國 立 交 通 大 學

財 務 金 融 研 究 所

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實質選擇權賽局與策略投資:
手機 EMS 產業之應用

Strategic Investments as a Real Options Game：
An Application to Cellphone EMS Industry

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摘要

在手機EMS產業中，產能的供應扮演極為重要的角色。企業為了獲得額外的訂單以及利潤往往利用企業購併的投資策略來獲取競爭優勢。本文嘗試把實質選擇權與賽局理論引入策略投資的決策之中，並以富士康與比亞迪的競爭為例，建構實質選擇權賽局來分析策略投資決策。本文利用賽局理論模型將競爭對手之反應納入分析，並在每一階段裡探討策略投資的可行性。此外，本文亦將實質選擇權的價值拆解為策略價值與彈性價值兩部分，配合比較靜態分析將各種可能的情境納入考量，將不同的策略價值呈現出來。最後，本模型估計購併專案的投資效益，並將將企業策略投資的競合關係進行整體性的分析。

關鍵字: 賽局理論、實質選擇權、策略投資、EMS 產業、富士康、企業購併

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Abstract

In cellphone EMS industry, capacity supply is an important concern for producer. In order to earn additional profit, managers may choose capacity expansion strategies, such as strategic M&A, to compete with their rivals. This study uses the options-game framework to value an M&A project between Foxconn and its competitor BYD, and analyzes the investment strategies in each stage. We take account of the effect of BYD's responses and distinguish the flexibility and strategic value. In addition, we examine how sensitive a particular NPV is to changes in underlying assumptions.

Key words: game, real options, strategic investment, EMS, M&A, Foxconn, BYD

誌謝

「論文是寫給人看的。論文的訓練過程才是論文的精華。」

終於，憑著恩師的兩句話完成本文，現在也已經看到當初努力的一點成果了。兩年前毅然決然投入研究所領域，從對學術研究懵懂無知的大學畢業生跨入交大財金所，我何其有幸，能在一開始轉變學習方向時就認識恩師—黃星華博士。恩師不僅在我遇到困難時給予適當的鼓勵，更讓我在他身上看到拼命努力學習的精神，讓我真正體會到什麼叫解決問題的能力。感謝恩師除了學術上引導我之外，生活態度及做人處事的道理上也使我受教許多。在北京清華大學交換學生期間，更跟著恩師遠端視訊做研究，恩師不辭辛勞的每個星期跟我在電腦前相約討論，並在研究過程中，讓我知道做任何事都必須具備明確的動機，有動機才有動力，有動力才能把事情順利完成，對我而言這樣的身教言教真是受益良多。同時，感謝口試委員張興華老師、林信助老師、李漢星老師對本論文所提供諸多寶貴意見，使我的論文更加完整。除了口試老師外，其他財金所的諸位老師嚴謹治學態度，亦是我應效法的榜樣。此外，語言中心的陳沛潔老師、吳思葦老師、秦毓婷老師在英文寫作上幫助我許多，每一次的諮詢都讓我的寫作功力大增。

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游景璁 謹誌

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1. Introduction

1.1 Background

Since the later 1990s, electronics manufacturing services (EMS) factories clustered together and became a partner of strategy alliance with original equipment manufacturer (OEM). In the originally service area, the EMS factories started to participate in the research and development of OEM industry, and provided the post-sale service to the OEM industry terminal customers. When the market is dominated by a small number of oligopolists, the EMS factories integrated into the coordination-effective industry and succeeded in global market. Nowadays, the influence of economical globalization and integration has led to the keen competition. The EMS enterprises which intend to survive in this market should enhance their competitiveness, advance their own value and strengthen the effectiveness of their investment strategies. The goal of enterprise investment is to make a best decision in an uncertain environment and then to realize its value maximization. Thus, choosing a reasonable method of investment strategy in this industry has becomes the key to modern management.

The traditional discounted-cash-flow (DCF) approach has been used to calculate the net present value (NPV) of projects. Since using this method in investment decision-making has neglected the flexibility and the opportunity cost of investment strategy, DCF approach was found insufficient when evaluating the investment project. The new method in investment decision must consider the flexibility of project, and can provide more feasible policies for enterprises in decision making. Since the beginning of 1980s, real option theory has been used academically, developed for solving the problems of neglected the flexibility value to provide brand new thinking. In the process of investment decision making, the real option method can help incumbent choose start point flexibility for existing projects and it also depend on the information at different stages for analysis.

1.2 Motivation and Purpose

The purpose of this paper is to use the options-game framework to appraise the project of M&A and investment for capacity expansion in the cellphone EMS industry, and analyze which strategies (proprietary or market shared) is the best for the companies when they face the same competitor. In other words, the expiration of investment decision-making method under the uncertainty environment was replaced by the options-game framework in this paper. Finally, this approach can depend on competition environments to adopt a suitable investment strategy.

When introduced the options-game framework, the case application explains the integration of real options models and game theory. It calculates the bilateral reward in games with option pricing model, and effectively modifies the dispute which the reward from game theory is too simplification.

1.3 Research Areas

Taking EMS mobile phone factory (Foxconn and BYD) for example, the manufacturer when they appraisal investment plan, the important consideration are the quantity of delivery, the competitor now and new factory order form price in the future, market's point of view of up-to-date mobile phone, as well as possibly make the investment strategy in the new market competition change. Obviously, when company incumbent makes certainly fixed produces investment plan, the difference of the demand of products may change the present value of income and the rival's investment in the future will be the most important challenge.

This thesis is based on the investment decision analysis foundation method and considers the characteristics of investment strategy. Then, the method observes the used literatures and past real cases of different industry to prove the practicability of the game theory, and proposes an approach which combines the game theory and real options in the decision analysis. Eventually, this paper utilizes the options-game approach which is the best strategy investment pattern in the EMS industry. The main innovations of this thesis are:

1. This research has established the options-game approach application method in the investment strategy of the EMS industry.
2. This research has analyzed how to distinguish between flexibility value and the strategic value in the investment through the practical application, and how to choose the optimal investment strategy.

In our study, we introduce the purpose and research areas in section 1, and then review previous literature in section 2. Next, we make specific statement about the background of Foxconn and BYD in section 3. In the section 4 and 5, we introduce the methodology and give the numerical result by case application. Finally, we give the conclusion of our study in section 6.

2. Literature Review

2.1 Real Option Model

2.1.1 Introduction

The real option model is a concept comes from the financial options. Financial options are one kind of contract, and it entrusts holder in certain time to purchase or sell specific quantity financial product right using the price which has agreed beforehand. While financial options are written on an underlying financial asset, a real option is based on an underlying real asset. Similar to a financial asset, the future value of the underlying real asset is uncertain. Real option entrusts with the right is also the options to investment or management. If company has real option to act the value change, chooses the investment plan or management nimbly depend on the basic property in certain deadline.

Black and Seholes (1973) proposed the famous option pricing model, and this model solved the European stock option pricing problem; Cox, Ross and Rubinstein (1979) founded the discrete time binomial option pricing law. These three articles have laid the financial option pricing rationale, and impelled the 20th century finance option to develop enormously.

The concept of option contains limits not merely of the financial derivation tool along with the option theory and the real situation development. Moreover, it has represented one kind of new financial thought, the financial theory and the real option theory. This kind of theory may widely apply in the each aspect of economic life, and smoothed the way for the economic evaluation in many domain applications.

At the end of 1980s to the beginning of the 90's, the real option theory appeared in the domain application and the promotion of enterprise's investment strategy, and it have represented the West in the aspect of business management breakthrough recently. Myers (1977) for the first time proposed " the real option " concept, and first conducts the profundity research to the option pricing theory in the investment project. He proposed that DCF-NPV is not suitable for to the investment strategy valuation, since the economic value of the investment strategy is composed completely by two parts: one was (static state, passive) direct cash flow NPV, and the other one was management elasticity and the strategy interaction option value.

2.1.2 Common Corporate Real Options

The real option is one new thinking mode, and it can help enterprise innovate their investment decision with this new method. Facing uncertainty environment challenge, the enterprise policy-makers should adopt positive treatment of the uncertainty of investment. In addition to discover any kind of uncertainty factor in the project, and uses these factors to enhance the project value. Specifically, enterprise can use the option to defer, option to growth, option to abandon, option to expend, and other corporate real options to increase project management flexibility and to dodge the risk of investment plan.

Kester (1984) compared some investment strategy with the option who can bring the investment opportunities and create the value in the future, and proposed the investment strategy and the option had similarity; Amram and Kulatilaka (1999) pointed out the real option is one of the thinking who introduced into the interior of the enterprise investment strategy decision-making from the money market rule. It can help the superintendent uses it to mark out plan and manage the investment strategy effectively.

Faulkne (1996): Regarding the valuation of investment strategy, real options method even better. He points out many well-known Japanese enterprises, taking example for EastrnanKedak now is uses the real option method to value at the investment strategy. This method is conducive to expose the neglect option value of DCF-NPV, and has guided the massive capitals to invest in the project correctly. Thus, it impelled the Japanese economy development in bloom. Dixit and Pindyck (1994) and Sharp (1991) employ the idea of real option to analyze firm's investment strategy. They were merely carried on the analysis in theirs descriptions from the specific aspect but not involved to the nucleus. They had not been able to reflect the real value in special cases and make the correct investment decision.

