UCD Michael Smurfit Graduate Business School

FIN40430 Strategic Finance

Individual Assignment

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Declaration

I hereby declare that the assignment titled **"Strategic Investment under Uncertainty: A Synthesis of Real Option Game Theory and Practice"** is my original work and has not been submitted, in part or full, for any other degree or diploma.

All work presented in this report has been carried out by me, except where explicitly stated otherwise. The data sources, tools, and methodologies have been appropriately acknowledged, and any assistance received during the project has been duly recognized.

This report complies with the academic and ethical standards required by **UCD Michael Smurfit Graduate Business School**.

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Strategic Investment under Uncertainty: A Synthesis of Real Option Game Theory and Practice

Executive Summary:

In order to provide an integrated knowledge of how businesses might combine financial flexibility with strategic foresight in capital-intensive and uncertain markets, this report synthesizes findings from four important research publications on real option games. A complete toolkit for assessing strategic investments is provided by real option games, which combine real options theory and game theory. This paper analyses competitive behaviour, flexibility, investment timing, and the trade-off between commitment and optionality through a review of the literature and practical applications. The results highlight the significance of dynamic investing strategies that take into account pressure from competitors as well as market volatility.

Introduction:

Real option games address the demand for dynamic investment analysis in the current turbulent, complicated, and competitive corporate environment by straddling the boundaries of financial theory and strategic management. The ability to make flexible, well-informed investment decisions is more important than ever as industries deal with rising levels of environmental uncertainty, geopolitical upheaval, and technological innovation. Conventional methods, such as discounted cash flow (DCF) and net present value (NPV), make assumptions about static circumstances and don't account for how markets and strategic relationships change over time.

The real options framework, which takes into consideration the value of flexibility more especially, the ability to postpone, expand, downsize, or terminate a project in response to changing market conditions was created to solve the drawbacks of static valuation. However, results start to be influenced by competitive activity when several firms have comparable possibilities. By adding strategic dependency, game theory improves real alternatives analysis in this situation. Real option games, then, integrate the strategic logic of game theory with the financial logic of optionality to help businesses make flexible and competitively aware investment decisions.

The benefit of managerial flexibility in the face of uncertainty is acknowledged by real options theory, which treats investment opportunities as contingent decisions similar to financial options, hence improving investment assessment. Game theory, on the other hand, explains how corporations engage strategically and how a rival's activities might change the value of an option. These two frameworks are combined to create "real option games," which enable businesses to examine how competitive dynamics affect the timing and value of investment choices. This report critically reviews four foundational papers:

1. *Strategic Options and Games* by Smit and Trigeorgis,
2. *Valuing Infrastructure Investment* by Cheah and Liu,
3. *Option Games: Balancing the Risks and Rewards of Strategic Decision Making* (Harvard Business Review), and

4. *Options in Technology Investment Games: The Real World TFT-LCD Industry Case* by Wu et al.

Review of "Strategic Options and Games":

Smit and Trigeorgis (2004) provide a theoretical synthesis that emphasizes how competitive behaviour affects the value or constraints of real options. Pre-emption games, where first-mover advantage is crucial; waiting games, where firms postpone investments; and cooperative games, where mutual delay may enhance joint value, are some of the strategic contexts identified in the article. The use of Nash equilibrium principles to formalize strategic interactions and calculate the best time to invest under various competitive circumstances is a key contribution. This study serves as the theoretical foundation for strategic option value analysis.

Key Contributions:

- The authors add oligopoly competition to the classic real options framework, in which businesses' investment choices are influenced by rivals' strategic moves in addition to the market volatility and potential returns.
- They examine pre-emption games, wars of attrition, and strategic delay, illustrating how the value of waiting is affected by what others might do.

Critical Insights:

- The main trade-off is between commitment and flexibility: while waiting gives flexibility but may result in lost first-mover advantages, committing early can discourage competitors but sacrifices flexibility.
- In addition to highlighting the fact that strategic is not just financial but also psychological and anticipatory, the study presents a formal framework that requires enterprises to assess the threats of rival moves as a risk to their option value.

Critique:

- Although the paper is conceptually extensive, it would be enhanced with further numerical demonstrations or applied case studies.
- The models mostly rely on comprehensive information and reasonable explanations, which might not hold true in unpredictable real-world situations.

