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Organizational Readiness and Managerial Drivers of Biotechnological Innovation Adoption in Saudi Pharmaceutical Companies

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ABSTRACT

Pharmaceutical companies face growing pressure to engage with biotechnological innovation as biologics, biosimilars, advanced bioprocessing, genomic medicine, precision therapeutics, and research-intensive product development reshape the basis of competition. These innovations can expand therapeutic possibilities, strengthen product differentiation, and support higher-value pharmaceutical manufacturing. Their adoption, however, introduces scientific, operational, financial, and regulatory demands that differ substantially from those associated with conventional pharmaceutical production. Biotechnology therefore represents both a strategic opportunity and a complex organizational transformation challenge. For Saudi pharmaceutical companies, biotechnology adoption is closely connected to healthcare transformation, pharmaceutical localization, industrial diversification, and the development of national life-science capabilities. Access to technology or investment capital alone does not ensure that a firm can evaluate, absorb, implement, and sustain biotechnology-based innovation. Adoption also depends on managerial commitment, R&D capability, workforce competence, regulatory preparedness, knowledge coordination, external collaboration, and implementation discipline. Weakness in any of these areas can delay adoption, increase risk, or limit the value created from biotechnology investments. This article develops a conceptual framework for understanding how organizational readiness and managerial drivers influence biotechnological innovation adoption in Saudi pharmaceutical companies. It treats adoption as a multidimensional organizational process rather than a discrete technology-acquisition decision. The framework explains how internal capabilities and managerial actions combine to shape adoption readiness, implementation quality, and innovation outcomes. The framework integrates insights from pharmaceutical innovation, biotechnology adoption, organizational readiness, strategic management, R&D capability, absorptive capacity, knowledge management, regulatory preparedness, and Saudi healthcare-sector transformation. It distinguishes readiness conditions from managerial drivers while explaining their interdependence during technology evaluation, capability development, partnership formation, regulatory alignment, and implementation. It also incorporates market, regulatory, localization, and healthcare-transformation conditions as contextual forces that may enable or constrain adoption. The resulting structure provides an analytically coherent basis for evaluating biotechnology adoption within Saudi pharmaceutical organizations. The principal contribution is an integrated explanation of how organizational readiness conditions and managerial drivers interact with the Saudi pharmaceutical-sector context. The framework proposes that biotechnology adoption becomes more credible when strategic alignment, scientific capability, financial commitment, workforce preparation, regulatory readiness, and implementation governance reinforce one another. It further argues that managerial action determines whether latent readiness is converted into coordinated adoption activity. This perspective supports more responsible, competitive, and sustainable biotechnology development in the Saudi pharmaceutical sector.

Keywords: Biotechnological innovation, Organizational readiness, Managerial drivers, Saudi pharmaceutical companies, Pharmaceutical innovation, R&D capability.

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Introduction

Biotechnology has become strategically important to pharmaceutical competition through biologics, biosimilars, cell-based therapies, genomic medicine, precision therapeutics, advanced diagnostics, and data-intensive drug discovery (Albalawi *et al*., 2025; Herrera *et al*., 2026). These areas depend on scientific knowledge, specialized infrastructure, regulated development processes, and collaboration across organizational boundaries. Pharmaceutical R&D has consequently moved beyond predominantly closed innovation structures toward networked models that connect firms with universities, biotechnology ventures, contract research organizations, technology providers, and public research institutions (Schuhmacher *et al*., 2022). Biotechnology adoption must therefore be understood as participation in an increasingly interconnected innovation ecosystem.

The strategic relevance of biotechnology is particularly pronounced in countries seeking to strengthen pharmaceutical security and reduce dependence on imported medicines. In Saudi Arabia, localization requires more than expanding conventional production capacity because sustainable drug security also depends on technical knowledge, supply-chain resilience, investment coordination, and the progressive development of higher-value manufacturing capabilities (Tawfik *et al*., 2022). Biotechnological innovation can contribute to this transition by supporting biologics production, advanced formulation, specialized manufacturing, and research-intensive product development (Martin *et al*., 2025). Nevertheless, these opportunities create substantial demands for organizational capability and managerial coordination.

Saudi biopharmaceutical development continues to face limitations in specialized scientific knowledge, upstream and downstream processing, advanced manufacturing experience, and the integration of research with commercialization (Alzahrani & Harris, 2021). These constraints illustrate why biotechnology adoption cannot be reduced to purchasing equipment, licensing a platform, or constructing a production facility. Firms must also develop the capacity to evaluate scientific opportunities, absorb external knowledge, meet quality requirements, manage technical uncertainty, and coordinate multidisciplinary work (Silva *et al*., 2026). Organizational readiness therefore becomes a central condition for converting biotechnology investment into sustained pharmaceutical capability.