Using the theory of real option to make investment strategy has further development and more comprehension. Since the investment strategy usually has many stage, many decision points, more and more scholars regard it as the compound option. At the same time, real option pricing method is no longer limits to

Black-Scholes option pricing model and Cox-Ross-Rubinstein option pricing models. Instead, it depends on the revision and relaxation of situations which have certain conditions or proposes to set new pricing model.

For example, Kulatilaka (1998) indicated that there are many interactions of real options in an identical investment strategy, and he emphasized it cannot estimate value by itself in the identical investment. Copeland and Antikarow (2001) constructed the multi-stage compound option using Cox-Ross-Rubinstein option pricing models, and appraised multiple period investment plans. Real option pricing model of investment strategy provided the realistic decision method in the economic life.

2.1.3 Real Option Diagnosis Research

Paddock, Siegal and Smith (1988) analyzed the right of rent in an offshore oil field project, and compared the difference between the value of traditional method of DCF and option to defer. Bailey (1991) examined the contingent-claims approach to valuing real assets. Empirical tests using prices of rubber and palm-oil estates and, the real option model differs markedly from conventional discounted-cash-flow models. Quigg (1993) first examine the empirical predictions of a real option-pricing model using a large sample of market prices. He found empirical support for a model that incorporates the option to wait to develop land. The option model has explanatory power for predicting transactions prices over and above the intrinsic value. Herath et al. (1999) offered that the NPV model is able to account for the sequential nature of decisions involved in an R&D project – the option to wait – without assuming the existence of a market valued security that reflects the project. He find that additional option valuation assumptions to reflect uncertainty bring little analytical advantage and great practical problems. He and Park (1999) also developed a valuation model incorporating the risk-free arbitrage features of the binomial option pricing model into a decision framework and applied it to the introduction of a new product: the new Mach III from Gillette. They demonstrated the value of innovation and its impacted on the stock value.

2.2 Game Theory

2.2.1 Introduction

In the game theory proposed by Von Neumann and Morgenstern (1942), they advocated when taking an action, the player should not only consider their own gains, but must also further consider the opponent's behavior, with its emphasis on a zero-sum game. It describes a situation in which a participant's gain or loss is exactly balanced by the losses or gains of the other participants, yet its application is very limited. It will be inapplicable when the counterparties are acting rationally in a strictly competitive non-zero-sum game.

Until Nash (1950) proposed Nash Equilibrium, showing that in non-zero sum and non-cooperative game, equilibrium must exist. As long as the opponent's strategy is identified, the competitor will be able to make the optimal response (best response). When each player has chosen a strategy that they consider as their best response, then the current set of strategy choices and the corresponding payoffs constitute the Nash equilibrium.

Game theory divides into two parts, one is cooperative game, and the other one is non-cooperative game. Cooperative game permits of profits, to some degree, consultations, negotiations, and even collusions between players, but cooperative Game does not allow both players to implement communication and negotiation. Hence, Non- Cooperative Game more conforms to the industrial competition situation. For a company, it has to make strategic investment decisions all the time. That is, a company must deliberate not only the competitor's reactions, but also exponential effects of the competitor’s reactions to company's value, including positive and negative effects.

2.2.2 Game Theory Diagnosis Research

Chuang, Wu and Varaiya (2001) applied a Cournot model to analyze industry investment, market participation, and the reliability of multi-player expansion rather than expansion by a traditional monopolist. Butterfield and Pendegraft (2001) cited game theory and an extension, the theory of moves, are presented as alternative methods of modeling IT investment decisions. This technique specifically considers investments motivated by operating or competitive necessity.

Kaleelazhicathu (2004) considered which game theory is a tool primarily used to solve multi-personal decision problems. Oligopolies like mobile communications industry, with typically 3 to 6 operators, provide ample opportunities to use game theory in solving such problems. His thesis gives an overview of game theory and looks at areas of application within the mobile industry. It also mentions the relevance of game theory in the Mobile Operator Business (MOB) game.

2.3 Real Options and Games

For the early literature about real options, researchers either ignored competitive entry or assumed that it was exogenous. If there is competition, each firm’s payoff is affected by the actions of the other players, and competitive interaction can change the optimal investment criterion. McGahan(1993) explored the tension between competitive pressure to invest and the real option value in an entry opportunity under uncertainty about demand. If an outsider's expectation about buyer valuation makes entry appear less attractive and if an incumbent can keep proprietary its updated information about demand, then it may be able to secure its advantage and partially deter imitators without a substantial initial capacity investment. Kulatilaka and Perotti (1998) proposed that in a Cournot duopoly setting the first firm to invest can gain a strategic advantage since market share and the value of early investment increase more with higher demand uncertainty than does the value of waiting. In addition to, they consider a Stackelberg growth option when a firm has a first-mover advantage and also conclude that higher demand uncertainty justifies earlier exercise of the growth option in 1999. Huisman (2001) showed that the new theory of strategic real options can be used to fill the "empty hole". Based on the work by Smets (1991) standard models are identified, and they are analyzed by applying a method involving symmetric mixed strategies. Finally, they established to what extent investments are delayed when technological progress is anticipated, and it is found that competition can be bad for welfare.

In the real competition environment, game theory reveals the strategic effect adopted by rival companies in the duopoly market. It strengthens real option theory which takes variety of opportunities for investment and management flexibility as options to analyze. Paxson and Pinto (2004) major reported investment plans indicate "leader-follower" patterns. Using three real competition options models (The options-game approach), they determine the optimal timing of 3G investment of one Portuguese mobile company, Optimus, taken as the follower. Smit and Trigeorgis (2004) synthesize the newest developments in corporate finance and related fields, in particular real options and game theory, to help bridge the gap between traditional corporate finance and strategic planning. They analyzed competitors' interaction in this game based on the theory of duopoly market and divided competitors' responses into Strategic Substitute and Complement. Moreover, they illustrate the use of real options valuation and game theory principles to analyze prototypical investment opportunities involving important competitive/strategic decisions under uncertainty in

2006.

The response of competitors to enterprises' investment strategies is evaluated through the analysis of the options-game approach in order to calculate the profit. The blind spot of real options which derives from neglect of competition in the dynamic market could be amended by means of game theory. Owing to the deficiency of entering limit, it causes competitor situation in distribution of new products, marketing plan and R&D. The decision-making pattern which is proposed in this research will be discussed and be explained through EMS investment competition cases in the section 5.

3. Overview of the EMS Industry

A generalized coordination EMS industry provides the service of entire process manufacture and the wholesale solutions for the international OEM; therefore, the OEM industry can apply the outsourcing strategy on enhance its core competitive power. For example, in the strategic cooperation implemented by Sony Ericsson Corporation and world-wide EMS enterprise Flextronics, Sony used OEM and passed on most of its products to electronics manufactory such as Flextronics, and mainly focused on R&D and marketing. Within years both companies reached to a great success. Similarly, Nokia Corp. used the same strategy with Foxconn and obtained the vast success in global market as well.

3.1 Foxconn Electronic Company

Foxconn is the trade name of the Taiwan based firm Hon Hai Precision Industry Corporation. Foxconn is the largest manufacturer of electronics, and mainly manufactures on contract to other companies. Presently, Foxconn has 40% market share in 2G and 3G mobile phone EMS industry. Although sometimes referred to as the OEM, Foxconn would be more accurately described as the original design manufacturer (ODM).

The global wireless communication industry is bloomy development, which attracts ESM industry to invest and to compete intensely. Under such circumstances, Hon Hai has set the Foxconn Precision Component Beijing Corporation in order to obtain the orders from Nokia, this business pursuit consist with of which that of Hon Hai : Hon Hai tends to set the R&D center nearby its major customers or to merge its component factories. Foxconn proceeds to vertical integration to enter the 2G and 3G mobile phone markets, and strives to obtain the orders from the first three international mobile phone corporations (Nokia, Samsung, and Motorola). The M&A strategy is provide to be successful, which is manifested in the fact that the 25% of Nokia's output and 40% of Motorola's were mainly taken by Foxconn. For instance, Foxconn not only merged Nokia's component factory in Finland to successfully strive the orders from Nokia, but also acquired the ODM factory, Chi Mei Communication Systems (CMCS), to improve the quality of its product research and development since CMCS has a strong team in designing. Nevertheless, due to decrease of Motorola and increase of Samsung and LG, Foxconn in 2007 turned its goal orders to Korea mobile phone corporations.

3.2 BYD Electronic Company

BYD Electronic, the subsidiary of BYD Company Limited, is engaged in the manufacture and sales of mobile phone components, mobile phone modules and assembly services to mobile phone manufacturers. Presently, BYD has 10% market share in 2G and 3G mobile phone EMS industry. One of its customers is Nokia, which is the world's leading mobile phone supplier.