Overall, this paper effectively sets the groundwork for understanding the intersection of competitive strategy with financial flexibility, which is an important idea in the fast-paced, unpredictable market of today.

Review of "Valuing Infrastructure Investment":

The real option games concept is applied to infrastructure investments by Cheah and Liu (2006). The primary focus of real option games is shifted in this paper to infrastructure investment, an area where strategic choices have significant, long-term consequences. The authors argue that standard valuation techniques, such as

Discounted Cash Flow (DCF) or Net Present Value (NPV), are unable to account for the complex risk and changing value of infrastructure investments.

The study divides infrastructure risk into four levels, each of which changes as a project progresses: demand, construction, regulatory, and operational risk. Real option analysis is presented as a way to value the freedom to postpone, increase, cancel, or reorganize infrastructure investments. Capital structuring receives particular emphasis, with the argument that the WACC (weighted average cost of capital) should be phase sensitive, reflecting varying risk exposures across time.

Key Contributions:

- Framing Infrastructure as a Strategic Asset Class: The paper highlights the growing interest from institutional investors in infrastructure as a stable, long-term, inflation-protected asset class. It underlines that infrastructure valuation is not just a technical challenge but also a strategic one.
- Risk Layers in Infrastructure Investment is associated with Construction Risk, (cost overruns, delays), Demand Risk (uncertain usage of assets), Regulatory and Political Risk and Operational Risk

Limitations and Critique:

- Limited Quantitative Application: Although the paper explains the rationale behind employing real options, it does not guide through any quantitative models or case based tests.
- Estimation Issues: Many variables (such as volatility and option life) are challenging to estimate in practice, just like in other real options applications, The authors mention this, but they don't provide any advice.
- Neglect of ESG and Social Impact Valuation: Despite acknowledging non-financial outcomes, the study could improve by adding ESG measures to valuation framework, which is becoming more and more important in today's infrastructure investing.

This research essentially shows how strategic game-theoretic thinking about stakeholder behaviour and government engagement, when combined with real options, may provide clarity and flexibility to infrastructure development. Infrastructure finance is not just a subset of capital budgeting, it's a field where real options and game theory converge in a meaningful, high-stakes way.

Review of "Option Games: Balancing the Risks and Rewards of Strategic Decision Making":

This study presents option games, a hybrid valuation method that improves how businesses make investment decisions in competitive and unpredictable contexts by combining game theory and real options analysis. The authors argue that rival behaviour and market volatility are not sufficiently taken into account by real options or classic DCF approaches alone. Practitioners can understand the idea of choice games thanks to Ferreira, Kar, and Trigeorgis (2009). They illustrate how real option valuation shifts under competition using a

simplified mining case involving two companies, MineCo and CompCo. Four strategic scenarios are examined in the article: both enterprises invest at the same time, one invests while the other waits, or both postpone.

Core Ideas:

- By taking into consideration both strategic interdependence (via game theory) and market uncertainty (through real alternatives), option games improve decision-making.
- Investment choices in capital-intensive, oligopolistic, and volatile markets should take into consideration market dynamics and the probable reactions of competitors, not only the cash flows from individual projects.
- The trade-offs between investing early to outsmart competitors and waiting for better knowledge is crucial, and timing is important.

Key Contributions:

- Conceptual Innovation: Combines two powerful but traditionally separate tools real options and game theory into one integrated decision-making framework.
- Scenario-Based Analysis: Breaks investment timing into four strategic scenarios (both invest now, one invests first, both wait, etc.), each with game-theoretic and probabilistic analysis.
- Quantitative Decision Support: Uses binomial trees and payoff matrices to model market demand evolution, costs, and competitor responses.
- Flexibility vs. Commitment Framework: Provides insight into how market conditions and competitive threats influence whether a firm should act early or defer.

Critiques and Limitations:

- Simplified Cost and Market Assumptions: Real-world unpredictability in the mining or manufacturing industries may be oversimplified by the model's assumptions of constant capital expenditures, no tax implications, and consistent operating expenses. It also assumes that firms would behave symmetrically and have access to the same information, which is rarely the case.
- Two-Player Limitation: Because the framework is based on duopoly dynamics, it cannot be applied to highly fragmented markets with numerous participants. Numerous competitors frequently engage in intricate, non-linear relationships in real-world sectors.
- Sector-Specific Nature: Although the tool is effective for heavy manufacturing or resource extraction, it could need to be significantly modified for use in industries with different cost structures and demand volatility, such as services, consumer goods, or digital platforms.
- Model Complexity for Practitioners: Even if the article makes the theory easier for executives to understand, putting the concept into practice still requires a high level of analytical complexity. This includes creating binomial demand trees and reward matrices, which are tools that managers don't often utilize in their daily decision-making.