The wider Saudi healthcare transformation provides a strategic environment that emphasizes service efficiency, private-sector participation, localization, institutional redesign, and stronger links between healthcare and industrial development (Suleiman & Ming, 2025). Pharmaceutical companies operate within this environment while responding to changing regulatory expectations, market demand, investment priorities, and national competitiveness objectives. These pressures can encourage biotechnology adoption, but they may also expose capability gaps in firms that lack experienced leadership, specialized talent, regulatory systems, or implementation governance (Meyer *et al*., 2026). The national context thus creates opportunity without guaranteeing organizational preparedness.

Existing discussions frequently address pharmaceutical biotechnology through scientific progress, investment requirements, regulation, or industrial policy while giving less integrated attention to the organizational and managerial mechanisms that determine adoption. Pharmaceutical transformation is not simply a technical modernization exercise; it requires coordinated changes in strategy, structures, skills, knowledge systems, operating processes, and managerial decision-making (Miozza *et al*., 2024; Hassan *et al*., 2026). This article therefore develops a framework linking organizational readiness, managerial drivers, adoption mechanisms, contextual conditions, and innovation outcomes. The framework is intended to explain why similarly situated companies may differ in their ability to initiate, implement, and sustain biotechnological innovation.

Biotechnological Innovation in Saudi Pharmaceutical Companies

Biotechnological innovation encompasses the development, acquisition, adaptation, and implementation of knowledge-intensive pharmaceutical technologies. Relevant domains include biologics, biosimilars, recombinant products, advanced vaccines, molecular diagnostics, biotechnology-enabled manufacturing, and research platforms supporting complex therapeutic pipelines. Saudi pharmaceutical manufacturing has expanded, yet dependence on imported products and limited breadth in advanced production indicate a continuing need for stronger R&D, investment, workforce, and industrial capabilities (Alshehri *et al*., 2023). Biotechnology adoption can support movement toward higher-value pharmaceutical activity when these foundational capabilities are developed in parallel.

The adoption of advanced pharmaceutical platforms requires more than general manufacturing competence because biotechnology involves specialized research infrastructure, sensitive process control, complex analytical systems, and demanding quality requirements (Pakalapati *et al*., 2024; Chandrasekhar *et al*., 2025). Experience with nanomedicine development in the Saudi pharmaceutical sector demonstrates the importance of research collaboration, technology transfer, infrastructure, regulatory support, and access to specialized expertise (Halwani *et al*., 2023). Similar conditions apply to biotechnology-based manufacturing and product development, where firms often depend on external scientific partners during early capability formation. Partnership capacity is therefore an integral part of biotechnology readiness rather than an optional supplementary resource.

Biotechnology adoption must also be distinguished from routine pharmaceutical product or process innovation. It generally involves greater scientific uncertainty, longer development horizons, higher capital commitments, more complex regulatory evidence, and stronger dependence on scarce technical talent. Saudi biotechnology development continues to encounter challenges related to commercialization capability, specialized workforce availability, import dependence, and regulatory efficiency (Alyaemni & Alghamdi, 2025). These conditions increase the importance of disciplined opportunity evaluation and careful alignment between technology ambitions and organizational capacity.

The strategic context extends beyond individual pharmaceutical firms because innovation inputs, skills development, technology acquisition, and organizational performance are influenced by the broader healthcare and industrial environment. Evidence from Saudi healthcare organizations indicates that R&D effort, professional training, software capability, and equipment acquisition can contribute to technology innovation and performance when organizational conditions are supportive (Akinwale & AboAlsamh, 2023). For pharmaceutical companies, this suggests that biotechnology opportunities must be assessed alongside healthcare transformation, localization expectations, market competition, regulatory demands, and internal capability pressures. **Figure 1** illustrates the strategic context of biotechnological innovation adoption in Saudi pharmaceutical companies.