In 2003, BYD followed Foxconn's "the reversion of vertically integrated strategy" and started to enter the EMS industry. Due to the growing demands on mobile phones in the global market, the mobile manufacturers have been moved to Asia and other new markets as Russia, Brazil, Mexico and Eastern Europe. Besides, the companies famous for designing mobile phones (such as Nokia, Motorola, Samsung, LG and SonyEricsson) have adopted the outsourcing strategy. They tended to choose the suppliers who pursue a vertical integrated goal and provided manufacturing/service platforms for global use as their cooperative partners. Therefore, BYD, proceeding as vertically integrated, started to offer mobile phone assembly service for Nokia and Motorola. In 2006, BYD firmly established their roles as "component suppliers of one-stop mobile phone" in the international market. After that, BYD further advanced the ability of product design and its production capacity to provide high-end products. It expanded new production facilities at Huizhou in Guangdong Province (China), Chennai (India), Komarno (Hungary), and Cluj (Romania) in order to make a platform for globalization production. At present, its assembly services for mobile phone modules have included the manufacturing of battery, keyboards, and cell phone components. Hence, BYD has obtained the authorization to assembling mobile phone.

4. Methodology

This section 4.1 and 4.2 follows Smit (2003) and then we use decision tree to describe the expansion of EMS industry. Afterwards, we evaluate the value of real option by the present value of growth opportunities (PVGO) approach, and use the decision tree which integrates game theory to be the target of this paper analysis.

4.1 Competitive Strategies Depending on Type of Investment and Nature of Competitive Reaction

Before the development of game theory, it is generally believed that the company may neglect the influence of strategies on the competitors' responses in perfect competition or the monopoly market, which is not true under duopoly market. Game theory is the method to understanding how interactions of decision making happen.

Fudenberg and Tirole (1984) presented that the outcomes of many strategic interactions in industrial organizations can be predicted by using the basic framework of strategic effects in simple two-period model, in which the interactions between company and its rival's influence on the investment decision ware analyzed. The response of competitor investment is faced by two affects (See Table 4.1):

(1)Nature of competitive reactions: Contrarian or Reciprocating

(2)Competitive strategies on type of investment: Tough or Accommodating

Specifically, a competitor's response to a strategic investment decision is likely to depend on two dimensions: the type of competitive actions－strategic substitutes or complements－and whether the strategic investment is tough or accommodating.

Table 4.1

Competitive Strategies Depending on Type of Investment and Nature of Competitive Reaction

	Contrarian (down-sloping reaction/strategic substitutes)	**Reciprocating** (up-sloping reaction/strategic complements)
Tough e.g. Proprietary investment	**Committing and offensive** Invest(+strategic effect)	**Flexible and inoffensive** Don't invest/wait (-strategic effect) (Nash Price competition)
Accommodating e.g. Shared investment	**Flexible and offensive** Don't invest/wait (-strategic effect)	**Committing and inoffensive** Invest(+strategic effect) (Leader-follower/accommodation or Nash Price competition)

Source: Smit and Trigeorgis (2004) pp. 232

4.1.1 Strategic Substitutes versus Strategic Complements

Strategic Substitutes (Quantity Competition) or Strategic Complements (Price Competition) has an essential difference: (1) Strategic Substitutes is the competition type where a competitor’s response to a strategic investment decision is using quantity to rival with its competitor (down-sloping reaction curves). (2) Strategic Complements is the competition type which a competitor’s response to a strategic investment decision is using price to rival its competitor (up-sloping reaction curves).

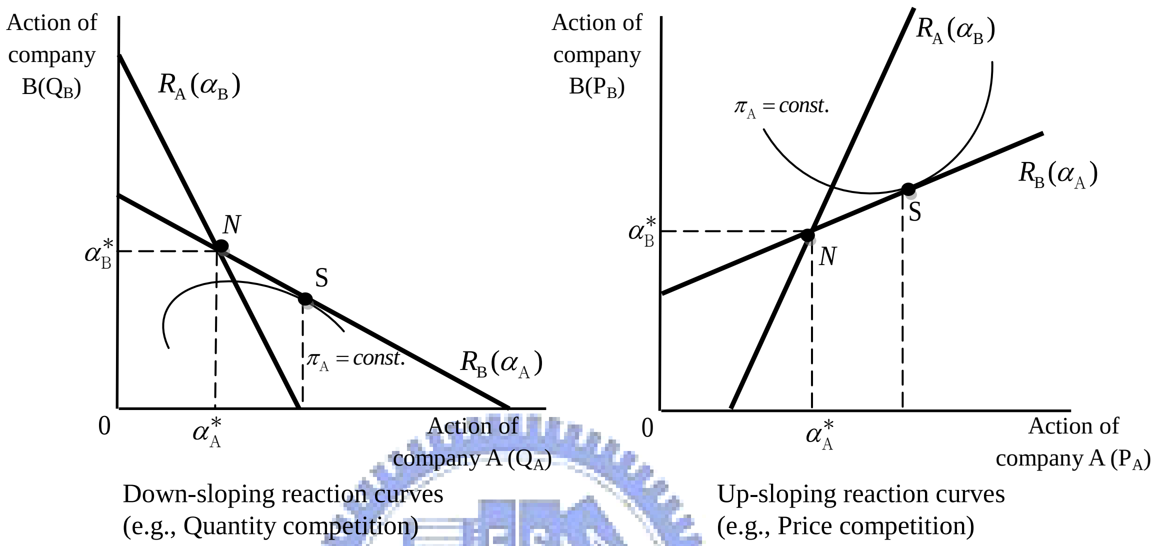


Figure 4.1 Strategic Substitutes versus Strategic Complements

4.1.2 Two-Stage Games: Strategic Value of Commitment

In the first stage, company A has to decide whether to invest an amount of money (K_A) to adopt the M&A strategy. In the second stage, both of them have to decide whether to invest in new factories to increase capacity or to accelerate resource utilization (expending), and then to choose the optimal strategies $\alpha_A^*(K_A)$ *and* $\alpha_B^*(K_A)$. Thus, the profit present value of two companies A and B in second stage are $V_A(K_A,\alpha_A^*(K_A),\alpha_B^*(K_A))$ *and* $V_B(K_A,\alpha_A^*(K_B),\alpha_B^*(K_A))$ which are effected by investing amount of money (K_A), and the optimal strategies $\alpha_A^*(K_A)$ *and* $\alpha_B^*(K_A)$ of both companies in second stage.

There are two effects in the first stage, one is direct effect such as Foxconn obtaining the orders from original mobile phone corporations to increase the profit which was earned in second stage, and the other is strategic effect which changes the rival’s behavior such as forcing them to accept small market shares or withdraw from a competition. To illustrate, Foxconn want to be monopolist who owns a large amounts of revenue in the market, so it considers investing through using the M&A strategy in the first stage investment to deter BYD from entering the market ($NPV_B < 0$).

If company A invests an amount of money (K_A) at the first stage, then the effect of present profit value on company B in the second stage is expressed as follows:

$$dV_B = \frac{\partial V_B}{\partial K_A} dK_A + \frac{\partial V_B}{\partial \alpha_A} d\alpha_A^* + \frac{\partial V_B}{\partial \alpha_B} d\alpha_B^* \tag{4.1}$$

$$\frac{dV_B}{dK_A} = \frac{\partial V_B}{\partial K_A} + \frac{\partial V_B}{\partial \alpha_A} \frac{d\alpha_A^*}{dK_A} \tag{4.2}$$

If the investment strategy of the first strategy is tough, then it causes its competitor's entry unprofitable in the second stage (e.g. $\frac{dV_B}{dK_A} < 0$), and will enable company B to defer the entry into the market. Instead, if the strategy which causes the rival to defer the entry into the market is useless, company A can use the accommodating strategy (e.g. $\frac{dV_B}{dK_A} > 0$), the strategy of which is invested in the first stage. Then, the effect of present profit value on company B in the second stage is expressed as follows:

$$dV_A = \frac{\partial V_A}{\partial K_A} dK_A + \frac{\partial V_A}{\partial \alpha_B} d\alpha_B^* + \frac{\partial V_A}{\partial \alpha_B} d\alpha_B^* \tag{4.3}$$

$$\frac{dV_A}{dK_A} = \frac{\partial V_A}{\partial K_A} + \frac{\partial V_A}{\partial \alpha_B} \frac{d\alpha_B^*}{dK_A} \tag{4.4}$$

Hence, the essential condition of the tough or accommodating strategy which company A used is $\frac{dV_A}{dK_A} > 0$, and the commitment effect consists to two components: direct effect and strategic effect, that is,

$$\frac{dV_A}{dK_A} = \frac{\partial V_A}{\partial K_A} + \frac{\partial V_A}{\partial \alpha_B}\frac{d\alpha_B^*}{dK_A} \tag{4.5}$$

$$(\textit{commitment effect} = \textit{direct effect} + \textit{strategic effect})$$

The direct effect is when A invests in the first stage, it influences company A's own second stage profit value with the competitor's reaction constant. The strategic effect results from the impact of company A's strategic investment on competitor B's optimal second-stage action, $\frac{d\alpha_B^*}{dK_A}$, and its resulting indirect damages on company A's profit value. The reliable investment strategy can change the rival's expectancy and then changes its reaction.

Company A adopts investment strategy at first stage to produce the strategic effect to its present profit value at second stage, the strategic of which can be distinguish into following two factors:

(1) In first stage, company A has tough or accommodating position to its competitor. If it is tough, then $\frac{dV_B}{dK_A} < 0$ (e.g., proprietary); Otherwise, if it is accommodating, then $\frac{dV_B}{dK_A} > 0$ (e.g., share the market).

