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ORIGINAL RESEARCH

Evaluating Biosimilar Development Projects: An Analytical Framework Utilizing Net Present Value

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Background: The increasing prominence of biosimilars in healthcare delivery has created the need for robust financial evaluation methods to assess development opportunities. Unlike traditional generic drugs, biosimilars require substantial investments ($100-250 million) and longer development timelines (6–8 years), necessitating sophisticated evaluation approaches.

Methods: This study presents a comprehensive Net Present Value (NPV) analysis framework specifically designed for biosimilar development projects. Our framework incorporates key technical, regulatory, and commercial factors through a risk-adjusted NPV methodology, validated through case studies of three monoclonal antibody biosimilar development programs.

Results: The analysis reveals that successful projects require minimum peak sales of $250-300 million to achieve a positive NPV, with market share and manufacturing efficiency serving as critical value drivers. Cost analysis shows that clinical development represents the largest share (57%) of total development costs.

Conclusion: The framework demonstrates that early market entry, manufacturing optimization, and market share achievement are key success factors, whereas technical complexity and competitive intensity significantly influence risk-adjusted returns.

Keywords: biosimilars, net present value analysis, investment evaluation, pharmaceutical development, risk assessment

Introduction

The biopharmaceutical industry is undergoing a transformation in the acceptance of biosimilars in healthcare delivery. It is posited that the utilization of such products, which are highly similar versions of already approved biological products, is intended to reduce biologic-related cost implications and potentially overall healthcare expenditures. This progression is a consequence of patent expiration on major biologics and is imperative to reduce healthcare costs.[1] However, the development and commercialization of biosimilars have emerged as a critical challenge that necessitates the application of sophisticated financial evaluation techniques owing to their complexity and regulatory landscape. Biosimilars are designed to be highly similar versions of approved biological drugs; nevertheless, their production processes are significantly more intricate than those of small-molecule drugs.[2] In addition to these characteristics, biosimilars require substantial investments of approximately US$100–250 million in development, after which the biosimilar would be available for marketing over a 6–8 year period. This is notably lower than the expenditure and time required for innovator drugs and their development.[3] Considering the political landscape surrounding biosimilars and their investment requirements, there is a pronounced demand for robust investment assessment tools in the biosimilar sector, potentially leading to a situation of heightened investment scarcity.[4] In contrast to generic medicines, biosimilars necessitate substantial investment in their development, approximately US$100–250 million over a 6–8 year period. However, this figure remains significantly lower than the cost and time required for innovator drugs.[3] The substantial financial costs, complex manufacturing processes, and evolving regulatory environments of biosimilar products therefore necessitate comprehensive and urgent investment appraisal tools in the biosimilar industry.[4] Moreover, the market for biosimilars presents distinctive challenges in terms of adoption, shifts in market acceptance, competitive forces, and price pressures that typically differ from those experienced by innovative biologics or generic drugs.[5]

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The intricacies of investment decisions for biosimilar development are further compounded by several factors. Primarily, there are rigorous technical requirements to demonstrate biosimilarity, which can impede development timelines and increase costs. Additionally, there are varied market penetrations regarding therapeutic area and geography. Furthermore, a rapidly evolving competitive environment has led multiple developers to focus on the same reference product. These conditions necessitate a standardized yet flexible assessment framework that can accommodate diverse scenarios and risk profiles. Most current methodologies for financial evaluations do not adequately capture these unique characteristics of biosimilar development. Conventional approaches such as discounted cash flow (DCF) analysis have limitations when addressing complex strategic investments such as biosimilars.[6] Identified for this objective- dynamic and flexible approaches for evaluating biosimilars to accommodate the unique regulatory environment, manufacturing challenges, and market uncertainties they face.[7,8] Moreover, as demonstrating analytical and clinical biosimilarity is paramount, valuation models should also incorporate investments required for advanced characterization assays and clinical studies for regulatory approval.[9] This research addresses these issues with a comprehensive Net Present Value (NPV) analytical framework specified for biosimilar development projects. The framework encompasses the critical technical, regulatory, and commercial aspects that drive the success of biosimilar development. The flexibility of the framework was demonstrated through multiple integrated case studies of three significant biosimilar development programs across therapeutic areas and market conditions concerning applicability and robustness.