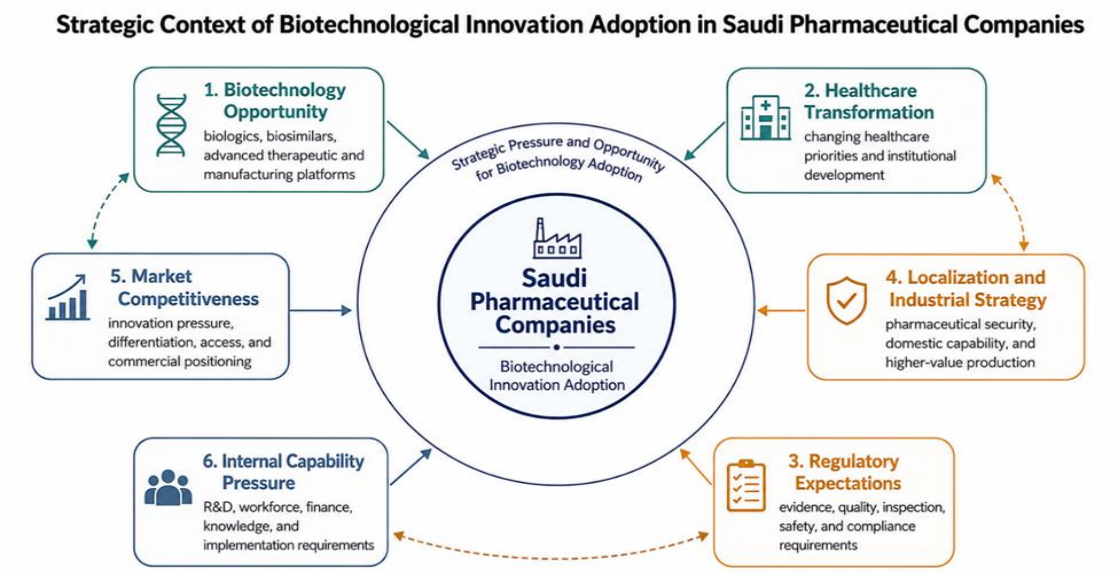

Figure 1. Strategic Context of Biotechnological Innovation Adoption in Saudi Pharmaceutical Companies

Alt-text: A conceptual diagram showing Saudi pharmaceutical companies positioned at the centre of intersecting forces, including biotechnology opportunity, regulatory expectations, market competitiveness, localization priorities, healthcare transformation, and internal organizational capability requirements.

Organizational Readiness for Biotechnological Innovation

Organizational readiness refers to the capacity of a pharmaceutical company to evaluate, adopt, implement, and sustain biotechnological innovation. It includes strategic direction, leadership commitment, an innovation-supportive climate, and organizational willingness to devote attention and resources to implementation. Research on innovation readiness

identifies strategic orientation, leadership, organizational climate, and commitment as mutually reinforcing conditions rather than isolated attributes (van den Hoed *et al*., 2022). A company may recognize a promising biotechnology opportunity while remaining unready to operationalize it.

Readiness also includes the psychological and behavioral preparedness of organizational members who must participate in implementation. Employees and managers need shared confidence that the proposed change is valuable, feasible, and supported by adequate resources. Organizational readiness can evolve during implementation as experience, resistance, leadership behavior, and perceived risks change (Caci *et al*., 2025). Readiness assessment should therefore be repeated across the adoption pathway rather than treated as a single pre-investment decision.

Biotechnology readiness is inherently socio-technical because scientific platforms must be integrated with people, processes, data, quality systems, regulatory requirements, and business objectives. Advanced-technology adoption research shows that technological preparedness alone is insufficient when expertise, workflow design, governance, data capability, and organizational strategy remain misaligned (Uren & Edwards, 2023). In pharmaceutical companies, this alignment must extend across R&D, manufacturing, quality assurance, regulatory affairs, supply chains, finance, information systems, and commercial functions. Readiness consequently reflects cross-functional implementation capacity rather than the isolated competence of a scientific or technical department.

Knowledge absorption is especially important because Saudi pharmaceutical companies may initially obtain biotechnology expertise through licensing, partnerships, recruitment, university collaboration, or technology transfer. Biopharmaceutical firms benefit from external knowledge when they can recognize, assimilate, transform, and apply it through internal routines (Russo-Spena & Di Paola, 2019). Potential and realized absorptive capacities should also be distinguished because acquiring knowledge does not automatically produce innovation capability or improved performance (Sancho-Zamora *et al*., 2021). **Table 1** summarises organizational readiness dimensions for biotechnological innovation adoption in Saudi pharmaceutical companies.

Table 1. Organizational Readiness Dimensions for Biotechnological Innovation Adoption in Saudi Pharmaceutical Companies: Strategic Alignment, R&D Capability, Workforce Readiness, Knowledge Management, Financial Commitment, Regulatory Preparedness, and Implementation Capacity

