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Research paper

Balancing Financial Viability and Public Value: An Economic–Accounting Appraisal of Academic Agribusiness Laboratories in The Philippines

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Abstract

This study evaluates the potential of an academic livestock laboratory to transition into an academic–agribusiness enterprise by examining market conditions, financial sustainability, and economic value creation. Analysis of household consumption patterns and retailer stocking behavior across Lipa City, Batangas City, Taysan, and Lobo reveals consistent demand for processed pork products and persistent supply gaps. The laboratory's product lines—Filipino-style sausage, sweet cured pork, cured pork, and sweet pork stew—align well with consumerer preferences, indicating that local markets can absorb expanded production and that market demand provides a supportive environment for enterprise development.

Financial assessment shows that while the laboratory is capable of generating stable revenues, it faces difficulty achieving full cost recovery using traditional accounting measures. Negative financial net present value, low internal rate of return, and an improving yet inadequate operating self-sufficiency ratio highlight the structural constraints of academic laboratories. These facilities operate with high training costs, intensive supervision, and process limitations that prevent full optimization for profit without compromising instructional and research functions.

Economic evaluation offers a contrasting perspective. When non-market benefits—such as human-capital development, extension services, consumer welfare gains from import substitution, local multiplier effects, and environmental offsets from biogas and fertilizer by-products—are incorporated, the project produces positive net benefits beginning in 2026. A positive economic net present value, a benefit–cost ratio above one, and a high economic internal rate of return indicate that societal benefits outweigh economic costs.

To synthesize these findings, the study presents the Academic–Agribusiness Laboratory Leverage Conversion Model, framing such facilities as hybrid institutions. The model illustrates that financial limitations coexist with substantial economic value, supported by market de-mand and circular-resource practices. Overall, the laboratory's sustainability is strengthened not through full commercialization but through development-oriented operations backed by strategic subsidies and institutional support.

Keywords: *Academic Laboratories; Cost Recovery; Economic Appraisal; Hybrid Enterprises; Public Value.*

1. Introduction

The global food system faces increasing pressure from population growth, changing consumption patterns, and the need for sustainable production. Processed meat products, in particular, continue to expand in demand across developing economies, reflecting both rising incomes and urbanization trends. Universities and research institutions are increasingly being positioned as contributors to agribusiness innovation and supply chain development, particularly through academic laboratories that can bridge training, research, and enterprise functions [1]. In the Philippines, persistent shortfalls in processed meat supply highlight the urgency of strengthening local capacity and reducing reliance on imports [2].

Despite these opportunities, academic laboratories in the Philippines are often financially weak, underutilized, and managed primarily as cost centers rather than as productive economic actors. While demand–supply projections suggest strong market opportunities for products such as Filipino-style sausage (longanisa), sweet cured pork (tocino), cured pork (tapa), sweet pork stew (hamonado), financial accounting assessments typically classify these facilities as non-viable. This reflects a mismatch between their revenue-generating potential and the traditional accounting requirement for full cost recovery [3]. Such framing risks underestimating the broader socio-economic contributions these laboratories generate.

From an accounting perspective, cost recovery frameworks emphasize operating self-sufficiency and the ability to cover both operating and capital expenditures. Financial appraisal tools such as Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR) remain the standard for assessing viability in both public and private enterprises [4]. However, Christensen and Lægreid argue that strict reliance on these indicators can obscure value creation in mission-driven organizations [5]. Guthrie, Manes, Rossi, and Orelli further stress that integrated reporting in public entities highlights non-financial value creation [6].

Economic theory offers a complementary lens to accounting measures. Samuelson established those certain goods produce non-excludable and non-rival benefits, thereby justifying public investment [7]. Musgrave extended this by showing the broader role of public finance in addressing social welfare gaps [8]. Higher education and academic laboratories fit within this framework by producing positive externalities such as training, innovation spillovers, and environmental benefits. Marginson argues that higher education serves the common good [9], while McMahon demonstrates the measurable social returns that extend beyond financial accounts [10].

These dual characteristics position academic laboratories as hybrid enterprises, combining public-good missions with private-enterprise functions. Battilana and Lee emphasize the tensions between social and commercial logics in such organizations [11]. Haigh, Walker, Bacq, and Kickul highlight the strategies hybrids adopt to manage these tensions [12]. More recent contributions by Bryson, Sancino, and Benington point to the importance of public value in sustaining hybrids [13], while Powell and Sandholtz discuss the evolving logics that shape hybrid enterprise governance [14]. This framework provides a useful basis for reconceptualizing academic laboratories in the agri-business sector.

While agribusiness feasibility studies are well documented, few integrate both financial accounting measures and economic valuation of hybrid academic enterprises. Existing studies typically assess profitability without considering public-good externalities or emphasize social contributions without examining accounting viability. This study bridges the two perspectives by evaluating both the financial and economic performance of university agribusiness laboratories in the Philippines. In doing so, it introduces the Academic–Agribusiness Laboratory Leverage Conversion Model, which frames these laboratories as hybrid enterprises requiring both accounting discipline and economic justification. This dual contribution responds to calls for interdisciplinary approaches that link accounting practices to broader economic and policy concerns [15].

2. Literature Review

The sustainability of university-based agribusiness laboratories has been examined from various perspectives, reflecting their role as educational facilities, income-generating units, and contributors to local development. Existing scholarship indicates that these laboratories occupy a unique institutional space, situated between the academic goals of higher education and the financial demands of enterprise operations. To understand their performance and long-term viability, it is necessary to examine the literature across several domains. This review, therefore, considers studies on agribusiness laboratories in higher education, accounting frameworks for cost recovery, economic theories of public goods and externalities, policy perspectives on higher education financing, and the growing body of research on hybrid organizations. Together, these strands of literature provide the theoretical foundation for assessing how academic laboratories can be evaluated within accounting and economics frameworks.

2.1. Academic laboratories in agribusiness

Academic laboratories have long been recognized as crucial components of higher education institutions, serving not only as training grounds but also as semi-commercial units that contribute to local economies [16]. In the agribusiness sector, they provide a venue where theoretical knowledge is applied to real-world production and marketing challenges. Their role in bridging research and practice is particularly important in developing countries, where gaps in technology transfer and enterprise incubation remain significant [17]. Through these laboratories, universities are able to simultaneously address workforce development, food production, and innovation diffusion.

The Food and Agriculture Organization emphasizes that academic and research-linked agribusiness units are key drivers of agricultural innovation systems by linking students, farmers, and local enterprises [1]. These laboratories often act as micro-enterprises embedded within universities, capable of producing goods that respond to market demand while also fulfilling educational objectives. This dual function gives them a unique position in national development strategies, particularly in contexts where higher education is seen as both a private investment and a public good [15].

In the Philippine context, university laboratories have historically been established to support agriculture and food-related programs, but their contribution to local markets remains underexplored. Studies note that while they have the potential to address persistent supply shortages in meat and processed food products, they are frequently constrained by limited funding, weak cost-recovery mechanisms, and insufficient integration with local industry [18]. As a result, their market contributions are often underutilized, even as they remain central to academic training.

World Bank reports stress that such laboratories are essential nodes in building resilient agricultural innovation systems, particularly in countries with rising food demand and structural supply gaps [2]. By engaging in small-scale production of commercially relevant goods, these units not only supplement national supply but also reduce reliance on imports. However, their limited ability to generate consistent revenue streams under traditional financial accounting frameworks often leads to their classification as financially unviable, despite evidence of broader social and economic contributions [3].

All of these suggest that academic laboratories in agribusiness should not be viewed solely as auxiliary units of universities but rather as hybrid enterprises that balance multiple objectives. Their ability to contribute to market supply, provide hands-on learning, and support local communities positions them as unique institutional actors that cannot be adequately assessed using conventional profitability measures alone [11]. This highlights the need for analytical frameworks that capture both their financial and non-financial contributions, thereby situating them more appropriately within accounting and economics discourse.

2.2. Financial accounting and cost recovery frameworks

Financial accounting has traditionally served as the foundation for evaluating the viability of enterprises, including those operating within the public and quasi-public sectors. Tools such as Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR) are widely regarded as the standard metrics for assessing investment feasibility in both private and government projects [4]. These measures enable decision-makers to evaluate cash flows against costs and to determine whether a venture can achieve profitability or meet required thresholds of return. In the context of academic laboratories, such metrics are often applied to assess their commercial sustainability, even when their functions extend beyond market-oriented outcomes [16].

The principle of cost recovery lies at the center of financial accounting assessments in public institutions. As Anthony and Govindarajan explain, the concept of operating self-sufficiency requires that revenues cover operating expenditures to ensure fiscal discipline [4]. This framework is embedded in public sector management practices, where efficiency and accountability are emphasized through measurable financial indicators. However, academic laboratories often struggle to achieve full cost recovery because their objectives include providing training, generating research outputs, and offering community services that do not yield immediate financial returns [18]. This creates tension between accounting-based evaluations and the actual mission of these institutions.

Christensen and Lægreid argue that strict reliance on traditional accounting frameworks risks undervaluing the contributions of mission-driven organizations [5]. Their work on public sector accounting shows that entities serving broader social functions cannot be fully assessed by balance sheets and income statements alone. Similarly, Guthrie, Manes Rossi, and Orelli highlight the importance of integrated reporting in public entities, noting that non-financial indicators such as knowledge transfer, innovation, and social value creation are essential to understanding performance [6]. Applying this reasoning to academic laboratories suggests that conventional cost recovery frameworks are inadequate in capturing their multifaceted contributions.

The limitations of purely financial metrics are particularly visible when academic laboratories operate in resource-constrained environments. World Bank findings indicate that while cost recovery in education and public services is necessary for sustainability, subsidies and alternative financing models are critical for ensuring equity and supporting broader development outcomes [3]. In the agribusiness sector, laboratories that attempt to recover costs solely through market revenues often face shortfalls that jeopardize their operations. Yet, when supplemented by government or institutional support, they can generate significant externalities such as student training, market stabilization, and local enterprise incubation [2].

Recent developments in accounting research suggest a shift toward more inclusive approaches to performance evaluation. Integrated reporting frameworks and sustainability accounting emphasize the importance of balancing financial viability with social and environmental outcomes [6]. In this view, academic laboratories should not be expected to achieve full financial self-sufficiency but rather to demonstrate accountability through a combination of cost recovery, educational outcomes, and contributions to economic development. Such perspectives provide a theoretical foundation for reframing academic laboratories as hybrid enterprises that require dual forms of accounting: one that measures financial viability and another that captures broader social and economic value [11].

2.3. Public goods, externalities, and higher education

The concept of public goods provides a powerful framework for analyzing higher education and its associated institutions, including academic laboratories. Samuelson established those certain goods are characterized by non-excludability and non-rivalry, meaning that consumption by one individual does not diminish availability to others and access cannot be restricted [7]. Education, research, and training outputs generated by universities and laboratories share these characteristics because they produce benefits that extend beyond direct participants. This theoretical foundation supports the argument that academic laboratories, though financially weak in market terms, justify public investment due to the broad distribution of their benefits.

Musgrave extended the discussion by situating public goods within the domain of public finance, emphasizing that governments play a critical role in funding and sustaining activities that produce positive externalities [8]. Academic laboratories exemplify such externalities by generating spill-over benefits, including improved human capital, innovation diffusion, and strengthened community enterprises. These benefits cannot be easily captured in financial accounts, which makes them vulnerable to underfunding when evaluated solely by profitability standards [3]. Thus, public finance theory supports subsidies and state interventions to sustain laboratories as providers of quasi-public goods.

