medium-term	Legal & Governance	100% compliance with legal & ethical standards
	D5	Develop multi-year AI plans balancing short- & long-term goals	Long-term	Strategy & Finance	Multi-year AI roadmap implemented & reviewed annually

The first dimension, Digital and Data Capabilities (**Table 6** Codes A1–A5), addresses challenges including fragmented legacy systems, inconsistent data, and limited real-time insights. In the foundation phase (0–6 months), IT and Data Management implement A1: a comprehensive data governance framework, ensuring 100% of critical data assets are governed. Simultaneously, HR & Leadership deliver A2: executive AI upskilling programs, targeting 90% of executives trained and certified to interpret AI insights strategically. In the integration and scaling phase (6–18 months), IT Infrastructure modernizes legacy systems through A3, achieving 80% coverage and seamless integration, while IT & Business Intelligence deploy A5: predictive analytics dashboards, aiming for 95% adoption across key business units. In the optimization and strategic alignment phase (18–24 months), Operations & IT expand A4: IoT infrastructure and automation, enabling 70% of production lines to be IoT-enabled and AI-integrated, enhancing operational efficiency and predictive decision-making.

The second dimension, Cultural and Organizational Change (**Table 6** Codes B1–B5), addresses resistance, siloed structures, and weak learning cultures. In the foundation phase, Change Management leads B1: structured change management and employee engagement programs, achieving 80% workforce participation, while Executive Management appoints B2: executive sponsors and AI champions to guide adoption across all business units. During the integration and scaling phase, Leadership & HR implement B3: managerial training and standardization of AI adoption processes, targeting 90% of managers trained, while Operations & IT foster B4: cross-functional collaboration and AI-driven project teams, ensuring 75% of projects are executed by integrated teams. In the optimization and strategic alignment phase, HR & Innovation deploy B5: continuous learning, innovation, and experimentation programs, engaging 80% of the workforce and embedding a culture of adaptability and sustained AI adoption.

The third dimension, Human-Centric and Ethical Leadership (**Table 6** Codes C1–C5), ensures workforce trust, transparency, and responsible AI use. In the foundation phase, Governance & AI Teams establish C1: ethical AI governance, conduct bias audits, and ensure explainable AI, reviewing 100% of AI projects. HR & Change Management implement C2: workforce communication and reskilling initiatives, reaching 85% employee awareness and participation, while Governance & Risk define C3: accountability structures and monitoring mechanisms, covering all AI initiatives. In the integration and scaling phase, HR & Operations lead C4: employee training and integration of AI into workflows, achieving 90% workforce coverage, while Change Management & IT implement C5: transparency and knowledge sharing, with 70% of teams sharing AI success stories. Collectively, these initiatives build workforce trust, ensure ethical adoption, and enable reliable integration of AI into daily operations.

The fourth dimension, Strategic Governance and Investment (**Table 6** Codes D1–D5), ensures initiatives are prioritized, coordinated, and strategically aligned. In the foundation phase, Executive Management develops D1: a unified AI roadmap, aligning 100% of initiatives with organizational strategy. During the integration and scaling phase, Finance & Strategy conduct D2: ROI-based project prioritization, targeting 80% of high-impact projects, while Executive Management operationalizes D3: AI steering committees and alignment reviews, ensuring quarterly oversight.

Legal & Governance implement D4: regulatory and compliance monitoring, achieving 100% adherence to ethical and legal standards. In the optimization and strategic alignment phase, Strategy & Finance implements D5: multi-year AI plans, balancing short-term wins with long-term objectives, with full implementation and annual reviews to maintain strategic alignment.

The roadmap is executed in three sequential phases, each building upon the previous. The foundation phase (0–6 months) focuses on governance, ethics, executive literacy, and foundational processes, achieving 100% of critical data assets governed, 90% executives trained, 80% workforce engagement, and 100% AI projects ethically reviewed. The integration and scaling phase (6–18 months) embeds AI into operations and culture, achieving 80% system coverage, 95% predictive dashboard adoption, 90% managers trained, and 75% of projects executed cross-functionally. The optimization and strategic alignment phase (18–24 months) emphasizes advanced analytics, IoT expansion, automation, continuous learning, knowledge sharing, and multi-year AI planning, targeting 70% of production lines to be IoT-enabled, 80% workforce engagement, and full multi-year roadmap implementation with annual review.

The strategic outcomes of this **Table 6**–anchored roadmap are substantial: operational efficiency is projected to improve by 20–30%, leadership effectiveness by 25%, workforce trust and engagement above 80%, and over 95% of initiatives aligned with organizational and national strategic objectives, directly contributing to Egypt Vision 2030.