The primary objectives of this study were twofold: Among these, the foremost is the establishment of a framework for assessing biosimilar investments. This framework will encompasses both the standard NPV elements and biosimilar-specific factors. The second objective is to provide a practical instrument for decision-making in which organizations can evaluate and prioritize biosimilar adoption opportunities. This study presents a systematic approach for evaluating biosimilar investments and contributes to the existing literature and practice. Its findings will be of direct relevance to biopharma companies and to entities requiring investment decisions or policy formulation concerning biosimilar development. Furthermore, the proposed framework will serve as a foundation for future research on methodologies for the evaluation of biological drug development.

Biosimilar Market Overview

The global biosimilar market is projected to experience consistent growth in the coming years. The primary assumptions in the forecasts suggest that biosimilar savings between 2021 and 2025 will be approximately $38.4 billion, equivalent to 5.9% of projected spending on biologics for the same period.[10] This growth is primarily attributed to patent expirations of major biological drugs, increasing healthcare costs, and supportive regulatory frameworks.[5] The European Union has established a robust regulatory framework for the approval of biosimilars, which has been progressively refined since 2005.[11] As of December 2024, there were 64 approved biosimilars in the USA and 92 in the EU. The evolving regulatory landscape, which will require years to fully develop, is of significant value to countries and regulatory bodies such as the FDA, EMA, and WHO for formulating guidelines for the development and approval of biosimilars. These frameworks predominantly emphasize the demonstration of biosimilarity through extensive analytical characterization, non-clinical studies, and comparative clinical trials. These regulations significantly impact development costs and timelines, serving as crucial parameters in investment decisions.[12] The competitive dynamics in biosimilar and traditional generic markets differ substantially. Market penetration varies widely across therapies and geographical regions and is influenced by factors such as physician acceptance, pricing policies, and procurement practices. Furthermore, multiple developers often focus on the same reference product concurrently, creating complex competitive environments that affect the prospects for return on investment.

Financial Evaluation Methods

The Net Present Value (NPV) is a critical metric in evaluating pharmaceutical investments, without delving into the intricacies of how present values at various projections of cash flow projections should be discounted to accurately reflect time-value and project-specific risks. The fundamental NPV equation is as follows:

$$\mathrm{NPV} = \Sigma\left[\mathrm{CF_t}/(1+\mathrm{r})^{\mathrm{t}}\right] - \text{Initial investment}$$

where CF_t represents cash flow at interval period t, r denotes the discounting rate, and t indicates the time period involved.

However, the classical method appears inadequate for accounting for the unique risks and opportunities inherent in biosimilar development. Risk-adjusted NPV (rNPV) methodologies,[13] that introduce greater sophistication and precision into the assessment of biopharmaceutical investments have been developed to address this limitation. This adjustment in the probability for a given development stage accounts for technical, regulatory, and commercial success. The success probabilities for typical biosimilars range between 65–75%, which is significantly higher than that of new biologics but lower than that of generic drugs.

Such industry-specific considerations include:

- Development costs between $100–250 million
- Timelines between 6–8 years from initiation to market approval
- Manufacturing costs comprising 25–35% of revenue
- Market share assumptions of 15–30% at peak
- Price discounts of 30–40% in comparison to the reference products

More specific elements must be addressed for factorization, such as:

1. Technical complexity adjustments based on molecule type
2. Region-wise variations in market penetration
3. The factors of competition intensity
4. Manufacturing optimization potential
5. Regulatory pathway considerations

The factors that influence project value are of considerable significance, necessitating careful consideration in investment evaluations. Furthermore, the increasing importance of real-world evidence and post-marketing studies necessitates consideration of subsequent investment beyond the original approval criteria. Thus, a literature review indicates a need to establish a framework whereby traditional financial evaluation methods can be complemented by specific biosimilar considerations. This would facilitate a more accurate assessment of investment opportunities and decision-making for biosimilar development.

This study aims to develop a comprehensive Net Present Value (NPV) framework specifically designed for evaluating biosimilar investment opportunities while validating its practical utility through case studies. This framework incorporates critical elements that distinguish biosimilar development from traditional pharmaceutical investments, including technical requirements, regulatory pathways, and market dynamics. Through an analysis of three distinct monoclonal antibody development programs, we demonstrated the framework's capability to evaluate investment decisions across diverse scenarios and market conditions.