Contemporary literature reinforces the relevance of public goods theory in higher education. Marginson stresses that universities contribute to the common good not only through direct knowledge transfer but also by shaping civic culture, enhancing social cohesion, and building national competitiveness [9]. Similarly, McMahon demonstrates that higher education generates long-term returns through improved productivity, reduced inequality, and enhanced social outcomes [10]. Applying these insights to academic laboratories suggests that their economic contributions extend well beyond product sales, encompassing broader educational and societal benefits that warrant recognition in both policy and accounting frameworks.

Empirical studies in development contexts further highlight the public-good role of academic institutions. The Asian Development Bank notes that higher education financing must reflect the dual character of education as both a private and a public good [15]. Without sufficient state support, institutions risk over-commercialization, which can compromise accessibility and equity. World Bank reports echo this concern by stressing that cost recovery in education and training systems must be balanced by subsidies to safeguard long-term public benefits [3]. This reinforces the idea that academic laboratories, even if financially unviable in strict accounting terms, deserve public support to sustain their externalities.

For academic laboratories in agribusiness, the implications of public goods theory are significant. By producing skilled graduates, disseminating innovations, and providing products that stabilize local markets, these laboratories generate benefits that are non-rival and widely shared. Their contributions to food security and workforce development cannot be captured fully by financial indicators like NPV or IRR [4]. Therefore, evaluating them requires frameworks that incorporate both accounting measures of cost recovery and economic measures of externalities. This dual assessment aligns with current debates in accounting and economics that advocate integrating financial viability with public value considerations [11].

2.4. Policy perspectives on higher education and agribusiness

Policy debates on higher education increasingly highlight the dual nature of universities as both providers of private benefits and generators of public goods. The Asian Development Bank emphasizes that financing models must account for this dual character, ensuring that institutions remain accessible while sustaining their social contributions [15]. In many developing economies, higher education is viewed not only as a pathway to individual advancement but also as a mechanism for national development, innovation, and poverty reduction. Academic laboratories, as extensions of higher education institutions, reflect these dual roles by simultaneously providing market-relevant training and producing goods with broader societal value [16].

World Bank studies underline the importance of balancing cost recovery with subsidies in the provision of education and public services [3]. Full cost recovery, while promoting efficiency and fiscal responsibility, often fails to accommodate equity concerns in contexts where public investment is required to achieve social goals. In agribusiness-related laboratories, applying a strict cost recovery model risks underfunding facilities that generate externalities such as workforce training, import substitution, and community-based enterprise development [2]. As such, policies that complement cost recovery with targeted subsidies are critical to ensuring both financial sustainability and continued delivery of public-good benefits.

National policies in agriculture and education also emphasize the strategic role of universities in promoting food security and innovation. Reports highlight those academic laboratories serve as incubators for small and medium enterprises by fostering value-added production and linking research outputs to industry practices [18]. In the Philippines, government strategies on agribusiness modernization identify higher education institutions as key partners in upgrading agricultural value chains. However, without appropriate funding mechanisms, laboratories struggle to compete with private enterprises, limiting their ability to fulfill both their academic and economic mandates [17].

International organizations have also stressed the importance of aligning higher education financing with broader development objectives. The FAO notes that agricultural innovation systems depend on strong institutional linkages, where universities act as anchors that connect training, research, and enterprise activities [1]. Similarly, the World Bank highlights that agribusiness laboratories embedded in universities can play a role in stabilizing markets by producing goods that meet unmet demand while generating skills for future entrepreneurs [2]. These insights reinforce the need for supportive policy environments that view academic laboratories not only as educational facilities but also as contributors to inclusive economic development.

The policy perspectives converge on the conclusion that academic laboratories in agribusiness cannot be sustained by market revenues alone. Their contributions to education, community development, and market stability require financing mechanisms that integrate accounting principles of cost recovery with economic recognition of externalities. Policies that strike this balance allow laboratories to operate as hybrid enterprises, ensuring accountability through financial reporting while justifying subsidies on the grounds of public value creation [11]. This perspective provides the foundation for developing analytical models that reflect the dual mission of academic laboratories in both financial and economic terms.

2.5. Hybrid enterprises and organizational frameworks

The concept of hybrid organizations has gained prominence in recent decades as scholars examine institutions that straddle the boundaries between commercial and social logics. Battilana and Lee explain that hybrid enterprises must simultaneously pursue financial sustainability and social missions, which often creates tensions in decision-making and accountability [11]. This duality is directly relevant to academic laboratories in agribusiness, which are expected to generate revenues from product sales while also fulfilling educational and research mandates. Unlike purely commercial firms, their performance cannot be assessed exclusively through profit indicators, as doing so would neglect their broader societal objectives [16].

Haigh, Walker, Bacq, and Kickul highlight that hybrid organizations often adopt multiple strategies to manage conflicting goals [12]. These include creating separate accounting systems for financial and social outcomes, forming partnerships to leverage external resources, and innovating business models that balance public value with market efficiency. Such strategies provide lessons for academic laboratories that struggle with cost recovery but remain vital for generating public-good benefits. By incorporating hybrid approaches, laboratories may better align financial accountability with their educational and community-oriented missions.

Bryson, Sancino, and Benington argue that the legitimacy of hybrid organizations depends on their ability to demonstrate public value [13]. In this sense, financial accounting alone is insufficient for accountability, as stakeholders expect evidence of social impact and broader economic contributions. For academic laboratories, demonstrating public value involves showing not only revenues and expenses but also the societal returns on investment, such as trained graduates, innovation spill-overs, and enhanced food security. This perspective suggests that academic laboratories require multidimensional reporting frameworks to sustain stakeholder trust and policy support.

Powell and Sandholtz add that hybrid enterprises evolve within dynamic institutional environments, adapting their governance mechanisms as they balance competing logics [14]. They emphasize that hybrids must be flexible, adjusting their structures to meet shifting demands from markets, governments, and communities. Academic laboratories operate in similarly fluid contexts, where government subsidies, market demand for processed products, and institutional expectations continuously reshape their operations. Understanding laboratories through the lens of hybrid enterprise theory allows for recognition of their adaptability as well as their vulnerabilities.

These insights create an entry point for reconceptualizing university agribusiness laboratories. When examined as hybrid enterprises, they can be positioned within a framework that incorporates both accounting indicators of financial viability and economic measures of public value. It is from this perspective that the present study introduces the Academic–Agribusiness Laboratory Leverage Conversion Model, advancing the discussion on how universities can sustain laboratories that are financially constrained yet socially indispensable [11].

2.6. International comparative perspectives on hybrid academic enterprises

Across different regions, universities and their laboratories increasingly function as hybrid enterprises, balancing academic missions with commercial and developmental roles. In European contexts, hybrid identity has been analyzed through the lens of organizational design and governance. Majoor-Kozlinska has shown that academic actors in hybrid universities occupy a central role by reconciling institutional tensions between educational missions and entrepreneurial logics, demonstrating how hybrid legitimacy is constructed through role integration and stakeholder alignment [50]. Similarly, Albers et al. [51] argue that differences in organizational architecture and internal governance structures explain why some universities succeed in embedding market orientation without undermining public trust, while others face persistent legitimacy challenges.

Emerging typologies of hybrid institutions further highlight the role of governance in sustaining dual missions. Leitão et al. [52] introduced the concept of Hybrid Civic Universities, emphasizing open innovation, participatory governance, and sustainability as pillars of hybrid identity. Their framework suggests that universities are more likely to maintain legitimacy when they transparently align civic missions with entrepreneurial activities, a finding directly relevant to the governance pillar of the conversion model proposed in this study.

Beyond higher education, comparative research in agribusiness and agricultural innovation underscores how institutional capacity shapes hybrid performance. Guo et al. [53], in a G20 efficiency study, found substantial differences in agricultural science and innovation outcomes across countries, with institutional support and policy frameworks strongly influencing performance. Such evidence highlights those assumptions regarding growth, efficiency, and subsidy roles cannot be generalized, but must instead be adapted to national and institutional contexts.

A relevant international benchmark can also be found in non-Asian hybrid meat-processing laboratories. For example, the Meat Processing Unit of Harper Adams University in the United Kingdom operates as a fully licensed commercial facility while simultaneously functioning as a teaching and research platform. Revenues from product sales support day-to-day operations, while capital expenditure is subsidized by the university—illustrating a mature hybrid model that balances commercial discipline with public-value delivery [58]. Likewise, the

Iowa State University Meat Laboratory in the United States integrates instruction, food safety research, extension services, and commercial processing. Its sustainability relies on diversified income streams—custom processing, value-added meat products, and externally funded research projects—making it one of the most frequently cited examples of a financially resilient university-based meat laboratory [59].
These international perspectives show that hybrid academic enterprises are neither uniform nor context-free. Their success depends on the integration of accounting discipline, economic contributions, and governance legitimacy within specific institutional environments. By situating the Philippine case alongside these comparative insights, the present study contributes to a broader conversation on how hybrid academic laboratories can balance financial viability with the delivery of public value across diverse settings.

2.6. Synthesis

The review of literature demonstrates that academic laboratories occupy a complex position at the intersection of education, agribusiness, and public policy. Studies emphasize their contribution to workforce development, technology transfer, and market supply [16–18], yet their sustainability is often questioned when assessed solely through financial accounting metrics such as NPV, IRR, and BCR [4]. Accounting perspectives rooted in cost recovery provide valuable insights into operational viability [5–6], but they are limited in capturing the broader contributions that laboratories make to society.
Economic literature shows that these contributions resemble public goods, generating externalities such as skill formation, research spillovers, and enhanced food security [7–10]. These benefits justify subsidies and government support, even when financial accounts report deficits [3]. Policy studies similarly emphasize the need to balance cost recovery with equity and development goals, positioning universities as strategic partners in agribusiness modernization and innovation systems [1–2], [15], [18].
Hybrid organization theory offers a lens for reconciling these competing perspectives, framing academic laboratories as entities that combine social and commercial logics [11–14]. This approach highlights the tensions laboratories face between financial discipline and public-value creation, while also suggesting strategies for sustaining legitimacy through multidimensional accountability.
Recent international scholarship adds a comparative dimension to this discussion. Majoor-Kozlinska highlights how academic actors in hybrid universities navigate institutional tensions, achieving legitimacy by aligning educational and entrepreneurial roles [50]. Albers et al. [51] show that governance and organizational design significantly shape the success of hybrid universities, while Leitão et al. [52] emphasize civic engagement and sustainability as pillars of hybrid legitimacy. Beyond higher education, Guo et al. [53] demonstrate that institutional support strongly influences the efficiency of agricultural innovation in G20 countries, underscoring that hybrid performance cannot be divorced from governance and policy context.
Recent scholarship continues to highlight important developments relevant to hybrid academic enterprises. For example, Gherardi, L. et al. emphasize that ESG-integrated reporting has become increasingly significant in public sector accountability, as it links financial metrics with environmental and social value creation [54]. Likewise, Manes-Rossi, F., Nicolò, G., & Argento, D. argue that sustainability-oriented reporting frameworks enhance transparency and legitimacy in public entities [55]. In parallel, Alves, R. G., Maia, R. F., & Lima, F. document how digital agribusiness laboratories in higher education leverage smart technologies to improve training delivery, optimize production processes, and strengthen integration with local supply chains [56]. Moreover, Verdouw, C., Tekinerdogan, B., Beulens, A., & Wolfert, S. note that post-pandemic public finance reforms increasingly favor blended or hybrid financing models for academic enterprises, recognizing the need to balance fiscal discipline with the delivery of broader public value [57].
Taken together, the literature indicates that while accounting and economic approaches offer valuable but partial perspectives, international evidence shows the necessity of integrating governance and legitimacy into any assessment framework. Despite these insights, a gap persists in integrating accounting measures of financial performance with economic valuation of public-good contributions in the Philippine context. Previous research has tended to isolate financial viability from externalities, resulting in incomplete assessments of academic laboratories. The present study addresses this gap by applying both financial and economic appraisal to university agribusiness laboratories in the Philippines. It further contributes a conceptual framework—the Academic–Agribusiness Laboratory Leverage Conversion Model—that situates these laboratories as hybrid enterprises requiring accounting discipline, recognition of their wider social and economic roles, and governance mechanisms that ensure long-term legitimacy.