In conclusion, by structuring the roadmap around the initiatives, codes, phases, responsibilities, and targets outlined in **Table 6**, the organization ensures that AI adoption is coherent, measurable, and strategically aligned. The structured brainstorming process enabled cross-functional idea generation, collaborative problem-solving, iterative refinement, and consensus-building, transforming AI initiatives from isolated projects into strategic drivers of operational performance, leadership effectiveness, workforce engagement, and long-term competitiveness. Guided by **Table 6** and **Figure 3**, this integrated roadmap provides Egyptian manufacturers with a clear, actionable, and sustainable framework to harness AI as a transformative force, ensuring technological readiness, cultural alignment, ethical integrity, and strategic impact.

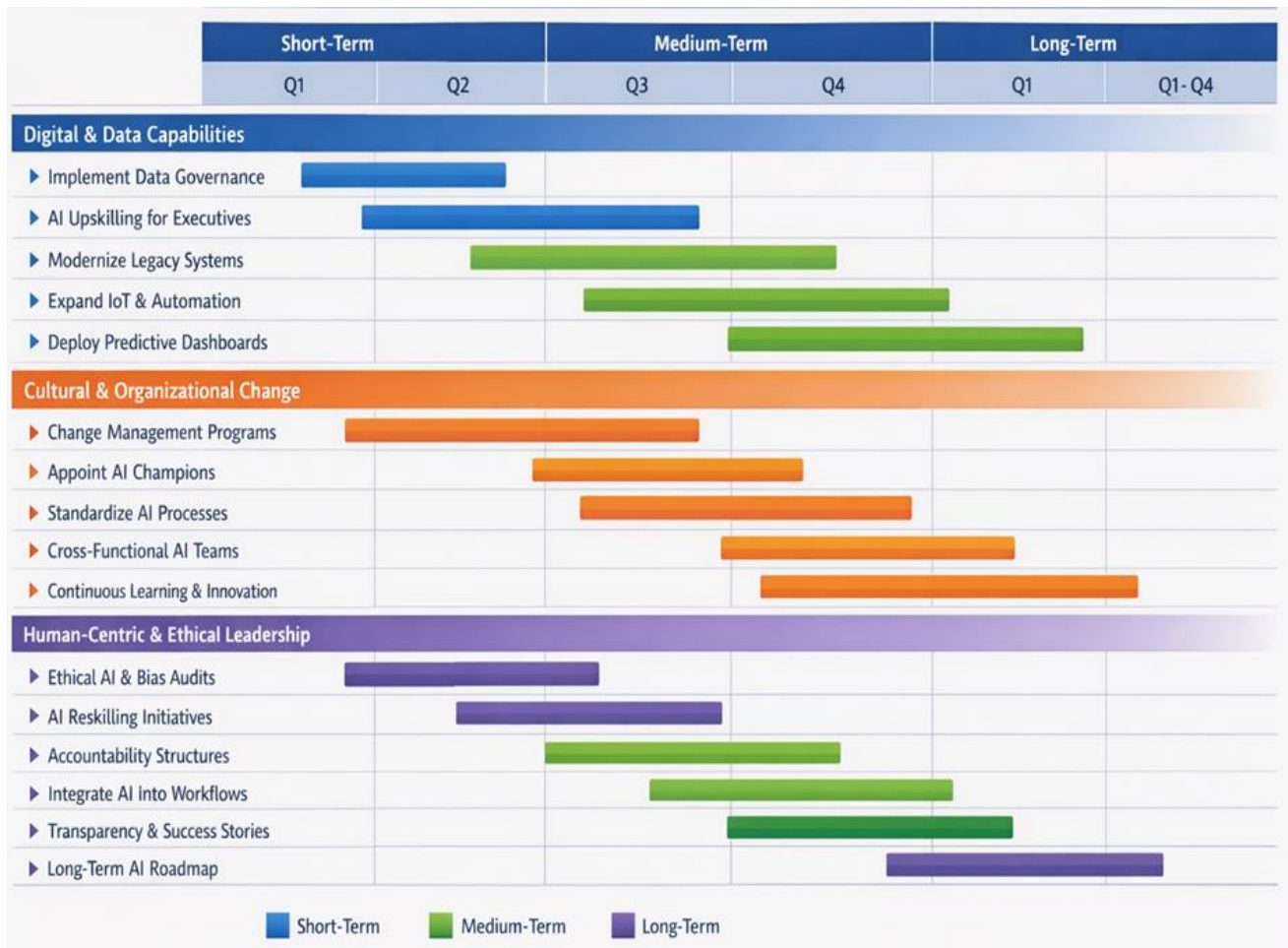


Figure 3. AI-Enabled Leadership Roadmap Gantt Chart.