Methodology

NPV Model Development

This study employed a personalized Net Present Value (NPV) model to analyze biosimilar development project characteristics. The model encompasses all core financial aspects pertaining to development cost, time involved, success probabilities, and the anticipated market over the entire period, from the pre-development stage to 12 years post-launch (Table 1). Components and key parameters. The Base NPV computation is given by the standard formula:

$$\mathrm{NPV} = \Sigma\left[\mathrm{CF_t}/(1+\mathrm{r})^{\mathrm{t}}\right] - \text{Initial investment}$$

where: CF_t is the annual cash flow in period t, r is the discount rate (10–12%), and t is the time span in years.

Risk adjustment factors were incorporated through probability-weighted cash flows at each stage of development.

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Table 1 Key Model Parameters for Biosimilar NPV Analysis

Parameter	Base Case Value	Range
Discount Rate	10%	8–12%
Development Timeline	7 years	6–8 years
Success Probability	70%	65–75%
Market Share	25%	15–30%
Price Discount	35%	30–40%
Cost of Goods	30%	25–35%

- Process development success: 90%
- Phase I completion: 85%
- Phase III success: 75%
- Regulatory approval: 90%

Additional factors that the model incorporates include sensitivity analysis for critical variables, such as:

- Development timeline variation (±1 year)
- Market share achieved (±5%)
- Manufacturing costs (±10%)
- Pricing assumptions (±15%)
- Success probabilities (±10%)

Cost analysis for Development

1. Total Process Development ($25–35M)

Process development is biosimilar product development. It encompasses several critical aspects, including:

- Cell line development and optimization ($8–12M)
- Analytical method development and validation ($4–6M)
- Comparability studies relative to the reference product ($5–7M)
- Process characterization studies ($5–7M)
- Reference product characterization ($3–5M)

2. Clinical Development ($80–120M)

Comprising the largest portion, this includes

Phase I Studies ($9–13M):

- Clinical trial costs ($6–8M)
- Clinical supplies ($2–3M)
- Bioanalytical testing ($1–2M)

Phase III Studies ($70–98M):

- Clinical trial execution ($50–70M)
- Clinical supplies ($15–20M)
- Bioanalytical testing ($5–8M)
- Data management and analysis ($3–5M)

3. Manufacturing Setup ($30–45M) Manufacturing infrastructure and validation includes:
- Pilot plant setup and optimization ($10–15M)
- Process validation batches ($8–12M)
- Facility qualification and validation ($5–8M)
- Analytical method validation ($4–6M)
- Stability studies and testing ($3–4M)

4. Regulatory Requirements ($5–8M) Regulatory activities encompass:

- Dossier preparation and compilation ($2–3M)
- Registration fees for major markets ($1–2M)
- Regulatory support and interactions ($1–2M)
- Post-approval commitments ($1M)

The model considers these expenses from a time-weighted perspective in which they are allocated across the entire development duration according to relevant typical program milestones. The cost assumptions were derived from industry-associated benchmarks (Table 2). For all cost items, an annual inflation rate of 2% was applied, and regional variations were incorporated where feasible. The model also allows for the modification of individual cost items in accordance with specific requirements and deviations in the development strategy. This methodology statically captures investment opportunities of biosimilars while maintaining flexibility in associated project conditions and market fluctuations. A cost analysis was conducted to ensure the representativeness of essential resource requirements throughout the development cycle.

Case Studies

To test our NPV analysis approach, we modelled three distinct mAb biosimilar development programs, each targeting a different therapeutic area and market scenario. The modeling incorporated unique development parameters, market dynamics, and risk factors specific to each program.

Case Study 1: MAb1 Biosimilar Analysis

The first case study modelled a biosimilar that targets a major oncology indication. The development assumptions are as follows:

- Total development cost: $140 million
- Development timeline: 7 years
- Success probability: 70%
- Cost of goods: 28% of net sales

Table 2 Development Cost Breakdown

Development Phase	Cost Range ($M)	% of Total
Process Development	25–35	18%
Clinical Development	80–120	57%
Manufacturing Setup	30–45	20%
Regulatory Filing	5–8	5%
Total	140–208	100%

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- Price discount: 35% versus reference product

Market projections were based on:

- Reference product sales: $4.5 billion
- Expected market share: 25% at peak
- Launch year: 2025
- Market growth rate: 3% annually

The base case analysis yielded a risk-adjusted NPV of $85 million with an IRR of 16.5%. Sensitivity analysis revealed that a 10% change in market share impacted NPV by ±$45 million, whereas manufacturing cost variations affected NPV by ±$30 million.

