# A STUDY TO DEVELOP A MODEL FOR FINANCIAL FEASIBILITY AND VALUATION OF A FIRM AND ITS INTELLECTUAL PROPERTY: A CASE OF INNOVATION-DRIVEN ENTERPRISE (IDE) OF AGRICULTURAL INDUSTRY IN THAILAND.

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**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF MANAGEMENT**
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This thesis, titled *"A Study to Develop a Model for Financial Feasibility and Valuation of a Firm and Its Intellectual Property: A Case of Innovation-Driven Enterprise (IDE) of Agricultural Industry in Thailand,"* marks an important milestone in my academic journey. It would not have been possible without the invaluable guidance, support, and encouragement of many individuals, to whom I am deeply indebted.

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## ABSTRACT

This study develops a valuation model for Intellectual Property (IP) and business valuation tailored to Innovation-Driven Enterprises (IDE) within Thailand's agricultural sector. Utilizing action research through a single-case study, the research aligns with Susman and Evered's five-step methodology (1978) and valuation criteria from Lagrost et al. (2010), adapted specifically to Thai agribusiness.

Participants comprised executives, finance and accounting specialists, and investors from Thai agricultural biotechnology IDEs. Four valuation approaches were assessed: Cost, Market, Income, and Option Pricing. The Cost Approach yielded the lowest IP values but provided valuable non-financial insights. The Market Approach was effective for early-stage ventures, while the Income Approach, contingent on detailed validation of variables, suited mature enterprises. The Option Pricing Approach offered the highest valuations but faced challenges in risk assessment, restricting its suitability to niche industries such as pharmaceuticals.

For business valuation, the study recommended the Market Approach initially, shifting to the Income Approach upon reaching stable growth. The resulting model strengthens IDEs' negotiations with venture capital investors, enhancing their potential for successful expansion.

KEYWORDS: Innovation Driven Enterprise (IDE)/ Intellectual Property (IP)/ Intellectual Property Valution/ Firm Valuation/ Valuation

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# CHAPTER 1
# INTRODUCTION

## 1.1 Research Background

The development of Small and Medium-sized Enterprises (SMEs) and Thailand's agricultural sector currently emphasizes innovation-driven strategies to enhance efficiency and competitiveness. Recognizing innovation as a critical strategic tool, the Thai government has integrated it into national development objectives (Royal Thai Government, 2024). Consequently, Innovation-Driven Enterprises (IDEs) have emerged as essential agents for transforming the agricultural sector, modernizing practices, and boosting the capacity of small enterprises within Thailand.

IDEs significantly accelerate economic growth by creating added value through innovation rather than relying on conventional cost-reduction approaches (Furman et al., 2002; Tan & Phang, 2005; Alston & Pardey, 2021). However, most IDEs are small enterprises or startups (Shefer & Frenkel, 2005), frequently encountering substantial barriers when expanding from niche markets to broader markets—a challenge famously described as crossing the "Chasm" (Moore & McKenna, 1999). Furthermore, the disparity in knowledge levels between IDE entrepreneurs and venture capitalists (VCs) often hampers successful investment outcomes (World Intellectual Property Organization, 2020).

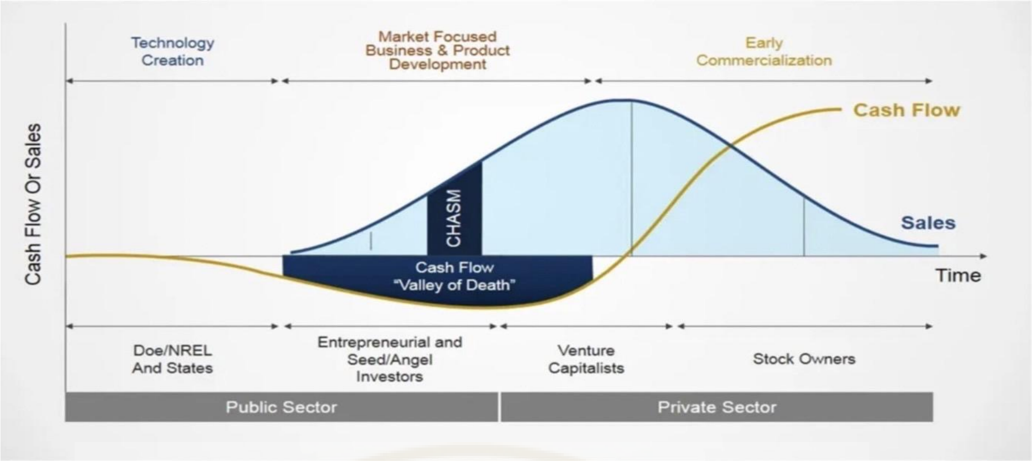


**Figure 1:** "Chasm" or Valley of Death in Innovation Development and Commercialization

Source: Moore & McKenna (1999). Crossing the chasm.

These issues provided the foundation for this thesis, which primarily aims to develop a valuation model assessing the financial feasibility and value of organizations and their intellectual property (IP). The resulting prototype model from this research is intended to generate outcomes and impacts by enabling early-stage IDEs in Thailand's agricultural industry to overcome the Chasm through fundraising from Corporate Venture Capital (CVC). Additionally, this model seeks to equip IDEs with the necessary knowledge and tools for effective valuation, enhancing negotiation capabilities with CVCs and increasing the likelihood of securing mutually beneficial deals.

This research adopts an Action Research framework (Jean & Jack, 2002; Somekh, 2005; Hammersley, 2004), receiving considerable support and collaboration from Morena Solutions Co., Ltd., a leading Thai agribusiness IDE. The company's management contributed significantly by providing practical business cases for developing and testing the feasibility and valuation model for organizational and IP valuation, thereby serving as a pilot example for broader application within the sector.

## 1.2 Research Objective

To investigate economic valuation methods applicable to both the business and intellectual property (IP) within Thailand's agribusiness sector, using Morina Solutions Co., Ltd. as a case study. The research explores four primary valuation approaches:

1.2.1 Cost Approach: Valuation based on incurred costs.

1.2.2 Market Approach: Valuation based on prevailing market prices.

1.2.3 Income Approach: Valuation derived from income generation capabilities.

1.2.4 Option Pricing Approach: Valuation determined through option contract pricing methodologies.

This research emphasizes identifying economically feasible valuation methods specifically tailored for enterprises and IP assets within Thailand's agricultural industry. Given the absence of prior empirical studies on this topic in Thailand, the findings aim to contribute academically and practically by enhancing knowledge transfer and investment opportunities. The research provides valuable insights into organizational valuation across diverse scenarios, generating multi-dimensional datasets of corporate value ranges. This comprehensive approach enhances strategic planning and negotiation effectiveness, facilitating informed decision-making and improving interactions with potential business investors.

## 1.3 Scope of the study

### 1.3.1 Content Scope:

This research focuses specifically on quantitative valuation methods, following Kamiyama et al. (2006), as these approaches yield results expressed in monetary economic values. The valuation methodologies employed are categorized into four distinct groups:

1.3.1.1 Cost Approach: Valuation based on incurred costs.

1.3.1.2 Market Approach: Valuation based on prevailing market prices.

1.3.1.3 Income Approach: Valuation derived from income generation capabilities.

1.3.1.4 Option Pricing Approach: Valuation determined through option contract pricing methodologies.

**1.3.2 Unit of Analysis:**

The analysis concentrates at the organizational level through a detailed case study of Morena Solutions Co., Ltd., and its stakeholders, including executives, employees, customers, and investors. Morena Solutions Co. is a biotechnology startup integrating scientific knowledge with biological applications, supported through both public and private sector investments. The company, founded by Dr. Kasidit Theeranitayatarn, a renowned innovator awarded internationally in biotechnology, aims to comprehensively develop agricultural and livestock production systems. Morena Solutions emphasizes environmentally friendly practices by employing advanced biotechnology to develop agricultural, livestock, and pet products, fostering rapid growth and stability within the market.

**1.3.3 Population and Sample Scope**

The population and sample include Morena Solutions Co., Ltd., analyzed at the organizational level, involving management teams, employees, and investors.

**1.3.4 Methodological Scope**

This research adopts an Action Research methodology, structured around the Five Phases Action Research Cycle (Susman & Evered, 1978). Primary data collection involves in-depth interviews and comprehensive analysis of financial documentation.

## 1.4 Research Contribution

1.4.1 Generation of new knowledge through a financial valuation model that assesses the monetary economic value of businesses and intellectual property, ensuring economic feasibility. This model will serve as a foundational tool supporting fundraising negotiations for innovation-driven enterprises within Thailand's agricultural sector.

1.4.2 Production of a master's thesis document fulfilling the requirements for graduation from the College of Management, Mahidol University. Additionally, the research will serve as an academically disseminated reference, suitable for publication within national or international academic platforms.

1.4.3 Transfer of innovative knowledge to entrepreneurs, enabling agricultural innovation-driven enterprises in Thailand to strategically apply this model for business planning, decision-making, presentations, and negotiations with investors, thereby enhancing their potential for securing future investments.

## 1.5 Alignment with Sustainable Development Goals (SDGs)

This research aims to develop a financial feasibility and valuation model for innovation-driven enterprises within Thailand's agricultural sector, aligning closely with several Sustainable Development Goals (SDGs) outlined by the United Nations (UN DESA, 2023). Specifically, this study supports the following SDGs:

1.5.1 Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

This involves fostering agricultural industry development by supporting entrepreneurs who utilize sustainable farming technologies that protect soil health, water resources, and overall environmental conditions. Successful scaling and widespread adoption of these innovations can indirectly enhance sustainable agricultural practices in Thailand, especially at mass production levels.

1.5.2 Goal 3: Ensure healthy lives and promote well-being for all at all ages by encouraging agricultural innovations that avoid chemical use, this research aims to enhance the health and quality of life for Thai farmers. Reducing chemical dependency minimizes health risks associated with chemical exposure, such as skin and respiratory cancers, thereby promoting broader well-being among agricultural communities.

1.5.3 Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

This goal is addressed by creating robust valuation frameworks for agricultural innovations, empowering entrepreneurs to successfully commercialize their products. Enhanced valuation tools increase the likelihood of securing necessary funding and developing effective marketing strategies, ultimately resulting in more innovations reaching market success and contributing to sustained industrial growth.

## 1.6 Definitions of Key Terms

**1.6.1 Intellectual Property (IP):** Refers to creations resulting from human ingenuity, innovation, or creativity, emphasizing intellectual outputs and expertise without limitations on the type or mode of expression. Intellectual property may manifest in tangible forms such as products or intangible forms including services, concepts, business methodologies, and industrial processes (Department of Intellectual Property, 2016).

**1.6.2 Patent:** Refers to a government-issued official document providing legal protection for inventions or product designs that meet specified legal criteria. It grants inventors or designers exclusive rights to produce, use, and commercialize the product for a defined period (Department of Intellectual Property, 2012).

**1.6.3 Petty Patent:** Refers to a government-issued official document similar to a patent but covering innovations with comparatively lower technological advancement or minor inventive steps. It typically protects practical enhancements, new methods of production, improvements in product quality, or creation of distinctly different products, such as engine mechanisms, pharmaceuticals, or improved methods for preserving agricultural products (Department of Intellectual Property, 2012).

**1.6.4 License:** Refers to an authorization granted by a technology owner allowing a licensee to use specific technology within predetermined terms and conditions. Licensing agreements may cover activities like production, sales, usage, or possession for resale, without transferring ownership rights (Technology Licensing Office, n.d.).

## 1.7 Conclusion

This research aims to study models for assessing feasibility and financial valuation of businesses and their intellectual property (IP), with a specific interest in innovation-driven enterprises (IDEs) within Thailand’s agricultural industry. The agricultural sector is crucial for Thailand's economic growth, especially through the introduction and commercialization of innovations, which consequently boost the nation’s economic value.

However, a significant portion of these innovative enterprises comprises early-stage startups, characterized by a critical need for investment to successfully navigate the 'Chasm' phase of innovation development. Currently, many IDEs struggle to secure funding from investors such as corporate venture capitalists (CVCs), primarily because they lack robust financial valuation models and feasibility assessments that are essential to facilitating successful negotiations and achieving mutually beneficial (win-win) investment agreements.

Thus, this study aims to develop and validate a financial feasibility and valuation model specifically tailored for IDEs within Thailand’s agricultural industry, using selected case studies as pilot examples. This research seeks to generate actionable knowledge that can be disseminated and applied broadly among similar enterprises. Ultimately, it is expected that the outcomes will enable Thai agricultural IDEs to improve their negotiation effectiveness with investors, significantly increasing their potential to achieve successful, mutually beneficial investment deals that foster sustained business growth.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Concepts and Theories on Intellectual Property Valuation

Lagrost et al. (2010) conducted a study on approaches to valuing intellectual property (IP), concluding that IP valuation processes can be broadly classified into two main categories: quantitative and qualitative methods (Kamiyama et al., 2006). Among these, only the quantitative methods yield measurable monetary outcomes that represent the economic value of IP. Building upon the framework proposed by Martin and Drews (2006), quantitative valuation approaches can be further divided into four methodological groups:

- **Cost Approach**, which estimates value based on the historical or replacement cost of developing the IP
- **Market Approach**, which derives value by comparing similar IP assets traded in the market
- **Income Approach**, which estimates value based on the future economic benefits the IP is expected to generate
- **Options Approach**, which applies real options theory to capture the value of managerial flexibility and strategic decision-making under uncertainty.

A structured decision-making framework is used to determine the most appropriate intellectual property (IP) valuation method for a given case. This framework involves four key steps:

**Step 1: Defining the Valuation Context** – This step involves clarifying the purpose and context of the valuation by addressing several guiding questions:

What is the objective of the IP valuation?

Which specific IP asset is being valued?

How will the valuation result be utilized?

Who will conduct the valuation?

**Step 2: Profiling the IP Asset** – At this stage, an overall assessment of the IP is conducted, taking into consideration the business characteristics, legal registration status, and prevailing economic conditions.

**Step 3: Selecting the Valuation Method** – One of the three main valuation approaches (cost, market, or income-based methods) is selected, guided by a structured decision-making matrix.

**Step 4: Executing the Valuation and Interpreting the Results** – The chosen method is applied to value the IP, followed by an analysis and discussion of the results obtained.

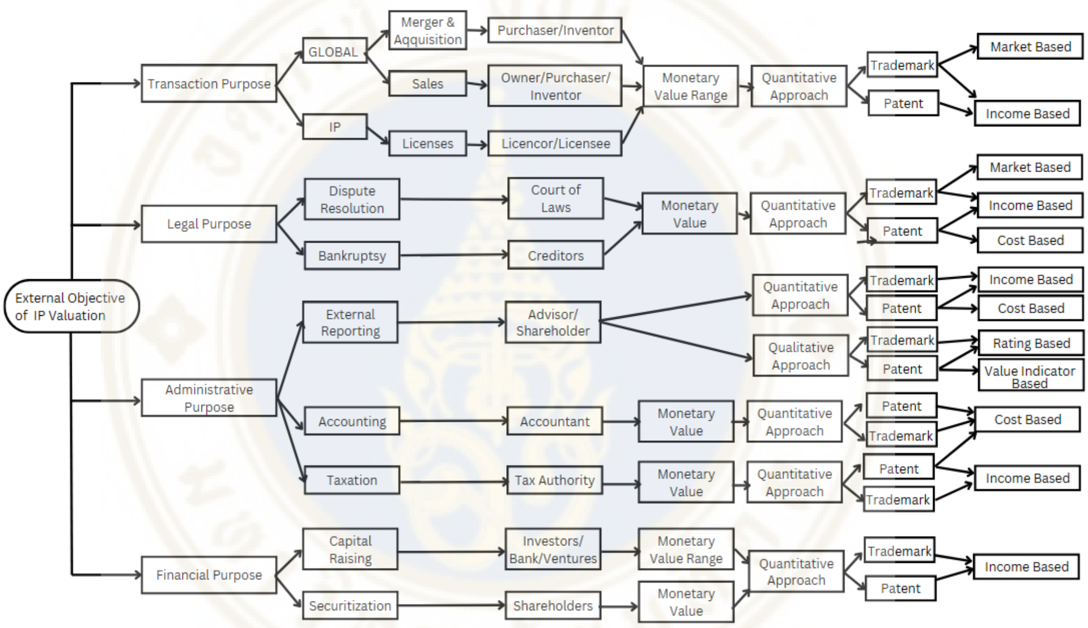


Figure 2: Decision Tree demonstrating the valuation method selection for IP valuation
Source: Lagrost, et al. (2010).

### 2.1.1 Cost-Based Valuation Approach

The cost approach to intellectual property (IP) valuation is generally divided into two main methods:

2.1.1.1 Historical Cost Method

Proposed by Parr (1998), the Historical Cost Method is a valuation technique that determines an asset's value based on the actual expenditures incurred in its creation or acquisition. This method is traditionally applied to the valuation of tangible assets such as land, buildings, and equipment.