Readiness dimension	Core organizational question	Observable readiness indicators	Principal managerial requirement	Consequence when readiness is weak
Strategic alignment	Is the biotechnology initiative clearly connected to corporate strategy, therapeutic priorities, localization objectives, and long-term competitive positioning?	Defined biotechnology priorities; executive-approved roadmap; portfolio criteria; alignment with business and sector objectives	Translate biotechnology ambitions into explicit strategic choices, governance responsibilities, and measurable priorities	Fragmented projects, opportunistic technology acquisition, and weak organizational commitment
R&D capability	Can the company evaluate scientific opportunities, conduct or coordinate development work, and integrate biotechnology into its product pipeline?	Experienced scientific leadership; laboratories or governed external access; development protocols; portfolio-management capability; translational expertise	Build internal scientific competence while determining which capabilities should be partnered, licensed, or developed internally	Dependence on external suppliers, weak technology evaluation, and limited ability to absorb transferred knowledge
Workforce readiness	Does the organization possess the scientific, technical, regulatory, quality, managerial, and data skills required for adoption?	Skills inventory; targeted recruitment; structured training; multidisciplinary teams; succession and retention plans	Develop continuous learning pathways and align specialist roles with implementation requirements	Implementation delays, operational errors, resistance, and excessive reliance on a small number of specialists

Knowledge management	Can external and internal knowledge be captured, shared, protected, transformed, and applied across functions?	Knowledge-transfer protocols; documentation standards; collaborative platforms; lessons-learned systems; intellectual-property controls	Establish cross-functional knowledge routines and balance knowledge sharing with confidentiality and ownership protection	Repeated mistakes, knowledge loss, weak absorptive capacity, and poor transfer from R&D to operations
Financial commitment	Are sufficient resources available for technology evaluation, infrastructure, talent, validation, compliance, and scale-up over an extended horizon?	Multi-stage investment plan; contingency funding; portfolio-risk criteria; total-cost assessment; milestone-based financing	Protect long-term capability investment while using staged commitments and evidence-based continuation decisions	Underfunded implementation, premature termination, stranded assets, or excessive financial exposure
Regulatory preparedness	Can the company anticipate and meet development, manufacturing, quality, pharmacovigilance, and market-access requirements?	Early regulatory engagement; qualified regulatory personnel; documented compliance pathways; evidence-generation plans; inspection readiness	Integrate regulatory strategy into technology and product decisions from the earliest adoption stage	Rework, approval delays, compliance deficiencies, and inability to commercialize the adopted innovation
Implementation capacity	Can the organization coordinate functions, redesign processes, manage risk, and scale the technology without destabilizing existing operations?	Cross-functional governance; implementation milestones; quality-risk management; process integration plans; performance indicators	Establish accountable program leadership, decision rights, escalation mechanisms, and continuous monitoring	Pilot projects that fail to scale, functional conflict, quality disruption, and unsustained adoption

Managerial Drivers of Innovation Adoption

Managerial drivers determine whether organizational readiness remains a latent capability or becomes coordinated adoption action. In global pharmaceutical companies, leadership influences the exploratory, transformative, and exploitative learning processes through which external scientific knowledge is absorbed and applied (Rezaei Zadeh *et al.*, 2022). Senior managers therefore shape biotechnology adoption by defining strategic priorities, legitimizing experimentation, assigning decision rights, and integrating technical learning with commercial objectives. Leadership is especially important when biotechnology initiatives require firms to operate beyond familiar products, processes, and risk profiles.

Strategic leadership provides direction while connecting biotechnology investment to the company's competitive position, therapeutic portfolio, localization goals, and long-term capability strategy. Evidence from a regional pharmaceutical-industry setting indicates that strategic leadership can strengthen innovation performance through direction setting, knowledge sharing, and coordinated organizational execution (Abdulaal & Zoubi, 2025). Managers must communicate why a biotechnology initiative matters, identify the capabilities required, and clarify how uncertainty will be managed. Without this strategic narrative, departments may interpret adoption as an isolated R&D project rather than an enterprise-level transformation.

Top management support becomes operational through resource allocation, governance attention, risk tolerance, and sustained sponsorship. Executive characteristics can influence pharmaceutical R&D intensity, patenting activity, and the broader pattern of innovative development (Tolstov & Knyazev, 2024). Biotechnology adoption consequently depends on whether senior decision-makers can balance short-term financial pressures against the longer development

horizons associated with scientific capability building. Effective support also requires milestone-based oversight so that managerial commitment does not become uncritical continuation of technically or commercially weak projects.

Knowledge coordination, employee engagement, and organizational agility complement formal leadership decisions. Knowledge-sharing routines can support innovation and organizational performance in pharmaceutical companies (Iqbal *et al*., 2025), while agility and employee engagement help translate innovation activity into quality-oriented performance (Rosemarino *et al*., 2025). Managers must therefore create cross-functional forums connecting R&D, manufacturing, quality, regulatory affairs, finance, supply chains, and commercial teams. **Figure 2** maps the managerial drivers that translate organizational readiness into biotechnology adoption action.