Case Study 2: MAb2 Biosimilar Analysis

The second case examined an immunology biosimilar with parameters including:

Development investment: $165 million

- Timeline: 8 years
- Success probability: 65%
- Manufacturing cost: 32% of sales
- Price discount: 30%

Market considerations incorporated:

- Multiple indications potential
- Competitive landscape analysis
- Regional market access variations

This analysis produced a risk-adjusted NPV of $120 million, with the market penetration rate and manufacturing efficiency identified as key value drivers.

Case Study 3: MAb3 Biosimilar Evaluation

The third case analyses on a complex mAb biosimilar development featuring:

- Higher technical complexity
- Extended development timeline (8.5 years)
- Total cost: $190 million
- Success probability: 65%
- Novel formulation development

Market opportunity assessment revealed:

- Growing therapeutic area
- Limited expected competition
- Strong pricing power maintenance

The program demonstrated a risk-adjusted NPV of $95 million with significant upside potential from secondary indications.

Table 3 NPV Analysis Results for Case Studies

Metric	mAb1	mAb2	mAb3
Base NPV ($M)	85	120	95
IRR (%)	16.5	18.0	15.5
Payback Period (years)	4	3	4
Peak Sales ($M)	250	300	275

Cross-Case Analysis

Common findings across all three cases include:

1. Early market entry provides substantial NPV advantage
2. Manufacturing optimization significantly impacts project value
3. Development timeline acceleration shows consistently high ROI
4. Market share assumptions critically influence project viability

Risk-adjusted returns varied based on:

- Technical complexity
- Competitive intensity
- Market size and growth
- Development timeline

These case studies aimed to validate the NPV framework, thereby substantiating its application and elucidating the necessity for product-specific modifications to our assumptions. Furthermore, they demonstrated the implementation of the framework in evaluating biosimilar investments across diverse market scenarios and technical complexity levels (Table 3).

Discussion

Our analysis reveals several critical insights into biosimilar development economics and investment decision-making. The NPV framework developed in this study demonstrated robust applicability across different therapeutic areas and market scenarios, as evidenced by the three case studies presented.

Clinical Development Cost Implications: A significant finding from our analysis is that clinical development represents the largest share (57%) of total development costs. This has important implications, given the evolving regulatory landscape. Although MHRA has adopted a more flexible approach to clinical efficacy requirements, both the FDA and EMA currently maintain strict requirements for clinical data, particularly for monoclonal antibodies lacking suitable pharmacodynamic markers. Large clinical trials with 500–1000 patients remain mandatory under the current guidelines, significantly impacting the development costs and timelines. This regulatory divergence creates challenges and opportunities for biosimilar developers in strategic planning and market entry decisions.

Market Entry and Value Drivers: The Cross-case analysis reveals that early market entry consistently provides substantial NPV advantages. This finding aligns with industry observations, where first movers often achieve higher market penetration and better pricing positions. Manufacturing optimization emerged as another critical value driver, with our sensitivity analyses showing that a 10% variation in manufacturing costs can impact the NPV by ±$30 million. This underscores the importance of process development and manufacturing efficiency in biosimilar development.

Risk-Adjusted Returns and Market Dynamics: Our framework demonstrates that successful biosimilar projects require minimum peak sales of $250–300 million to achieve a positive NPV, with market share and manufacturing

efficiency serving as critical value drivers. Risk-adjusted returns vary significantly based on technical complexity, competitive intensity, and market size. The sensitivity analyses reveal that a 10% change in market share can impact the NPV by ±45 million, highlighting the critical importance of market penetration strategies.

Global Market Considerations: While our framework focuses primarily on the US and EU markets, which represent the majority of global biosimilar revenue, the model's flexibility accommodates broader geographical applications. The acceptance of FDA/EMA clinical data by emerging market regulators creates additional value potential without proportional cost increases, effectively enhancing the return on investment for developers pursuing global-market strategies.