(2) In second stage, the reaction of the rival is $R_B(\alpha_A) = \alpha_B(\alpha_A)$, which is strategic substitute ($\frac{\partial \alpha_B}{\partial \alpha_A} < 0$, quantity competition) or strategic complement ($\frac{\partial \alpha_B}{\partial \alpha_A} > 0$, price competition). And the strategic effect is following:

$$\frac{d\alpha_B^*}{dK_A} = \frac{\partial V_B}{\partial \alpha_B}\frac{d\alpha_B^*}{dK_A} = \frac{\partial V_A}{\partial \alpha_B}\left(\frac{d\alpha_B^*}{d\alpha_A^*}\frac{d\alpha_A^*}{dK_A}\right) = R'_B(\alpha_A^*) \times \frac{d\alpha_A^*}{dK_A} \tag{4.6}$$

where $R'_B(\alpha_A^*)$ denotes the slope of company B's reaction function to A's action.

4.2 Price Competition

In the competition of Foxconn and BYD, the nature of competitive reaction is reciprocating. Bertrand (1883) developed the duopoly market model (Bertrand model) which took the price as the competition factor. In this section, we present the analytic derivation of reaction functions and equilibrium outcomes for market structures under price competition. We assume for simplicity that the demand for product is linear in prices:

$$Q_i(P_i, P_j, \theta_{i,t}) = \theta_{i,t} - bP_i + dP_j \tag{4.7}$$

The quantity sold by company i is a function of its own price (P_i) as well as that of its competitor (P_j). The coefficients b and d capture the sensitivities of the quantity sold to the firm's own and its competitor's price settings, respectively. The profits of each firm i (i = A or B) are then given by

$$\pi_i(P_i, P_j, \theta_{i,t}) = (P_i - c_i)(\theta_{i,t} - bP_i + dP_j) \tag{4.8}$$

The reaction function of each company i is again obtained by maximizing its profit value $V_i(P_i, P_j) \equiv \frac{\pi_i}{k}$ over its own price (P_i). Setting $\frac{\partial V_i}{\partial P_i} = 0$, gives

$$R_i(P_j) = \frac{(\theta_{i,t} + dP_j)(1 + bq_i) + bc_i}{b(2 + bq_i)} \tag{4.9}$$

A company engaged in price competition has a best (profit-maximizing) response to competitor price changes according to its reaction function. Substituting the expression for $R_i(P_j)$ in the place of P_j in equation (4.9) gives the general asymmetric Nash equilibrium price expression:

$$P_i^* = \frac{2b(\theta_{i,t} + dc_i) + d(\theta_{j,t} + bc_j)}{4b^2 - d^2} \tag{4.10}$$

The equilibrium prices for different market structures under reciprocating price competition can be seen in Table 4.2.

Table 4.2

Equilibrium Prices for Different Market Structures under Reciprocating Price Competition

Action (A,B)	Market Structure N/M/S/A/D	Equilibrium Price, Pi
Period 2		
(DI, DI)	Nash price competition (N)	$\dfrac{2b(\theta_{i,t}+bc_i)+d(\theta_{j,t}+bc_j)}{4b^2-d^2}$
(DI, DD)	Monopolist (M)	$\dfrac{\theta_t+c(b-d)}{2(b-d)}$
(II, DI)	Stackelberg price leader (S^L)	$\dfrac{2b(\theta_{i,t}+bc_i)+d(\theta_{j,t}+bc_j-dc_i)}{4b^2-2d^2}$
	Stackelberg price follower (S^F) (mainly aimed at Pj)	$\dfrac{\theta_j}{2b}+\dfrac{C_j}{2}+\left[\dfrac{2bd(\theta_i+bC_i)+d^2(\theta_j+bC_j-dC_i)}{2b(4b^2-2d^2)}\right]$
(DD, DD)	Abandon (A)	
Period 1		
(I, I)	Nash (N)	$\dfrac{2b(\theta_{i,t}+bc_i)+d(\theta_{j,t}+bc_j)}{4b^2-d^2}$
(I, D)	Stackelberg price leader (S^L) / Monopolist (M)	$\dfrac{2b(\theta_{i,t}+bc_i)+d(\theta_{j,t}+bc_j-dc_i)}{4b^2-2d^2}$
(D, D)	Defer (D)	

Source: Smit and Trigeorgis (2004), pp. 265-266

4.3 Decision Tree Analysis

The construction of the decision tree is crucial, and we use it to describe in detail how decision of M&A investment and expansion game happened. First, Figure 4.2 constructs two different competitive strategies on type of investment: Proprietary or Market Shared. Second, if company A makes the M&A investment, it has options to choose whether to execute expansion investment in period 1.

Panel A describes that company uses proprietary investment strategy to deter the rival from entering market, and then earns the profit as a monopolist. For example, Foxconn can delay BYD Electronic being listed in Hong Kong by action at law, which causes BYD unable to collect enough money to make M&A investment, and then Foxconn merges with LG's component suppliers gain the manufacturing potency of LG's mobile phone. Simultaneously, it prevents BYD from obtaining the Korean mobile phone orders (detail see Figure 4.3). After Foxconn chooses the first action, demand move again and the decision is repeated at period 2.

Panel B illustrates the company who uses accommodating investment strategy to share market profit with its competitor (detail see Figure 4.4). For instance, Foxconn obtains the property rights of the Diabell, which is one of LG's component suppliers, and leaves the options for BYD to decide whether to merge with other component factories (Sinyoung, Mosen and the other five factories). If BYD invests in M&A, then both companies can share market. Thus, Figure 4.4 depicts a simultaneous game which determines whether the companies can successfully obtain the order from LG.

4.4 EMS Valuation as an Options Game

This research uses PVGO approach to analyze real options in the M&A project. The PVGO is a concept that originated with the work of Miller and Modigliani (1961). The value of the firm is separated into the value of assets in place plus the NPV of future growth projects.

4.4.1 The Value of Asset in Place

We assume the project will last n periods and generate an expected (free) cash flow TCF_t, $t = 1, 2, \ldots, n$ in each of these periods. We also assume that the cash flows are paid immediately at the end of each time period in a manner analogous to the dividends of a stock.

$$V_t = \frac{TCF_{t+1}}{k-g} \tag{4.12}$$

Where V_t is the project value in period i; k is weight average capital cost, and g is the perpetual expected growth rate of cash flow. Note that V_t does not include the cost of investment at period i, I_i. In order to construct a binomial option framework, it is assumed that the project value of the next period can either move up by rate u with probability p or move down by rate d with probability $1-p$, where p presents risk-neutral probability.

Let σ be the volatility, r be the risk-free discount rate, and t be the subinterval of a small period. Cox et al. (1979) derived $p=\dfrac{e^{rt}-d}{u-d}$, $u=e^{\sigma\sqrt{t}}$ and $d=\dfrac{1}{u}$. Using these formulas, the binomial option framework of the project with its cash flow can be constructed as Figure 4.2 illustrates. We consider a situation where there is uncertainty about the value of V at period 1. In addition to the above, assume: V_1^+ = Present value at period 1 of the future cash flows from expending if market is favorable; V_1^- = Present value at period 1 of the future cash flows from expending if market is unfavorable. The value of asset in place ($V_{i,j}$) at period i and state j can be calculated by the following recursive equation (4.13) to (4.15).

$$V_{i,j}=V_0=\frac{pV_1^+ +(1-p)V_1^-}{1+r},\ i=0,\ j=0 \tag{4.13}$$

$$V_{i,j}=V_1^+=\frac{pV_2^{++}+(1-p)V_2^{+-}}{1+r},\ i=1,\ j=0; \tag{4.14}$$

$$V_{i,j}=V_1^-=\frac{pV_2^{-+}+(1-p)V_2^{--}}{1+r},\ i=1,\ j=1; \tag{4.15}$$

4.4.2 Competitive Equilibrium Expansion

This section surveys the basis for the formulas used to calculate the present value of a proposed M&A investment of a two-stage decision structure. We consider the situation where there is uncertainty about the success of the M&A activity. For company A, the value of the M&A project calculated using the traditional NPV approach is:

$$NPV_A = \frac{V_t - I_c}{(1+r)^{\Delta t}} - K_A \tag{4.16}$$

K_A = M&A investment at period 0 (cost of real option);

I_t = Cost to expending at period t (exercise price);