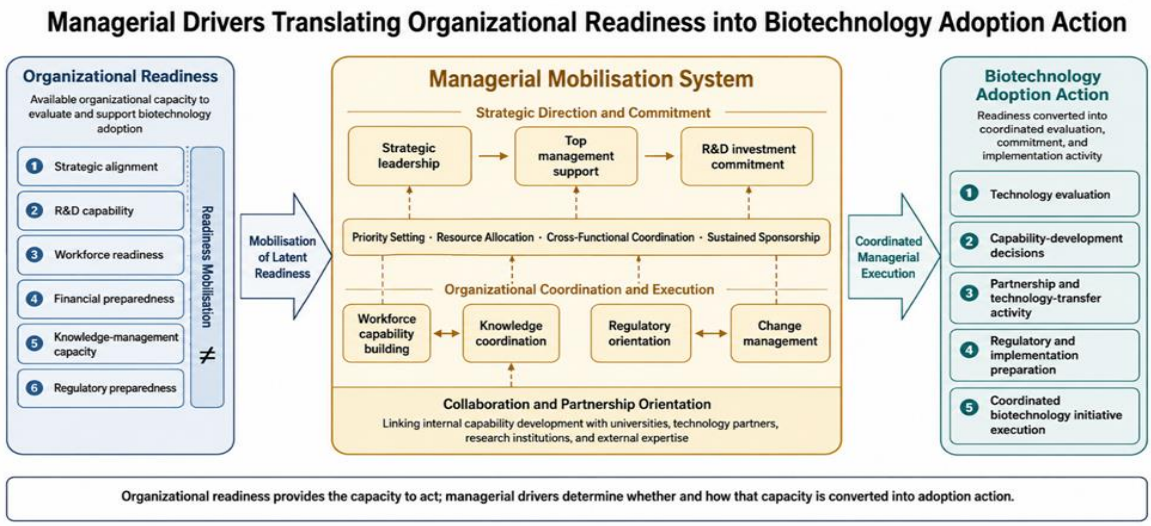

Figure 2. Managerial Drivers Translating Organizational Readiness into Biotechnology Adoption Action

Alt-text: A left-to-right process diagram showing organizational readiness moving through managerial drivers such as strategic leadership, investment commitment, knowledge coordination, regulatory orientation, collaboration, and change management toward biotechnology adoption action.

Regulatory, Market, and Strategic Context in Saudi Arabia

Biotechnology adoption in Saudi pharmaceutical companies is influenced by a regulatory environment that increasingly expects firms to demonstrate mature quality, documentation, inspection, and risk-management capabilities. Saudi experience with smart good-practice inspections shows that pharmaceutical organizations must maintain reliable evidence and compliance systems across evolving inspection formats (Alhomaidan *et al*., 2024). Regulatory readiness should therefore be incorporated into technology evaluation rather than addressed after technical implementation has begun. Early regulatory orientation can reduce costly redesign and clarify the evidence required for development, manufacturing, and commercialization.

Post-market governance is equally important because biotechnology products can introduce complex safety, traceability, and pharmacovigilance responsibilities. Findings from Saudi pharmacovigilance inspections reveal that documentation quality, governance arrangements, corrective actions, and operational oversight remain material organizational requirements (Almutairi *et al*., 2025). A company may possess strong scientific capability yet remain unable to sustain adoption if its surveillance, reporting, and quality systems are fragmented. Regulatory readiness must consequently extend across the full innovation lifecycle.

Market access and regulatory timing also shape the commercial attractiveness of biotechnology investment. Comparative evidence on targeted oncology therapies indicates that submission and approval timing can contribute to delayed access to innovative medicines in Saudi Arabia (Alnuhait *et al*., 2024). Pharmaceutical companies must therefore develop regulatory-strategy capability that connects development planning, evidence generation, submission sequencing, and market-entry decisions. Adoption speed should not be measured only by the date of technology acquisition but by the firm's ability to move responsibly toward approved and accessible products.

Financial sustainability and stakeholder coordination form another part of the external context. Saudi experience with managed entry agreements highlights the importance of evidence generation, multi-stakeholder coordination, market-access governance, and financially sustainable access arrangements (Al-Omar *et al*., 2025). These conditions can influence which biotechnology products are commercially viable and how uncertainty about value, outcomes, and affordability is managed. Saudi pharmaceutical biotechnology adoption should therefore be assessed as both a firm-level organizational decision and an ecosystem-level process involving regulators, payers, healthcare institutions, research partners, investors, and industrial-policy actors.