3. Methodology

This section presents the research design, respondents, data-gathering instruments, and analytical techniques employed in the study. It explains the procedures followed in collecting and processing the data, including the formulas and assumptions used in financial and economic appraisal. The methodology is organized to show first the sources of information and respondents, followed by the tools and instruments used, and then the analytical framework applied in evaluating the financial and economic viability of the university agribusiness laboratories.

3.1. Research design

This study employed a descriptive–evaluative design anchored in both accounting and economics frameworks. Financial appraisal was conducted using Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR), consistent with established accounting tools for investment evaluation [4–6]. To complement this, economic net benefits were assessed in line with public goods theory and the recognition of externalities in higher education [7–10]. This dual framing reflects the hybrid nature of aca-demic laboratories, which combine financial accountability with broader social contributions [11–14].

3.2. Study area and sampling procedure

The study covered four municipalities and cities in Batangas Province: Taysan, Batangas City, Lipa City, and Lobo. Respondents consisted of both household consumers and processed meat retailers. Household population figures were obtained from the Philippine Statistics Authority (PSA) for benchmark years 1991, 1995, 2000, 2007, 2010, 2015, 2020, and 2024. Since no official population estimates were available for 2021–2023, interpolation was conducted using the compound annual growth rate (CAGR) formula, defined as

$$\mathrm{CARG} = \left(\frac{\mathrm{End}}{\mathrm{Start}}\right)^{\frac{1}{n}} - 1$$

Where start represents the earlier population count, End the later population, and n the number of years. The same method was used to generate forecasts from 2025 to 2035. The use of CAGR was justified because it provides a smooth annualized growth rate that accounts for compounding effects, thereby offering a more reliable approximation than linear interpolation when data points are sparse.

From the estimated household population of 196,868, a total sample of 384 respondents was drawn using proportionate allocation. The final distribution was 19 from Taysan, 170 from Batangas City, 176 from Lipa City, and 19 from Lobo. Respondents were purposively selected on the basis of being responsible for food purchasing in their households.

On the supply side, processed meat retailer populations were estimated using retail density data from the Philippine Institute for Development Studies (PIDS), which were available only for 1995 and 1997. These values were extrapolated using CAGR and adjusted by 7.6 percent, based on PSA estimates of the proportion of retailers engaged in meat sales. This approach was necessary because official disaggregated counts of processed meat retailers were unavailable; using retail density allowed indirect estimation, while the 7.6 percent adjustment ensured the estimates were specific to meat products. From the computed retailer population of 6,693,769, a total of 385 retailers were surveyed, distributed proportionately as 19 in Taysan, 167 in Batangas City, 180 in Lipa City, and 19 in Lobo.

The estimated retailer population represents a national-level extrapolation based on PIDS retail density and PSA proportions for meat retailers. Because PSA does not publish disaggregated provincial counts, the estimate serves as the theoretical universe from which the provincial sample was proportionately drawn. A full explanation of this estimation technique allows consistency with market sizing studies that rely on density-based extrapolations.

It should be noted that the computed retailer population of 6.69 million represents a national-level extrapolation derived from PIDS retail-density ratios and PSA demographic shares. Because PSA does not release provincial-level retailer counts, this national estimate functions as the theoretical universe for deriving the proportional sample allocated to Batangas. This procedure follows standard market-sizing methodologies used when subnational retailer directories are unavailable.

3.3. Data gathering instrument

Two structured questionnaires were developed to collect primary data from households and retailers. The household questionnaire focused on frequency and quantity of processed meat purchases, brand preferences, and purchasing behavior, allowing the estimation of demand patterns across different population groups. The retailer questionnaire gathered information on daily sales volume, number of packs available, product variety, and days of operation. These instruments provided a consistent basis for quantifying supply levels in relation to consumer demand.

To supplement survey data, a price monitoring tool was also employed. This involved canvassing local markets and browsing official and commercial websites to capture current prices of raw materials, packaging, and processed meat products. Incorporating both physical canvassing and online price checks ensured that the study reflected actual market conditions while accounting for variations across outlets. The triangulation of household, retailer, and price data strengthened the reliability of the estimates and supported the projection of historical demand and supply levels into future scenarios.

3.4. Data analysis

The data analysis combined accounting-based financial appraisal with economic valuation techniques to provide a comprehensive assessment of demand, supply, and market performance. Demand estimation relied on household consumption data, while supply projections were derived from retailer information and adjusted growth models. The analysis also incorporated assumptions and forecasting methods to capture future trends in consumption, supply, and laboratory production. To ensure alignment with both accounting and economics perspectives, the study applied conventional investment appraisal tools alongside economic welfare analysis. The succeeding discussion presents the computational methods, forecasting models, and assumptions used in quantifying demand, supply, market gaps, and laboratory contributions to the processed meat sector.

Demand was calculated by multiplying the average household consumption by the total number of households, while projections were derived by applying CAGR to both population and consumption growth. Supply was estimated from retailer data scaled to the estimated population of retailers. To forecast the number of packs of processed meat available in future years, a logistic growth model was used:

$$Q_t = \frac{K}{1 + e^{-r(t-t_0)}}$$

Where Q_t represents projected sales at time t, K is the carrying capacity (maximum sales volume), r is the intrinsic growth rate, and t_0 is the inflection point. The logistic function was applied to account for the saturation effect in markets, where growth slows as it approaches maximum potential, thereby avoiding the overestimation that would result from linear or purely exponential models.

The market gap was computed as the difference between demand and supply,

$$\text{Market Gap} = \text{Demand}_t - \text{Supply}_t$$

While the market share of the academic laboratory was calculated as the ratio of projected laboratory production to total demand,

$$\text{Market Share}t_t = \frac{\text{Lab Production}_t}{\text{Total Demand}_t} \text{ x } 100$$

Laboratory production was assumed to grow at five percent annually, expressed as

$$\text{Production}_t = \text{Production}_{t-1} \times (1 + 0.05)$$

The assumption of 5 percent growth was based on incremental improvements in herd management and productivity typically observed in small-scale academic and demonstration farms. This provided a conservative estimate, avoiding the over-optimism of higher growth assumptions.

To ensure internal consistency in the financial analysis, a set of baseline assumptions was defined. These assumptions guided the computation of costs, revenues, and investment indicators, and they reflect both standard practices in livestock-based agribusiness and the operational realities of academic laboratories. Table 1 presents the key assumptions applied in this study, covering technical yields, product specifications, inflationary adjustments, labor requirements, depreciation policies, and supplementary income from by-products.

Table 1: Key Assumptions for Financial and Investment Analysis

Parameter	Assumption	Basis / Justification
Economic Parameters		
Inflation rate	4.2% annually	PSA long-term inflation average
Exchange Rate (PHP-US$)	PHP1.00-US$57.66	Bangko Sentral ng Pilipinas (2025)
Discount rate	12%	Benchmark for agri-investments/ ADB
Project horizon	10 years	Matches planning cycle
Livestock Production		
Production model	Farrow-to-Finish	Ensures piglet supply
Carcass yield	70% of live weight (~84 kg → 58.8 kg)	Standard industry yield
Annual production growth	5% increase in output	Consistent with demand growth
Surplus piglets sold	35 head first year, scaled annually	Derived from the herd model
Product Processing		
Pack size	250 g retail pack	Market standard
Selling price (raw pork equivalent)	US$2.61/kg	Based on OPEX hog production
By-Product Recovery (computed by getting the average weight of each part multiplied by the number of hog products per year		
Offals (heart, liver, lungs, etc.)	6–7 kg/pig, priced US$1.73–US$4.33/kg	Secondary markets
Head parts (snout, tongue, etc.)	~3 kg/pig, priced US$3.12–US$3.81/kg	
Bones & trotters	~10 kg/pig, priced P US$1.73– US$3.81/kg /kg	
Blood	3.8 kg/pig @ US$1.04/kg	Used in the food/pet market
Skin	4.5 kg/pig @ US$2.60/kg	Chicharon/collagen
Fatty trimmings	2.5 kg/pig @ US$2.60/kg	Rendered fat
Costing & Operations		
Labor	3 caretakers (farm), 5 workers (processing)	With 4.2% annual escalation
Utilities	Adjusted annually by inflation	Electricity, water, cold storage
Depreciation	Straight-line, 10–20% salvage	Per asset category
CAPEX phasing	Pigpen expansion (Years 0, 2034); processing/cold storage expansion (2031–2032)	Based on production growth

The study employed a 5 percent annual growth assumption for laboratory production. This rate was selected as a conservative estimate consistent with incremental improvements in herd management, feed conversion, and productivity typically observed in smallholder and demonstration farms. Recent analyses of livestock innovation adoption in Asia, such as smart livestock technology in Japan, report productivity gains within a 4–7 percent range, suggesting that a 5 percent benchmark is both realistic and prudent for academic laboratory operations (Kondo, S. et al.) [39].

Cost estimates for feed, utilities, and other operating expenditures were derived from farm-gate and wholesale data published by the Philippine Statistics Authority (PSA) and validated through local market canvassing and online price monitoring. This was further supported by reports showing that feed markets in the Philippines are projected to expand at an annual rate of about 5.8 percent, highlighting volatility in input costs that must be factored into financial appraisal (6Wresearch) [40]. Sensitivity analysis was therefore applied to account for price fluctuations, which have historically ranged from 8–12 percent in Philippine feed markets (Agriculture Canada) [41].

Depreciation was computed using straight-line assumptions in line with established agricultural accounting practices, ensuring comparability with similar financial appraisal studies and transparency in cost allocation (de Vries, A. et al.) [42].

The use of the compound annual growth rate (CAGR) in population and demand forecasting was also justified on methodological grounds. CAGR accounts for compounding effects and provides a more accurate trajectory than linear models when data points are sparse, a method widely applied in demographic and market projection literature (World Bank) [43].

Financial viability was evaluated using standard investment appraisal methods. Costs included feed, veterinary care, utilities, labor, and capital outlays, while revenues were based on projected sales of fresh and processed products such as sweet cured pork, cured pork, and Filipino-style sausage and sweet pork stew. Net Present Value (NPV), Internal Rate of Return (IRR), Benefit–Cost Ratio (BCR), and Payback Period (PBP) were calculated to assess profitability. These were expressed as:

$$NPV = \sum_{t-1}^{n} \frac{R_t - C_t}{(1+r)^t} - I_0$$

$$0 = \sum_{t-1}^{n} \frac{R_t - C_t}{(1+r)^t} - I_0$$

$$BCR = \frac{\sum_{t-1}^{n} \frac{R_t}{(1+r)^t}}{\sum_{t-1}^{n} \frac{C_t}{(1+r)^t}}$$

Where R_t denotes revenues, C_t costs, r the discount rate, n the number of years, and I_0 the initial investment. These indicators were selected because they are widely used in agribusiness feasibility analysis and provide complementary perspectives on investment attractiveness.