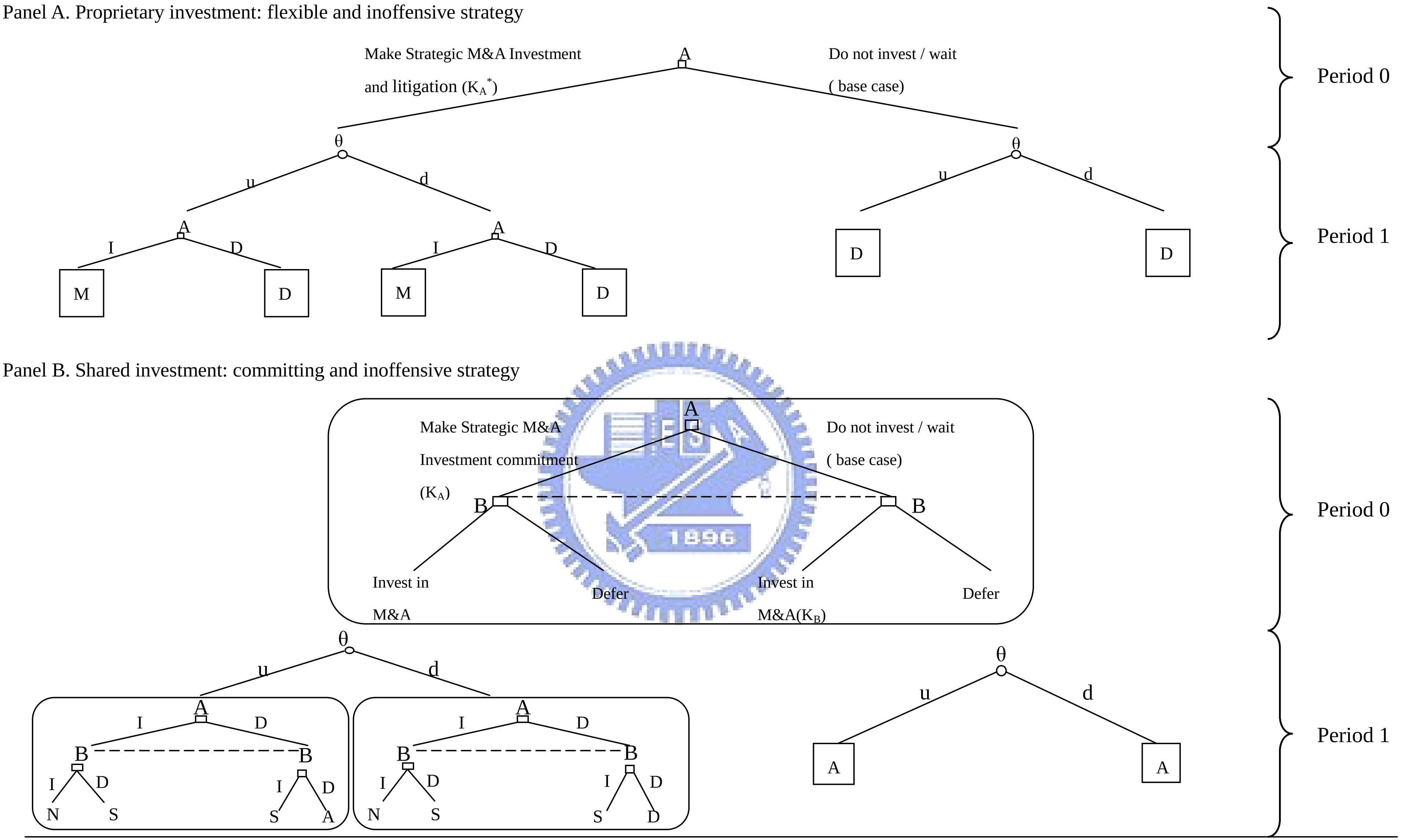
V_t = Present value at period t of the future cash flows from expending

If the M&A activity is unsuccessful, then company A cannot expand because there is no enough purchase orders. Take the Foxconn for example, in period 0, it has successfully used the M&A strategy to merge Diabell, the important component factory, and then make an investment (I_t) to expand its business in period 1. First, we take the additional capacity ($\Delta Q_{t,\mathrm{F}}$) created by the expending strategy, and multiply the price of four investment-timing scenarios: Nash, Stackelberg Leader, Stackelberg Follower and Monopolist; Further, we obtain the additional cash flow of competitions ($\Delta TCF_{t,\mathrm{F}}$) under the expending state, and use the above method to calculate the additional expansion value. In addition, in the real options concept, the option to expand would be analogous to a call option ($C_{t,\mathrm{F}}$) on this added cash flow value.

The exercise price would be equal to the extra investment outlay (I_t) required building additional capacity, and then the option to expand ($C_{t,i} = \Delta V_{t,\mathrm{F}} - I_t$, i = Foxconn or BYD) can be expressed as: (1) both companies invest simultaneously (N) $C^N{}_{t,i} = \Delta V^N{}_{t,i} - I_t$ (2) the first mover (L) preempts the market $C^{\mathrm{L}}{}_{t,i} = \Delta V^{\mathrm{L}}{}_{t,i} - I_t$ (3) the second mover (F) follows the leader $C^{\mathrm{F}}{}_{t,i} = \Delta V^{\mathrm{F}}{}_{t,i} - I_t$ (4) the monopolist (M) monopolizes the market $C^{\mathrm{M}}{}_{t,i} = \Delta V^{\mathrm{M}}{}_{t,i} - I_t$. For each subgame, we first identify pure dominant strategies, and then find the Nash equilibrium to be the result that neither company can improve by making a unilateral move.

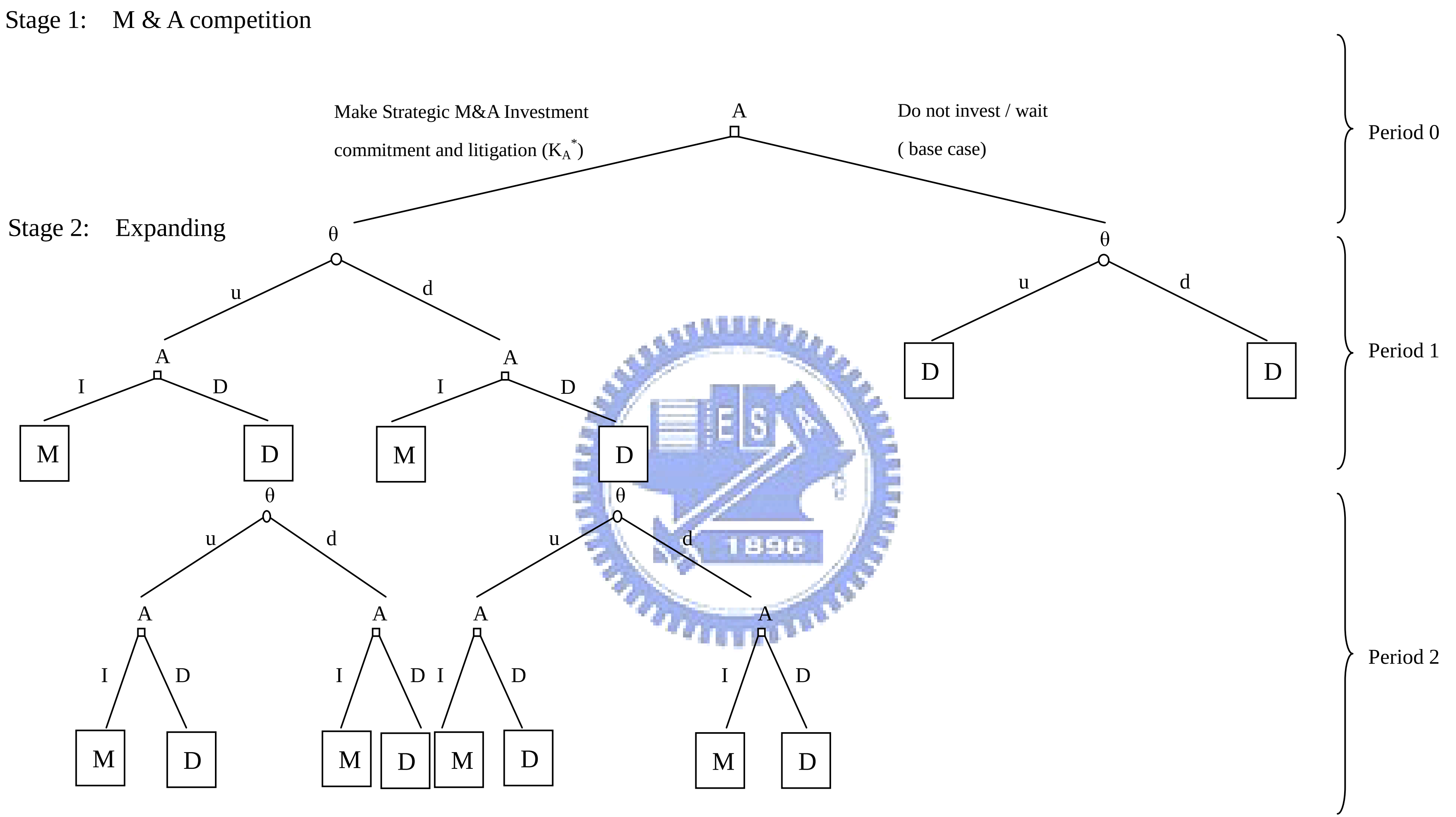
We use backward induction to calculate the value, which is the result of the strategic choice by Subgame Perfect Nash Equilibrium. Moreover, backward induction is the method using the associated risk-neutral probabilities to compute the process which moves backward over random demand moves. In my case, the expansion option value for company *i* (*i* = Foxconn or BYD) at time *t* ($PVGO_{i,t}$) is estimated by adding to the expectation of future growth value to the cash-flow value creation at the current expansion subgame, $C_{t,i}$:

$$PVGO_{i,t} = Max\left[0, \frac{pC^{+}_{i,t+1} + (1-p)C^{-}_{i,t+1}}{(1+r)^{\Delta t}}\right] \tag{4.17}$$