Adoption Barriers and Implementation Capabilities

External collaboration can accelerate biotechnology adoption, but it also creates tensions involving knowledge ownership, intellectual property, partner dependence, and strategic control. Pharmaceutical firms in developing-country contexts must balance the benefits of open innovation with the need to protect proprietary knowledge through staged and carefully governed collaboration (Bhatnagar *et al*., 2023). Weak partnership governance may expose firms to knowledge leakage or unclear ownership, whereas excessive protection may prevent meaningful learning. Implementation capability therefore includes the ability to structure collaboration without undermining knowledge absorption.

Biotechnology implementation can also generate interconnected technological, organizational, regulatory, cybersecurity, workforce, and sustainability challenges. Pharmaceutical Industry 4.0 research demonstrates that advanced-technology deployment affects multiple organizational systems rather than a single technical function (Mastrantonas *et al*., 2024). Although biotechnology differs from digital manufacturing, both require integration across validated processes, data systems, quality requirements, infrastructure, and human expertise. Fragmented implementation increases the risk that one capability develops faster than the systems required to support it.

Specialized workforce readiness is a persistent constraint because biotechnology requires scientific depth together with regulatory, manufacturing, quality, data, and managerial competence. Pharmaceutical organizations preparing for advanced technologies need multidisciplinary capability, data literacy, continuous learning, and redesigned professional-development pathways (Maclean *et al*., 2026). Recruitment alone is insufficient when knowledge remains concentrated in isolated specialists or external consultants. Firms need structured learning systems that distribute expertise and preserve organizational knowledge as personnel and partnerships change.

Barriers can be reduced when managerial commitment is matched by finance, infrastructure, skills, collaboration, regulatory alignment, and cross-functional execution. Research on critical success factors in emerging-market pharmaceutical companies shows that these implementation conditions operate jointly rather than independently (Debnath *et al*., 2023). Managers should therefore treat barriers as an interdependent portfolio of organizational risks and monitor whether capability development is progressing at a pace consistent with technology commitments. **Table 2** compares managerial drivers, adoption barriers, and implementation capabilities affecting biotechnological innovation adoption.

Table 2. Managerial Drivers, Adoption Barriers, and Implementation Capabilities in Saudi Pharmaceutical Biotechnology Innovation: Leadership Actions, Organizational Constraints, Capability Requirements, and Risk-Mitigation Pathways

Managerial driver	Principal adoption barrier	Required implementation capability	Managerial action	Risk-mitigation pathway	Expected adoption effect
Strategic leadership	Unclear biotechnology priorities and fragmented project selection	Strategic portfolio governance	Define therapeutic, manufacturing, and capability priorities linked to corporate strategy	Apply transparent selection criteria, stage gates, and executive review	Greater strategic fit and reduced investment dispersion

Top management support	Short-term financial pressure and inconsistent sponsorship	Long-horizon resource commitment	Protect essential capability investments while retaining milestone-based accountability	Use staged funding, continuation criteria, and portfolio-risk limits	More stable implementation without unconditional commitment
R&D investment commitment	High capital cost and scientific uncertainty	Scientific evaluation and development planning	Fund feasibility work, translational capability, validation, and scale-up planning	Separate exploratory, developmental, and commercialization investment decisions	Better evidence quality and reduced premature scale-up
Workforce capability building	Shortage of specialized scientific, technical, regulatory, and quality talent	Recruitment, training, retention, and succession systems	Build multidisciplinary teams and continuous-learning pathways	Conduct skills audits, partner-supported training, and knowledge-retention planning	Stronger internal competence and lower dependency risk
Knowledge coordination	Knowledge silos, weak documentation, and limited absorptive capacity	Cross-functional knowledge-management routines	Connect internal units with external scientific and technology partners	Establish transfer protocols, shared repositories, lessons-learned reviews, and intellectual-property controls	Improved knowledge conversion and organizational learning
Partnership orientation	Dependence on technology providers and unclear intellectual-property ownership	Alliance and technology-transfer governance	Define partner roles, ownership, access rights, milestones, and exit provisions	Use staged collaboration, due diligence, joint governance, and performance review	Higher collaboration value with controlled dependency
Regulatory orientation	Complex evidence requirements and late compliance intervention	Integrated regulatory and quality planning	Involve regulatory affairs and quality teams during opportunity evaluation	Develop early evidence maps, inspection-readiness plans, and regulatory-engagement pathways	Lower rework risk and more credible commercialization planning
Change-management capability	Employee resistance and disruption of established processes	Communication, participation, workflow redesign, and implementation support	Explain the rationale for adoption and involve affected functions in design	Use readiness assessments, pilot learning, role clarification, and feedback mechanisms	Greater organizational acceptance and implementation continuity
Financial governance	Uncertain commercial returns and reimbursement conditions	Business-case development and value monitoring	Link scientific milestones to market, access, and affordability assumptions	Conduct scenario analysis, sensitivity testing, and periodic value reassessment	More disciplined continuation, adaptation, or termination decisions
Implementation governance	Functional conflict and failure to scale successful pilots	Program management, quality-risk control, and	Establish accountable leadership, decision rights,	Monitor technical, regulatory, financial, workforce, and	Improved scale-up quality and sustained adoption

	performance monitoring	escalation routes, and indicators	operational performance together