Under this approach, the asset value is calculated using the actual financial investment (F) combined with the time cost of money (T)—which reflects the opportunity cost of capital over the investment period. The time cost is typically computed using prevailing interest rates during the period in which the expenditures were made via this equation:

$$Asset\ Value = F + T$$

Where:

**F** = historical monetary expenditure or funding invested in the development or acquisition of the asset

**T** = the opportunity cost of capital over time

Although straightforward, this method has a significant limitation: it does not establish a direct relationship between the historical costs of developing the intellectual property and its potential to generate future income. As a result, the values derived from this approach tend to be lower than those estimated using market- or income-based valuation methods.

Due to its low complexity and minimal data requirements, the Historical Cost Method is often employed as a baseline or minimum value reference against which results from other valuation methods can be compared.

2.1.1.2 Replacement Cost Method and Reproduction Cost Method

Reilly and Schweihs (Eds.) (1998) further developed cost-based valuation approaches by incorporating economic principles such as price equilibrium to establish the Replacement Cost Method. This method estimates the value of an asset based on the cost required to replace the asset with a new one that has equivalent utility and characteristics. Building on this concept, they also introduced the Reproduction Cost Method, which measures the cost of constructing a new asset that is an exact replica of the original, using the same materials, design, and specifications.

These methods build upon the Historical Cost Method by adding an additional factor—a reasonable risk premium—to account for the expected return required to compensate for bearing risk. The valuation formula is expressed as:

$$Asset\ Value = (F + T) * M$$

Where:

**F** = Actual monetary investment (Funding Invested)

**T** = Opportunity cost of capital over time (Time Cost of Money)

**M** = Expected rate of return associated with reasonable risk (Risk Premium)

Despite the added risk-adjusted factor, these methods still share a key limitation with the historical cost approach: they do not incorporate the income-generating potential of the intellectual property being valued. As a result, while they provide a more refined cost basis, they may still underestimate the economic value of IP assets when compared to income- or market-based valuation methods.

### 2.1.2 Market Approach to Valuation

The market approach estimates the value of an intellectual property (IP) asset by analyzing market transactions involving comparable assets. This method relies on identifying actual market prices from transactions involving IP assets with similar characteristics to the one being valued. For meaningful comparisons to be made, there must be an active and observable market in which such assets are traded. Hagelin (2002) emphasizes two essential conditions for reliable use of this method:

- The market must exhibit a sufficient level of activity or awareness.
- The market must have adequate transaction volume to ensure meaningful comparisons.

However, if such a market does not exist or lacks sufficient comparability, the absence of a reliable reference price may diminish the credibility and accuracy of the valuation outcome. A key limitation of this approach is its dependence on the nature of the IP asset. Given that many IP assets possess unique and highly specific characteristics, it is often challenging to find truly comparable market transactions. This scarcity of directly comparable data increases the risk of valuation inaccuracy due to limited availability of transaction benchmarks.

2.1.2.1 Market Multiples Method

One practical technique within the market approach is the Market Multiples Method, which has gained popularity in both asset and firm valuation contexts. According to Damodaran (2012), this method involves deriving valuation metrics—such as price-to-earnings (P/E), price-to-sales (P/S), or EV/EBITDA ratios—from comparable transactions or publicly traded entities. These multiples are then applied to the subject IP asset or company based on relevant financial indicators. While this method benefits from its simplicity and intuitive appeal, it requires careful selection of comparable benchmarks and an understanding of contextual differences, such as industry, growth potential, and risk profile, to avoid misapplication.

The valuation formula for the Market Multiples Method is expressed as:

$$Asset\ Value\ =\ (Project\ or\ Firm's\ Parameter\ ) * Market\ Ratio$$

Where:

**Project or Firm's Parameter** = usually Net income, Revenue, EBITDA

**Market Ratio** = the ratio selected for valuation e.g. P/E, P/S

**2.1.3 Income Approach**

The income approach determines the value of intellectual property (IP) based on the premise that such assets have the capacity to generate future economic benefits—typically in the form of net income or cash flows—over their useful economic life (Kaplan & Ruback, 1995). This method assumes that the IP will hold measurable value if the expected income stream is sufficient to justify the risks associated with developing, owning, or exploiting the asset. In essence, the approach links the economic worth of an IP asset to its capacity to generate returns that exceed the associated risk-adjusted cost of capital.

A core advantage of the income approach lies in its forward-looking perspective. Rather than focusing on sunk costs or market comparables, it considers the future revenue-generating potential of the IP asset, making it especially suitable for high-growth and innovation-driven enterprises such as agritech startups in Thailand. This is particularly relevant in sectors where tangible benchmarks are limited, and the asset's intrinsic value stems from its contribution to future earnings.

Among the techniques within this approach, the Discounted Cash Flow (DCF) Method is one of the most widely recognized and applied tools for IP valuation (Damodaran, 2012). The DCF method involves estimating the asset's future cash flows and discounting them back to present value using an appropriate discount rate that reflects the risk profile of the investment. The key idea is to quantify how much future financial benefit the IP will bring, expressed in today's terms.

A specific variation of this method—Free Cash Flow to the Firm (FCFF)—offers a comprehensive measure of the IP's contribution to value creation. The FCFF model evaluates the total cash flows available to all capital providers (equity holders and debt financiers), thereby excluding any effects of capital structure (Damodaran, 2012). This approach is particularly advantageous for valuing IP assets as it offers a capital-neutral perspective, highlighting the economic productivity of the IP itself, regardless of how the business is financed.

In the Thai context, IP valuations using the DCF method typically apply one of two discount rates: the Cost of Equity or the Weighted Average Cost of Capital (WACC). The Cost of Equity is commonly derived using the Capital Asset Pricing Model (CAPM), which factors in the risk-free interest rate, the IP or company's beta (a measure of systematic risk or volatility), and the expected market risk premium (Damodaran, 2012). This model represents the return expected by investors in exchange for bearing the risk of holding the IP asset.

Alternatively, the WACC incorporates both the cost of equity and the after-tax cost of debt, thereby reflecting the average return required by all capital providers. This makes WACC particularly suitable for valuing assets in businesses where both equity and debt financing are significant components of the capital structure (Damodaran, 2012). In practice, Thai valuation professionals often consult data sources such as ThaiBMA and SET for localized market rates, beta values, and debt cost benchmarks to construct realistic discount rate assumptions.

The main equation for DCF (using FCFF) and discount rate (WACC) is as follows:

$$\text{Cost of Equity} = \text{Risk-Free Rates} + (\beta \times \text{Market Risk Premium})$$

$$\text{WACC} = \left(\text{Cost of Equity} \times \frac{Market\ Equity\ Value}{Market\ Equity\ Value + Debt\ Value}\right) + \left(\text{Cost of Debt} \times (1\text{-Tax Rate}) \times \frac{Debt\ Value}{Market\ Equity\ Value + Debt\ Value}\right)$$

$$\text{FCFF} = \text{NOPAT} - \Delta\text{NOWC} - (\text{CAPEX} - \text{Depreciation})$$

$$\text{Asset Value} = \sum \frac{\text{FCFF}_n}{(1+\text{WACC})^n}$$

If the valuer anticipates or possesses evidence suggesting that key valuation inputs may change over the course of the asset's economic life, it becomes necessary to adjust the valuation model accordingly. This is because any alteration in the capital cost structure of the project can significantly impact the present value estimation. Failure to account for such changes may result in a valuation that no longer reflects the asset's true intrinsic value.

### 2.1.4 Option Pricing Approach

The Option Pricing Approach is a valuation method for intellectual property (IP) assets grounded in option pricing theory, which originates from financial economics. This theory is used to determine the value of options—derivative financial instruments that grant the holder the right, but not the obligation, to buy or sell an underlying asset at a predetermined price (known as the exercise or strike price, *K*) within a specified period before the option's expiration date.

There are two principal types of options:

**Call Option** – the right to buy the underlying asset at the strike price.

**Put Option** – the right to sell the underlying asset at the strike price.

At expiration, if the market price (S) of the underlying asset exceeds the exercise price, the holder of a call option may exercise the option, purchasing the asset at a lower price and immediately selling it at the higher market price to realize a profit. Conversely, if the market price is below the strike price, the holder may choose not to exercise the option, resulting in a loss limited to the original option premium paid.

In the context of this study, the option pricing approach is adapted to model IP or business assets as the underlying asset in real-option scenarios—particularly focusing on call options. This is due to the fundraising perspective of the valuation, where investors are granted a right to invest under favorable conditions. According to Lagrost et al. (2010), IP valuation using option pricing methods can be implemented using three main techniques.

2.1.4.1 Binomial Option Pricing Model

The Binomial Option Pricing Model was developed by Cox, Ross, and Rubinstein (1979) as a simplified yet powerful method for pricing options.

Initially created as a pedagogical tool to help students understand the mechanics behind the more complex Black–Scholes model (Black & Scholes, 1973), the binomial model simulates the price evolution of the underlying asset through a discrete-time, tree-like structure.

In this model, time is divided into discrete intervals, and at each step, the price of the underlying asset can move up or down by specific factors, creating a binomial tree. Each node in the tree represents a potential future price of the underlying asset. This allows the model to capture multiple possible future outcomes and reflect the value of flexibility under uncertainty—an essential feature in valuing innovation-driven or IP-intensive assets.

The model's significance was later formalized in the joint publication by Cox, Ross, and Rubinstein titled *Option Pricing: A Simplified Approach* (1979), which laid the foundation for using binomial methods in practical option pricing scenarios, particularly when real options must be evaluated in stages with multiple decision points.

The operational foundation of the Binomial Option Pricing Model (BOPM) begins with the discrete-time multiplicative binomial structure introduced by Cox, Ross, and Rubinstein (1979). The model is built on the assumption that the underlying asset behaves similarly to a stock, and its future value can move in two possible directions over each time step. Specifically, the asset price (S) can increase to uS or decrease to dS, where u and d are multiplicative factors representing upward and downward movements, respectively. The likelihood of an upward movement is denoted by q, and a downward movement occurs with probability (1 − q).

This binomial framework is particularly useful in valuing options because it allows for the modeling of price evolution over multiple periods, capturing the dynamic nature of real investment opportunities. Damodaran (2012) further applied this principle by combining risk-free lending or borrowing instruments with the underlying asset to construct a replicating portfolio, which mimics the cash flow behavior of an option. This portfolio forms the basis for determining the option's intrinsic value using no-arbitrage principles.

For a multi-period binomial model, the value of a call option can be calculated recursively using the following equations:

$$C_T = max[0, S_T - K]$$
$$C = [p \cdot C_u + (1-p) \cdot C_d] / r$$
$$p = \frac{r-d}{u-d}$$

Where:

**$C_t$** is the value of the call option at time t

**$S_t$** is the underlying asset price at time t

**K** is the strike (exercise) price

**p** is the risk-neutral probability of an upward price movement

**R** is the risk-free interest rate over the period

**$C_u$**, **$C_d$** are the option values in the up and down states, respectively

Although the binomial model is relatively straightforward to implement and allows the valuer to flexibly simulate various future price paths for the underlying asset, it has limitations—particularly in scenarios with a high number of time steps or complex decision points. As the number of branches increases, the computational complexity of the model grows exponentially, making it less practical for real-world valuation cases involving a wide range of contingencies.

This computational challenge has led to the development of more continuous models, notably the Black–Scholes Option Pricing Model (1973), which addresses many of the scalability issues inherent in binomial models and will be discussed in the next section.

2.1.4.2 Black and Scholes Option Pricing Model

The Black and Scholes Option Pricing Model is one of the most influential models for valuing financial options, originally introduced by Black and Scholes (1973). While it shares conceptual similarities with the binomial option pricing model proposed by Cox, Ross, and Rubinstein (1979)—particularly in modeling the movement of the underlying asset's price—it departs by applying continuous-time mathematical finance, specifically partial differential equations, to handle a potentially infinite number of price movements.

At the heart of the Black–Scholes framework lies the assumption that the underlying asset price (S) follows a stochastic differential equation

(SDE) characterized by Geometric Brownian Motion. This model assumes that the asset's price evolves randomly over time, but within a defined probabilistic structure, allowing for the derivation of a closed-form solution for the option's fair value.

The general form of the Black–Scholes formula for a European call option is expressed as:

$$C_t = S * N[d_1(t, S)] - e^{-r\cdot(\Delta t)} K * N[d_2(t, S)]$$

$$d_1(t, S) = \frac{1}{\sigma\sqrt{\Delta t}}\left[ln\left(\frac{S}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)(\Delta t)\right]$$

$$d_2(t, S) = d_1(t, S) - \sigma\sqrt{(\Delta t)}$$

Where:

**$C_t$** = Call option value at time t

**S** = Current price of the underlying asset

**K** = Strike (exercise) price of the option

**r** = Risk-free interest rate

**σ** = Volatility of the asset's returns

**Δt** = Time to maturity

**N** = Cumulative standard normal distribution function N(0,1)

The model can be solved directly via partial differential equations (PDEs) or through the Feynman & Kac (1950)'s theorem, which links stochastic processes with PDEs to produce a probabilistic solution.

While the Black and Scholes model provides a mathematically elegant and widely accepted approach for pricing options, its real-world application—especially in valuing intellectual property—faces several practical limitations due to its underlying assumptions:

- The risk-free interest rate remains constant throughout the option's life.
- The underlying asset does not pay dividends during the period.
- The asset price follows a continuous-time diffusion process governed by a Geometric Wiener process.

● The option must be European-style, meaning it can only be exercised at the expiration date, not before.

These assumptions—particularly the final one—can constrain the model's applicability in real-world IP valuation contexts. In practice, IP-based real options, such as those involving patents or proprietary technologies, often require flexibility in timing and discrete decision points, characteristics more aligned with American-style or compound options. Consequently, while the Black–Scholes model provides a valuable theoretical foundation, its precision is best suited to European options and may not fully reflect the strategic value of intellectual property in dynamic innovation-driven environments.

2.1.4.3 Real Option Pricing Model

The Real Option Pricing Model represents an advanced valuation framework that extends financial option pricing theory to real-world investment scenarios where decision-making involves substantial uncertainty, irreversibility, and strategic flexibility. Unlike traditional financial options that are based on tradable securities, real options treat tangible investment projects or assets (real assets)—such as natural resource exploration, R&D initiatives, or infrastructure developments—as the underlying asset. These decisions often involve large upfront investments and considerable risk, such as the possibility of project abandonment mid-way if commercial viability is not achieved.

A classic example is an investment in an oil drilling or mining project, where the initial outlay is significant, but the outcome remains uncertain. If successful, the project generates substantial future returns that justify the initial risk. The managerial decision to proceed, delay, or abandon such a project closely resembles the right—but not the obligation—to exercise an option, thus forming the conceptual foundation of real options.

The concept of real options was first introduced by Myers (1977), who coined the term to describe investment opportunities in real assets that exhibit characteristics similar to financial options. Myers' work paved the way for a growing body of literature that applied financial theory to capital budgeting and project evaluation. Notably, Brennan and Schwartz (1985) extended this theory by adapting the Black–Scholes (1973) framework to assess the value of mining and natural resource projects. Their research highlighted a critical issue: many assumptions embedded in the Black–Scholes model—such as constant volatility, frictionless markets, and continuous tradability—do not hold in real asset contexts.

These limitations were further discussed in studies by Capinski and Patena (2003) and Fernández (2019), both of whom acknowledged that classical financial models require significant adjustments to accommodate the unique characteristics of real asset investment decisions.

In response to these challenges, contemporary research and practical frameworks for real option valuation have been substantially refined. Influential contributions include works by Amram and Kulatilaka (2000), Damodaran (2000), and Shockley (2007), who have developed more practical guidelines for identifying and valuing real options within strategic and financial planning.

At the core of these models lies the analogy between real options and financial stock options. Using the Black–Scholes equation as a theoretical baseline, analysts can map the key variables from financial options to real investment projects. The following conceptual mappings are commonly used in real options analysis:

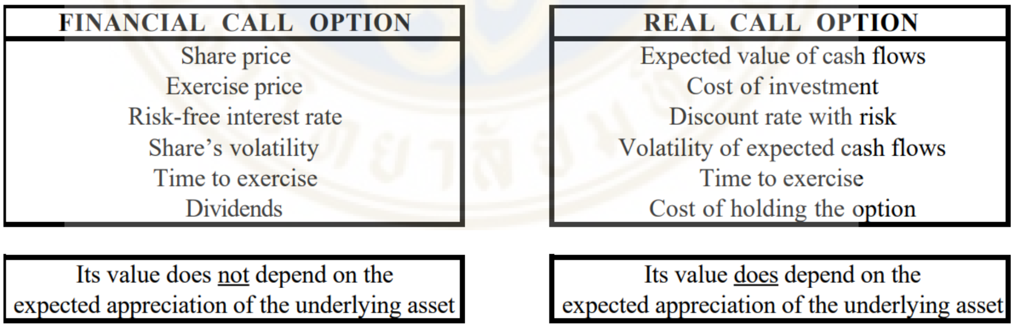


Figure 3: Diagram demonstrating the Variables interchange from Financial Call Option to Real Options Model

Source: (Fernández, 2019).