4. Conclusion and future work

This study provides a comprehensive review and exploratory investigation of Artificial Intelligence (AI) adoption and its impact on leadership effectiveness in Egypt's manufacturing sector, based on data from 60 senior leaders across eight industries. Results reveal uneven AI adoption across organizational functions: it is most advanced in strategic planning and customer analytics, moderate in operations, production, quality, and supply chain, and minimal in workforce analytics and innovation/R&D. This indicates a selective, efficiency-focused deployment rather than an integrated, enterprise-wide approach.

Leadership effectiveness is constrained by technological, organizational, human, ethical, and strategic barriers. Legacy systems, fragmented governance, limited data quality, cultural resistance, and ethical concerns limit leaders' ability to fully leverage AI insights, restricting operational agility, workforce engagement, and long-term competitiveness. Addressing these challenges requires a holistic, multidimensional strategy integrating digital capability development, cultural transformation, human-centered ethical AI practices, and robust governance frameworks.

Using a structured brainstorming methodology, executives, managers, and AI experts collaboratively generated, refined, and prioritized actionable initiatives. This informed a phased, KPI-driven AI-enabled leadership roadmap, incorporating robust

data governance, executive AI upskilling, cross-functional collaboration, ethical AI practices, and strategic alignment. The roadmap demonstrates how AI adoption can evolve from isolated projects into sustainable strategic enablers, improving leadership effectiveness, operational performance, workforce engagement, and long-term competitiveness.

In conclusion, by aligning technological, organizational, and ethical dimensions, organizations can strengthen leadership capabilities, foster innovation, enhance workforce engagement, and achieve sustainable competitive advantage.

Theoretical Implications: This study contributes to understanding AI-enabled leadership by linking technology adoption with organizational, cultural, and governance factors. It highlights how varying levels of AI integration influence leadership effectiveness, decision-making, and strategic alignment. The structured brainstorming methodology is shown to be a critical mechanism for generating actionable, contextually relevant, and strategically aligned AI initiatives.

Practical Implications: The research provides a structured roadmap for systematic AI implementation, emphasizing digital capabilities, ethical practices, and cultural readiness. Organizations can leverage these insights to prioritize investments, design targeted training, and optimize AI integration across operational and strategic functions. By combining technology adoption with cross-functional collaboration and ethical oversight, AI initiatives can deliver measurable operational and strategic value.

Managerial Implications: Leaders should emphasize executive sponsorship, structured change management, and workforce engagement. Effective AI-enabled leadership requires balancing technological adoption with human-centered practices, maintaining employee trust, and aligning AI initiatives with organizational objectives. The brainstorming methodology supports managers in identifying, refining, and prioritizing initiatives that are practical, innovative, and sustainable.

Study Limitations: The study has several limitations. The sample of 60 leaders from 15 firms may limit generalizability. The cross-sectional design captures adoption and perceptions at a single point in time, potentially overlooking temporal changes. Reliance on self-reported surveys and interviews may also introduce response biases.

Future Research Directions: Future research should adopt longitudinal designs to examine how AI adoption evolves and affects leadership effectiveness, operational efficiency, and strategic outcomes. Expanding studies across industries, regions, and emerging economies would enhance generalizability and account for variations in organizational structures, norms, and regulatory environments. Further research should investigate the relationship between AI adoption, organizational culture, and innovation, as well as emerging technologies such as generative AI and advanced predictive analytics. Human–AI collaboration, including trust, engagement, fairness, and workforce acceptance, should be studied alongside ethical frameworks, reskilling programs, and structured change management. Governance mechanisms, such as steering committees and cross-functional teams, should also be examined to understand ways structured oversight supports sustainable, scalable, and human-centered AI adoption in emerging economies.

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Data availability statement: All data supporting this study are contained within the article.

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Abbreviations

Abbreviation	Full term	Short definition
AI	Artificial Intelligence	Systems performing tasks requiring human intelligence.
R&D	Research and Development	Innovation and product/process development activities.
KPI	Key Performance Indicator	Metrics to measure progress toward objectives.
HR	Human Resources	Manages workforce recruitment, development, and engagement.
IT	Information Technology	Systems and infrastructure for managing information.
IoT	Internet of Things	Networked devices are collecting and exchanging data.
ROI	Return on Investment	Measure of investment profitability or value gained.

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