Proposed Organizational Readiness and Managerial Adoption Framework

The proposed framework contains four interacting components: organizational readiness conditions, managerial drivers, adoption mechanisms, and innovation outcomes. Organizational-level adoption research indicates that top-management support, organizational culture, structure, expertise, and technological preparedness can shape adoption through a broader readiness pathway (Ali *et al*., 2022). In the present framework, readiness constitutes the firm's capacity to act, whereas managerial drivers determine whether that capacity is mobilized purposefully. Neither component is sufficient alone because prepared organizations may delay action, while committed managers may pursue adoption without the capabilities needed for responsible implementation.

Adoption mechanisms translate readiness and managerial intent into operational activity. These mechanisms include technology evaluation, capability development, partnership formation, implementation planning, regulatory alignment, and performance monitoring. University-industry collaboration can improve pharmaceutical R&D performance when firms possess sufficient absorptive capacity to recognize and use the knowledge generated through collaboration (Melnychuk *et al*., 2021). External relationships are therefore treated as capability-dependent adoption mechanisms rather than automatic sources of innovation.

The framework also recognizes that biotechnology adoption frequently involves public research institutions, regulators, healthcare organizations, investors, and other ecosystem partners. Pharmaceutical public-private partnerships are more useful when their governance and evaluation focus on innovation and health impacts rather than resource inputs alone (de Vrueh & Crommelin, 2017). Knowledge conversion is a central pathway within the framework because external expertise creates value only when it becomes embedded in organizational routines. Organizational learning can mediate the relationship between absorptive capacity and innovation by transforming acquired knowledge into usable capabilities (Sancho-Zamora *et al*., 2022). Managers should therefore evaluate whether partnerships, training, licensing, and technology-transfer activities are strengthening internal competence or merely sustaining external dependence. **Figure 3** visualises the proposed organizational readiness and managerial adoption framework.

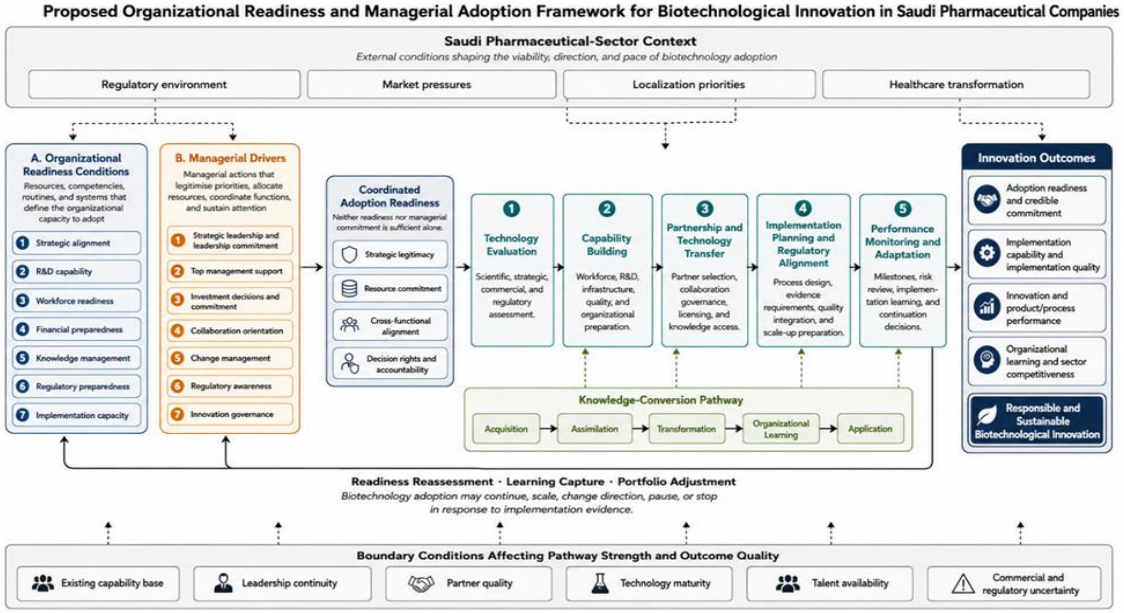

Figure 3. Proposed Organizational Readiness and Managerial Adoption Framework for Biotechnological Innovation in Saudi Pharmaceutical Companies

Alt-text: A layered conceptual framework showing organizational readiness conditions and managerial drivers feeding into adoption mechanisms, moderated by Saudi regulatory, market, and strategic context, and leading to innovation adoption outcomes.