Sustainability was assessed through the Triple Bottom Line (TBL) framework. Economic sustainability was measured through profitability and cost recovery, social sustainability through training opportunities, student engagement, and local employment, and environmental sustainability through feed efficiency, waste utilization, and energy use. Indicators were drawn both from field observations and benchmarks established in the literature.

Governance and policy support were analyzed by reviewing programs under the Department of Agriculture (DA), Department of Science and Technology (DOST), Commission on Higher Education (CHED), and local government units. Stakeholder perspectives gathered from retailer surveys and administrator interviews were also incorporated. International practices, such as agri-environmental subsidies and green financing schemes in Europe and cooperative food hubs in the United States, were used as comparative benchmarks to contextualize local gaps and opportunities.

Finally, findings across demand–supply dynamics, financial analysis, sustainability assessment, and policy review were synthesized to propose an integrated framework for sustaining academic laboratories through agribusiness. This framework positions laboratories not merely as academic facilities but as hybrid institutions capable of generating revenue, supporting food systems, and fulfilling their public-good mandate.

To strengthen the validity of the economic analysis, a set of explicit assumptions was established to guide the estimation of benefits and costs. These assumptions drew upon both primary data from household and retailer surveys as well as secondary benchmarks from government agencies and international references. Table 2 summarizes the key assumptions, including valuation bases for non-market benefits such as training, consumer surplus, and local economic multipliers, as well as externalities like carbon and water use. Defining these parameters ensured that the resulting estimates reflect realistic conditions while maintaining transparency and replicability in the appraisal process.

Table 2: Key Assumptions for Estimating Economic Benefits and Costs

Category	Assumption	Basis of Valuation
Import-substitution welfare	Locally produced processed meat (sausages, cured pork) substitutes imported pork products at equal market value.	Average CIF import prices of pork (PSA; DA-BAI trade data)
Training & extension value	Each student practicum is valued as the avoided cost of equivalent external training or certification.	Mean training fee per student × number of trainees (CHED-recognized program rates)
Energy offset (biogas)	305 pigs generate ~20 m³ biogas/day; 1 m³ biogas ≈ 2 kWh electricity	DOE biogas conversion factor; regional retail electricity tariff
Fertilizer credit (composted solids)	Nutrient content of composted manure valued against equivalent NPK fertilizer	DA-FPA official NPK market price references
Consumer surplus	Computed using price elasticity of demand (-0.8) applied to household consumption change	Household survey consumption; PSA elasticity benchmarks
Local multiplier effect	Indirect & induced impacts estimated using a livestock agribusiness Type II multiplier of 2.0	PIDS & World Bank Input–Output multipliers
Research & innovation spillover	Value of additional theses, prototypes, and pilot innovations enabled by the facility	Benchmark valuation of research outputs in agri-innovation studies (avoided cost method)
Institutional accreditation benefits	Contribution of the laboratory to accreditation outcomes is valued as avoided preparation cost and incremental prestige value.	AACCUP/ISO audit cost benchmarks; institutional valuation models
Avoided SUC procurement cost	The university uses in-house meat for events and training instead of procuring from external vendors.	Price differential between market procurement and in-house production
Food safety/traceability benefit	Value of reduced food-borne risk due to controlled production and traceability	Proxy valuation from avoided-risk models in livestock safety literature
Nutrition/protein access benefit	Economic benefit of access to affordable protein products for local households	PSA household food expenditure patterns; FAO protein valuation model
Resource operating cost (explicit OPEX)	Same values used in the financial operating model	Computed OPEX schedule from project financial statements
Capital expenditure (economic outlay)	Treated as a lump-sum outflow in investment years; converted into economic cost	Project CAPEX phasing from the investment plan
Carbon externality	2.5 tCO_2e/pig/year × social cost of carbon (USD 50/tCO_2e)	IPCC and World Bank carbon pricing guidelines
Water use & effluent externality	50 L/day/pig valued at wastewater treatment cost per m³	DENR effluent fees; LGU tariff rates
Faculty supervision opportunity cost	0.25 FTE of faculty time valued using consultancy-equivalent SUC rate	CHED–SUC salary scale & consultancy benchmarks

3.5. Ethical considerations

Ethical standards were observed throughout the conduct of the study. Participation of both household consumers and retailers was strictly voluntary, and respondents were informed of the purpose of the research before data collection. Verbal consent was obtained before administering the questionnaires, and participants were assured that they could withdraw at any point without consequence. No personal identifiers were recorded in the survey instruments, ensuring anonymity and confidentiality of responses. The data gathered was used solely for academic purposes and was stored securely to prevent unauthorized access. In collecting price information through market canvassing and website browsing, only publicly available data was utilized, with no engagement in deceptive or intrusive practices. These measures ensured that the study complied with ethical norms in social science research and upheld the rights and dignity of all participants.

4. Results and Discussion

This section presents the findings of the study and interprets them in relation to accounting and economics frameworks. The results are organized to show, first, the demand and supply conditions for processed meat products in the selected municipalities of Batangas Province. These are followed by the estimation of demand–supply gaps and the projected market share of the university agribusiness laboratory. The discussion then turns to financial and economic appraisal results, using NPV, IRR, BCR, and Economic Net Benefits to assess viability. Finally, the implications of the findings are analyzed through the lens of hybrid enterprise theory, situating the laboratories within both financial accountability and public-good contributions.

4.1. Market context for financial and economic appraisal

Table 3 presents the projected household demand for processed meat products in Batangas Province from 2020 to 2035. Demand estimates, derived from household consumption and population growth using CAGR, indicate a steady upward trend across tocino, tapa, longganisa, and hamonado. This reflects the growing importance of processed meat in household food baskets, consistent with consumption studies that highlight shifting preferences toward convenient protein sources.

Table 3 presents the demand, supply, and market gaps for four processed pork products in Batangas Province from 2020 to 2024. Household demand for Filipino-style sausage rose from 48.4 to 50.9 million packs, while supply increased from 0.4 to 4.5 million, leaving a gap of 46.4 million packs in 2024. Similar gaps were observed for sweet cured pork (32.3 million), cured pork (14.6 million), and sweet pork stew

(6.7 million). These persistent shortfalls suggest that household demand is rising faster than supply, a pattern consistent with broader shifts in Southeast Asian diets toward higher meat and processed food consumption as incomes grow [19][20].

Table 3: Estimated Historical Demand, Supply, and Market Gap for Filipino-Style Sausage, Sweet Cured Pork, Cured Pork, and Sweet Pork Stew in Selected Cities and Municipalities

	Filipino-style Sausage (Longanisa)			Sweet cured pork (Tocino)			Cured Pork (Tapa)			Sweet pork stew (Hamonado)		
Year	HD	HS	HMG	HD	HS	HMG	HD	HS	HMG	HD	HS	HMG
2020	48.4	0.4	48.0	34.3	0.3	33.9	15.8	0.2	15.6	8.1	0.1	7.9
2021	49.0	0.8	48.3	34.7	0.6	34.1	16.0	0.4	15.6	8.2	0.3	7.9
2022	49.6	2.0	47.6	35.2	1.9	33.3	16.2	1.0	15.2	8.3	0.9	7.4
2023	50.3	3.2	47.0	35.6	2.6	33.0	16.4	1.4	14.9	8.4	1.3	7.0
2024	50.9	4.5	46.4	36.1	3.7	32.3	16.6	1.9	14.6	8.5	1.7	6.7

Note: Values have been scaled by 1,000,000 for clarity and represent million packs (250 g).
Legend: HD = Historical Demand, HS = Historical Supply, HMG = Historical Market Gap.

Although retailer supply expanded during the period, its coverage of household demand remained small: in 2024, supply accounted for only 8.8% of Filipino-style sausage demand, 10.2% of sweet cured pork, 11.4% of cured pork, and 20.0% of sweet pork stew. This low coverage highlights structural bottlenecks in the value chain, including limited processing capacity and distribution inefficiencies. FAO reports on meat processing in developing economies emphasize that such supply gaps are common when local processors operate at a small scale and face constraints in technology adoption and market integration [21].

From an accounting standpoint, these demand–supply figures form the basis for projecting revenues in financial appraisal. Forecasted household demand establishes the potential sales environment against which Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR) can be evaluated [4]. At this stage, however, it is important to note that large demand gaps do not automatically translate into positive financial outcomes for small laboratories, since their capacity to capture market share remains limited.

From an economics perspective, unmet demand reflects forgone welfare gains. Studies on food security and market efficiency show that under-supply in protein markets reduces consumer surplus and increases reliance on imports, thereby weakening local value chains [22]. Even modest laboratory contributions can therefore have significance beyond their financial accounts, as they add to local supply and reduce structural dependence on external sources. These broader benefits will be discussed further in the economic appraisal section.

The evidence from 2020 to 2024 points to a consistent pattern: household demand for processed pork products continues to expand, while supply remains far behind. For the university laboratory, these gaps suggest that there is space in the market to place its products, but the question remains whether such opportunities can translate into sustainable financial returns. At the same time, the size of the shortfalls raises policy questions about how even small-scale laboratory output might contribute to consumer welfare and local food security. These issues are examined more closely in the following appraisal of financial indicators and economic contributions.

The projections from 2025 to 2035 indicate that household demand for all four processed pork products will continue rising steadily, while supply growth remains much slower. By 2035, Filipino-style sausage demand is projected at 58.4 million packs against a supply of only 12.2 million, leaving a gap of 46.2 million packs. Sweet cured pork shows a similar gap of 32.7 million, cured pork 12.5 million, and sweet pork stew 4.3 million packs. These persistent shortfalls suggest that even with gradual expansion in retailer supply, household demand will continue to outstrip local availability.

From an accounting perspective, these projected demand and supply levels form the foundation for the laboratory's revenue forecasts. They provide the quantity assumptions that feed into Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit–Cost Ratio (BCR) calculations [4]. However, as Anthony and Govindarajan note, cost recovery depends not only on the size of market demand but also on the scale of enterprise operations and unit margins [4]. This means that despite large market gaps, the laboratory's financial viability will ultimately hinge on its capacity to capture a measurable share of demand.

Table 4: Estimated Projected Demand, Supply, and Market Gap for Filipino-Style Sausage, Sweet Cured Pork, Cured Pork, and Sweet Pork Stew in Selected Cities and Municipalities

	Filipino-style Sausage (Longanisa)			Sweet cured pork (Tocino)			Cured Pork (Tapa)			Sweet pork stew (Hamonado)		
Year	PD	PS	PMG	PD	PS	PMG	PD	PS	PMG	PD	PS	PMG
2025	51.5	5.5	46.0	36.5	4.7	31.8	16.8	2.4	14.4	8.6	2.2	6.4
2026	52.2	6.3	45.9	37.0	5.3	31.7	17.0	2.8	14.2	8.7	2.6	6.1
2027	52.8	7.3	45.5	37.5	5.9	31.5	17.2	3.3	13.9	8.8	3.1	5.7
2028	53.5	8.0	45.4	38.0	6.4	31.6	17.4	3.7	13.7	8.9	3.4	5.5
2029	54.2	8.9	45.3	38.5	6.9	31.5	17.7	4.3	13.4	9.0	3.9	5.2
2030	54.8	9.5	45.3	39.0	7.3	31.7	17.9	4.7	13.2	9.2	4.2	5.0
2031	55.5	10.2	45.4	39.5	7.7	31.8	18.1	5.2	12.9	9.3	4.6	4.7
2032	56.2	10.6	45.6	40.0	7.9	32.1	18.3	5.6	12.8	9.4	4.9	4.5
2033	57.0	11.3	45.7	40.5	8.3	32.2	18.6	6.0	12.6	9.5	5.1	4.4
2034	57.7	11.6	46.1	41.0	8.5	32.5	18.8	6.2	12.6	9.6	5.2	4.4
2035	58.4	12.2	46.2	41.6	8.9	32.7	19.0	6.5	12.5	9.8	5.5	4.3

Note: Values have been scaled by 1,000,000 for clarity and represent million packs (250 g).
Legend: PD = Projected Demand, PS = Projected Supply, PMG = Projected Market Gap.