This paper does a good job of explaining how option games might improve capital-intensive, uncertain industries' investment choices. Compared to conventional valuation models, the framework offers deeper strategic insight by taking into consideration both rival conduct and market volatility. It helps businesses strike a balance between commitment (moving quickly) and flexibility (waiting), which is crucial in situations with high stakes and risk.

Option games are useful for businesses considering significant investments in R&D, infrastructure, resource extraction, or new markets; they are not only scholarly resources. This strategy might establish itself as a mainstay in strategic finance with the development of more user-friendly modelling tools and wider industry use.

Review of "Options in Technology Investment Games: The Real World TFT-LCD Industry Case":

This study examines how businesses in capital-intensive, high-tech sectors like the TFT-LCD industry can use game theory and real option theory to make better investment choices. It focuses on AU Optronics (AUO), assesses whether the company should make investments in next-generation production facilities in light of the unstable market and competition from Korean rivals such as LG.

According to standard Net Present Value (NPV) analysis, these investments were not feasible because of their negative returns. However, the study found that flexible, phased investment techniques provided hidden value when employing a real options approach. The competitive interactions were then modelled using game theory, which demonstrated that by investing gradually and focusing on mainstream PC panels, AUO could avoid price wars and reach strategic equilibrium.

Key Contribution:

- Bridging Real Options and Game Theory: This paper uses an option games framework (based on Smit and Trigeorgis) to value investment decisions under uncertainty and strategic interactions.
- Real-World Industry Focus: Applies this hybrid model to AU Optronics (AUO), a major Taiwanese TFT-LCD firm, considering investment in 5^{th} or 6^{th} generation production lines.
- Multi-Stage Investment Modelling: Breaks down investment into four stages, each with embedded flexibility (defer, abandon, switch products).
- Dynamic Competitive Analysis: Uses game trees to model AUO's strategic interaction with LG, a first mover. Demonstrates equilibrium outcomes based mutual best responses.

Critiques & Limitations:

- Simplified assumptions: For example, the model oversimplifies real-world financial modelling by assuming a 0% tax rate.
- Restricted scope: A two-player game (AUO vs. LG) is the main focus, but real marketplaces frequently have additional competitors.

- Lack of wider generalizability: Although the model is rich in this particular business, its structure might not be readily applicable to non-tech industries or service sectors.

This study effectively illustrates how game theory and real options may be combined to examine strategic technological investments. It emphasizes how businesses can benefit from adaptable, phased investments and strategic foresight into the actions of competitors. The study offers scholars and professionals alike a solid framework for evaluating crucial choices in the face of uncertainty and competition.

Comparative Analysis:

Each paper contributes distinct insights that collectively strengthen the real option games framework:

Theme	**Strategic Options and Games**	**Infrastructure Investment**	**HBR Option Games**	**TFT-LCD Case Study**
Focus	General strategic modelling	PPP and regulation	Capital-intensive sectors	Technology manufacturing
Flexibility	Delay, scale, abandon	Staged approvals	Delay vs. commit	Staged investment
Competition	Game-theoretic equilibrium	Government coordination	Leader-follower dynamics	Sequential strategic play
Valuation	Analytical modelling	Modified DCF + real options	Binomial trees, matrices	Empirical modelling + games

The literature shows that combining optionality with strategic analysis leads to more robust investment decisions. Managers can better respond to uncertainty and competitive threats by valuing flexibility while anticipating strategic behaviour.

Managerial Implications:

Real option games offer a structured approach for firms to:

- **Time investments strategically** by analysing rival behaviour and market conditions.
- **Retain flexibility** through staged or phased investments that allow for future expansion, contraction, or abandonment.
- **Coordinate or deter competitors** via early moves in pre-emption settings or delay in cooperative environments.

- **Evaluate infrastructure and public-private projects** where government actions introduce non-market risk.

By integrating competitive foresight with flexible investment logic, managers can pursue strategies that are resilient to both volatility and rivalry.