The relationships proposed in the framework are contingent rather than universal or linear. In pharmaceutical alliances, innovation outcomes can vary according to development stage, partner type, and firm-specific uncertainty (Jung *et al*., 2023). The framework further assumes that advanced pharmaceutical adoption requires integration across technology, process, quality, data integrity, regulatory systems, and human capability (Reinhardt *et al*., 2020). Biotechnology adoption may therefore stall, change direction, or be discontinued when contextual conditions or implementation evidence no longer support the original strategic case.

Practical Implications and Future Research

Saudi pharmaceutical executives can use the framework to conduct readiness assessments before committing to biotechnology platforms, partnerships, or manufacturing investments. Managers should compare the perspectives of executives, scientists, regulatory specialists, quality professionals, production teams, and commercial decision-makers because readiness priorities can differ across stakeholder groups (van den Hoed *et al*., 2024). A practical assessment should examine strategic fit, scientific capability, workforce competence, financial resilience, regulatory preparedness, knowledge systems, and implementation governance. The resulting diagnosis can guide capability audits, managerial training, investment sequencing, and decisions about whether to build, partner, license, or defer.

Implementation plans should translate readiness findings into accountable actions and measurable milestones. Pharmaceutical-manufacturer evidence indicates that executive sponsorship, workforce understanding, regulatory compliance, operational integration, and structured change management are important deployment conditions (McDermott *et al*., 2024). Saudi firms can strengthen adoption by establishing biotechnology steering committees, regulatory-engagement pathways, university-industry partnerships, technology-transfer protocols, workforce-development programs, and integrated monitoring indicators. Policymakers and research institutions can support these efforts through shared infrastructure, translational programs, specialized training, and clearer pathways linking research outputs with industrial development.

Future research should empirically test the framework across Saudi pharmaceutical companies of different sizes, ownership structures, portfolios, and levels of biotechnology experience. Enterprise-wide pharmaceutical adoption is likely to benefit from structured pathways combining strategy, governance, maturity assessment, implementation, and cross-functional scaling (Phiri *et al*., 2025). Surveys, comparative case studies, longitudinal designs, and multi-stakeholder investigations could examine whether different readiness and managerial configurations predict adoption quality, implementation resilience, and innovation performance. Research should also assess whether these configurations contribute to pharmaceutical R&D productivity and ecosystem transformation rather than assuming that technology investment alone generates innovation (Schuhmacher *et al*., 2025).

Conclusion

This article has developed a conceptual framework explaining how organizational readiness and managerial drivers shape biotechnological innovation adoption in Saudi pharmaceutical companies. The framework distinguishes the capacity to adopt from the managerial action required to mobilize that capacity. It also positions adoption as a process involving evaluation, capability formation, implementation, learning, and adaptation. This structure moves analysis beyond technology availability and investment intention.

Biotechnology adoption depends on coordinated readiness across strategy, R&D, finance, workforce competence, knowledge management, regulation, quality systems, and implementation governance. Managerial leadership connects these dimensions by allocating resources, legitimizing priorities, coordinating organizational functions, and managing uncertainty. Adoption is consequently more credible when ambition is matched by the internal capacity to absorb, regulate, operationalize, and sustain innovation. Weak alignment can produce underused assets, fragmented projects, compliance problems, or unsustainable dependence on external partners.

The framework also emphasizes that Saudi pharmaceutical companies operate within a broader regulatory, market, healthcare, and industrial ecosystem. Localization priorities and healthcare transformation can encourage biotechnology investment, but external opportunity cannot substitute for firm-level capability. Regulators, research institutions, investors, universities, healthcare organizations, and technology partners all influence the conditions under which firms can develop and commercialize biotechnology-based innovations. Sector progress will therefore depend on coordinated firm-level and ecosystem-level capability building.

The future of pharmaceutical biotechnology in Saudi Arabia will be shaped by the quality of organizational preparation as much as by the availability of scientific opportunity and investment. Companies that combine disciplined readiness assessment with strategic leadership, regulatory alignment, workforce development, responsible collaboration, and adaptive implementation will be better positioned to create durable innovation capability. The objective should not be adoption for its own sake, but the development of pharmaceutical organizations able to evaluate and implement biotechnology responsibly. Such organizations can contribute to a more competitive, resilient, and sustainable Saudi pharmaceutical sector.

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