From an economics perspective, the persistence of unmet demand points to forgone welfare gains. Samuelson's theory of public goods and Musgrave's work on public finance both emphasize that when markets underprovide essential goods, public investment can be justified to close the gap [7] [8]. In this case, the inability of private supply to meet demand indicates inefficiencies that reduce consumer welfare, consistent with findings in food security studies showing that demand–supply imbalances in protein markets translate into higher prices and limited access [22]. Even modest laboratory output can therefore be economically significant by contributing to consumer surplus and reducing reliance on imports.

These dual perspectives underscore the relevance of treating academic laboratories as hybrid enterprises. As Battilana and Lee argue, hybrid organizations operate at the intersection of social mission and commercial logic [11]. In this study, the demand–supply projections serve not only as inputs for financial appraisal but also as indicators of public value creation. The Academic–Agribusiness Laboratory Leverage Conversion Model integrates these dimensions by showing how unmet market demand provides both a potential revenue base and a rationale for policy support.

In short, the projected demand–supply gaps through 2035 highlight the scale of opportunity and constraint: they show why financial appraisal is necessary to test viability, why economic valuation is needed to capture externalities, and why an integrated framework is required to reconcile the two.

The projected market gaps identified earlier provide the backdrop for estimating the potential market share of the proposed academic–agribusiness laboratory. Table 5 shows that even with assumed annual production growth, the laboratory's contribution to total supply remains extremely modest. In 2025, its share ranges from 0.045% for Filipino-style sausage to 0.115% for sweet pork stew, increasing only gradually to 0.064% and 0.165% respectively by 2035. These figures confirm that while unmet demand is substantial, the scale of laboratory operations allows it to capture only a fraction of the market.

From an accounting standpoint, these small market shares are significant because they define the revenue base for cash-flow projections and investment appraisal. As Garrison and Noreen emphasize, the proportion of demand an enterprise can capture determines the magnitude of revenues and hence the feasibility of recovering fixed and variable costs [23]. In the case of the university laboratory, limited market penetration implies that NPV, IRR, and BCR values will be sensitive to unit prices, cost structures, and the efficiency of operations, rather than to aggregate demand conditions.

Table 4: Estimated Projected Market Share of Processed Meat Produced by Proposed Academic-Agribusiness Laboratory

Year	Filipino-style Sausage (Longanisa)	Sweet cured pork (Tocino)	Cured Pork (Tapa)	Sweet pork stew (Hamonado)
2025	0.045%	0.051%	0.079%	0.115%
2026	0.046%	0.053%	0.082%	0.119%
2027	0.048%	0.055%	0.085%	0.124%
2028	0.050%	0.057%	0.088%	0.128%
2029	0.052%	0.059%	0.091%	0.133%
2030	0.054%	0.061%	0.094%	0.138%
2031	0.056%	0.063%	0.098%	0.143%
2032	0.058%	0.066%	0.101%	0.148%
2033	0.060%	0.068%	0.105%	0.154%
2034	0.062%	0.071%	0.109%	0.159%
2035	0.064%	0.073%	0.113%	0.165%

From an economics perspective, however, even a small share of production can carry weight in terms of welfare gains and externalities. Musgrave argues that public investments can be justified not only by scale but also by the nature of benefits they produce [8]. Here, the laboratory's output represents more than commercial sales: it supports training, technology demonstration, and partial import substitution. FAO's analysis of agri-food systems shows that localized production, even at low market share, enhances resilience and reduces exposure to volatile import prices [21].

The implications for the hybrid enterprise model are clear. As Battilana and Lee note, hybrids are not evaluated solely on financial returns but also on their ability to generate social value [11]. The laboratory's projected shares illustrate this logic: while financially small, the operation has broader economic significance by addressing structural gaps and contributing to public goods. Within the Academic–Agribusiness Laboratory Leverage Conversion Model, such outcomes justify a blended approach of limited subsidy, operational efficiency, and partnership building to ensure long-term viability.

Taken together, the market share estimates highlight both constraint and potential. They underscore the limits of financial self-sufficiency if judged purely on revenue terms, but they also point to meaningful contributions when economic and educational externalities are taken into account. This dual interpretation sets the stage for the detailed financial and economic appraisal presented in the following section.

4.2. Financial appraisal

Table 5 shows the projected cash-flow trajectory for the proposed academic–agribusiness laboratory from 2024 to 2035. Revenues begin in 2025 at US$126.6 thousand and expand steadily to nearly US$288.0 thousand by 2035. Operating expenditures (OPEX) grow in parallel, but at a slower pace, increasing from US$116.9 thousand in 2025 to US$185.8 thousand in 2035. This widening gap between revenues and OPEX signals the laboratory's capacity to achieve increasing operating surpluses. Earnings before interest, taxes, depreciation, and amortization (EBITDA) follow this upward path, rising from just under US$10 thousand in the first year of operations to more than US$100 thousand by the end of the projection period.

Earnings before interest and taxes (EBIT) also exhibit a strong positive trajectory. After accounting for annual depreciation, EBIT grows steadily from US$1.3 thousand in 2025 to almost US$92 thousand in 2035. This pattern indicates that the laboratory can achieve scale economies over time, where unit costs decline relative to output, allowing profitability margins to expand. Koller, Goedhart, and Wessels emphasize that such sustained improvement in EBIT relative to OPEX is a hallmark of operational strength, particularly in organizations with limited initial market share but consistent demand growth [24].

Nevertheless, the cash-flow profile reveals that capital expenditures (CAPEX) exert significant pressure on financial performance. The initial investment of US$299.3 thousand in 2024 generates a steep negative cash flow before operations commence. A second major outlay of US$76.2 thousand in 2031 once again pulls net cash flow into deficit despite positive operating results. Only after 2032 do cash flows stabilize and remain consistently positive, closing at nearly US$92 thousand in 2035. This mirrors the experience of capital-intensive agribusiness ventures, where profitability on paper may be positive, but liquidity constraints from large fixed investments limit financial flexibility in early and middle years [25].

Table 5: Summary of Projected Cash Flow

Year	Total Revenue	Operating Expenditure (OPEX)	EBITDA	Depreciation	EBIT	Capital Expenditure (CAPEX)	Net Cash Flow
2024	-	-	-	-	-	299.29	-299.3
2025	126.6	116.9	9.7	8.4	1.3	27.7	-26.4
2026	137.2	122.3	14.9	6.9	8.0	-	8.0
2027	148.8	128.3	20.5	6.9	13.6	-	13.6
2028	161.5	133.8	27.6	6.9	20.7	-	20.7
2029	175.2	139.7	35.6	6.9	28.6	-	28.6
2030	190.2	145.8	44.4	6.9	37.5	-	37.5
2031	206.5	152.2	54.3	10.4	43.9	76.2	-32.3
2032	224.3	159.0	65.3	10.2	55.1	38.1	17.0

2033	243.8	168.6	75.2	10.2	65.0	-0	65.0
2034	264.9	177.3	87.7	10.2	77.5	33.4	44.1
2035	288.0	185.8	102.1	10.2	91.9	0.0	91.9

Note: Amounts are expressed in Thousand US Dollar (US$=PHP57.66)
OPEX- Excluded the Depreciation
EBITDA- Earnings Before Interest, Taxes, Depreciation, and Amortization
EBIT- Earnings Before Interest and Taxes

This distinction between profitability and liquidity is critical from an accounting standpoint. As White, Sondhi, and Fried argue, earnings metrics such as EBIT reflect profitability but do not capture the cash impact of large, lumpy investments [26]. Cash-flow analysis, therefore, provides a more realistic assessment of financial resilience, especially for enterprises that combine commercial activities with broader institutional mandates. In this case, the laboratory demonstrates that while it can generate surpluses from operations, its ability to finance major capital needs from internal resources remains constrained.

For academic–agribusiness laboratories, this type of financial trajectory is not unusual. OECD studies on financing sustainable agriculture note that education-oriented enterprises often face long payback periods because they combine production with training and demonstration functions, which dilute immediate returns [25]. In such contexts, positive operating performance is a necessary but insufficient condition for financial viability, as capital recovery typically requires either concessional financing or subsidy support.

The projections in Table 5 highlight the dual reality faced by the laboratory: steady improvements in revenue, EBIT, and operating surpluses, but persistent vulnerability to the timing and scale of capital expenditures. These results provide the foundation for the next stage of analysis, which evaluates investment indicators such as Net Present Value (NPV) and Internal Rate of Return (IRR) to assess whether long-term financial returns meet conventional appraisal thresholds.

Table 6: Operating Self-Sufficiency and Investment Appraisal Indicators

Year	TR	OPEX	OSSR	Remarks
2024	0.00	0.0		Initial capital outlay (subsidy-supported)
2025	126.59	116.9	1.08	Costs covered, but CAPEX creates deficit
2026	137.24	122.3	1.12	First year of positive EBIT
2027	148.84	128.3	1.16	Surplus begins to accumulate
2028	161.47	133.8	1.21	Operating sufficiency improves
2029	175.23	139.7	1.25	Higher margins from scaled processing
2030	190.21	145.8	1.30	Stronger revenue growth
2031	206.55	152.2	1.36	CAPEX expansion temporarily reduces flow
2032	224.35	159.0	1.41	Sufficiency regained post-expansion
2033	243.75	168.6	1.45	Major recovery and surplus
2034	264.91	177.3	1.49	Consistent surpluses sustained
2035	287.97	185.8	1.55	Closing the gap, approaching long-term break-even
Investment Appraisal Indicator		Estimate		Remarks
Net Present Value		- 180.5		not financially viable.
Internal Rate of Return		-1.22%		Cash inflows are insufficient vs. outflows.

Legend: TR- Total Revenue expressed in Thousand US Dollars (US$=PHP57.66).
OPEX- Operating Expenditure expressed in Thousand US Dollar (US$=PHP57.66).
OSSR- Operating Self-sufficiency Ratio.

Table 6 complements the cash-flow projections by summarizing performance indicators that highlight both operating and investment dimensions. The Operating Self-Sufficiency Ratio (OSSR) exceeded 1.0 from the first year of operations in 2025, showing that revenues are sufficient to cover operating costs without external subsidy. This ratio improves steadily to 1.55 by 2035, reflecting the combined effect of rising revenues and economies of scale in processing. OSSR is widely used in non-profit and quasi-commercial enterprises as a measure of financial sustainability, since it signals the ability to fund operations from internally generated income [23]. From this perspective, the laboratory demonstrates strong operating viability across the projection horizon.

However, the investment appraisal results tell a more critical story. The Net Present Value (NPV) of –US$180.5 thousand and Internal Rate of Return (IRR) of –1.22 percent fall well below conventional thresholds for project acceptance. In corporate finance, projects with negative NPV are considered to destroy value, as discounted cash inflows cannot recover initial and subsequent capital outlays [24]. The negative IRR further reinforces this conclusion, indicating that the project fails to generate a positive return relative to its cost of capital. This divergence between positive operating sufficiency and negative investment returns illustrates a classic tension in capital-intensive ventures: daily operations may be sustainable, but long-term capital recovery is not achieved [26].