Conclusion:

The benefit of flexibility and the impact of competition are both incorporated into real option games, which offer a thorough framework for strategic investment. By recognizing that businesses in the real world don't operate alone and that unpredictability is not just a risk but also an opportunity when harnessed appropriately, they go beyond conventional financial models. Companies are able to maximize not only the value of individual projects but also their overall strategic orientation by combining option theory and game theory.

Furthermore, this method gives decision makers the means to assess a project's strategic ramifications of commitment, flexibility, and timing in addition to its financial benefits. In today's dynamic and fast-paced global economy, it is essential to be able to predict and react to the actions of competitors as well as to adapt to outside shocks or changes in policy.

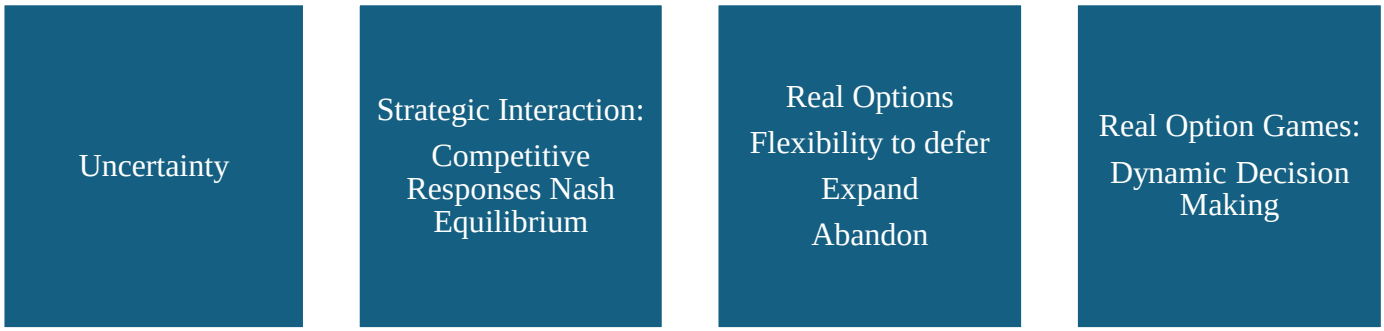
Moreover, the practical examples examined in this research demonstrate how well theoretical models may be applied in real-world settings. Businesses that employ actual option games are better able to manage risk and capital allocation, whether they are in high-tech manufacturing, resource extraction, or infrastructure building.

Future studies and practice should concentrate on facilitating greater access to these tools through industry-specific models, decision support systems, and cross-functional cooperation between strategists, financial analysts, and legislators in order to fully realize the promise of real option games. These developments have the potential to make genuine option games a crucial component of contemporary businesses' strategic finance toolkit.

Appendices:

Appendix A: Key Concepts Diagram

- Diagram illustrating the integration of Real Options and Game Theory into Option Games.



- Shows the flow from uncertainty to flexibility, then to strategic interaction.

Appendix B: Scenario Matrix from HBR Case

- Four potential strategic outcomes:
    1. Both firms invest early.
    2. Firm A invests; Firm B waits.
    3. Firm B invests; Firm A waits.
    4. Both firms wait.

	Firm A	Firm B
Invest	(0, 0)	(15, 10)
Waits	(10, 20)	(5, 5)

- Accompanied by payoff matrix illustrating outcomes.

Appendix C: AUO vs. LG Investment Timeline

- Timeline diagram outlining investment decisions by AUO and LG.
- Highlights key differences in timing, scale, and strategic positioning.

Appendix D: Strategic Option Typologies (Smit & Trigeorgis)

- Pre-emption Game
- War of Attrition (Waiting Game)

- Coordination Game
- Each typology summarized with visual illustrations and implications.

References:

- Cheah, C.Y.J. & Liu, J. (2006). Valuing infrastructure investments: An option game approach to public–private partnerships. *Construction Management and Economics*, 24(5), 379–389.
- Ferreira, N., Kar, J., & Trigeorgis, L. (2009). Option games: The key to competing in capital-intensive industries. *Harvard Business Review*, March 2009.
- Smit, H. T. J. & Trigeorgis, L. (2004). Strategic options and games. In: *Real Options and Investment under Uncertainty*.
- Wu, C. H., Li, S. H., Ong, C. H., & Pan, F. C. (2007). Options in technology investment games: The real world TFT-LCD industry case. *International Journal of Technology Management*, 39(1/2), 4–21.