By mapping the variables from financial options theory to real investment contexts, the Real Options framework allows investors to evaluate project opportunities as contingent rights rather than static commitments. In this analogy, the underlying asset corresponds to the investment project, while the investment cost plays the role of the exercise price. An investor will choose to exercise this “option to invest” only if the net present value (NPV) of the project’s expected future cash flows exceeds the total investment required.

This condition is conceptually identical to a call option: just as an investor profit from exercising a call option when the stock price exceeds the strike price, a firm benefits from investing in a project when the present value of expected cash inflows surpasses the capital outlay. The uncertainty in project cash flows reflects the volatility in asset prices in financial options, and the time until the investment opportunity expires aligns with the option’s time to maturity.

Substituting these real-world variables into the Black–Scholes option pricing formula, the value of the real option (i.e., the project) can be represented as:

$$V_t = CN[d_1(t, C)] - e^{-r\cdot(\Delta t)}KN[d_2(t, C)]$$

$$d_1(t, C) = \frac{1}{\sigma\sqrt{(\Delta t)}}\left[ln\, ln\left(\frac{C}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)(\Delta t)\right]$$

$$d_2(t, C) = d_1(t, C) - \sigma\sqrt{(\Delta t)}$$

Where:

**C** = Present value of expected project cash flows (NPV)

**K** = Investment cost

**Vt** = Option value of the project (Real Option Value)

**r** = Risk-free interest rate

**Δt** = Time until the investment opportunity expires

**σ** = Volatility (uncertainty in project returns)

This formula quantifies the value of strategic flexibility—the ability to defer or abandon an investment depending on unfolding information—thereby capturing the impact of uncertainty more accurately than traditional valuation methods.

Consequently, the Real Options Approach often produces a more realistic and dynamic valuation than the conventional Discounted Cash Flow (DCF) method, which assumes a fixed and deterministic stream of future cash flows. While DCF remains useful for assessing value under stable conditions, it fails to account for managerial flexibility and changing market conditions that can significantly alter the course of a project.

However, it is important to note that real options valuation still inherits some of the limitations of the DCF framework, particularly the reliance on cash flow projections and underlying assumptions. The accuracy of the valuation heavily depends on the quality and realism of these estimates. Furthermore, by introducing additional variables—such as volatility, timing flexibility, and option-like decision nodes—the complexity of the valuation increases significantly, requiring deeper technical expertise and more sophisticated modeling tools.

## 2.2 Diffusion of Innovation Theory

The Diffusion of Innovation Theory, developed by communication scholar Everett M. Rogers, provides a framework for understanding how new ideas and technologies spread throughout a society and eventually become widely adopted innovations (Rogers, 1995). The theory posits that diffusion is the process by which an innovation is communicated through specific channels over time among members of a social system.

One of the core insights of the theory is that innovation adoption follows a bell-shaped curve, dividing individuals into five adopter categories based on their propensity to embrace new ideas:

**Innovators** – These individuals are risk-takers and eager to experiment with new technologies. They are typically the first to adopt innovations and are driven by curiosity and a desire for novelty.

**Early Adopters** – Similar to innovators, early adopters are open to new ideas but adopt them more thoughtfully. They often serve as opinion leaders within their communities, influencing the broader acceptance of innovations.

**Early Majority** – This group is more cautious and deliberative, choosing to adopt innovations only after observing tangible benefits and success among earlier adopters.

**Late Majority** – More skeptical by nature, the late majority adopts innovations only when they become mainstream and widely used, often due to social or economic pressure.

**Laggards** – Representing the final group to adopt innovations, laggards are typically resistant to change and prefer traditional methods. They are often influenced the least by trends and technological shifts.

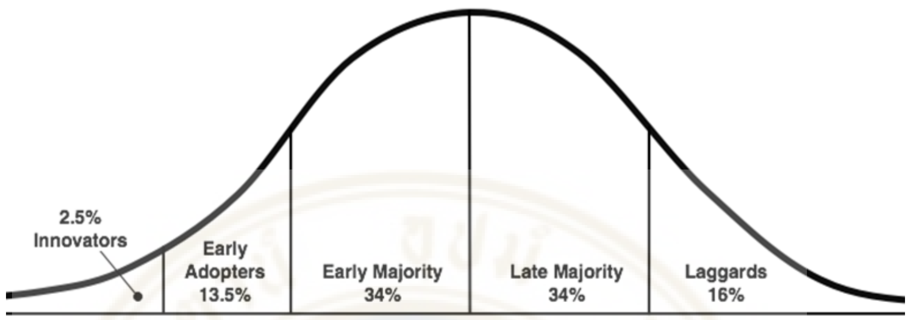


Figure 4: Diagram demonstrating the Diffusion of Innovation
Source: Boston University (2022).

**2.3 Funding Life cycle of Early-Stage Enterprises**

The financial trajectory of early-stage enterprises typically follows a staged investment lifecycle, characterized by progressive capital requirements, high risk, and evolving investor expectations. According to Damodaran (2012), the funding process for startups can be segmented into distinct phases, each reflecting a different level of operational maturity, cash flow dynamics, and valuation uncertainty. These stages are particularly relevant for innovation-driven enterprises (IDEs), such as agritech startups, which often operate under conditions of significant technological uncertainty and delayed revenue realization.

**Seed Stage:** In this initial phase, the focus is on transforming a concept or prototype into a viable business model. Capital is often sourced from founders, friends and family, or angel investors. Funding at this stage is used primarily for early product development, market validation, and sometimes basic IP protection. Valuation is highly speculative, often based on qualitative assessments rather than financial forecasts.

**Startup Stage:** Once the business model is defined and initial proof-of-concept is achieved, the startup seeks more formal capital to scale operations. This phase often involves pre-revenue ventures with high burn rates. Investors, such as angel groups or early-stage venture capital (VC) firms, begin to apply more rigorous valuation techniques, including scenario-based DCF and real options, to factor in strategic uncertainty and staged decision-making (Damodaran, 2012).

**Growth Stage (Early Expansion):** At this point, the company begins to generate revenue but is typically still operating at a loss due to reinvestment in scale-up activities such as team expansion, product iteration, or market entry. Funding is secured through larger VC rounds. Valuation techniques during this stage become more robust, often incorporating **Free Cash Flow to Firm (FCFF)** models and industry benchmarks (Damodaran, 2012). Intellectual property, if developed and protected earlier, begins to contribute meaningfully to valuation through licensing potential, technological defensibility, and revenue-generating capability.

**Late-Stage / Mezzanine Funding:** Firms that reach this stage demonstrate more stable revenue growth and clearer paths to profitability. Capital raised here is typically used for large-scale commercialization, infrastructure, or preparation for an exit (e.g., IPO or acquisition). Investors often use **market-based valuation multiples** (e.g., EV/EBITDA, P/S) along with DCF models, and may also apply **real options** when significant strategic decisions remain (e.g., market expansion, product pipeline development).

**Exit and Liquidity Event:** This final stage may involve acquisition, public offering, or internal buyouts. The firm's valuation is typically determined by public market conditions or strategic fit for the acquirer. At this point, IP assets may be valued independently using income-, market-, or options-based approaches depending on the buyer's strategic objectives.

Understanding this lifecycle is critical for both startup founders and investors, as each stage carries distinct implications for risk tolerance, valuation methodologies, and capital structure strategy. For agritech startups in Thailand, aligning funding strategies with valuation approaches—particularly those that account for the uncertain and staged nature of innovation—can significantly enhance the firm's ability to attract appropriate financing at each stage.

## 2.4 The Innovation Development "Chasm" Concept

The concept of the "chasm" in innovation diffusion was introduced by Geoffrey A. Moore and Regis McKenna in their influential work *Crossing the Chasm* (Moore & McKenna, 1999). The term refers to a critical gap that exists between the early adopters and the early majority within the bell-shaped curve of Rogers' (1995) Diffusion of Innovation Theory.

This gap represents a major barrier for companies seeking to launch and scale new technologies or products. While early adopters are generally risk-tolerant, visionary, and willing to engage with incomplete or experimental innovations, the early majority consists of more pragmatic users who demand reliability, proven benefits, and structured support. Consequently, marketing strategies and product features that resonate with early adopters often fail to appeal to the early majority, creating a discontinuity in the adoption curve.

Successfully "crossing the chasm" requires companies—particularly startups—to significantly refine both their product offering and go-to-market strategy. This often involves substantial investment in capital expenditures (CapEx) to enhance product readiness and in working capital management to support sales, distribution, and customer service infrastructure. Firms must also tailor their messaging to emphasize risk reduction, return on investment, and compatibility with established systems—key concerns of the early majority.

For early-staged innovation-driven enterprises (IDEs), particularly in sectors like agritech where commercialization can be complex and infrastructure-intensive, failing to bridge this gap can result in stalled growth or premature exit. Therefore, understanding and preparing for the chasm is critical in aligning fundraising milestones with market readiness and adoption strategy.

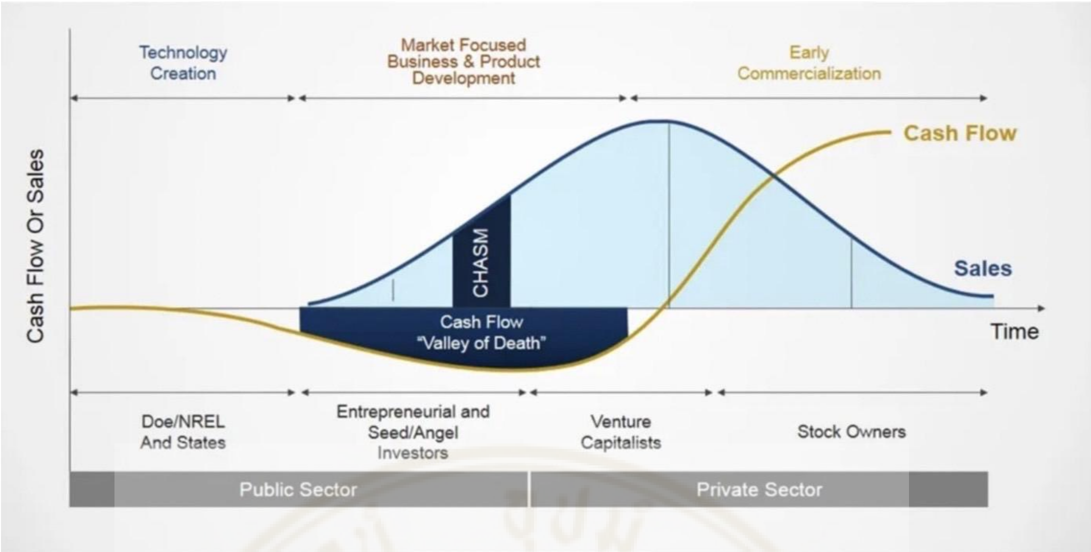


Figure 5: "Chasm" or "Valley of Death" in the Development of Innovation
Source: Moore & McKenna, (1999).

## 2.5 Intellectual Property-Based Financing

In recent years, the role of **intellectual property (IP)** has expanded beyond its traditional function as a legal asset to become an increasingly important instrument in corporate finance. According to a study by the Thailand Development Research Institute (TDRI, 2018), IP-based financing can generally be categorized into four primary forms:

**IP-Backed Lending:** This involves using intellectual property as collateral for securing loans. While common in developed economies, this form of financing has not yet been fully implemented in Thailand. At present, Thai financial institutions may consider IP assets as supporting factors in credit evaluation, but not as primary collateral in secured lending arrangements.

**IP Securitization:** IP securitization refers to the conversion of future income rights from IP licenses into a lump-sum financing instrument in the present. This typically involves issuing non-debt securities backed by anticipated royalty streams or licensing revenues. For example, copyright owners may issue securities tied to expected future earnings and sell them to investors in exchange for immediate capital. This method is more commonly used by IP owners with well-established revenue records and strong market reputations.

**IP Sale and Leaseback:** In this structure, a company sells its IP assets to a financing entity and then leases them back for continued operational use. This allows firms to unlock capital from their intangible assets while retaining functional control over the technology or brand. IP sale and leaseback is particularly useful for firms seeking liquidity without losing access to the assets that are critical to their ongoing business operations.

**Venture Capital Equity Investment:** Venture capital (VC) investment is a widely adopted form of IP-driven financing, particularly for technology-intensive startups. VC firms typically provide funding in exchange for equity ownership, and may also offer convertible loans or debt. These investors focus on high-growth-potential businesses, often in innovation-based sectors, where IP constitutes a significant portion of the company's valuation and strategic defensibility.

Each of these financing mechanisms reflects a different risk–return profile and level of IP maturity, requiring tailored strategies for IP management, valuation, and disclosure. For innovation-driven enterprises (IDEs) in Thailand's agritech sector, understanding and leveraging these IP-based funding structures can significantly enhance access to capital while preserving ownership flexibility and long-term strategic value.

## 2.6 Action Research Theory

The concept of action research originated in the 1940s with the work of American psychologist Kurt Lewin, and has since evolved through the contributions of numerous scholars including Kemmis, McTaggart, Rapoport, and others (Kemmis & McTaggart, 2007; Masters, 1995). This research methodology combines inquiry with action in a participatory process aimed at solving real-world problems while contributing to academic knowledge.

A widely accepted definition of action research, as outlined by McTaggart (1994) and Rapoport (1970), frames it as a method that "aims to simultaneously assist in the practical concerns of people in problematic situations and to further the goals of social science by means of collaboration within a mutually acceptable ethical framework.” Within this framework, four foundational principles guide action research practices:

- **Empowerment of participants in the decision-making process**
- **Collaboration through participatory engagement**
- **Generation of practical and theoretical knowledge**
- **Promotion of social transformation**

The methodology is typically operationalized through a cyclical process, originally conceptualized as a four-phase loop: planning, acting, observing (or evaluating), and reflecting (Kemmis & McTaggart, 2007; Masters, 1995).

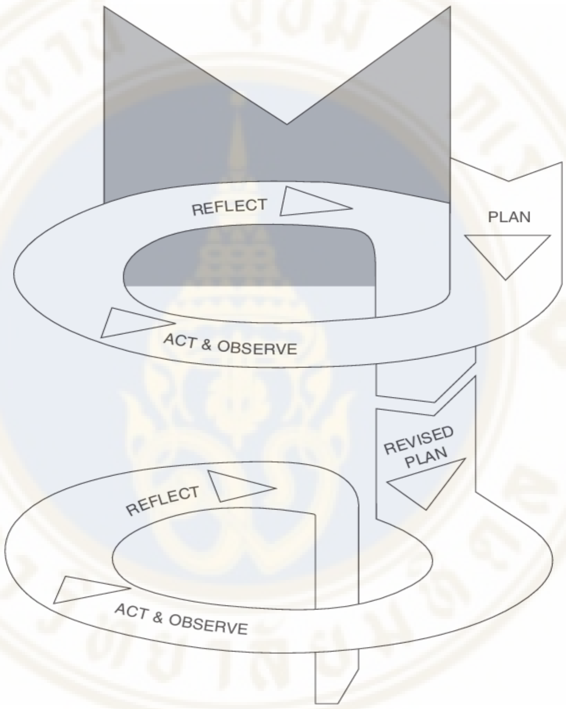


Figure 6: Concept of Participatory Action Research
Source: Kemmis & McTaggart (2007).

Building upon this foundation, Susman and Evered (1978) proposed an enhanced model—known as the Five Phases of the Action Research Cycle—which has become a widely adopted framework in contemporary applied research. The five phases are as follows:

**Diagnosing:** In this initial stage, researchers and stakeholders collaboratively identify the organizational context, external environment, and the core problems that require intervention.

**Action Planning:** Once the problem has been clarified, the research team works with organizational participants to formulate a conceptual framework for problem-solving. This involves selecting appropriate theories or best practices to structure the intended intervention.

**Action Taking:** The chosen intervention strategy is implemented within the organization. Both researchers and practitioners play active roles in initiating or supporting changes aimed at resolving the identified problems.

**Evaluating:** Following implementation, researchers and organization members assess the outcomes to determine whether the intervention successfully addressed the problem, and if not, identify reasons for its limitations.

**Specifying Learning:** In the final phase, the knowledge gained from the entire process—both in terms of organizational change and methodological insights—is documented and synthesized to inform future practice and research.