The coexistence of strong OSSR and weak NPV/IRR highlights the limitation of relying on a single indicator in financial appraisal. As Brealey, Myers, and Allen emphasize, comprehensive evaluation requires integrating both profitability and value-creation measures [24]. For higher education enterprises, this distinction is especially relevant: while self-sufficiency ensures continuity of teaching and research activities, investment appraisal criteria determine whether such initiatives can expand or replicate without external support [25].

From an economic standpoint, these findings provide justification for considering subsidies or concessional financing. Musgrave's framework on public finance argues that when projects generate external benefits but cannot meet private investment criteria, government support is warranted to sustain socially desirable activities [8]. In this case, the laboratory's ability to fund its operations internally shows efficiency, but the inability to recover capital through market revenues alone signals the need for blended financing models.

Taken together, Table 6 shows that the laboratory is best interpreted as a financially constrained but operationally sustainable hybrid enterprise. Its OSSR trajectory reflects the strength of its internal operations, while its negative NPV and IRR point to structural barriers in achieving full capital recovery. This dual outcome underscores why hybrid models are needed: to balance accounting-based investment criteria with the broader economic and social returns that the laboratory produces.

Table 7: Sensitivity Analysis of Investment Indicators Under Alternative Scenarios

Scenario	Key Assumption	NPV	IRR (%)	Remarks
Base Case	Revenue growth = 5% annually; OPEX as projected; discount rate = 12%	–180.5	–1.22	Not financially viable; OSSR >1 but negative capital returns.
Optimistic Revenue	Revenue growth = 7% annually	450.2	4.85	Becomes viable; higher throughput offsets cost base.
Pessimistic Revenue	Revenue growth = 3% annually	–900.7	–5.13	Severe shortfall; project not viable even with cost control.
Reduced Feed Costs	10% lower feed prices	220.4	3.15	Improved viability; feed efficiency is critical to margins.
Increased Feed Costs	10% higher feed prices	–750.9	–4.46	Feed volatility strongly undermines viability.
Lower Discount Rate	Discount rate = 10%	−185.27	–1.22	Loss reduced but still unviable; concessional financing alone is not enough.
Higher Discount Rate	Discount rate = 14%	−216.25	–1.22	More negative NPV; higher cost of capital further depresses returns.

Legend: NPV- Net Present Value expressed in thousand US$ (US$=PHP57.66).

Table 7 presents the results of sensitivity analysis on Net Present Value (NPV) and Internal Rate of Return (IRR) under alternative scenarios. The base case, which assumes annual revenue growth of 5 percent, yields an NPV of –US$180.5 thousand and an IRR of –1.22 percent, confirming the lack of financial viability under standard assumptions. This aligns with the earlier investment appraisal results, where operational sufficiency did not translate into capital recovery.

Under the optimistic revenue scenario, with 7 percent growth, NPV improves dramatically to US$450.2 thousand, and IRR rises to 4.85 percent. Although still below the 12 percent discount rate, these figures suggest that accelerated throughput could make the laboratory financially viable. Conversely, a pessimistic scenario of only 3 percent revenue growth results in severe deficits (NPV –US$900.7 thousand, IRR –5.13 percent), highlighting the project's vulnerability to weak market performance. This confirms the observation of Brealey, Myers, and Allen that investment outcomes in agribusiness enterprises are highly elastic to revenue assumptions, given their narrow margins [24].

Feed costs emerge as another critical driver. A 10 percent reduction in feed prices improves viability substantially (NPV US$220.4 thousand, IRR 3.15 percent), while a 10 percent increase pushes NPV to –US$750.9 thousand and IRR to –4.46 percent. This aligns with international evidence that input price volatility is the dominant risk factor in livestock-based agribusiness [27]. For the laboratory, this suggests that efficiency in feed use and procurement strategies would be central to financial resilience.

Discount rates also influence the results. At a lower discount rate of 10 percent, the project's NPV improves to –US$185.3 thousand, indicating that concessional financing reduces—but does not eliminate—the investment loss. Since the IRR remains at –1.22 percent, the project continues to fall short of break-even even under more favorable borrowing conditions. When the discount rate increases to 14 percent, the NPV further declines to –US$216.3 thousand, demonstrating that higher capital costs exacerbate already marginal cash flows. These results highlight the project's sensitivity to financing conditions and underscore that access to concessional credit alone is insufficient; improvements in revenue generation and cost efficiency are more decisive in moving the project toward financial viability. This demonstrates the sensitivity of the project to financing conditions and reinforces the role of concessional credit in supporting hybrid educational enterprises [28].

From an accounting perspective, these results illustrate the risk-adjusted nature of investment appraisal, where small shifts in assumptions can transform the viability outlook. From an economic perspective, they justify public or institutional support to mitigate risks associated with volatile markets and capital costs. As Trigeorgis notes, real options reasoning suggests that flexibility in scaling, input management, or financing terms can significantly improve outcomes for capital-intensive projects [29]. For the academic–agribusiness laboratory, sensitivity analysis underscores the importance of strategic interventions—such as feed cost management, revenue diversification, or concessional financing—to secure sustainability despite structural constraints.

4.3. Economic appraisal

While financial appraisal focuses on the laboratory's ability to recover costs and generate returns under accounting standards, economic appraisal extends the analysis to consider broader welfare and societal impacts. This section evaluates the economic net benefits of the proposed academic–agribusiness laboratory, accounting for consumer surplus, import substitution, training spillovers, and other externalities that are not captured in financial indicators. By framing the laboratory as both a market actor and a provider of public goods, the economic appraisal highlights its contributions to efficiency, equity, and resilience in local food systems. In doing so, it situates the laboratory within the wider policy discourse on hybrid enterprises that balance financial sustainability with social and developmental objectives [7] [8] [11].

Table 8 presents the projected economic benefits of the proposed academic–agribusiness laboratory from 2025 to 2035. The largest contributions come from the local ripple effects of indirect and induced spending, which grow from US$25.3 thousand in 2025 to US$57.6 thousand by 2035. These reflect the multiplier effect of laboratory operations on nearby markets and suppliers, consistent with regional development studies showing that agri-food enterprises create strong backward and forward linkages in local economies [30]. Alongside this, the training and extension value associated with student practicums contributes significantly, rising from US$20.0 thousand in 2025 to over 30.0 in 2035. Together, these two components account for more than 60 percent of the total estimated economic benefits, underscoring the dual role of the laboratory as both a market actor and a capacity-building institution.

Table 8: Estimated Economic Benefit

Benefit Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1. Total Revenue	126.6	137.2	148.8	161.5	175.2	190.2	206.5	224.3	243.8	264.9	288
2. Import-substitution welfare	5.1	5.5	6.1	6.6	7.3	7.9	8.7	9.5	10.4	11.4	12.4
3. Training & Extension Value	20	20.84	21.72	22.63	23.58	24.57	25.6	26.67	27.79	28.96	30.18
4. Energy Offset (Biogas)	4.23	4.58	4.97	5.39	5.85	6.36	6.9	7.5	8.15	8.86	9.64
5. Fertilizer Credit (Compost)	1.53	1.65	1.79	1.94	2.1	2.27	2.45	2.66	2.89	3.14	3.41
6. Consumer Surplus	0.38	0.41	0.45	0.48	0.53	0.57	0.62	0.67	0.73	0.79	0.86
7. Local Ripple Effect (Multiplier)	25.32	27.44	29.76	32.3	35.05	38.04	41.3	44.86	48.75	52.98	57.6
8. Research & Innovation Spillover	3	3.3	3.6	3.9	4.3	4.7	5.2	5.7	6.3	6.9	7.6

9. Institutional Accreditation Benefit	1.5	1.6	1.7	1.9	2	2.2	2.4	2.6	2.8	3.1	3.3
10. Avoided SUC Procurement Cost	2.5	2.7	2.9	3.1	3.4	3.7	4	4.3	4.7	5.1	5.5
11. Food Safety / Traceability Benefit	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.5	2.8	3
12. Nutrition / Protein Access Benefit	2	2.2	2.4	2.6	2.9	3.2	3.5	3.9	4.3	4.7	5.1
Total Economic Benefit	193.36	208.72	225.59	243.94	263.91	285.61	309.27	334.96	363.11	393.63	426.59

Note: Amounts are expressed in Thousand US Dollar (US$=PHP57.66).

Beyond direct revenues from processed pork products, the academic laboratory generates a spectrum of economic benefits that reflect its multidimensional role in the local agrifood system. As shown in Table 8, several complementary benefit streams—ranging from welfare gains to environmental offsets—collectively expand the facility's economic footprint and demonstrate value that conventional financial analysis cannot capture.

Import-substitution welfare effects, which rise from US$5.1 thousand in 2025 to US$12.4 thousand in 2035, indicate the growing contribution of local production to stabilizing pork supply and reducing exposure to volatile import prices. This aligns with literature emphasizing the importance of local value chains in enhancing market resilience and reducing dependency on external suppliers [31]. Similarly, the increasing value of biogas energy recovery—expanding from US$4.2 thousand to US$9.6 thousand—illustrates the laboratory's capacity to convert waste into renewable energy, reinforcing circular economy strategies in livestock systems, an approach widely advocated in sustainable agriculture research [31].

Fertilizer credits derived from composted manure provide additional recurring savings by substituting synthetic fertilizers, while consumer surplus gains—although modest in absolute terms—expand consistently over time. These indicate improved household access to competitively priced animal protein products, especially in peri-urban municipalities where market concentration can limit competition.

The expanded benefit categories further highlight contributions that earlier frameworks often overlook. The valuation of training and extension services demonstrates how the laboratory supports human capital formation—an area Samuelson and Musgrave identify as a core public good whose social returns often exceed private gains [7] [8]. Research and innovation spill-overs, accreditation-related value, and avoided SUC procurement costs strengthen this argument by showing that the laboratory not only supports learning but also reduces administrative burdens, facilitates program compliance, and enhances the institution's overall performance. Food safety and traceability benefits—reflected in reduced contamination risks—also represent meaningful welfare gains, particularly in local contexts where informal markets dominate meat distribution.

Combined, these diverse benefit streams raise total economic benefits from US$131.7 thousand in 2025 to more than US$300.5 thousand by 2035. This upward trend indicates that the laboratory's economic value grows not only because of operational expansion but also due to the compounding effects of knowledge dissemination, environmental stewardship, and community-level market improvements. Boardman et al. argue that properly conducted economic appraisals must account for such externalities to accurately estimate the true social value of public-sector projects [32]. The laboratory fits this profile: its contributions extend well beyond financial returns, reinforcing its role as a hybrid institution that integrates education, production, and community benefit.

In essence, the composition and trajectory of these benefits show that the laboratory delivers tangible and intangible returns that justify continued investment even when financial indicators alone may appear weak. These economic gains provide the rationale for government support, SUC subsidies, and partnerships with local industries. The next analytic step involves assessing whether these benefits exceed total economic costs (Table 9), thereby determining the net value added by the academic laboratory to the wider local economy.

Table 9: Estimated Economic Cost

Economic Cost \ Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Resource Operating Cost (explicit OPEX)	299.3	116.9	122.3	128.3	133.8	139.7	145.8	152.2	159.0	168.6	177.3	185.8
Capital Expenditure (economic outlay)	-	27.7	-	-	-	-	-	76.2	38.1	0.0	33.4	-
Carbon externality (energy + manure)	-	6.1	6.6	7.2	7.8	8.5	9.2	10.0	10.8	11.8	12.8	13.9
Water use & effluent externality	-	3.7	4.0	4.3	4.7	5.1	5.5	6.0	6.5	7.1	7.7	8.3
Faculty supervision—opportunity cost	-	4.0	4.2	4.3	4.5	4.7	4.9	5.1	5.3	5.6	5.8	6.0
Total Economic Cost	299.3	158.9	137.6	144.6	151.3	158.4	165.9	250.0	220.2	193.5	237.4	214.6

Note: Amounts are expressed in Thousand US Dollar (US$=PHP57.66).