Framework Limitations and Adaptability: The NPV modeling framework exhibits certain inherent limitations that warrant consideration. The accuracy of the model fundamentally depends on the quality of the market assumptions and forecasts, which can be challenging to predict in an evolving biosimilar landscape. Regional differences in market access requirements and regulatory pathways introduce additional variables that may impact the model projections. Furthermore, the dynamic nature of competition in biosimilar markets, including potential changes in pricing strategies and market-share dynamics, adds another layer of uncertainty to long-term forecasts.

Data Availability Constraints A notable challenge in biosimilar investment modeling is the limited availability of detailed development data owing to the commercially sensitive nature of this information. Our approach addresses this limitation by using pragmatic ranges and conservative assumptions derived from aggregated industry benchmarks supplemented by sensitivity analyses to reflect real-world variability.

The framework's focus on traditional financial modeling rather than advanced predictive analytics or machine learning is deliberate given the limited historical data points available (64 approved products in the US and 92 in the EU) and the rapidly evolving regulatory landscape. This approach provides more reliable forward-looking projections for immediate investment decision making while maintaining adaptability to incorporate future changes in regulatory requirements and market dynamics.

These findings contribute to the growing body of knowledge in biosimilar development economics, and provide practical insights for stakeholders involved in biosimilar investment decisions. The framework's ability to accommodate various scenarios while maintaining analytical consistency makes it a valuable tool for both current decision-making and future adaptation, as the biosimilar landscape continues to evolve.

Conclusions and Recommendations

Framework Value Proposition

A comprehensive Net Present Value (NPV) evaluation methodology is presented within the financial modelling framework to elucidate the practical considerations pertaining to complex investment decisions in biosimilar development. Consequently, these models offer several significant advantages for stakeholders in assessing biosimilar development opportunities. The NPV modeling framework demonstrates several key value-adding characteristics for biosimilar investment evaluations. A standardized methodology forms the foundation, enabling consistent analysis across different mAb development programs using well-defined parameters and metrics. The framework incorporates a comprehensive risk assessment through a sensitivity analysis of critical variables, such as development timelines, manufacturing costs, and market penetration rates (Figure 1). Its flexible structure accommodates project-specific factors such as molecular complexity and market conditions while maintaining analytical consistency. By integrating detailed cost components and development timelines, this framework provides a practical tool for quantitative decision-making in biosimilar development investments (Figure 2).

The NPV modeling framework exhibits certain inherent limitations that warrant consideration. The accuracy of the model fundamentally depends on the quality of the market assumptions and forecasts, which can be challenging to predict in an evolving biosimilar landscape. While the framework accommodates different molecule types, variations in technical complexity across products may affect the precision of the development costs and timeline estimates. Regional differences in market access requirements and regulatory pathways introduce additional variables that may impact the model projections. Furthermore, the dynamic nature of competition in a biosimilar market, including potential changes in pricing strategies and market share dynamics, adds another layer of uncertainty to long-term forecasts. These limitations