This iterative and participatory approach is particularly valuable for research involving complex, real-world contexts such as innovation-driven enterprises (IDEs), where stakeholder involvement, adaptive learning, and organizational transformation are integral to both problem-solving and knowledge creation.

## 2.7 Related Studies

A number of prior research works provide valuable insights into valuation methodologies relevant to intellectual property (IP) and innovation-driven enterprises, particularly in high-uncertainty sectors such as biotechnology and agritech.

**Rasmussen and Lindberg (2020)** conducted a strategic and financial analysis of Aker BioMarine, a krill-based product manufacturer, in order to estimate its intrinsic share value. They applied a fundamental valuation approach using the Discounted Cash Flow (DCF) model, complemented by a market multiples analysis. Their study concluded that the true market value of the stock was NOK 101.67 per share as of October 30, 2020—approximately 23.98% above its actual closing price on that date—suggesting potential undervaluation. The study is particularly relevant as it demonstrates how combined valuation techniques can be adapted to companies whose core assets include proprietary technologies and IP.

**Vetsch (2021)** applied a real options valuation framework to assess the value of early-stage agricultural technology startups. Using a dataset of 12 agtech firms in the U.S. funded between 2015 and 2019, the study found that real options more effectively captured the uncertainty and flexibility inherent in agtech ventures compared to traditional DCF models. The value of the real options was shown to correlate strongly with factors such as company maturity, R&D intensity, and market size, making it a compelling approach for IP-intensive startup environments.

**Muchtar et al. (2023)** proposed a valuation system for innovation technologies in Indonesia by comparing three principal methods: the Income Approach, Cost Approach, and Market Approach, using a case study of a biotechnology firm. Their findings revealed that the Income Approach yielded the highest valuation due to its ability to incorporate both future benefits and associated risks. In contrast, the Market Approach reflected real-time supply and demand conditions, while the Cost Approach resulted in the lowest valuation due to its disregard for profit-generating potential or technological distinctiveness.

**Ramírez-Atehortúa et al. (2022)** evaluated the financial value of a patented rail-cable management system designed for easier installation and maintenance. Using the Market Approach, the authors benchmarked the patent against similar IP transactions within the same sector and region. The estimated value ranged from USD 1.5 million to 2.5 million, depending on the commercialization strategy—licensing, sale, or joint venture. The study recommended a strategic partnership model to maximize the patent’s utility.

**Kellogg and Charnes (2000)** argued that conventional valuation techniques such as DCF and market multiples are unsuitable for biotechnology firms, citing Agouron Pharmaceuticals as a case study. They introduced two real options approaches: the decision-tree method, which maps R&D projects as sequential contingent investments, and the binomial-lattice model, which adds growth options for scalability or abandonment flexibility. Their findings showed that the real options models were more realistic and yielded higher valuations, with the binomial-lattice method outperforming the decision-tree in terms of reflecting dynamic market potential.

**Samuel et al. (2018)** also focused on Agouron Pharmaceuticals and confirmed that traditional methods like DCF or EBITDA multiples underestimate the value of biotech ventures due to their inability to account for uncertainty and flexibility. The authors compared decision-tree and binomial-lattice real options methods, concluding that the latter produced higher valuations by incorporating growth potential, especially in fast-moving markets. The study reinforced the suitability of real options in guiding investment decisions in innovation-driven sectors.

**Van Triest and Vis (2007)** explored valuation techniques for cost-reducing patents, which differ from revenue-enhancing technologies. Their work emphasized that conventional valuation methods often fail to consider competitive strategy. Using game theory—specifically the Prisoner's Dilemma—the study modeled patent usage behavior in a duopolistic market between Borealis (patent owner) and Basell (competitor) within the European polypropylene film industry. They assessed four competitive scenarios and compared the results with DCF and real options methods. The game theory approach yielded valuations higher than DCF but lower than real options, underscoring the strategic relevance of modeling competitive interactions in IP valuation.

Based on the literature review and analysis of related research concerning valuation processes and models—with particular emphasis on methods suitable for intellectual property (IP), especially in the context of agricultural and biotechnology-related technologies—several key insights emerge. In cases where the assets or investment projects being valued exhibit a high degree of uniqueness—such as patent-based technologies aimed at improving production efficiency or early-stage biotechnology firms—the most appropriate valuation methods tend to be those that do not rely heavily on observable market data. These include the Cost Approach, Income Approach, and notably the Real Option Approach.

Nevertheless, the Market Approach remains viable in situations where sufficient comparable transaction data can be obtained, allowing for meaningful benchmarking. When comparing valuation outcomes across methods, studies consistently show that the Real Options Method, as part of the Option Pricing

Approach, tends to generate the highest asset values. This is primarily because it incorporates the widest range of uncertainties, flexibilities, and future decision paths into the valuation model. However, this comes at the cost of increased modeling complexity and computational demand.

The next most effective method in terms of valuation magnitude is the Income Approach, particularly the Discounted Cash Flow (DCF) model. DCF is widely recognized for its theoretical robustness and practical applicability, featuring straightforward mathematical formulations and moderate data requirements. While it has limitations—especially regarding its dependence on static assumptions about future cash flows—it remains the most commonly used method due to its accessibility, transparency, and broad acceptance.

In summary, the literature indicates that for IP assets in agritech and biotech sectors, valuation methods should be selected based on the nature of the asset, the availability of market data, and the need to capture uncertainty and managerial flexibility.

Table 1: Related Studies

| Order | Study Name | Researcher | Valuation Approach | Results |
|---|---|---|---|---|
| 1 | License to krill: A fundamental valuation of Aker BioMarine | Rasmussen, A. K., & Lindberg, E. (2020). | Income Approach: DCF<br>Market Approach: Market Multiples | Researcher focused mainly on Income Approach |
| 2 | Real Options for Agriculture Technology:<br>A Venture Capital Valuation Approach | Vetsch, L. T. (2021). | Option Pricing Approach: Real Options<br>Income Approach: DCF | Real Option’s Value > DCF |
| 3 | Development of a Valuation System of Technology for the Enhancement of | Muchtar, N. H., Palar, M. R. A., & Amirulloh, | Income Approach: DCF<br>Cost Approach<br>Market Approach: Similar Technologies | DCF > Market Approach > Cost Approach |

| | | | | |
|---|---|---|---|---|
| | Innovation in Indonesia. | M. (2023). | | |
| 4 | Monetary valuation of a technological patent under transfer alternatives.<br>The case of a products manufacturer company for the electrical and telecommunications sector in Medellín-Colombia | Ramírez-Atehortúa, F. H., Atehortúa-García, C., & Montes-Gómez, L. F. (2022). | Market Approach: Comparing Similar Technology Patents | No comparisons |
| 5 | Real-options valuation for a biotechnology company. | Kellogg, D., & Charnes, J. M. (2000). | Options Approach: Real Options ( Binomial Lattice and Decision Tree )<br>Income Approach: DCF | Real Options: Binomial Lattice > Real Options: Decision Tree > DCF |
| 6 | A Strategic Framework for Technology Valuation in Agriculture and Allied Sectors in India–Case Study of Chitosan | Samuel, M. P., Sastry, R. K., & Pavani, S. (2018). | Options Approach: Real Options ( Binomial Lattice and Decision Tree )<br>Income Approach: DCF | Real Options: Binomial Lattice > Real Options: Decision Tree > DCF |
| 7 | Valuing patents on cost-reducing technology: A case study | Van Triest, S., & Vis, W. (2007). | Using the game theory Options Approach: Real Options<br>Income Approach: DCF | Real Option's Value > Value from The Game Theory > DCF |

## 2.8 Conclusion

From the review of relevant theories and literature, the researcher concludes that quantitative valuation methods applicable to intellectual property (IP) can be categorized into four primary groups:

**1. Cost Approach** – Valuation based on historical or replacement cost of the asset.

**2. Market Approach** – Valuation based on comparable market transactions.

**3. Income Approach** – Valuation based on the asset's projected future income.

**4. Option Pricing Approach** – Valuation based on financial option theory, capturing uncertainty and strategic flexibility.

To achieve the core objective of this research—developing a valuation model that businesses can apply when negotiating with potential investors—it is essential to employ multiple valuation methods. This multi-method approach enables the generation of a valuation range, providing entrepreneurs with a spectrum of monetary estimates for their IP or innovation-driven firm. This range helps define the fair value boundaries that external investors are likely to consider acceptable during funding negotiations.

The selection of appropriate valuation methods must consider not only the potential value outcomes, but also the relevance of underlying assumptions, the availability and reliability of data, and the entrepreneur's capacity to implement each method. Each method reflects different perspectives on value and involves varying levels of complexity and data dependence.

Based on the literature review and the practical needs of IP-rich businesses—particularly within the agricultural and biotechnology sectors—the researcher has selected the following four methods to be integrated into the proposed valuation model:

**1. Cost Approach** – To provide a conservative baseline or minimum value estimate.

**2. Market Approach** – To benchmark the asset's value using comparable IP transactions (where available).

**3. Income Approach** – To assess the asset's ability to generate future economic benefits, particularly through the **Discounted Cash Flow (DCF)** model.

**4. Option Pricing Approach** – To account for uncertainty, flexibility, and staged investment decisions using methods such as **Real Options Analysis**.

## 2.9 Conceptual Framework of the Research

Based on the review of relevant theories and literature, and the rationale behind the selection of appropriate valuation methods for use in this study, a conceptual framework has been developed to guide the design and implementation of the research.

The conceptual framework builds upon and adapts the valuation method selection structure proposed by Lagrost et al. (2010), integrating it with the objective of constructing a multi-method valuation model for both firm value and intellectual property (IP) assets. This model is specifically tailored for innovation-driven enterprises (IDEs) in the agricultural technology and biotechnology sectors.

In this research, the valuation process will be carried out using multiple approaches. The results obtained from each valuation method will be compared and analyzed to derive a comprehensive view of the asset's economic value and to establish a value range suitable for practical application, particularly in investment negotiations.

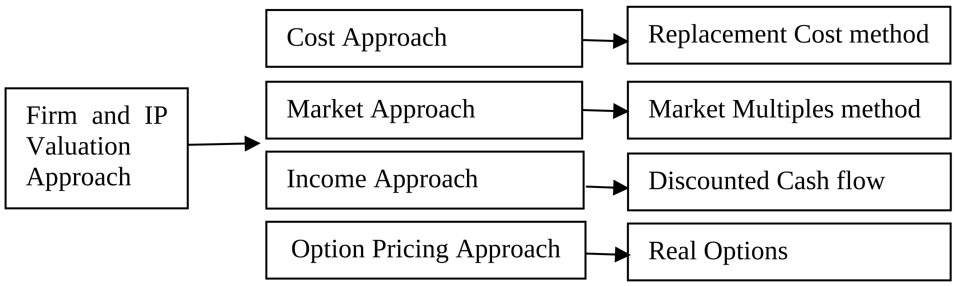


Figure 7: Conceptual Framework

Source: Adapted from Lagrost, et al. (2010).

# CHAPTER 3
# METHODOLOGY

This study is designed as an applied research project that seeks to construct a financial valuation model for assessing both the monetary value of intellectual property (IP) and the firm value of innovation-based enterprises.

## 3.1 Type of Research

The research adopts an Action Research approach, which is particularly well-suited for addressing real-world problems through the application and contextual adaptation of theoretical frameworks. Action research allows for the integration of both qualitative and quantitative research methods and supports collaborative problem-solving between researchers and practitioners (Jean & Jack, 2002; Somekh, 2005; Hammersley, 2004).

The implementation of this study follows the Five Phases Action Research Cycle developed by Susman and Evered (1978), which includes the following stages:

**1. Diagnosing:** In this phase, the researcher collaborates with the enterprise to identify the organizational context, current challenges, and valuation-related issues that require resolution.

**2. Action Planning:** Based on the diagnosed problems, the researcher and the entrepreneur co-develop a conceptual framework that outlines the decision-making process and identifies possible solutions. This phase incorporates relevant financial theories and best practices.

**3. Action Taking:** The proposed valuation strategies and frameworks are applied within the organizational setting, aiming to implement a financial model that meets the practical needs of the enterprise.

**4. Evaluating:** The researcher and organization jointly assess the results of the intervention to determine the effectiveness of the model and to identify areas for refinement or improvement.

**5. Specifying Learning:** The final phase involves the identification and articulation of the knowledge and insights gained from the intervention process, which are then used to improve the model and inform broader applications.

## 3.2 Population and Sample Group

The sample group selected for this study consists of individuals directly involved with or related to a biotechnology-based agricultural innovation enterprise. The sampling technique employed is non-probability sampling, specifically through purposive sampling, which allows for the intentional selection of participants based on their relevance to the research objectives. The criteria used to identify and select participants are as follows:

**1. Internal accounting and finance personnel** of the company: A minimum of 3 to 5 individuals with direct responsibilities related to the company's financial records

**2. Executive management team**

**3. Investors**: A minimum of 3 to 5 individuals who have either invested in the company or are active stakeholders with an interest in its financial valuation.

**4. Relevant government officials**: At least 1 representative

**5. Customers of the company**: A minimum of 5 individuals

## 3.3 Data Used in the Research

To support the development of a financial valuation model tailored to intellectual property and innovation-driven enterprises, this study utilizes both primary and secondary data sources as follows:

### 3.3.1 Primary Data

Primary data is collected through in-depth interviews with selected participants from the defined sample group. The researcher conducts interviews and field visits to gather relevant qualitative insights directly from stakeholders. These interactions are intended to capture contextual and experiential information regarding

IP valuation, business strategy, and investment perspectives within the target enterprise.

### 3.3.2 Secondary Data

Secondary data is obtained from a variety of sources, including academic research reports, corporate financial statements (used for comparative valuation analysis), journal articles, and relevant databases and literature from domestic and international institutions. These sources provide background knowledge, theoretical context, and supporting data necessary for model development and cross-validation.

## 3.4 Data Collection Tools and Procedures

### 3.4.1 Semi-Structured Interview Protocol

To gather comprehensive and relevant information for the development of the financial valuation model, the researcher employed a semi-structured interview approach, comprising both open-ended and closed-ended questions. The data collection was conducted through two main qualitative techniques: Focus Group Discussions (FGD) and In-depth Interviews with key stakeholders. The structure and scope of the interviews were organized using the 5W1H framework as follows:

**WHO (Respondents):**

1. Marketing personnel of the company
2. Finance officers
3. Accounting officers
4. Executive management
5. Company investors

**WHAT (Interview Content):**

1. Description of the IP assets intended for valuation
2. Estimated project duration for commercializing the IP
3. Revenue projections from IP commercialization
4. Cost projections associated with IP commercialization
5. Overall company revenue and cost forecasts
6. Review and interpretation of the company’s financial statements

7. Capital structure, tax treatment, depreciation methods, and cost of debt
8. Investor expectations regarding return on investment (ROI)
**9.** Investor expectations concerning investment duration

**WHY (Purpose of Data Collection):**

1. Cost-related forecasts are used to implement the Cost Approach
2. Capital structure, cost of debt, tax assumptions, and investor expectations are applied in the calculation of the discount rate used in both firm-level and IP-specific project valuations
3. Revenue forecasts, cost projections, depreciation, discount rate, and investor return expectations are all utilized in the application of the Income Approach, Market Approach, and Option Pricing Models

## 3.5 Data Analysis

### 3.5.1 Quantitative Data Analysis (Document Analysis)

Quantitative data were analyzed through document analysis, focusing primarily on the company's financial statements and other related documents. These data served as the foundation for applying valuation models, including assessments of financial feasibility and economic value of both the organization and its IP assets.

### 3.5.2 Analytic Induction

Analytic induction was applied to derive generalized insights from observed phenomena and factual evidence obtained through focus group interviews. This method allowed the researcher to interpret meaning and construct conclusions based on recurring patterns and consistencies in stakeholder responses, particularly regarding their experiences with valuation, strategy, and investment decision-making.

### 3.5.3 Thematic and Content Analysis

Thematic and content analysis was used to identify key patterns, themes, and meanings emerging from participants' direct experiences. This approach supported the construction of deeper interpretations by connecting individual insights to shared understandings between the researcher and the sample group.