Table 9 presents the projected economic costs from 2024 to 2035. Resource operating costs remain the dominant component, starting at US$116.9 thousand in 2025 and rising steadily to US$185.8 thousand by 2035. This reflects the recurring expenditures needed to sustain operations, with feed, energy, and labor as the primary cost drivers. Operating costs are not only the largest share of economic costs but also the most predictable, providing a stable baseline against which other cost components are assessed.

Capital expenditures represent the second major category, with an initial outlay of US$299.3 thousand in 2024 and another round of investment in 2031 (US$76.2 thousand). Smaller injections occur in 2032 and 2034, amounting to US$38.1 thousand and US$33.4 thousand, respectively. These intermittent but substantial outlays reflect the capital-intensive nature of livestock and meat-processing enterprises, where facility upgrades and equipment replacements are periodically required. As recent studies in agribusiness finance emphasize, such lump-sum investments significantly shape long-term viability, especially in hybrid organizations with constrained revenue streams [33].

In addition to direct expenditures, the table includes several categories of externalities and implicit costs. Carbon externalities—arising from manure management and energy use—grow from US$6.1 thousand in 2025 to nearly US$13.9 thousand by 2035, reflecting the rising environmental footprint of scaled operations. Water use and effluent disposal add another layer of external costs, reaching US$8.3 thousand by 2035. These components underscore the importance of integrating environmental costs into economic evaluations, aligning with current frameworks for sustainable agriculture that emphasize "true cost accounting" [34].

Faculty supervision is included as an opportunity cost, representing the value of academic staff time diverted from teaching and research to support laboratory operations. This cost rises modestly over the projection period, from US$4.0 thousand in 2025 to US$6.0 thousand in 2035. While not a cash expense, it reflects the trade-offs faced by higher education institutions when integrating commercial functions with academic mandates. Recent work in higher education economics highlights these implicit costs as central to understanding the real resource allocation of university-based enterprises [35].

Total economic costs, combining all explicit, external, and implicit categories, decline after the initial capital year (US$299.3 thousand in 2024) but remain substantial across the period, ranging between US$137.6 thousand and US$250.0 thousand. The inclusion of environmental and opportunity costs ensures that the estimate captures not only financial outflows but also broader social costs of operation. This provides the foundation for computing the Economic Net Benefit (ENB), which compares the benefits outlined in Table 8 with the costs presented here to determine the overall contribution of the laboratory to social welfare.

While the analysis of economic costs highlights the financial, environmental, and opportunity costs associated with the laboratory, these figures alone do not capture its overall contribution. To fully assess viability, it is necessary to weigh these costs against the wide range of benefits identified earlier, including revenues, training outputs, consumer welfare, and environmental offsets. The comparison of these benefits and costs provides the basis for estimating the Economic Net Benefit (ENB), which reflects the laboratory's net impact on social welfare. The following section presents these results and interprets their implications for economic viability and policy relevance.

Table 10 presents the evolution of the academic–agribusiness laboratory's Economic Net Benefit (ENB) from 2024 to 2035, revealing a trajectory characteristic of hybrid educational–productive enterprises. As expected, the laboratory incurs a substantial economic loss in 2024 (–US$299.3 thousand), driven by the initial capital outlay required to rehabilitate facilities, expand livestock structures, and integrate processing and waste-to-energy components. From 2025 onward, however, the laboratory begins to generate positive and increasing economic value, with ENB rising from US$34.46 thousand in 2025 to US$212 thousand by 2035.

Table 10: Estimated Economic Net Benefit

Year	Economic Benefit	Economic Cost	Economic Net Benefit
2024	–	299.3	–299.3
2025	193.36	158.9	34.46
2026	208.72	137.6	71.12
2027	225.59	144.6	80.99
2028	243.94	151.3	92.64
2029	263.91	158.4	105.51
2030	285.61	165.9	119.71
2031	309.27	250	59.27
2032	334.96	220.2	114.76
2033	363.11	193.5	169.61
2034	393.63	237.4	156.23
2035	426.59	214.6	212

Economic Appraisal Indicator	Estimate	Remarks
Net Present Value	270.77	Economic costs exceed benefits in present-value terms.
Internal Rate of Return	25.7%	Economic returns are substantially above the discount rate.
Benefit Cost Ratio	1.20	Benefits outweigh economic costs (BCR > 1).

Note: Economic Cost, Economic Benefit, Economic Net Benefit, and NPV expressed in Thousand US Dollar (US$=PHP57.66).

This upward pattern reflects the laboratory's ability to accumulate non-market and intermediate economic benefits that are not visible in financial accounting systems. These include training and practicum values, import-substitution welfare, consumer surplus, biogas energy recovery, fertilizer credits, and local multiplier effects—all of which grow as throughput expands and operational efficiency improves. Unlike private revenue streams, these benefits compound over time through knowledge spill-overs, environmental savings, and community linkages—characteristics commonly documented in the economics of public education and agricultural research institutions [34].

The ENB profile also illustrates a structural feature of academic laboratories operating in agrifood systems: they often require front-loaded investments, but their long-term value is realized through continuous educational output, skill development, and local economic stimulation. This aligns with literature showing that training farms, food hubs, and research facilities produce substantial social returns to investment, even when short-term financial metrics appear unfavorable [36]. Similarly, impact assessments of agricultural innovation platforms indicate that community-level spill-overs—particularly those linked to market access, knowledge dissemination, and environmental improvements—grow steadily once operational capacity stabilizes [37].

A temporary reduction in ENB appears in 2031 due to additional capital expenditures; however, the economic gains rebound immediately in subsequent years. This sensitivity to reinvestment cycles reflects the dual mandate of the laboratory: while infrastructure upgrades momentarily elevate economic costs, they also expand the laboratory's ability to deliver instruction, research, and extension services, thereby increasing downstream economic benefits. Such reinvestment dynamics are consistent with the behavior of public knowledge institutions, where periodic capital injections are necessary to maintain relevance, safety standards, and technological capability [38].

The economic appraisal indicators reinforce the long-term value of the project. A positive NPV (US$270.77 thousand) and high IRR (25.7%) demonstrate that, when evaluated through a social welfare lens, the project yields a return well above the discount rate. The Benefit–Cost Ratio of 1.20 further indicates that each dollar of economic cost generates US$1.20 in benefit. These findings contrast sharply with the financial analysis, which showed limited commercial viability. This divergence highlights a key principle in welfare economics: when institutions produce public goods—such as training, food safety externalities, environmental co-benefits, and local economic multipliers—financial profitability alone cannot serve as the determinant of value [7]. Public funding is justified precisely because these benefits are non-excludable and underprovided by markets, a concept emphasized in classical and contemporary public economics [8][34].

The results in Table 10 demonstrate that the academic–agribusiness laboratory is not financially self-sustaining, but it is economically viable and socially valuable. The project delivers growing economic net benefits after the initial investment phase, validating its role as a hybrid institution capable of advancing instruction, applied research, extension, and community development. These findings justify continued support from the university and government stakeholders, and they provide the empirical foundation for the Academic–Agribusiness Laboratory Leverage Conversion Model presented in the next section.

Table 11: Robustness Check on Economic Viability Under Varying Shadow Price Assumptions

Scenario	Assumption on Shadow Prices (Training & Environmental Benefits)	Economic NPV	Economic IRR	BCR	Remarks
Baseline valuation	As in the main analysis (current shadow prices)	270.77	25.7	1.2	Economically attractive; benefits clearly exceed costs.
Low shadow prices	50% lower than baseline (≈10% reduction in total benefits)	110.31	17.9	1.08	Still economically viable; benefits only modestly above costs
High shadow prices	50% higher than baseline (≈10% increase in total benefits)	431.23	32.9	1.32	Very strong economic case; high returns to public support

The sensitivity analysis in Table 11 illustrates how changes in the valuation of non-market benefits affect the overall economic attractiveness of the academic–agribusiness laboratory. Using the baseline shadow prices, the facility records an economic NPV of US$270.77 thousand, an IRR of 25.7%, and a BCR of 1.20, indicating that the project produces net social gains even after accounting for all economic costs. This aligns with the principle that economic evaluations must capture both market and non-market benefits when assessing development-oriented institutions [32].

When shadow prices for training and environmental benefits are reduced by 50 percent, the economic NPV decreases to US$110.31 thousand, and the BCR falls slightly to 1.08. Despite this downward adjustment, benefits continue to exceed costs. This outcome reflects the nature of educational and research-oriented laboratories, where even conservative valuation still captures the substantial human-capital gains and community spill-overs generated by academic facilities [7]. The persistence of positive returns under this scenario suggests that the project's viability does not rely on optimistic assumptions.

Under the high valuation scenario—where shadow prices are increased by 50 percent—the economic NPV rises to US$431.23 thousand, and the IRR reaches 32.9%. Such results demonstrate that as society assigns greater value to skills development and environmental services, the economic case for public investment strengthens considerably. This is consistent with the argument that agribusiness-linked laboratories contribute meaningfully to regional development through innovation, training, and value-added activities [11].

The overall pattern across scenarios reveals a resilient economic case for the laboratory. Regardless of whether benefits are valued conservatively or generously, the project continues to produce net positive economic contributions. This robustness is characteristic of hybrid institutions whose impacts extend beyond direct cash flows, particularly when environmental and knowledge-related benefits are involved [34]. It also reinforces the rationale for government support, since public institutions often produce goods that markets undervalue or fail to supply at socially optimal levels [8].

The sensitivity analysis confirms that the project's economic viability is stable under a wide range of valuation assumptions. Even with substantial reductions in benefit values, the net benefits remain positive. Such robustness strengthens the justification for implementing the academic–agribusiness laboratory model and highlights its capacity to generate long-term socio-economic gains for the region.

4.4. Model integration: academic–agribusiness laboratory leverage conversion

The contrasting outcomes of financial and economic appraisal highlight the need for an integrated framework to understand the dual role of the academic–agribusiness laboratory. On one hand, financial indicators reveal challenges in achieving cost recovery and capital sustainability; on the other, economic measures demonstrate substantial welfare gains, knowledge spillovers, and environmental benefits. This tension is characteristic of hybrid enterprises, which operate at the intersection of market and mission. The Academic–Agribusiness Laboratory Leverage Conversion Model is introduced here as a conceptual tool to reconcile these perspectives, showing how accounting-based metrics and economics-based valuations can be combined to guide decision-making, justify targeted subsidies, and strengthen the laboratory's position as both a revenue-generating unit and a provider of public goods.

A closer look at the appraisal results reveals the roots of this divergence. Financial analysis paints a conservative picture because it is bounded by internal revenues and costs. High upfront capital expenditures, volatility in feed and energy inputs, and limited scale constrain profitability, resulting in negative NPV and IRR under base-case assumptions. In contrast, the economic appraisal incorporates wider benefits such as consumer surplus, training outputs, and environmental offsets, producing positive ENB and benefit–cost ratios. This shows that the same project can appear "unviable" under strict accounting rules but "highly beneficial" when evaluated through a social welfare lens.

This paradox is well documented in the literature on hybrid enterprises. Hybrids are organizations that combine social and commercial logics, often creating tensions between the pursuit of revenue and the delivery of public value. The academic–agribusiness laboratory fits this category precisely: it must cover operational costs and ensure efficiency, but it also serves as a training ground for students, a source of extension services, and a contributor to environmental management. Like social enterprises or cooperatives, it cannot be understood solely through the lens of financial return on investment, nor can it rely exclusively on economic justification without accountability to resource efficiency.