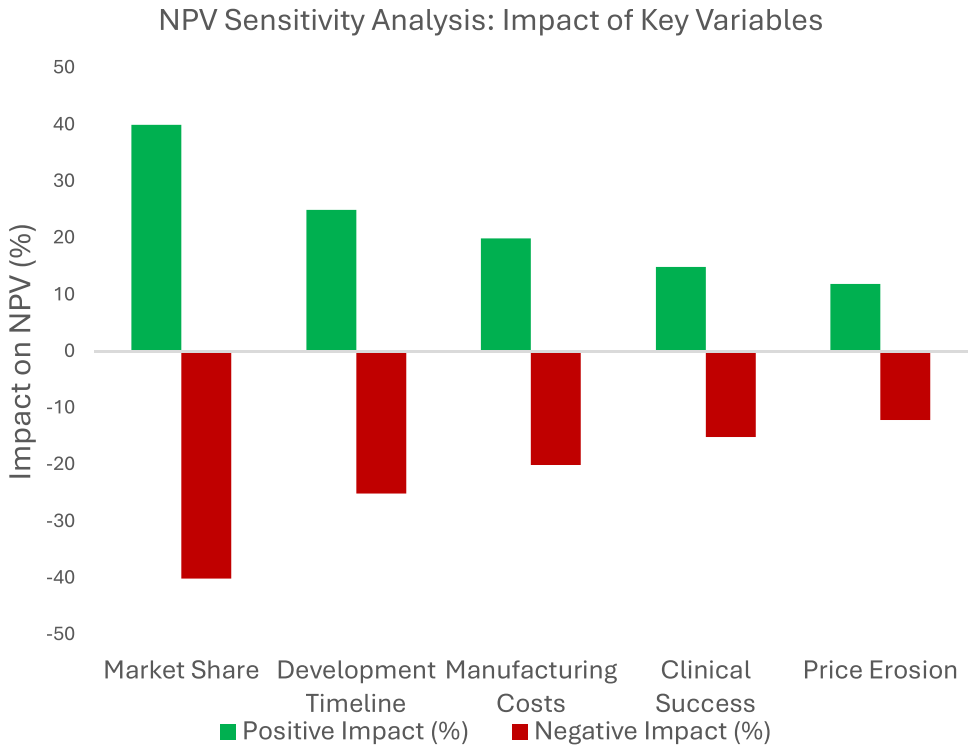

Figure 1 Sensitivity Analysis Impact on NPV.

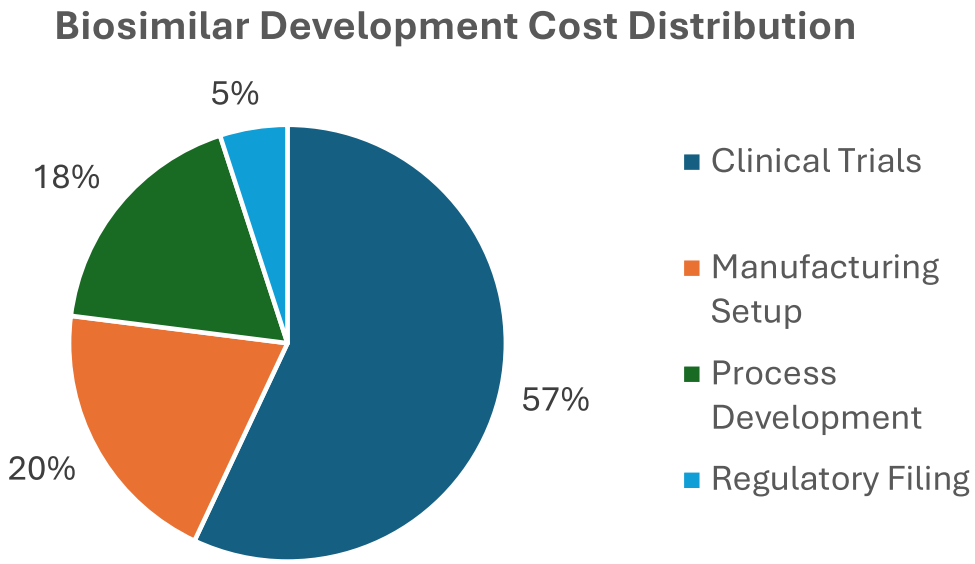

Figure 2 Biosimilar development cost distribution.

underscore the importance of regular model updates and the careful consideration of assumptions when applying the framework to specific biosimilar development decisions.

Future Directions

The NPV modeling framework can be enhanced through several key technical refinements. Future developments should focus on incorporating machine learning algorithms to improve predictive capabilities, particularly in risk assessment and

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market dynamics. Enhanced modeling tools could enable a more sophisticated analysis of competitive scenarios and real-time integration of market data, leading to more dynamic and responsive financial projections. The implementation of advanced statistical methods would strengthen the ability of the framework to capture complex market interactions and development uncertainties.

The analytical capabilities of the framework could extend beyond individual project assessments to broader applications in biopharmaceutical development. Portfolio-level analysis could optimize resource allocation across multiple biosimilar programs, whereas manufacturing strategy evaluation could better inform capacity planning decisions. The model can also support partnership valuations and technology transfer assessments, providing quantitative metrics for strategic business development decisions. Integration with market access planning tools would enable a more comprehensive evaluation of commercialization strategies.

The emerging market considerations present unique opportunities for model expansion. Future iterations should address the regional variations in regulatory requirements and market access pathways, particularly in developing economies. The framework can be adapted to evaluate local manufacturing requirements and market-specific pricing dynamics. Additionally, incorporating different healthcare system structures and reimbursement mechanisms would enhance the model's global applicability. These refinements would strengthen the framework's utility for evaluating biosimilar opportunities across diverse international markets.

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Disclosure

The authors report no conflicts of interest in this work.

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