## 3.6 Research Timeline

Table 2: Research Timeline

| Timeline and Research Process | | Jan 24 | Feb 24 | Mar 24 | Apr 24 | May 24 | Jun 24 | Jul 24 | Aug 24 | Sep 24 | Oct 24 | Nov 24 | Dec 24 | Jan 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Problem, Objective and Framework | ■ | ■ | | | | | | | | | | | |
| 2 | Research Design | | | ■ | ■ | | | | | | | | | |
| 3 | Validation | | | | | ■ | ■ | | | | | | | |
| 4 | Data Gathering | | | | | | | ■ | ■ | ■ | ■ | | | |
| 5 | Data Analysis | | | | | | | | | | ■ | ■ | | |
| 6 | Data Processing | | | | | | | | | | | ■ | ■ | |
| 7 | Discussion and Conclusion | | | | | | | | | | | | | ■ |

## 3.7 Conclusion

This study was designed to collect and analyze data for the development of a valuation model for organizational value and intellectual property (IP) assets. The research process was divided into two key components: A review of existing literature and academic sources, including scholarly articles, financial documents, and technical reports; and Primary data collection through interviews with stakeholders directly involved with the organization and the IP assets being evaluated.

The combined data were then applied within the framework of established valuation formulas to calculate the financial value of both the firm and its associated IP. The study employed four principal valuation methods as the foundation for model construction:

**1. Cost Approach** – estimating value based on historical or replacement cost.

**2. Market Approach** – benchmarking against comparable asset sales.

**3. Income Approach** – calculating value based on expected future cash flows.

**4. Option Pricing Approach** – incorporating uncertainty and strategic flexibility using financial option theory, such as the **Real Options Method**.

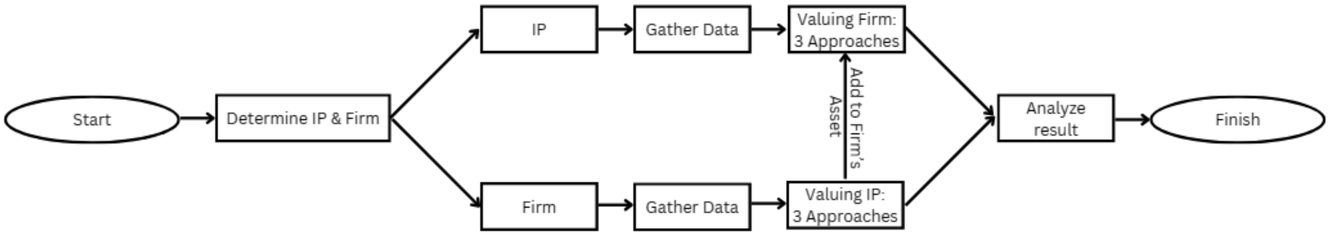


Figure 8: Research Workflow

# CHAPTER 4
# RESULTS

## 4.1 Case Study: Innovation-Driven Enterprise in Thailand's Agribusiness Sector

### 4.1.1 Company Overview and Strategic Assessment

Disclaimer: Due to a Non-Disclosure Agreement (NDA) with the Pet Food Biotechnology firm, all confidential information have been replaced with placeholder names and figures for research purposes only.

Pet Food Biotechnology Firm A was established on February, 2016, and operates in the field of research, manufacturing, and distribution of agricultural enhancement products using nano-biotechnology, that is fully chemical-free. The company's primary focus has been on the agritech sector, but it has recently diversified into the pet health product segment in response to rising global trends in pet wellness and animal care.

The firm holds three core patented technologies that are jointly implemented across its product lines. For the purpose of this study, the company has requested the valuation of these three IP assets as a bundled unit, citing their interdependence in actual application and value contribution.

To understand the company's current standing, its internal and external environment was assessed using SWOT Analysis, Porter's Five Forces, and PESTEL Analysis. A summary of the SWOT analysis is presented below:

Table 3: SWOT Analysis

| | |
|---|---|
| **Strengths** | • The company possesses a reasonably high production capacity<br>• Their unique, proprietary technologies are difficult to replicate.<br>• The R&D and innovations have received multiple international awards, all backed by patents.<br>• Continuous investment in innovation is supported by national government agencies. |
| **Weakness** | • Some products face delays in regulatory approval and certification processes.<br>• The company has a limited number of personnel in production and R&D functions.<br>• Being a small enterprise, it has low bargaining power with both customers and suppliers. |
| **Opportunity** | • Growing global demand for environmentally friendly (green) products and sustainable technologies.<br>• Rising awareness and market expansion in the health and wellness sector, both domestically and internationally. |
| **Threats** | • Presence of large, well-established competitors offering substitute |

| | |
|---|---|
| | products.<br>● Long-term impact of climate change may affect agricultural production and farmer purchasing power, which could reduce revenue in the agribusiness product segment. |

Table 4: Five Force Analysis

| Force | Impact Level | Explanation |
|---|---|---|
| Threat of New Entrants | High | The company is highly exposed to the threat of new entrants, particularly due to the growing popularity of green products and the pet humanization trend, which has attracted a large number of both local and international startups into the market. |
| Threat of Substitute Products | High | The company faces significant pressure from substitute products, as new research outputs and technologies emerge continuously, increasing the likelihood of more effective alternatives. In addition, traditional chemical-based agricultural inputs still dominate parts of the market. |
| Supplier Bargaining Power | Low | The company is relatively protected from supplier power because it sources raw materials from multiple suppliers, and these materials are not highly specialized. |

| | | |
|---|---|---|
| | | The company adds proprietary value through its own formulation and processing. |
| Customer Bargaining Power | Low (Pet Product Segment) High (Agricultural Product Segment) | In the pet care product segment, most customers are individual consumers with low negotiating power. However, in the agricultural segment, the company serves medium-to-large corporate clients, who exert significant influence on pricing and terms. |
| Industry Rivalry | High (Pet Product Segment) Low (Agricultural Product Segment) | Competition is intense in the pet product market due to a high number of competitors and product variety. In contrast, rivalry in the agricultural segment remains low, as few companies possess the specialized innovation capabilities required to compete. |

Table 5: PESTEL Analysis

| Factor | Impact Description |
|---|---|
| Political | The company is affected by policy instability and uncertainty in government R&D funding, which changes frequently with new administrations. - There is potential risk from international trade barriers or protectionist measures imposed by foreign governments. |
| Economic | Ongoing geopolitical conflicts and wars in various regions worldwide have disrupted both export channels and imports of raw materials, potentially affecting supply chains and leading to pricing pressures in the industry. |

| | |
|---|---|
| Social & Cultural | The company must respond to rapid changes in consumer behavior, especially rising expectations for sustainable, health-conscious, and cruelty-free products. |
| Technological | Global technological advancements are accelerating, which may reduce the useful life cycle of the company's existing innovations more quickly than anticipated. This puts pressure on continuous R&D efforts. |
| Environmental | The company benefits from increasing consumer and regulatory emphasis on green products, carbon credits, and organic product certifications, aligning well with its biotechnology-based, chemical-free solutions. |
| Legal | Legal uncertainty exists regarding plant-based raw materials that require special government permits (e.g., hemp), which may affect production flexibility and compliance costs. |

#### 4.1.2 Necessity of Fundraising

Pet Food Biotechnology Firm A has recently expanded into a new product line focused on pet health and wellness, a sector currently experiencing strong global growth. The company has also conducted customer satisfaction research to inform its strategic marketing initiatives. Based on this, the firm anticipates a significant increase in revenue generation over the next five years.

Despite its strong revenue potential, the company currently lacks sufficient investment in the necessary assets and infrastructure required to support and scale its operations in line with projected income levels. Furthermore, there has not yet been a formal financial assessment to determine the specific amount of capital shortfall. These factors underscore the company's urgent need to raise additional funding to capitalize on emerging opportunities and ensure sustainable growth.

## 4.2 Intellectual Property Valuation Model

#### 4.2.1 Method 1: Cost Approach

The model begins with a capital investment in laboratory tools and R&D materials totaling THB 2,000,000. Human capital costs were calculated based on a research team comprising three full-time researchers, each receiving a monthly salary of THB 40,000, over a research period of two years.

The total personnel cost was derived as follows: THB 40,000 × 3 researchers × 12 months × 2 years, amounting to THB 2,880,000. When combined with the capital cost of equipment and materials, the total investment for developing the three interconnected patents equals THB 4,880,000.

Table 6: Cost Approach: Historical Cost Method for IP valuation

| *Assumption* | *Value* |
|---|---|
| Material and Instrument Cost | THB 2.00 Millions |
| Researcher’s wage per month per person | THB 40,000 |
| Researchers usage per year | 3 people |
| Research and Development Period | 2 years |
| Total Labor Cost | THB 2.88 Millions |
| IP Value: Historical Cost | THB 4.88 Millions |

Subsequently, by incorporating the historical development cost of THB 4.88 million with an assumed risk-free interest rate of 2.65% (as reported in September 2024), which serves as the expected rate of return and the opportunity cost of capital, the resulting Replacement Cost is calculated at THB 5.14 million.

Table 7: Cost Approach: Replacement Cost Method for IP valuation

| *Assumption* | *Value* |
|---|---|
| Total Historical Cost | THB 4.88 Millions |
| Expected Rate of Return | 2.65% |
| IP Value: Replacement Cost | THB 5.14 Millions |

Although the Cost Approach offers a conservative estimate grounded in tangible historical expenditures, its application in this study was primarily intended for internal benchmarking. The result—calculated at THB 5.14 million based on a base cost of THB 4.88 million and adjusted using a 2.65% risk-free rate—was presented during an internal meeting between the research team and the executives of the Innovation-Driven Enterprise (IDE). During this session, the Cost Approach valuation was discussed alongside the outputs of the Market, Income, and Option Pricing Approaches, enabling the team to compare value ranges across different methodologies.

However, after strategic consideration of the firm's upcoming fundraising efforts and anticipated negotiations with venture capital (VC) investors, it was collectively agreed that the Cost Approach valuation would be retained for internal reference only. Due to its tendency to under-represent the commercial and growth potential of intellectual property—particularly in early or early-growth stage innovation-driven enterprise contexts—the method was deemed unsuitable for external presentation. Instead, the company opted to highlight only the more dynamic valuation methods in its investor communications, as these better reflect the future-oriented value creation potential expected by VC stakeholders.

Following the completion of the investment discussions, VC stakeholders informally expressed their perspective regarding the role of the Cost Approach in IP valuation. From their point of view, the Cost Approach retains practical relevance when the intellectual property is used for internal management or non-financing purposes. They noted that, in such contexts, the method's simplicity and reliance on observable development expenditures make it a useful baseline, particularly when more complex valuation inputs are unavailable or unnecessary.

It is important to note that the investors were not made aware of the actual valuation outcome derived from the Cost Approach during the negotiation process. Their comments instead reflect a general opinion formed after the deal had largely concluded, emphasizing that while the Cost Approach may not capture the full commercial or strategic value required for external fundraising, it still serves a valid function for internal benchmarking or accounting-based assessments of intellectual property.

### 4.2.2 Method 2: Market Approach

The Market Approach was applied using market multiples to estimate the value of the firm's intellectual property (IP). This model follows the recommendation of Damodaran (2012), which suggests aligning valuation multiples with the startup's life cycle stage. Given that the subject firm is classified as an innovation-driven biotechnology enterprise in the early growth phase, the selected multiple must reflect the financial characteristics typical of firms at this stage.

Startups in the early growth stage often begin generating consistent revenues but typically lack operational and working capital efficiency, resulting in negative net profits or EBITDA. As such, profitability-based multiples—such as the Price-to-Earnings (P/E) or Enterprise Value-to-EBITDA (EV/EBITDA) ratios—are often non-meaningful (nmf) or inapplicable for analysis. Therefore, the Price-to-Sales (P/S) ratio was deemed the most appropriate valuation multiple, given its ability to reflect top-line performance regardless of bottom-line volatility.

Based on projected IP-driven revenue of THB 9,600,000 for the following year and a weighted average P/S ratio of 2.80—from the calculated P/S ratio from the listed firms in the Stock Exchange of Thailand of the similar industry (data as of June 2024)—the estimated value of the IP under the Market Approach was derived. The final valuation, computed using the P/S multiple, is summarized in the table 8.

Table 8: Market Approach: Market Multiples using Price-to-Sales(P/S) ratio for IP valuation

| *Assumption* | *Value* |
|---|---|
| Fertilizer Sector P/S ratio [39] | 0.85x |
| Healthcare Product Sector P/S ratio [39] | 4.75x |
| Product 1: Agriculture Nutrients Revenue portion | 50% |
| Product 2: Pet Healthcare Revenue portion | 50% |
| Overall P/S Ratio | 2.80x |
| IP contribution in total revenue (year 1) | THB 9.6 Millions |
| IP Value: Market Multiples | THB 25.04 Millions |

Source: Stock Exchange of Thailand. (2024). Market data. Retrieved September 20, 2024, from https://www.set.or.th/

During the internal meeting between the research team and the executive team of the innovation-driven enterprise (IDE), the Market Approach was reviewed alongside the other three valuation methods. Based on the company's growth stage and revenue profile, this approach was deemed practically reliable and appropriate, particularly given its alignment with real-world transaction data and sector-specific sales benchmarks. The simplicity of the Price-to-Sales (P/S) ratio and its independence from profitability made it well-suited for early-stage enterprises where EBITDA or net income may not yet reflect the underlying economic value of the intellectual property.

The IDE and researchers reached a consensus that the Market Approach could serve as a primary valuation method, especially in tandem with the Income Approach, which also reflects forward-looking earning potential. Given that both approaches were grounded in reasonable assumptions and context-specific data, it was agreed that whichever approach yielded the higher valuation figure would be presented to potential investors, particularly to emphasize the upside potential of the IP assets during funding negotiations. This decision was made strategically, aiming to strike a balance between conservative valuation integrity and presenting the business in a favorable light.

**4.2.3 Method 3: Income Approach**

The Income Approach estimates the value of the intellectual property by assessing the future economic benefits it is expected to generate over its useful life. The valuation model in this study consists of three core components: the calculation of Free Cash Flow (FCF), the determination of the Weighted Average Cost of Capital (WACC), and the estimation of the asset's value using the Net Present Value (NPV) method. This approach is particularly well-suited for IP assets that serve as active revenue-generating components within the business model.

The FCF calculation begins with projected revenue derived specifically from the IP over a five-year forecast horizon, with Year 0 representing the current fiscal year. The useful economic life of the IP was assumed to be five years, based on researcher estimates and industry benchmarks. Cost structures were projected as follows: Cost of Goods Sold (COGS) at 40% of revenue, sales and marketing expenses at 10%, and general and administrative expenses (G&A) at 10% of revenue. EBITDA was then derived by deducting all forecasted operating costs from revenue.

To obtain FCF, planned capital expenditures—primarily the R&D investment previously assessed under the Replacement Cost Method—were subtracted from EBITDA. A detailed breakdown of the Revenue, Cost, and EBITDA projection is provided in Table 9 and the calculation of FCF is provided in Table 10.

Table 9: Income Approach: Revenue, Cost, and EBITDA projection for IP valuation

| *Assumption* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| Revenue Contributions (THB Millions) | - | 24.00 | 26.40 | 29.04 | 31.94 | 35.14 |
| COGS margins | 40% | 40% | 40% | 40% | 40% | 40% |
| COGS | - | 9.60 | 10.56 | 11.62 | 12.77 | 14.05 |
| Selling Expense margin | Initial launch | 10% | 10% | 10% | 10% | 10% |
| Selling Expense (THB Millions) | 2.40 | 2.40 | 2.64 | 2.90 | 3.19 | 3.51 |
| GA margin | Initial launch | 10% | 10% | 10% | 10% | 10% |
| GA (THB Millions) | 2.40 | 2.40 | 2.64 | 2.90 | 3.19 | 3.51 |
| EBITDA (THB Millions) | -4.80 | 14.40 | 15.84 | 17.42 | 19.16 | 21.08 |

Table 10: Income Approach: Calculation of FCF for IP valuation

| *Assumption* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| EBITDA (THB Millions) | -4.80 | 14.40 | 15.84 | 17.42 | 19.16 | 21.08 |
| Investments (THB Millions) | -5.14 | - | - | - | - | - |
| Free Cash Flow (FCF) (THB Millions) | -9.94 | 14.40 | 15.84 | 17.42 | 19.16 | 21.08 |

Once the Free Cash Flow (FCF) for each year had been projected, the next step was to determine an appropriate discount rate to apply in the Net Present Value (NPV) analysis. For this study, the Weighted Average Cost of Capital (WACC) was selected as the discount rate, as it reflects the blended cost of capital from both equity and debt sources used to finance the asset. WACC is considered a comprehensive measure of opportunity cost, accounting for the relative proportions and risks associated with each funding component.