Universities occupy a particularly important place within this hybrid landscape. Unlike private agribusinesses, academic laboratories are mandated to generate knowledge and build human capital. These are classic public goods—non-excludable and non-rival in nature—that are systematically undervalued by markets. At the same time, universities face pressure to demonstrate cost discipline and reduce dependence on subsidies. The proposed model responds to this institutional reality by providing a structured way for universities to justify support based on demonstrated public value, while simultaneously embedding financial discipline in their operations.

Neither financial appraisal nor economic appraisal alone can provide sufficient guidance. Financial appraisal ensures efficiency but tends to understate contributions that fall outside revenue accounts. Economic appraisal demonstrates welfare gains but does not inform day-to-day cash management. The gap between these two perspectives creates uncertainty for decision-makers: should projects that lose money financially but deliver significant external benefits be sustained, and if so, under what conditions. An integrated model is therefore essential to reconcile these perspectives and provide rules for support, scaling, and accountability.

The framework in Figure 1 demonstrates how accounting, economics, and governance perspectives can be aligned through a structured mechanism of conversion. By explicitly linking market context to financial and economic scorecards, and by defining levers to bridge any gaps, the model provides a practical tool for balancing financial discipline with public value creation. This integration ensures that academic laboratories can operate sustainably while justifying public and institutional support through measurable social benefits.

The Academic–Agribusiness Laboratory Leverage Conversion Model addresses the gap between financial and economic perspectives by combining three interdependent pillars: accounting discipline, economics and public value, and governance legitimacy. Together, these pillars provide the foundation for a conversion mechanism that translates market opportunities into dual scorecards. The financial scorecard tracks revenues, margins, and cash flow, while the economic scorecard captures training outputs, welfare contributions, and environmental externalities. When financial returns fall short but economic returns are strong, conversion levers such as targeted subsidies, concessional financing, or partnerships are activated to ensure sustainability. In this way, the model operationalizes the balance between private viability and public value.

The three pillars can be briefly described as follows. Accounting discipline ensures financial control through cash-flow analysis, OSSR, NPV, IRR, and liquidity monitoring [4] [24]. Economics and public value capture external benefits such as training outputs, consumer surplus, and environmental offsets that extend beyond standard accounting measures [32] [34]. Governance and legitimacy strengthen transparency and accountability by linking funding support to both financial prudence and demonstrated public value [6] [13]. Together, these pillars establish a dual scorecard that reflects both private viability and public impact, allowing decision-makers to evaluate the laboratory's performance through a hybrid lens.

The model also describes how market opportunities are translated into financial and economic outcomes, and how gaps between the two are bridged. Market projections are first converted into financial indicators, with demand–supply estimates determining market share, revenues, and margins, which then inform NPV and IRR calculations. At the same time, the same activities are translated into economic outcomes, where training benefits, consumer welfare, and environmental gains are aggregated into ENB and economic BCR. When these two pathways diverge, conversion levers are used to ensure alignment. These include:

- targeted subsidies for training or other public-good outputs,
- concessional financing to reduce effective discount rates,
- partnerships with MSMEs or cooperatives to share costs,
- environmental credits such as those generated by biogas or waste valorization, and phased investments that respond to favorable market signals

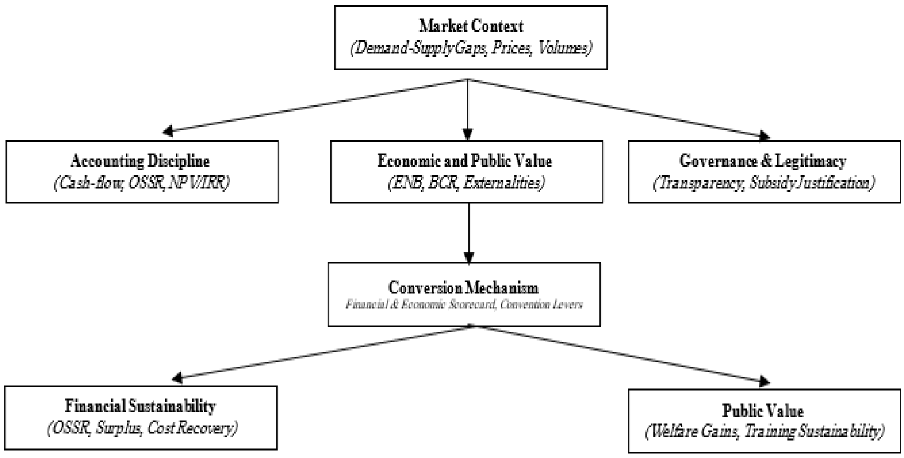

Fig. 1: Academic-Agribusiness Laboratory Leverage Conversion Model.

To avoid arbitrary or excessive reliance on subsidies, the model sets out auditable decision rules. Laboratories are expected to continue operating and improving without intervention when OSSR remains at or above 1.20 for at least three consecutive years, and unit margins are stable. They qualify for targeted support only when financial indicators such as NPV are negative but economic indicators such as BCR remain strongly positive, ensuring that subsidies are tied to demonstrated public value. Expansion is scaled cautiously when sensitivity analysis shows high dependence on a few risk variables, with capital expenditures staged as "real options" rather than irreversible commitments. These rules balance efficiency with fairness, ensuring that support flows only when justified by measurable outcomes.

The model also outlines a phased roadmap toward sustainability. The sequence begins with stabilizing operations through better procurement and yield management. Once operations are steady, efficiency systems and integrated reporting of dual scorecards are introduced. Blended finance is then accessed under concessional terms that are explicitly aligned with ENB results. Partnerships with local processors and retailers follow, enabling economies of scale and cost-sharing. Finally, capital expansion is staged in phases triggered by specific demand and cost thresholds, allowing flexibility in responding to market uncertainty.

To remain adaptive, the model requires regular monitoring of paired key performance indicators. Financial KPIs include OSSR, operating margins, the cash conversion cycle, and traditional NPV/IRR. Economic KPIs measure trainee-hours, consumer surplus, local multiplier effects, carbon offsets, and water-use intensity. Linking these two sets of metrics through regular reviews with university and policy stakeholders ensures that funding is conditional on both financial prudence and public-value creation. This strengthens credibility and long-term legitimacy [34] [36] [38].

By combining accounting discipline with economic valuation and embedding decision rules for subsidy and finance, the model provides both a practical and a theoretical framework. It shows how academic laboratories can remain operationally accountable while maximizing public value, bridging the gap between private returns and social benefits. The relevance of such a model extends beyond academic theory.

Strengthening the conversion model requires embedding managerial and technical levers that evolve to influence both financial and economic outcomes. In the early stages, stabilizing operations should prioritize procurement discipline, feed efficiency, and the use of basic digital tools for monitoring costs and inventories. Empirical studies show that digital innovations such as IoT sensors and precision farming applications significantly improve efficiency, reduce losses, and enhance resilience in agricultural systems (Finger et al.) [44]; Plakantara et al. [45]. As operations expand, process optimization and waste minimization through lean scheduling, cold-chain logistics, and integrated supply-chain platforms become critical. Research demonstrates that digital platforms and blockchain-enabled systems can enhance transparency, reduce spoilage, and add social value in short food supply chains (Masi et al.) [46].

Parallel to these operational measures, the laboratory's role as a training hub should be leveraged by embedding extension and student practicum systems into operations, since human capital formation amplifies both private efficiency and public value. Digital extension services and participatory learning models have been found to accelerate technology adoption and strengthen agrifood value chains, particularly in developing contexts (Masi et al.) [46]. During the scaling phase, blended and concessional finance mechanisms can be introduced to bridge gaps between financial shortfalls and demonstrated public value. Evidence indicates that concessional loans, blended structures, and risk-sharing arrangements are increasingly used to catalyze private investment in socially beneficial projects that are not viable on commercial terms alone (Anjanappa) [47]; Flammer [48]; EBRD [49].

Finally, capital expansion should be staged as real options, introducing advanced systems such as biogas digesters, composting units, and digital traceability solutions only when market signals justify investment. Studies confirm that digital transformation in agrifood chains not only enhances efficiency but also strengthens traceability and resilience, although adoption barriers require a phased and adaptive approach (Finger et al.) [44]. By explicitly sequencing these managerial and technical levers into the roadmap, the model demonstrates how operational choices directly shape the dual scorecard, reinforcing its credibility as both a conceptual framework and a practical guide for decision-making.

For policymakers and university administrators, it provides a transparent framework for deciding when to grant subsidies, how much support is justified, and under what performance thresholds assistance should be withdrawn. For laboratory managers, it offers operational guardrails that combine financial prudence with recognition of broader social impacts. By making these mechanisms explicit, the model strengthens both accountability and legitimacy, ensuring that academic laboratories can sustain their dual mission in a resource-constrained environment.

5. Conclusion

This study assessed the potential of an academic livestock laboratory to evolve into an academic–agribusiness enterprise by examining its market environment, financial performance, and economic contributions. Market analysis revealed robust and sustained demand for processed pork products across Lipa City, Batangas City, Taysan, and Lobo. Household consumption patterns and retailer stocking behaviors showed persistent supply gaps, indicating that local markets can readily absorb the laboratory's output. The product lines—Filipino-style sausage, sweet cured pork, cured pork, and sweet pork stew—align well with consumer preferences, demonstrating that market demand provides a strong platform for laboratory expansion rather than a constraint.

Financial appraisal, however, showed that despite the laboratory's ability to generate stable revenues, full cost recovery remains difficult under conventional accounting indicators. The project registers a negative financial NPV, low IRR, and an OSSR that improves over time but remains insufficient to repay capital costs without external support. These outcomes reflect the inherent nature of academic laboratories: they are structurally cost-intensive due to training-oriented workflows, high supervision demands, and the need to prioritize instructional and research quality over profit maximization. As such, financial self-sufficiency is hard to attain without subsidies, grants, or blended financing mechanisms.

Economic evaluation produced a more favorable picture. When non-market benefits and externalities were considered—such as training and human-capital formation, extension services, local multiplier effects, welfare gains from import substitution, biogas energy offsets, fertilizer credits, and consumer surplus—the project generated positive net benefits beginning in 2026. The resulting ENPV, BCR greater than one, and high EIRR demonstrate that the laboratory's overall contribution to society outweighs its economic costs. These findings show that the laboratory's real value extends beyond profitability, rooted instead in its roles in skills development, environmental sustainability, and strengthening local agricultural systems.

To reconcile the contrast between financial and economic outcomes, the study advances the Academic–Agribusiness Laboratory Leverage Conversion Model, which frames state university laboratories as hybrid institutions. The model explains how the laboratory's financial constraints stem from its academic mandate, while its economic value is amplified through market demand, circular-resource use, and community spill-overs. It also elucidates how subsidies and institutional support operate as leverage mechanisms—reducing financial pressure while enabling the laboratory to continue delivering educational, research, and extension services.

This study demonstrates that academic laboratories need not be fully commercialized to be worthwhile. Their sustainability lies in functioning as development-oriented hybrid enterprises. Even without achieving financial sufficiency, they generate substantial economic value that merits continued public investment. Strengthened policy support, targeted subsidies, and strategic agribusiness integration are therefore essential to ensure that SUC-based laboratories serve as catalysts of regional development rather than cost centers struggling to survive.

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AI-assisted tools (ChatGPT, OpenAI) were used to refine language and improve readability; all analysis and interpretations are the author's own.

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