Notes: The combination of competitive decisions (A or B) and market demand moves (θ) may result in one of the following market structure game outcomes:
The square (□) in represent the decision note which company A chooses the actions to the next period, and the circle (○) shows the resolution of market demand uncertainty on this two period example. N: Cournot Nash price competitive equilibrium outcome; S: Stackelberg leader / follower outcome; M: Monopolist outcome; A: Abandon (0); D: Defer / stay flexible (option value)

Figure 4.2 Competitive Investment Strategies in the M&A: Proprietary versus Shared Investment



Notes: The investment decisions and market demand moves (θ) may result in one of the following market structure game outcomes:

M: Monopolist outcome; A: Abandon (0); D: Defer / stay flexible (option value)

Figure 4.3 Proprietary Investment

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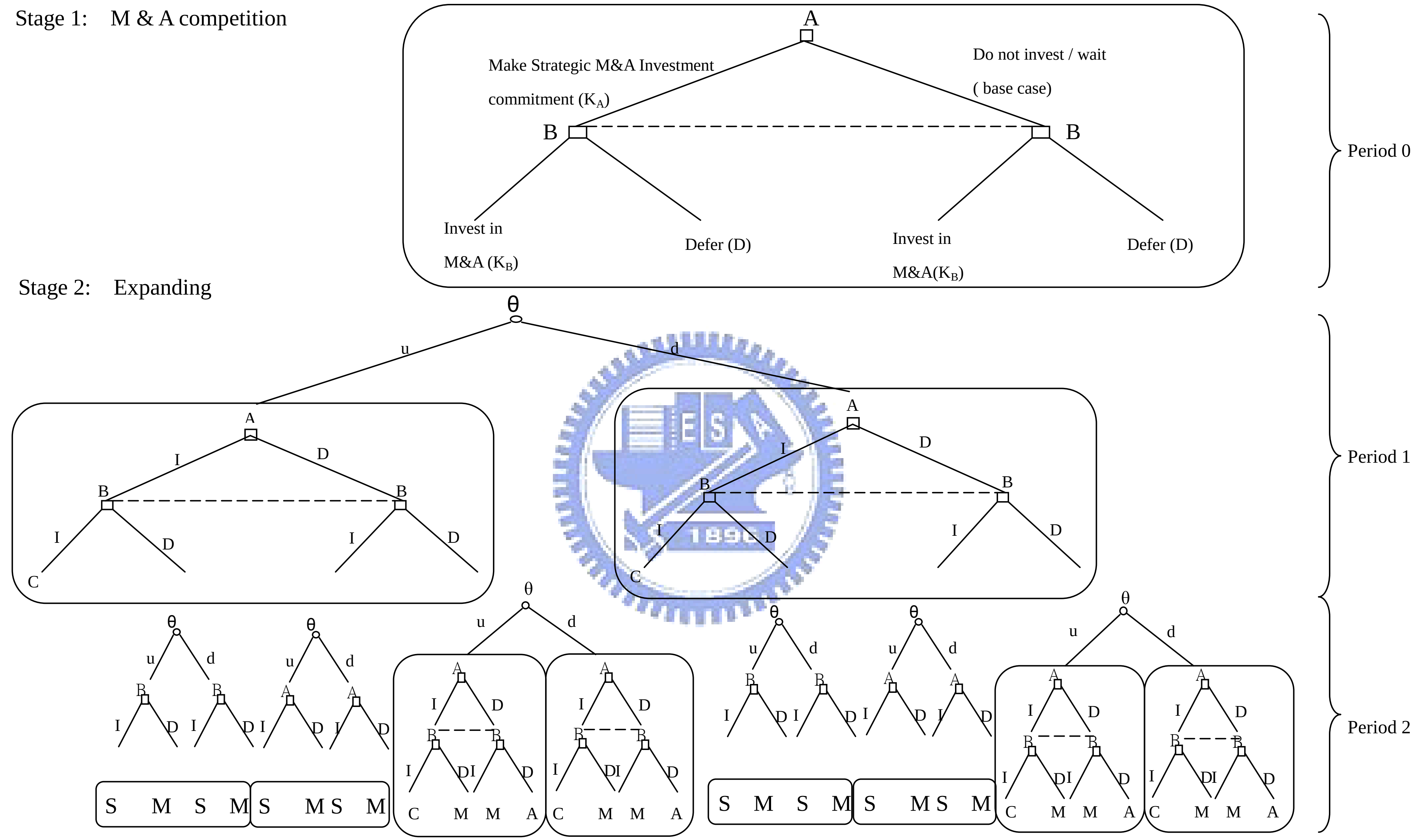


Notes: The combination of competitive decisions (A or B) and market demand moves (θ) may result in one of the following market structure game outcomes:

N: Cournot Nash price competitive equilibrium outcome; S: Stackelberg leder / follower outcome;

M: Monopolist outcome; A: Abandon (0); D: Defer / stay flexible (option value)

Figure 4.4 Shared Investment

5. Case Studies

5.1 Competitive Strategy Measure

Foxconn and BYD are EMS providers who improve the technical design and provide post-sale service to the OEM industry. The type of competitive actions that belong to the cellphone EMS industry is price competition. In order to ascertain the relationship between Foxconn and BYD, we use the competitive strategy measure (CSM), which was provided by Sundarum et al. (1996). Their experiment pointed out the rule: When CSM is less than zero, it defines quantity competition, and when CSM is greater than zero, it defines price competition.

Since there are seasonal fluctuations in the EMS industry, we derive the quarterly change to compute the measure. Using 16 quarters of data on net income and net sales from 2003 to 2007, we obtained the CSM which is 0.463. Since it is greater than zero, it implies that the competitive action of Foxconn and BYD is price competition.

5.2 Parameters Estimation and Results

5.2.1 Market Demand Estimation and Nash Equilibrium Price Expression

According to both companies' quarterly reports, we use 20 quarters of data on the quantity and average price of orders from 2003 to 2007 to develop a regression equation: The market demand function of Foxconn and BYD:

$$Q_{\mathrm{F}}(P_{\mathrm{F}}, P_{\mathrm{B}}, \theta_{\mathrm{F},t}) = \theta_{F,t} - 528990 P_F + 602799 P_B \tag{5.1}$$

where Q_F is the purchase orders quantity of mobile phones from Foxconn, P_F is the order price of Foxconn, P_B is the order price of BYD, and $\theta_{\mathrm{F},t}$ is the market demand of Foxconn at period t. We consider that the date from quarterly reports can substitute for market demand, since EMS industry' orders equal to its customers' quantity demand. In this regression equation, we obtained the series of $\theta_{\mathrm{F},t}$ from 2003 to 2007, and then we computed the volatility of market demand ($\theta_{\mathrm{F},t}$) which was 0.7633. Our following step is to derive $u = e^{\sigma\sqrt{t}}$ =2.145, $d = \frac{1}{u} = 0.466$, and $p = \frac{e^{rt} - d}{u - d} = 0.326$, where the average risk free rate was 4.06% during 2007.

5.2.2 Value of Growth Opportunities Estimation

According to the computed result above, we use the *u* and *d* to estimate the additional quantity ($\Delta Q_{t,\mathrm{F}}$) in each state, and then use the coefficient of regression equation to compute the Nash equilibrium price expression (Nash, Stackelberg Leader, Stackelberg Follower and Monopolist) in the second stage. Table 5.1 shows the competition price on the different market structure and different interaction actions. We take both companies' total addition quantity ($\Delta Q_{t,\mathrm{F}}, \Delta Q_{t,\mathrm{B}}$) in the second stage, and multiply the price of four investment-timing scenarios to obtain the total additional cash flow ($\Delta TCF_{t,\mathrm{F}}$,$\Delta TCF_{t,B}$), which was created by the order from LG's mobile phones and the equilibrium price from Table 5.1.

Based on (4.12) and (4.16) where *k* = 16.74%, *g* =13.16% for Foxconn (23.36% and 19.07% for BYD), Figure 5.1 and 5.2 illustrate the valuation results for the proprietary investment and shared investment in both periods during the expansion stage. In Figure 5.1, if Foxconn invests 0.064 billion dollars (K^*_{A}), it has the option to capture the whole market share by taking legal action to delay BYD from entering market and merging LG's component supplier in stage 1. It then has the choice to invest 1 billion dollars to expand its capacity by building an industrial park in northeast China or not in stage 2.