The WACC model comprises two core components: the Cost of Equity and the Cost of Debt. The Cost of Equity was calculated using the Capital Asset Pricing Model (CAPM), which considers the risk-free rate, the market risk premium, and the company's beta coefficient. In this case, the risk-free rate was derived from the yield on 10-year Thai government zero-coupon bonds, reported at 2.65% by the Thai Bond Market Association (ThaiBMA) as of September 2024. The market risk premium was sourced from Statista, with a value of 4.96% during the same period.

of the company compared to the broader market. To ensure relevance, the beta value was estimated based on a group of publicly listed companies in the Stock Exchange of Thailand (SET) that operate in similar industries. This sector-specific data was used to compute an unlevered beta ($\beta_U$), which adjusts for differences in capital structure and provides a more accurate risk profile for early-stage firms like the subject company. The calculation of unlevered beta is provided in the following tables

Table 11: Income Approach: unlevered beta calculation for IP valuation

| *Stock Name: Listed Fertilizers and Agriculture Chemical firms* | $\beta_L$ | *Debt-to-Equity* | *Tax Rate* | $\beta_U$ |
|---|---|---|---|---|
| PATO | 0.07 | 0.22 | 20% | 0.06 |
| PMTA | 0.42 | 0.50 | 20% | 0.30 |
| JCKH | 2.01 | 2.47 | 20% | 0.68 |
| SWC | 0.15 | 0.66 | 20% | 0.10 |

Source: Stock Exchange of Thailand. (2024). Market data. Retrieved September 20, 2024, from https://www.set.or.th/

Table 12: Income Approach: unlevered beta calculation for IP valuation (continued)

| *Stock Name: Listed Pet food and Pet products firms* | $\beta_L$ | *Debt-to-Equity* | *Tax Rate* | $\beta_U$ |
|---|---|---|---|---|
| BID | 0.43 | 0.44 | 20% | 0.32 |
| AAI | 2.02 | 0.14 | 20% | 1.82 |
| ITC | 1.29 | 0.12 | 20% | 1.18 |

Source: Stock Exchange of Thailand. (2024). Market data. Retrieved September 20, 2024, from https://www.set.or.th/

Based on the unlevered beta ($\beta_U$) values estimated from comparable businesses across different product categories, the weighted average of the median unlevered betas was calculated. As presented in Tables 11 and 12, the resulting consolidated unlevered beta for the subject firm is 0.57. This value reflects the inherent business risk without the influence of capital structure and serves as the foundation for computing the levered beta that reflects the company's actual financial leverage.

To obtain the firm-specific levered beta ($\beta_L$), the following standard formula from Damodaran (2012) was applied:

$$\beta_{\text{Levered}} = \beta_{\text{Unlevered}} \times (1 + (1 - \text{Tax rate}) \times \text{Debt-to-Equity})$$

This adjustment incorporates the effect of the company’s capital structure, where D/E is the debt-to-equity ratio and the tax rate accounts for the benefit of interest expense deductibility. The calculation, detailed in Table 13, enables a more accurate estimation of the Cost of Equity under the firm's current financing structure and is used in the final WACC determination.

Table 13: Income Approach: levered beta calculation for IP valuation

| *Assumptions* | *Value* |
|---|---|
| This Company’s $\beta_U$ | 0.57 |
| This Company’s D/E ratio | 1.75 |
| This Company’s Tax Rate | 0%* |
| This Company’s $\beta_L$ | 1.14 |

*Note: the company currently has the full tax benefit and the loan interest subsidization from the Board of Investment Thailand (BOI) throughout the entire projection period.*

With all the required inputs established—including the risk-free rate, market risk premium, and levered beta—the variables were substituted into the Capital Asset Pricing Model (CAPM) to determine the firm's Cost of Equity. CAPM is a widely accepted framework in financial theory that estimates the expected return on equity based on systematic market risk (Sharpe, 1964). The full calculation using this model is presented in the table 14

Table 14: Income Approach: Cost of Equity calculation for IP valuation

| *Assumptions* | *Value* |
| --- | --- |
| This Company's $\beta_L$ | 1.14 |
| Market Risk Premium | 4.96% |
| Risk Free Rates | 2.65% |
| This Company's Cost of Equity | 8.30% |

For the Cost of Debt, interest rates for each debt instrument were extracted from the company's financial statement notes. These rates were then used to compute the weighted average cost of debt, reflecting the effective borrowing cost across all outstanding obligations. The full calculation and supporting data are summarized in Table 15.

Table 15: Income Approach: Cost of Debt Calculation for IP valuation

| *Assumptions* | | *Value* |
| --- | --- | --- |
| Bank Loan: Principal | | THB: 15 millions |
| Bank Loan: Interest rate | (MLR +2%) | 9.05% |
| Shareholders Loan: Principal | | THB 8 Millions |
| Shareholders Loan: Interest rate | | 2.00% |
| This Company's Cost of Debt | | 6.60% |

Once the Cost of Debt, tax rate, and Cost of Equity were determined, the Weighted Average Cost of Capital (WACC) was calculated by taking the weighted average of the after-tax Cost of Debt and the Cost of Equity. The weights were based on the proportion of market capitalization and total debt relative to the combined value of both components. This provides a comprehensive discount rate that reflects the firm's actual capital structure.

In the final step of the Discounted Cash Flow (DCF) method, the WACC was applied to discount projected Free Cash Flows in order to estimate the Net Present Value (NPV) of the IP asset. The complete WACC calculation is presented in Table 16, and the DCF valuation results are shown in Table 17.

Table 16: WACC Calculation for IP valuation

| *Assumptions* | *Value* |
|---|---|
| Cost of Debt | 6.6% |
| Tax Rate | 0% |
| After Tax Cost of Debt | 6.60% |
| Total Debt | THB 23 millions |
| Cost of Equity | 8.30% |
| Equity Value | THB 14 millions |
| WACC | 7.24% |

Table 17: Income Approach: DCF for IP valuation

| *Assumption* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| Free Cash Flow (FCF) (THB Millions) | -9.94 | 14.40 | 15.84 | 17.42 | 19.16 | 21.08 |
| Present Value (PV) of FCF (THB Millions) | -9.27 | 8.95 | 9.18 | 9.41 | 9.661 | 9.91 |
| Net Present Value (THB Millions) | 37.84 | | | | | |

Based on the results of the Income Approach, the Net Present Value (NPV) calculation indicated that the total value of the company's intellectual property (IP), under the stated assumptions, is estimated at THB 30,739,538.

During the internal meeting between the research team and the executive team of the Innovation-Driven Enterprise (IDE), the Income Approach was evaluated alongside the other three valuation methods. Similar to the Market Approach, this method was recognized as one of the two most reliable and contextually appropriate frameworks for valuing the company's intellectual property. The rationale for its selection was based on its ability to incorporate forward-looking financial projections, capture the earning potential of the IP, and reflect the time value of money through the use of a calculated discount rate.

The Income Approach was considered especially suitable for innovation-driven enterprises, as it directly links the value of the IP to its future contribution to cash flow generation. After reviewing the assumptions, financial structure, and projected revenues, the IDE and research team agreed that this approach offers a comprehensive and investor-relevant perspective. As a result, and in accordance with the previously agreed internal policy, the valuation method that produced the higher estimated value—in this case, the Income Approach with a result of THB 30.74 million—was selected as the primary valuation figure to be used in communications with potential venture capital investors.

#### 4.2.4 Method 4: Real Option Approach

For the Option Pricing valuation, the researcher employed two complementary methods: the Decision-Tree Method and the Binomial Lattice Method, presented by Brigham and Daves (2019). Both models were initiated using the same set of input data—namely, the three possible Net Present Value (NPV) outcomes previously calculated under the Discounted Cash Flow (DCF) method. These included a Base Case, a Best-Case Scenario, and a Worst-Case Scenario, all projected to occur within the following year.

The scenario probabilities were derived from a combination of researcher estimates and input from the company's executive team as well as industry-specific venture capital advisors. These experts noted the firm's high-growth potential within the biotech agribusiness sector. The assigned probabilities for each scenario are summarized in Table 18.

Table 18: IP valuation's Option Pricing Approach: NPV Scenario Analysis

| *Assumptions* | *Value* |
|---|---|
| NPV from DCF Method | THB 37.84 Millions |
| Chance of getting a Best Case | 40% |
| Multiplier Factor for a Best Case | 130% |
| Chance of getting a Base Case | 50% |
| Multiplier Factor for a Base Case | 100% |
| Chance of getting a Worst Case | 10% |
| Multiplier Factor for a Worst Case | 70% |

The scenario probabilities were derived from a combination of researcher estimates and input from the company's executive team as well as industry-specific venture capital advisors. These experts noted the firm's high-growth potential within the biotech agribusiness sector. The assigned probabilities for each scenario are summarized in Table 18.

Under the Decision Tree Analysis Method, The expected value of the IP was calculated by computing the weighted average (expected value) of the Net Present Value (NPV) outcomes, based on their assigned probabilities. This expected value (C) was then discounted using the discounting factor (R) derived from the firm's Weighted Average Cost of Capital (WACC), which was estimated at 7.24% over the relevant time horizon ($\Delta t$). The final result from the Decision Tree Method produced an IP valuation of THB 31,242,599, as shown in Table 19.

$$\text{IP Value} = \text{Expected Values of NPV Scenarios} \times (1+ \text{Discounted Rates})^\wedge(\Delta t)$$

$$\text{IP Value} = S \times (1+R)^\wedge(\Delta t)$$

Table 19: IP valuation's Option Pricing Approach: Decision Tree Analysis Method

| *Assumptions* | *Value* |
|---|---|
| NPV: Best Case | THB 49.20 Millions |
| NPV: Base Case | THB 37.84 Millions |

| | |
|---|---|
| NPV: Worst Case | THB 26.49 Millions |
| S: Expected Value ( NPV scenarios ) | THB 41.25 Millions |
| R: WACC | 7.24% |
| Δt: Time Period | 1 year |
| IP Value: Decision Tree Analysis | THB 38.46 Millions |

In applying the Binomial Lattice Method, the model follows the standard framework of Binomial Option Pricing Theory, which separates the initial investment from the present value of the underlying asset to avoid double counting. In this context, the present value of the underlying asset ($S_0$) was calculated as the sum of the IP valuation derived from the Income Approach (THB 30.74 million) and the replacement cost from the Cost Approach (THB 5.14 million), resulting in a total asset value of THB 35.88 million. The initial investment of THB 5.14 million was treated as the strike price (K), and the Weighted Average Cost of Capital (WACC) was used as the discount rate for the model.

Unlike the Decision Tree method, which directly evaluates discrete NPV scenarios, the Binomial Lattice approach begins by calculating the standard deviation (σ) of the projected NPV to reflect the uncertainty associated with the asset's value. From this, the upward (u) and downward (d) movement factors are derived, along with the projected asset values in each state ($V_u$ and $V_d$). These values are then used to compute the option value of the IP using the Binomial Option Pricing formula, as outlined in Damodaran (2012).

$$u = EXP(\sigma \times \sqrt{\Delta t}\,),\ \ d = 1/u$$

$$V_u = Max((S_0 \times u) - K, 0),\ \ V_d = Max((S_0 \times d) - K, 0)$$

$$\text{Asset Value} = EXP(-R \times \Delta t) \times [\ (\tfrac{EXP(R \times \Delta t) - d}{u-d}) \times V_u + (1 - \tfrac{EXP(R \times \Delta t) - d}{u-d}) \times V_d]$$

Table 20: IP valuation's Option Pricing Approach: Binomial Lattice Method

| *Assumptions* | *Value* |
|---|---|
| $S_0$: Current Underlying Asset Value | THB 42.88 Millions |
| Δt: Time Period | 1 year |
| K: Strike Price | THB 5.14 Millions |
| σ: Standard Deviation of Underlying Asset Values | 17.62% |

| | |
|---|---|
| R: Discounts Rate | 7.24% |
| u | 1.473 |
| d | 0.703 |
| $V_u$ | THB 56.01 Millions |
| $V_d$ | THB 25.08 Millions |
| IP Value: Binomial Lattice Method | THB 38.03 Millions |

During the internal meeting between the research team and the IDE executive team, the Option Pricing Method was reviewed in parallel with the other valuation approaches. While both the Decision Tree and Binomial Lattice models offered advanced analytical depth and reflected the strategic flexibility embedded in the company's innovation activities, concerns were raised regarding the subjectivity of the risk-related inputs, particularly the assignment of probability weights and volatility estimates. These parameters, while grounded in industry expertise and financial modeling standards, were perceived as potentially difficult to defend in high-stakes investor negotiations.

As a result, and following a similar rationale to that applied to the Cost Approach, the Option Pricing results were ultimately retained for internal benchmarking purposes only. The team agreed that introducing valuation outputs based on assumptions open to interpretation could invite unnecessary debate or negotiation friction. Thus, although recognized as valuable from a theoretical and strategic standpoint, this method was excluded from the set of valuation figures formally presented to venture capital investors.

## 4.3 Firm Valuation Model

Disclaimer: Due to a Non-Disclosure Agreement (NDA) with the Pet Food Biotechnology firm, all confidential information have been replaced with placeholder names and figures for research purposes only.

### 4.3.1 Method 1: Income Approach – Free Cash Flow to the Firm (FCFF)

The firm valuation model using the Income Approach is based on the same core assumptions applied in the valuation of intellectual property (IP) under the Income Approach. Specifically, the discount rate used in this model is the Weighted Average Cost of Capital (WACC), consistent with the calculation presented in Section 4.2.2. This rate serves as the key input for discounting the firm's projected Free Cash Flow to the Firm (FCFF). The detailed WACC calculation is presented in Table 21.

Table 21: Firm valuation's Income Approach: Discount Rate Assumption

| *Assumptions* | *Value* |
|---|---|
| Cost of Debt | 6.6% |
| Cost of Equity | 8.3% |
| Book Value of Debt | THB 23 Millions |
| Book Value of Equity | THB 14 Millions |
| WACC | 7.24% |

The next step involved projecting the company's revenue, cost structure, and net profit (net income) over a five-year forecast period. These projections form the foundation for estimating future free cash flows, which are then discounted using WACC to determine the firm's enterprise value. The full financial forecast assumptions are summarized in Table 22.

Table 22: Company's Financial Projection

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| Total Revenue | 8.03 | 12.25 | 23.88 | 28.65 | 34.38 | 41.26 |
| COGS | 3.85 | 4.00 | 9.55 | 11.46 | 13.75 | 16.50 |
| Gross Profit | 4.19 | 8.25 | 14.33 | 17.19 | 20.63 | 24.75 |
| Selling Expense | 4.21 | 4.29 | 4.38 | 4.46 | 4.55 | 4.64 |
| GA | 2.40 | 2.40 | 2.64 | 2.90 | 3.19 | 3.51 |
| Depreciation | 0.49 | 0.96 | 1.15 | 1.38 | 1.65 | 1.98 |
| EBIT | 0.49 | 0.96 | 1.15 | 1.38 | 1.65 | 1.98 |
| Interest Cost | 0.51 | 0.80 | 0.54 | 0.48 | 0.32 | 0.16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Income Tax | 0.25 | 1.29 | 1.85 | 2.48 | 3.26 | 4.19 |
| Net Income | 1.00 | 5.16 | 7.41 | 9.92 | 13.03 | 16.75 |

Once the net profit projections were established, the next step was to calculate Free Cash Flow, which serves as the basis for the NPV estimation in the firm valuation. In this study, the researcher applied the Free Cash Flow to the Firm (FCFF) method, as outlined by Damodaran (2012). The FCFF model consists of three primary components: Net Profit After Tax (NPAT), Net Working Capital (NWC), and Net Capital Expenditures (Net CAPEX). The process begins by adjusting net profit by subtracting after-tax interest expenses, resulting in NPAT. The detailed calculation of this component is presented in Table 23.

Table 23: Firm valuation's Income Approach: NPAT Calculation

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| Total Revenue | 1.00 | 5.00 | 7.30 | 9.82 | 12.96 | 16.72 |
| Interest Cost | -0.51 | -0.80 | -0.54 | -0.48 | -0.32 | -0.16 |
| Tax Rate | 20% | 20% | 20% | 20% | 20% | 20% |
| NPAT | 1.41 | 5.64 | 7.73 | 10.21 | 13.22 | 16.84 |

The Net Working Capital (NWC) component was derived by projecting operating assets and liabilities, based on ratios linked to either cost or revenue growth. Specifically, Accounts Payable (AP) was estimated relative to cost structures, while Accounts Receivable (AR) and Inventories were projected in proportion to revenue. These projections reflect the working capital required to support ongoing operations.

For Net Capital Expenditure (Net CAPEX), the calculation followed the standard approach of subtracting depreciation from the gross capital expenditure on fixed assets, in accordance with the framework proposed by Damodaran (2012). The complete equations and assumptions used in the calculation are provided in Table 24 and Table 25.

$$FCFF = NPAT - \Delta NWC - NetCAPEX$$

$$NPAT = NetProfit - Interest * (1 - TaxRate)$$

$$NWC = AR + Inventories - AP$$

$$\text{Net CAPEX} = \text{CAPEX} - \text{Depreciation}$$

Table 24: Firm valuation’s Income Approach: ΔNWC Calculation

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| Account Recievable | 18.00 | 2.57 | 3.08 | 3.69 | 4.43 | 5.32 |
| Inventories | 0.90 | 23.88 | 28.65 | 34.38 | 41.26 | 49.51 |
| Account Payables | 1.60 | 0.96 | 1.15 | 6.19 | 8.86 | 11.79 |
| NWC | 17.30 | 25.49 | 30.58 | 31.88 | 36.84 | 43.03 |
| ΔNWC | 4.50 | 8.19 | 5.10 | 1.30 | 4.95 | 6.20 |

Table 25: Firm valuation’s Income Approach: Net CAPEX Calculation

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| CAPEX | 7.00 | 2.40 | 2.88 | 3.46 | 4.15 | 4.98 |
| Depreciation | 0.49 | 0.96 | 1.15 | 1.38 | 1.65 | 1.98 |
| Net CAPEX | 6.51 | 1.44 | 1.73 | 2.08 | 2.50 | 3.00 |

With all three components—NPAT, Net Working Capital (NWC), and Net Capital Expenditure (Net CAPEX)—determined, the Free Cash Flow to the Firm (FCFF) was calculated and used to estimate the firm’s value via the Net Present Value (NPV) method. The valuation included a Terminal Value projection, which was estimated using the Constant Growth Model, assuming long-term economic growth based on Thailand’s inflation outlook (NESDC, 2024) and GDP growth forecast (Bank of Thailand, 2024), in line with the method proposed by Damodaran (2012).

The Terminal Value was derived by projecting FCFF in Year 6, then discounting it alongside the forecasted cash flows to present value. This calculation reflects the enterprise value under a going-concern assumption, and the detailed computation is shown in Table 26, Table 27, and Table 28.

$$\text{Sustainable Growth Rate (SGR)} = \text{GDP Growth} + \text{Inflation}$$

$$\text{Terminal Value of FCFF} = \frac{\text{FCFF}_n * (1 + \text{SGR})}{\text{WACC} - \text{SGR}}$$

Table 26: Firm valuation's Income Approach: FCFF Calculation

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|---|
| NPAT | 1.41 | 5.64 | 7.73 | 10.21 | 13.22 | 16.84 |
| ΔNWC | 4.50 | 8.19 | 5.10 | 1.30 | 4.95 | 6.20 |
| Net CAPEX | 6.51 | 1.44 | 1.73 | 2.08 | 2.50 | 3.00 |
| FCFF | -9.60 | -3.99 | 0.90 | 6.83 | 5.77 | 7.65 |

Table 27: Firm valuation's Income Approach: Terminal Value Calculation

| *Assumption (THB Millions)* | *Value* |
|---|---|
| FCFF at Year 5 | 7.65 |
| Averaged GDP Growth (Data as of Sep. 2024) | 2.20% |
| Averaged Inflation Rate (Data as of Sep. 2024) | 1.64% |
| Sustainable growth Rate (SGR) | 3.84% |
| Terminal Value | 230.07 |

Source: Bank of Thailand. (2024), Office of the National Economic and Social Development Council (NESDC). (2024).

Table 28: Firm valuation's Income Approach: Discounted Cash Flow of FCFF

| *Assumption (THB Millions)* | *Year 0* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* | *Year 6* |
|---|---|---|---|---|---|---|---|
| FCFF | -9.60 | -3.99 | 0.90 | 6.83 | 5.77 | 7.65 | 230.07 |
| Present Value of FCFF | -9.60 | -3.76 | 0.72 | 5.48 | 4.30 | 5.32 | 151.22 |
| Net Present Value | 163.27 | | | | | | |

The results of the firm valuation using the Income Approach revealed that the company's estimated value, calculated through the Net Present Value (NPV) of projected FCFF, is approximately THB 163.27 million, based on the assumptions and methodology described above.

During internal discussions between the research team and the IDE executive team, it was acknowledged that as the company advances, it is expected to continuously develop new and more sophisticated technologies, potentially rendering earlier innovations obsolete. In this context, the process of identifying, isolating, and valuing each individual technology or patent could become increasingly resource-intensive. Furthermore, since the IDE currently has no plans to license its proprietary technologies externally, the necessity for standalone IP valuation on a recurring basis was considered operationally impractical.

Consequently, both the researchers and the IDE team agreed to adopt the firm-level valuation as the preferred metric, as it more holistically reflects the value of the business model—which inherently incorporates the firm's technology portfolio. Consistent with previous decisions, the two most reliable approaches were identified as the Income Approach (DCF) and the Market Multiples Method, and the higher valuation figure—in this case, the Income Approach—was selected for use in strategic planning and investor engagement.

**4.3.2 Method 2: Market Approach – Market Multiples**

This model builds upon the same assumptions used in the Market Approach for IP valuation, specifically the use of peer group data from publicly listed companies operating in business sectors comparable to the Biotechnology IDE firm. The analysis involves selecting relevant market multiples from these comparable firms (peers), as shown in Tables 29 and 30

Table 29: Biotechnology Firm's Peers Company

| *Stock Name: Listed Fertilizers and Agriculture Chemical firms* | β | *D/E* | *Tax Rate* | *P/E* | $\frac{EV}{EBITDA}$ | *P/S* |
|---|---|---|---|---|---|---|
| PATO | 0.07 | 0.22 | 20% | 16.69 | 12.69 | 2.19 |
| PMTA | 0.42 | 0.50 | 20% | 8.72 | 4.53 | 0.23 |
| JCKH | 2.01 | 2.47 | 20% | nmf | 20.25 | 0.57 |
| SWC | 0.15 | 0.66 | 20% | 30.52 | 11.76 | 1.09 |

Source: Stock Exchange of Thailand. (2024). Market data. Retrieved September 20, 2024, from https://www.set.or.th/

Table 30: Biotechnology Firm's Peers Company (continued)

| *Stock Name: Listed Pet Food and Pet Healthcare Product Manufacturers* | β | *D/E* | *Tax Rate* | *P/E* | $\frac{EV}{EBITDA}$ | *P/S* |
|---|---|---|---|---|---|---|
| BID | 0.07 | 0.22 | 20% | 17.07 | 13.95 | 0.40 |
| AAI | 0.42 | 0.50 | 20% | 22.68 | 14.89 | 2.26 |
| ITC | 2.01 | 2.47 | 20% | 23.76 | 21.27 | 3.93 |

Source: Stock Exchange of Thailand. (2024). Market data. Retrieved September 20, 2024, from https://www.set.or.th/

The valuation multiples selected for this market-based firm valuation, following the Benchmarking Method outlined by Damodaran (2012), include the Price-to-Earnings (P/E) ratio, the Enterprise Value-to-EBITDA (EV/EBITDA) ratio, and the Price-to-Sales (P/S) ratio. These multiples were sourced from comparable publicly listed companies and applied in reverse to derive the estimated firm value.

The process began by calculating the company's Earnings Per Share (EPS), which was then multiplied by the sector-average P/E ratio to estimate the firm's equity value. Next, the EBITDA figure from the previously constructed DCF model was used alongside the EV/EBITDA multiple to calculate the enterprise value. Finally, the projected revenue from the DCF model was applied in conjunction with the P/S ratio to yield an alternative estimate of equity value. The relevant equations and calculation results are detailed in Tables 31, 32, and 33.

$$\mathrm{P/E} = \frac{\text{Share Price}}{\text{EPS}} = \frac{\text{Market Value of Equity}}{\text{Net Profit}}$$

$$\text{Equity Value} = \text{EPS} * \mathrm{P/E} * \text{No. of shares} = \text{Net Profit} * \mathrm{P/E}$$

$$\mathrm{EV/EBITDA} = \frac{\text{Enterprise Value: EV}}{\text{EBITDA}}$$

$$\text{Enterprise Value} = \text{EBITDA} * \mathrm{EV/EBITDA}$$

$$\mathrm{P/S} = \frac{\text{Market Value of Equity}}{\text{Revenue}}$$

$$\text{Equity Value} = \text{Revenue} * \text{P/S}$$

Table 31: Firm valuation's Market Multiple Method using Price-to-Earning(P/E) ratio

| *Assumptions (THB Millions)* | *Value* |
|---|---|
| Net Profit at Year 1 | 5.00 |
| Median Value of Peers Company's P/E ratio | 19.875 |
| Equity Value | 99.30 |

Table 32: Firm valuation's Market Multiple Method using EV/EBITDA ratio

| *Assumptions (THB Millions)* | *Value* |
|---|---|
| EBITDA at Year 1 | 8.20 |
| Median Value of Peers Company's EV/EBITDA ratio | 14.42 |
| Enterprise Value | 118.25 |

Table 33: Firm valuation's Market Multiple Method using Price-to-Sales(P/S) ratio

| *Assumptions (THB Millions)* | *Value* |
|---|---|
| Revenue at Year 1 | 23.88 |
| Median Value of Peers Company's P/S ratio | 1.099 |
| Equity Value | 26.24 |

During internal discussions between the research team and the executive team of the IDE, the Market Multiples method was acknowledged as a reliable and appropriate valuation approach for the firm. Its strength lies in its alignment with real-world market benchmarks derived from comparable publicly listed companies, which made it particularly useful for cross-validating the enterprise's estimated worth. Given its simplicity, transparency, and relevance for investor communication, the Market Approach was considered one of the two most credible valuation frameworks, alongside the Discounted Cash Flow (DCF) method.

Following the same decision-making criteria adopted in previous stages, both the research and executive teams agreed to use the valuation result with the higher estimated value for presentation to prospective venture capital (VC) investors. Between the two reliable methods—DCF and Market Multiples—the Income Approach (DCF) yielded a higher firm valuation figure and was therefore selected as the primary value to be communicated externally. The Market Multiples result, while supportive and consistent, was retained for internal benchmarking and validation purposes.

## 4.4 Summary

Based on the comprehensive analysis conducted in this study, both the intellectual property (IP) and the firm as a whole were valued using multiple established methodologies. The objective was to determine a range of values derived from each approach to support strategic decision-making and investor communication.

The summary of the results from each IP valuation method is presented in Table 34, while the final outcomes of the firm-level valuation methods are shown in Table 35. These tables reflect the respective values derived from the Cost Approach, Market Approach, Income Approach, and Real Option Approach for the IP, as well as from the DCF and Market Multiples methods for the firm. These results were used collaboratively by the researchers and the IDE management team to select the most credible and strategic values for presentation to potential investors.

Table 34: IP Valuation Results

| *Valuation Methods* | *Value (THB Millions)* |
|---|---|
| Cost Approach: Historical Cost Method | 4.88 |
| Cost Approach: Replacement Cost Method | 5.14 |
| Market Approach: Market Multiples using P/S Ratio | 25.04 |
| Income Approach: Free Cash Flow Discounted Cash Flow Method | 30.74 |
| Real Options Approach: Decision Tree Analysis Method | 31.24 |
| Real Options Approach: Binomial Lattice Method | 31.09 |

Table 35: Firm Valuation Results

| *Valuation Methods* | *Value (THB Millions)* |
|---|---|
| Market Approach: Market Multiples using P/E Ratio | 99.30 |
| Market Approach: Market Multiples using EV/EBITDA Ratio | 118.25 |
| Market Approach: Market Multiples using P/S Ratio | 26.24 |
| Income Approach: FCFF Discounted Cash Flow Method | 163.27 |

Accordingly, the valuation results for the company's intellectual property (IP) range from THB 4.88 million, as estimated using the Historical Cost Method, to THB 31.24 million based on the Decision Tree Analysis under the Real Options Pricing Method.

For the overall enterprise valuation, the results span from THB 26.24 million, derived from the Market Multiples Method using the Price-to-Sales (P/S) Ratio, to a maximum of THB 163.27 million, estimated using the Free Cash Flow to the Firm (FCFF) Discounted Cash Flow Method.

# CHAPTER 5
# DISCUSSION AND CONCLUSION

## 5.1 Application of the Valuation Model in the Investment Process

The valuation model developed in this research was ultimately put to use in a real-world fundraising context, following the completion of financial modeling and internal alignment between the IDE management team and the researchers. The process began after the IDE team successfully generated interest from venture capital (VC) investors by presenting a compelling narrative of their current business model and future growth potential. The investors had already reviewed the capital requirement and use-of-funds breakdown—including working capital buffers, the clearing of existing shareholder loans, and the acquisition of additional innovation assets. What remained was to validate these requests through a defensible financial valuation.

To support the funding justification, the team selected the Income Approach using the Free Cash Flow to the Firm (FCFF) method as the primary valuation model to present. This choice aligned with the team's strategic direction, as the firm-level FCFF model inherently captured the business model’s integrated value and long-term economic outlook. The valuation outcome was intended not only to estimate the company’s fair market value but also to substantiate the scale and structure of the capital being requested.

When the valuation results were reviewed by the VCs, it is worth noting that no disputes were raised regarding the methodology selected. Instead, the discussions shifted immediately to the assumptions underlying the inputs, such as the projected revenue growth rate, cost structures, and discount rate components—particularly the Cost of Equity, Cost of Debt, WACC, and Sustainable Growth Rate (SGR). This indicated a strong level of implicit trust in the valuation method itself, especially given that it mirrored the tools and logic commonly used in the VC industry.

As negotiations unfolded, both sides engaged in iterative adjustments of key variables. The VC team presented alternative scenarios with more conservative assumptions, particularly in the risk-related inputs, while the IDE team defended its projections based on historical performance and forward-looking plans. Ultimately, the two parties reached a consensus by agreeing to adopt midpoint values between the IDE team's original inputs and the VCs' proposed revisions. This compromise valuation was then used as the basis for contract formation and equity structuring in the investment deal.

## 5.2 Implications for IDE Valuation in Thailand's Agritech Sector

Following the conclusion of the investment deal, post-negotiation feedback was gathered from the VC representatives to gain further insight into their perspectives on the valuation approaches typically used in early-stage, innovation-driven enterprises (IDEs). Although only the firm-level valuation using the Income Approach was formally presented during negotiations, the investors were later asked to reflect on the conceptual strengths, practical usability, and limitations of the other valuation methods explored in this research. Their responses offer important context on how different valuation techniques are perceived in actual deal-making environments—particularly in the context of agritech startups in emerging markets like Thailand. The following subsections summarize the investors' general views on each valuation approach as applied in this study.

### 5.2.1 Discussion on Intellectual Property Valuation Methods

5.2.1.1 Valuation of IP Using the Cost Approach

Among the four methods applied, the Cost Approach produced the lowest IP valuation, which aligns closely with established valuation theory. This method calculates value based solely on the historical or replacement cost of creating the IP, without capturing its potential to generate future income or strategic advantage. As such, it reflects the financial investment incurred, rather than the economic value of the asset.

From the perspective of the venture capitalist (VC) investors interviewed, the Cost Approach still holds practical utility in certain contexts—particularly when the IP is not intended to be monetized directly. Examples include internal accounting, intra-group technology transfers, or legal documentation purposes where simplicity and auditability are prioritized over strategic valuation. In these cases, the ability to assign a conservative, objective value based on verifiable costs is considered adequate and even preferable, despite its inherent limitations in reflecting the asset's full commercial potential.

5.2.1.2 Valuation of IP Using the Market Approach

Although the Market Approach produced a relatively modest valuation compared to other methods, it remains one of the most trusted and widely accepted approaches among practitioners and investors. This credibility stems primarily from the reduced burden of proof placed on the IP holder when seeking investment. Unlike income- or option-based methods, the Market Approach requires fewer assumptions or speculative inputs to justify the asset's value.

This method tends to gain greater investor confidence when the IP or the associated business is still in its early stages, where key variables such as future income potential, business risk, and market opportunity lack robust supporting data. In such cases, venture capital (VC) investors often find it difficult to rely on projections with high uncertainty. The Market Approach mitigates this concern by grounding the valuation in actual market data from comparable businesses, offering a more objective, industry-relevant reference point. As such, it serves as a practical bridge between theoretical valuation and real-world investor expectations, particularly for early-stage IP commercialization.

5.2.1.3 Valuation of IP Using the Income Approach

The Income Approach is widely regarded as the most credible and comprehensive method among all IP valuation techniques. Its strength lies in its ability to reflect critical value-driving factors, including the IP's future income-generating potential, required investment, and the cost of capital expected by investors.

This method enables stakeholders to evaluate the viability of an IP asset through the lens of projected cash flows and intrinsic economic value. However, its primary limitation is the burden of proof it places on the IP owner, who must justify every major input—making it more suitable for startups with an established operational foundation rather than for early-stage technologies lacking reliable financial data.

Another major advantage of the Income Approach is its suitability for sensitivity analysis, which allows users to adjust variables and test the robustness of the business model. This is particularly valuable in evaluating project-specific risks, such as variations in capital expenditures, growth rates, or market volatility. By modeling different scenarios, stakeholders can better understand how unexpected events—such as economic downturns or structural industry changes—might impact IP value.