When demand is down ($\theta_{\mathrm{F},1} = d\theta_{\mathrm{F},0}$) and Foxconn invests, the resulting

Monopolist value at the end (where $P_{F,1}^{M}$ is monopolist price at period 1 and c_F is average cost) is

$$\mathrm{C}_{\mathrm{F},1}^{-}=\frac{\Delta Q_{F,1}^{-}(P_{F,1}^{M}-c_F)}{k-g}-I_1=\frac{15021645(75.084\text{-}52.3)}{0.1674\text{-}0.1316}-1000000000=8.55\ (billions).$$

When demand is up ($\theta_{\mathrm{F},1}=u\theta_{\mathrm{F},0}$), Foxconn can invest immediately (42.9 billion dollars) or defer the expanding investment for one period making the value of backward induction ($\mathrm{C}_{\mathrm{F},1}^{+}$) 79.3 billion dollars. Thus, the expected equilibrium value is computed by using equation (4.17):

$$\mathrm{NPV}_{\mathrm{F}}^{*}=\frac{pC_1^{+}+(1-p)C_1^{-}}{1+r}-K_{\mathrm{A}}^{*}=\frac{0.326(79.3)+0.674(8.55)}{1.046}-0.064=30.2.$$

Table 5.1 Nash equilibrium price expression

Action (A,B)	Market Structure N/M/S/A/D	Foxconn Equilibrium Price, P_F		BYD Equilibrium Price, P_B	
Period 2		upper	Down	upper	down
(DI, DI)	Nash price competition (N)	68.48	57.35	44.34	38.48
(DI, DD) (DD,DI)	Monopolist (M)	95	62.19	49.74	41.54
(II, DI) (DI,II)	Stackelberg price leader (S^L)	83.44	62	47.29	39.6
(DI, II) (II,DI)	Stackelberg price follower (S^F)	64.99	49.04	44.33	37.41
(DD,DD)	Abandon (A)				
Period 1					
(I, I)	Nash price competition (N)	61.04		40.54	
(I, D) (D, I)	Stackelberg price leader (S^L)/Monopolist (M)	75.08		62.68	
(D, D)	Defer (D)				

In Figure 5.2, If Foxconn invests 12.8 million dollars (K_{A}) and BYD invests 12.8 million dollars (K_{B}) at same time, both of them obtain the option to choose whether to invest 1 billion dollar to expand its capacity by building industrial park at northeast China or not in stage 2. In the same way, when demand is up ($\theta_{\mathrm{F},1} = u\theta_{\mathrm{F},0}$) and both companies defer (D, D) then market demand move down and both companies invest (I, I). The Cournot-Nash equilibrium value (N) at the end (where $P^{\mathrm{N}}_{F,2}$ is monopolist price at period 1 and c_F is average cost) is

$$C^{N+-}_{\mathrm{F},2} = \frac{\Delta Q^{+-}_{F,2}(P^{N}_{F,2} - c_F)}{k-g} - I_2 = \frac{32228000(68.481\text{-}52.3)}{0.1674\text{-}0.1316} - 1000000000 = 13.5.$$

When demand is up in period 2, the resulting Cournot-Nash equilibrium value is 65.9. Thus, the expected equilibrium value is computed by using equation (4.17):

$$C^{D+}_{F,1} = \frac{pC^{N+}_{F,2} + (1-p)C^{N-}_{F,2}}{1+r} = \frac{0.326(65.9) + 0.674(13.5)}{1.046} = 29.4.$$

Focused on the subgame in period 1 (where demand is up, $\theta_{\mathrm{F},1} = u\theta_{\mathrm{F},0}$), the result of Nash equilibrium by eliminating of weakly dominated strategies are (D, I) and (I, D) and are showed in the Table 5.2. Consequently, we find the mixed strategy equilibrium ($p^* = 0.472, q^* = 0.805$), using the method which is defined in Appendix A to obtain the result of subgame (where P_1=0.28 and P_2=0.65).

$$C^{+}_{F,1} = P_1(\mathrm{C}^{\mathrm{D}}_{\mathrm{F},1}) + P_2(\mathrm{C}^{\mathrm{Mix}}_{\mathrm{F},1}) + (1\text{-}P_1\text{-}P_2)(\mathrm{C}^{\mathrm{I}}_{\mathrm{F},1}) = 19.9.$$

Table 5.2 The Subgame in period 1

favorable		BYD	
		Invest	Defer
Foxconn	Invest	(15.8, 5.8)	**(58.5, 9.4)**
	Defer	**(22.8, 12.6)**	(29.4, 9.4)

unfavorable		BYD	
		Invest	Defer
Foxconn	Invest	**(2.6, 1.6)**	(2.9, 0.2)
	Defer	(0, 1.7)	(1.1, 1.1)

When demand is down ($\theta_{\mathrm{F},1} = d\theta_{\mathrm{F},0}$), the result of Nash Equilibrium by eliminating of weakly dominated strategies is (I, I), and the Cournot-Nash equilibrium value is 2.6. Thus, in the same ways, the expected equilibrium value is computed by using equation (4.17):

$$\mathrm{NPV}_{\mathrm{F}}^{*}=\frac{pC_1^{+}+(1-p)C_1^{-}}{1+r}-K_{\mathrm{A}}^{*}=\frac{0.326(19.92)+0.674(2.65)}{1.046}-0.018=7.9\,.$$

5.2.3 Base Case NPV Estimation

In the beginning, if both companies choose not to take any strategies (proprietary or shared investment), they would keep their original business, obtaining the orders from international mobile phone corporations (i.e. Nokia and Motorola). After obtaining the result of the volatility (σ), we compute the value of asset in place ($V_{\mathrm{i,j}}$) which is made up by quantity ($Q_{t,\mathrm{F}}$) in each state and the price of Nash competition from Table 5.1. Then, the value of asset in place ($V_{\mathrm{i,j}}$) at period *i* and state *j* can be calculated by using equation (4.13) to (4.15):

$$\mathrm{V}_{\mathrm{i,j}}=V_0=\frac{pV_1^{+}+(1-p)V_1^{-}}{1+r}=\frac{0.326(175)+0.674(11.8)}{1.046}=62.8 \qquad ,i=0,\ j=0;$$

$$\mathrm{V}_{\mathrm{i,j}}=V_1^{+}=\frac{pV_2^{++}+(1-p)V_2^{+-}}{1+r}=\frac{0.326(387)+0.674(84)}{1.046}=175 \qquad ,i=1,\ j=0;$$

$$\mathrm{V}_{\mathrm{i,j}}=V_1^{-}=\frac{pV_2^{-+}+(1-p)V_2^{--}}{1+r}=\frac{0.326(26.1)+0.674(5.68)}{1.046}=11.8 \qquad ,i=1,\ j=1;$$

5.3 Value Component

Now we would like to separate the different value components from the total value and to identify sign of the strategic effects. Generally, total value creation (expanded NPV) consists of the net present value (NPV) plus the value of the growth opportunities (PVGO). Furthermore, PVGO has two main effects on a company's value compared to M&A strategy: (1) flexibility (2) strategic commitment effect. In the broader context of consolidating flexibility and strategic considerations of competitive interaction, expanded NPV becomes

$$\begin{aligned}&\text{Expanded (strategic) NPV} = \text{direct NPV} + \text{PVGO}\\&= \text{direct NPV} + \left[\text{flexiblity (option) } + \text{strategic (game-theoretic) value}\right].\end{aligned}$$

This analysis further considers the degree of strategic effect and the flexibilities of first-stage M&A investment and Table 5.3 make summaries of value components for the strategic M&A investment for Foxconn.

Table 5.3

Value Components for the Strategic M&A Investment for Foxconn

	Base Case (no M&A)	Proprietary M&A (K_A^*=0.64)	Shared M&A (K_A=0.012)
1. Strategic reaction		0	-5.668
2.Strategic preemption		0	12.32
3.Strategic value (1+2-K)		-0.64	6.62
4.Flexibility	0	30.9	1.28
5.Bace case (direct) NPV	62.8	62.8	62.8
Total Expanded NPV	62.8	93.06	70.75

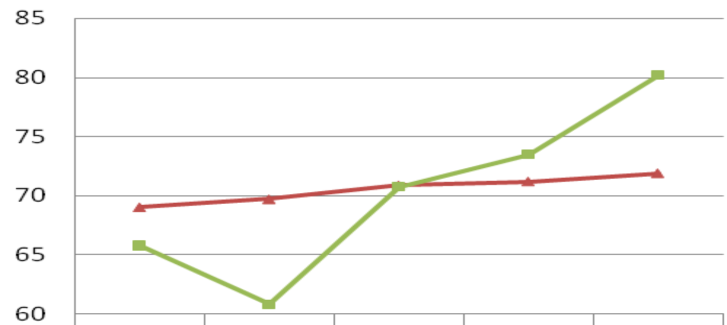
(The detail record of computation, see Appendix B)

In the first-stage proprietary M&A investment, since Foxconn directly earns monopolist profit, it does not have any effect of strategic reaction and strategic preemption. In addition, Foxconn has an option to expand and can choose whether to make expansion investment in period 2. Thus, it has highly flexibility (30.9), and the expanded NPV of proprietary M&A investment is 93.08.

On the other hand, in the shared M&A investment, BYD may enter the market by merging another component factories; therefore Foxconn faces the reversal sign of the strategic reaction effect (-5.668) by offensive strategy of M&A investment under reciprocating competition. The expanded NPV of shared M&A investment is 70.75.

5.4 Scenario Analysis

In this part, we compare the NPV under different volatility in the following situations: one is NPV with game theory and the other one is the NPV without game theory. Figure 5.3 show the result of different NPV under different volatility. When market demand under high volatility, the NPV without game theory less than the NPV with game theory. If we do not consider the competitor's responses, we will not change the type of investment. In our case, Foxconn do not change its strategy when market demand under high volatility. However, when the NPV of shared investment is greater than the NPV of proprietary investment, Foxconn will change its investment type. Therefore, NPV with game theory can examine how sensitive a particular NPV when we use this framework in another case study.