Despite its realism, the Income Approach is also data-intensive and assumption-sensitive. If revenue forecasts or cost structures lack credibility, the resulting valuation may be significantly over- or under-stated. Moreover, the model's complexity can introduce risks of misinterpretation if insufficient data is available. Nevertheless, when applied to ventures with a demonstrable financial track record and investor-aligned inputs, the Income Approach is considered the most reliable method for IP valuation, especially in capital-raising contexts.

5.2.1.4 Valuation of IP Using the Real Options Approach

Although the Real Options Approach produced the highest valuation of the intellectual property (IP) among the four methods applied, its credibility and practical applicability were perceived as more limited than the Income and Market Approaches—particularly from the perspective of venture capital (VC) investors. The primary concern lies in the method's dependence on additional variables, such as scenario analysis probabilities and growth factor estimations, which are inherently difficult to forecast and even more challenging to validate in investor discussions. Due to the complexity of the models and the limited number of practitioners capable of executing them correctly, VCs often expressed skepticism toward this method's reliability in early-stage startup settings.

As a result, the use of Real Options valuation tends to be restricted to simpler models, such as Decision Tree Analysis, which are easier to understand and more transparent in their computational logic compared to advanced models like the Binomial Lattice or Black-Scholes frameworks. Furthermore, this approach appears more suitable for certain industries or specific business contexts where key variables can be estimated with greater accuracy. Examples include early-stage pharmaceutical product launches or government-contract-driven ventures (B2G), where revenue streams and costs are more predictable than in general market-facing businesses.

In practical terms, Real Options models are rarely used to determine a precise IP value for pricing or funding purposes. Instead, they are more often employed during the contract negotiation stage, serving as tools to define the valuation boundaries—i.e., best- and worst-case scenarios—to help manage investment risk. In this light, the Real Options Approach functions more as a risk analysis and strategic planning tool than as a primary valuation technique. While it adds value to the negotiation and structuring process, its role in core valuation remains secondary and highly context-dependent.

In summary, all four IP valuation approaches—Cost, Market, Income, and Real Options—offer valid frameworks depending on the stage of business, data availability, and the purpose of valuation. Each method provides different insights into the value of intellectual property, and when used appropriately, they can support investment decision-making effectively.

However, their practical relevance is strongly influenced by the IDE's strategic objective. If the intention is to license the IP to third parties, presenting each method individually to establish the standalone value of each asset is entirely reasonable. On the other hand, when the IDE aims to attract strategic partners or new equity stakeholders, investors are less interested in the isolated value of each IP and more focused on the integrated revenue-generating potential of the IP portfolio as a whole. In such cases, IP valuation serves best when framed as a component of a broader, cohesive business model rather than as independent technical assets.

### 5.2.2 Discussion on Firm Valuation Methods

5.2.2.1 Firm Valuation Using the Cost Approach

While the Cost Approach can be applied in certain valuation contexts, it was intentionally excluded from the core valuation model in this study due to several critical limitations—particularly in relation to its compatibility with the venture capital (VC) investment landscape.

In VC settings, the standard valuation focus is placed on forward-looking measures such as terminal value and projected cash flows, rather than retrospective cost-based metrics. As such, the Cost Approach is often viewed as less relevant in early-stage investment decision-making.

This method is typically more appropriate for mature businesses with stable operations, where cost structures are well-documented and verifiable, such as publicly listed companies or enterprises with established financial control systems. In contrast, startups often lack consistent cost records, face high variability in operational models, and undergo frequent changes—making cost-based valuations resource-intensive and time-consuming.

The challenge becomes even more pronounced when intellectual property (IP) is involved, as cost-based valuation requires ongoing revaluation to reflect dynamic R&D expenditures and may fail to capture the true economic value or future earning potential of the IP.

For these reasons, valuation methods favored by VC investors—such as the Discounted Cash Flow (DCF) or Market Multiples Approach—emphasize revenue potential, risk-adjusted returns, and scalability, rather than historical expenditures. This further reinforces the limited practical utility of the Cost Approach in the valuation of innovation-driven enterprises (IDEs), particularly in high-growth sectors like agritech.

5.2.2.2 Firm Valuation Using the Market Approach

The Market Approach is another widely accepted method for firm valuation, particularly relevant for innovation-driven enterprises (IDEs) and startups. In these contexts, firm value is not solely determined by historical costs or financial statements but instead reflects the price investors are willing to pay when comparing the subject company to similar businesses in the market. This method is considered the second most credible approach after the Discounted Cash Flow (DCF) method and is often used alongside it—particularly when valuing a company’s intellectual property.

However, in real-world negotiation scenarios, the application of the Market Approach does not imply rigid adherence to financial modeling. Both investors and founders often introduce qualitative or strategic factors beyond numerical valuations to influence the final deal. These may include special privileges, business synergies, exclusive rights, or other forms of strategic value that enhance the perceived worth of the deal beyond the baseline valuation provided by market multiples.

Therefore, while the Market Approach provides a valuable benchmark for setting valuation expectations, the final investment decision is still heavily shaped by negotiated terms and mutual perceptions of strategic value. As a result, the agreed firm valuation in startup transactions may vary considerably from the model-derived value, underscoring the inherently subjective nature of early-stage investment valuation.

5.2.2.3 Firm Valuation Using the Income Approach

The Income Approach is considered the most credible method for firm valuation, much like its use in intellectual property (IP) valuation. This approach is based on the projection of future cash flows and returns that the business is expected to generate, enabling investors to derive a fair and economically justified valuation—as long as the underlying assumptions and input factors are reliable and verifiable.

From the perspective of venture capital (VC) investors, the application of the Income Approach—especially when integrated with IP valuation—can partially reflect the innovative capacity of a business. By analyzing the proportion of revenues generated from intellectual property or proprietary technologies, investors can infer how effectively a startup's innovations contribute to its competitive advantage. A higher share of revenue derived from IP is often seen as a strong indicator of genuine technological differentiation and commercial potential.

VCs are also mindful that startups inherently bear greater risks than listed companies operating within the same industry. This is to be expected, as public companies typically have well-established operating histories and lower structural risks. Consequently, VCs apply adjusted valuation parameters when using Discounted Cash Flow (DCF) models for startups. These include double-digit discount rates (WACC), higher costs of debt, and costs of equity that may reach up to 20%, reflecting the elevated risk profile of early-stage firms.

In conclusion, while the Income Approach provides the most theoretically accurate valuation, its practical application in startup valuation requires careful parameter adjustments to reflect each firm's specific risk level. The use of industry-accepted VC standards ensures that the valuation outcomes are both realistic and aligned with the startup's true growth potential.

5.2.2.4 Firm Valuation Using the Real Options Approach

The Real Options Approach represents an alternative method for valuing innovative firms. However, similar to the Cost Approach, this research has chosen not to incorporate it as part of the core valuation model due to practical limitations—especially those related to data availability and complexity. These limitations are consistent with those encountered in the valuation of intellectual property (IP) under this method.

A major constraint to adopting the Real Options Approach for firm-level valuation lies in the difficulty of estimating probabilities for various scenarios and decision pathways. While projecting possible outcomes for a single innovation is already challenging, evaluating an entire firm—typically consisting of multiple products, services, and rapidly evolving strategies—adds significant complexity.

As such, this method is generally not feasible as a standard approach for valuing startups, particularly those in early stages with high uncertainty and limited historical performance data.

Nonetheless, the Real Options framework remains applicable in specific contexts. One notable example is its use in structuring investment contracts through decision tree frameworks, similar to its application in IP valuation. This allows stakeholders to define value boundaries in advance—such as upper and lower limits—based on agreed conditions. By doing so, both investors and founders can proactively mitigate uncertainty and maintain flexibility to adjust strategies in response to future developments.

From the venture capital (VC) perspective, real-world negotiations often do not rely on a single valuation methodology across all branches of a decision tree. Each party may apply the method that best serves their objectives—for example, VCs may use the Income Approach to estimate future cash flows, while founders may rely on market growth projections as a basis for initial value estimates. Ultimately, the agreed valuation is often shaped more by strategic negotiation than by a purely financial model.

In summary, while the Real Options Approach is theoretically appealing, its practical application tends to be niche and auxiliary—primarily used to inform contract structuring and investment decision-making frameworks, rather than to serve as a central method for firm valuation. This is especially true in the case of startups, where high uncertainty and a multitude of interacting variables render the method less suitable for core valuation purposes.

## 5.3 Comparison with Related Studies

The findings from this research align with several prior studies but also reveal some important contextual deviations, particularly in the application of valuation models in Thailand's Agritech IDE sector. For example, Rasmussen & Lindberg (2020) and Muchtar et al. (2023) highlighted the reliability of Discounted Cash Flow (DCF) and Market Multiples methods in assessing firm and technology value, particularly when financial and market data are sufficiently available. In the present study, these two approaches were also selected as the most appropriate models for both intellectual property (IP) and firm valuation, further reinforcing their generalizability.

However, when compared with studies like Vetsch (2021) and Samuel et al. (2018), which promoted the use of Real Option valuation methods in early-stage and high-risk innovation-driven startups, this research diverges. Despite testing Real Options methods such as Decision Tree and Binomial Lattice, the findings revealed that the high contextual uncertainty in government support policy, along with investor discomfort with probabilistic assumptions, rendered these methods less practical. Thus, while Real Options provided the highest theoretical valuation, their credibility and relevance were challenged in the negotiation context.

Furthermore, the IP-specific cost approach findings in this study reflected similar insights as reported by Kellogg & Charnes (2000), where historical or replacement costs often undervalued technology assets compared to income-based or option-based approaches. However, in this research, investors acknowledged the practicality of cost-based valuations only for non-financial or internal purposes, aligning with Ramírez-Atehortúa et al. (2022), who noted the context-dependent utility of simpler models.

Lastly, the research confirms that while global studies emphasize methodological sophistication, local context, data reliability, and investor expectations remain critical factors in determining which valuation methods are ultimately used in practice. This insight is particularly crucial for emerging markets like Thailand, where policy volatility and limited access to comparable market transactions influence the feasibility and acceptance of each valuation approach.

Table 36: Comparisons with the Related Studies

| Valuation Approach | Key Findings in This Study | Related Studies with Similar Findings | Related Studies with Different Findings |
|---|---|---|---|
| Income Approach | Gives the most balanced and trusted result when supported by solid forecast data. | Muchtar et al. (2023); Rasmussen & Lindberg (2020); Kellogg & Charnes (2000) | Vetsch (2021) and Samuel et al. (2018) ranked Real Options higher than Income Approach |
| Cost Approach | Gives the lowest value and is mainly used for internal or legal purposes. | Muchtar et al. (2023) | - |

| | | | |
|---|---|---|---|
| Market Approach | Is tied to be the most trusted but the result varies by the market situation; useful for early-stage ventures. | Muchtar et al. (2023); Ramírez-Atehortúa et al. (2022) | - |
| Real Options Approach | Yields the highest valuation but is rarely used due to complexity and low reliability. | Vetsch (2021); Samuel et al. (2018); Kellogg & Charnes (2000); Van Triest & Vis (2007) | - |

## 5.4 Recommendations

### 5.4.1 Practical Recommendations for Innovation-Driven Enterprises (IDEs)

**Choose valuation approaches based on the objective of fundraising**

- If the fundraising goal is to license technology or prepare for exit, IP valuation should be prioritized.
- If the aim is to secure strategic partnerships or accelerate business growth, firm valuation becomes more relevant and informative.

**Select methods that align with the business context**

- Consider the industry type, startup stage, and the availability of data.
- For early-growth IDEs that generate stable revenues but lack positive net earnings, the most suitable approaches are typically Income Approach or Market Approach.
- Avoid using Real Options in cases where probability and future cash flow scenarios are too uncertain or if analytical resources are limited.

**Case-specific recommendation for Agritech IDEs**

• Agritech enterprises generally benefit from strong global growth trends (e.g., green economy, sustainable agriculture), but their growth potential may be hindered by the inconsistency in government support.

• Therefore, methods that rely heavily on uncertain future conditions, such as Real Options, are not recommended.

• In this research case, the firm was in an early-growth stage with stable revenues. The final valuation method selected was Discounted Cash Flow (DCF) under the Income Approach, as it provided the highest valuation and was well-accepted by venture capital investors.

**5.4.2 Academic and Policy Recommendations for Government and Research Institutions**

**Support the development of valuation frameworks tailored to Thai IDEs**

• Research Institutions should consider allocating more research funding to the innovations with the pre-commercialization feasibility and valuation studied to increase the rate of IDE funding success as the IP itself is developed from the bottom up already.

**Support the tools for scenario analysis and financial risk modeling**

• Government Agency should consider providing a public financial database linking the data to the related agency like Department of Business Development (DBD) or the Department of Revenue, allowing IDEs to access the nescessary information with the affordable cost.

**Bridge collaboration between researchers and venture capitalists**

• Encourage joint initiatives between academia and VC firms to co-develop practical valuation frameworks that are applicable in real investment contexts and reflect investor expectations.

**Encourage further research across different stages and sectors**

• Since this study focuses on a single case of an early-growth stage IDE in Thailand's agribusiness sector, additional studies should explore valuation model applications across different stages of startup development (e.g., seed, expansion, pre-

IPO) and other sectors (e.g., deep tech, fintech, health tech) to enhance generalizability and inform more comprehensive policy-making.

## 5.5 Limitations of the Study

Despite the comprehensiveness of the research design and the practical relevance of the findings, this study is subject to several limitations that should be acknowledged:

**Single Case Study Scope**

This research focuses on a single Innovation-Driven Enterprise (IDE) operating in the agribusiness biotechnology sector in Thailand. While this in-depth approach allows for detailed model construction and contextual analysis, the findings may not fully reflect the diversity of challenges and valuation practices across other industries or business stages.

**Stage-Specific Observations**

The selected IDE is in the early-growth stage, where revenue has already been established but scalability and capital structure are still evolving. Therefore, the valuation model presented may not be fully applicable to startups in pre-revenue seed stages or mature firms approaching IPO.

**Sectoral Context of Agribusiness**

The model's assumptions are grounded in trends and market dynamics specific to agritech and pet-related biotechnology. The reliability of the proposed valuation logic may differ when applied to IDEs in different sectors such as fintech, or healthcare, which may involve different asset profiles, capital needs, and risk tolerances.

**Sensitivity to Market Assumptions**

Certain valuation methods used in the study, particularly the Income Approach and Real Options Method, depend heavily on forecast inputs such as discount rates, growth assumptions, and scenario probabilities. These inputs are subject to subjective judgment and can vary widely based on investor perception or external economic shocks.

**Time Constraints in Fundraising and Negotiation**

The process of finding the right strategic investor and finalizing a deal through financial modeling and negotiation takes substantial time. In this study, it took at least two quarters to identify a suitable partner and three additional months to conduct pitching and negotiations. If the research were to be expanded to monitor multiple IDEs simultaneously, such delays could introduce logistical and resource-based limitations, affecting both data consistency and outcome comparability.

## 5.6 Conclusion

This research aimed to construct an economically feasible valuation model for Innovation-Driven Enterprises (IDEs), particularly in the Thai agribusiness biotechnology sector, by integrating widely recognized financial valuation approaches. Through an action research methodology applied to a real case of a growth-stage IDE, the study provides both theoretical clarity and practical applicability for IP and firm valuation processes in startup investment contexts.

The study utilized four primary valuation approaches—Cost Approach, Market Approach, Income Approach, and Real Options Approach—for both intellectual property (IP) valuation and firm-level valuation. These methods were applied to a real firm seeking funding from venture capitalists (VCs) and analyzed in parallel with internal discussions and actual negotiation processes. The Income Approach, especially through Discounted Cash Flow (DCF) using Free Cash Flow to Firm (FCFF), emerged as the most widely accepted and useful tool for both researchers and investors. The Market Approach, using comparable multiples, served as a strong secondary benchmark. Conversely, although the Real Options Approach provided the highest theoretical valuation, its practical application remained limited due to complexity and data uncertainty.

Key insights from the study include the importance of aligning valuation methods with the startup's stage and fundraising purpose. If the IDE seeks to license its IP externally or prepare for exit, IP valuation becomes essential. However, if the IDE is focused on attracting strategic partners and scaling operations, a holistic firm valuation approach is more relevant. In this specific case, the IDE's strategic direction and its industry context—agribusiness biotechnology—favored the firm-level DCF model as the valuation standard for negotiation.

Despite the limitations outlined in the previous section, the findings present a foundational model for future research and practice. Expanding the study across different industries, business models, and growth stages would enhance the generalizability of the valuation model and refine its components. Overall, this research reaffirms the need for valuation methods that are both rigorous and contextually adaptable to the evolving landscape of innovation-driven enterprises.

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