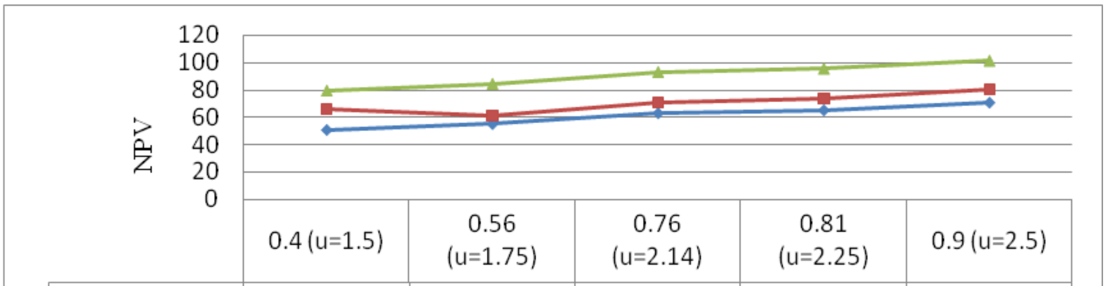


σ(volitility)	0.55	0.65	0.75	0.85	0.95
NPV without game theory	69.01	69.69	70.87	71.2	71.9
NPV with game theory	65.78	60.82	70.75	73.5	80.18

Figure 5.3 NPV with Game Theory versus NPV without Game Theory

Afterwards, we set two variables which are risk-free rate and market demand (R_f and θ_t) to compare the value of base case and the difference expanded NPV, hoping to describe the strategy value and the flexibility between the different investment types under uncertainty by scenario analysis. Table 5.5, demonstrates the relationship between risk-free rate and the flexibility; the higher risk-free rate is, the higher expanded value and flexibility are (See Figure 5.4).

Panel A. The Expanded NPV of Foxconn versus Different Volatility



	0.4 (u=1.5)	0.56 (u=1.75)	0.76 (u=2.14)	0.81 (u=2.25)	0.9 (u=2.5)
base case	50.45	54.82	62.81	65.06	70.62
Shared	65.78	60.82	70.76	73.5	80.18
Proprietary	79.53	84.41	93.1	95.51	101.41

Panel B. The Flexibility of Proprietary Investment versus Different Risk-free Rate

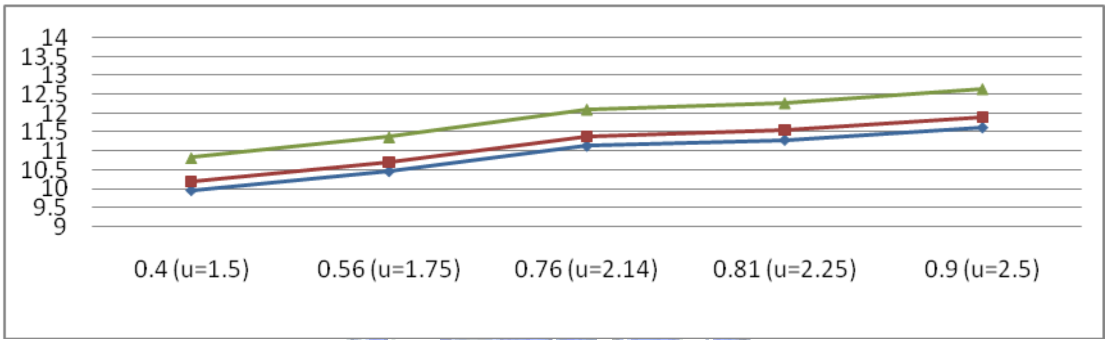
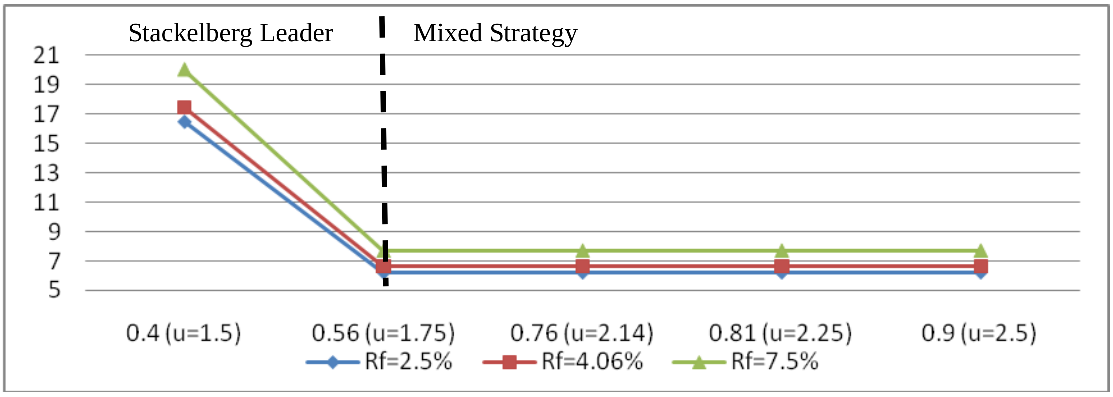


Figure 5.4 Expanded NPV and Flexibility under Different Risk-free Rate

The rise of risk-free rate enhances the market rate and also increases the interest cost. Furthermore, if the initial investment outlay (I_t) is regarded as the exercise price of options, the higher risk-free rate lowers the present investment outlay. Meanwhile, the higher volatility rate is, the higher value of options is, which is as same as the feature of financial options. Due to the higher volatility, the opportunity of making profit by expanding capacity is also higher as the opportunity of options in the money increases.

In the influence of volatility, different volatility can change the results of subgame and causes the increase of strategic value (See Figure 5.5). When the volatility changes from 0.56 to 0.4, the result of competition would become Stackelberg Leader (I, D), and a decrease of flexibility value is covered with an increase of strategic value which improves the expanded NPV of shared investment.

Panel A. The Strategic Value of Shared Investment versus Different Risk-free Rate



Panel B. The Flexibility of Shared Investment versus Different Risk-free Rate

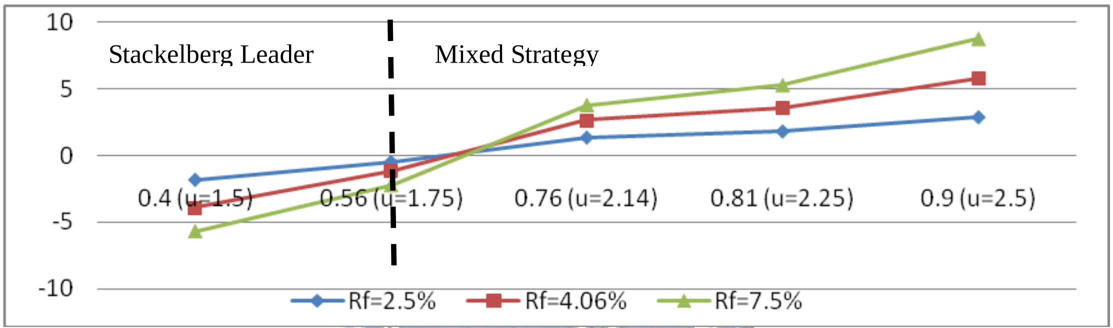


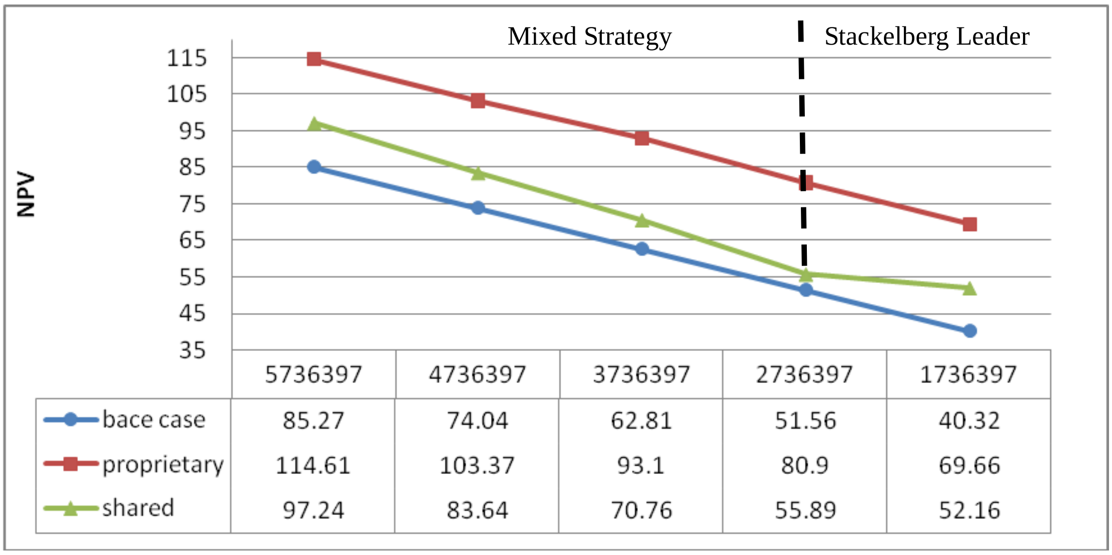
Figure 5.5 Strategic Value and Flexibility under Different Risk-free Rate

Table 5.6 and Figure 5.6 display the NPV under different market demand (θ), the higher market demand is, the higher expanded value is.

Table 5.5 The Net Present Value under Different Market Demand

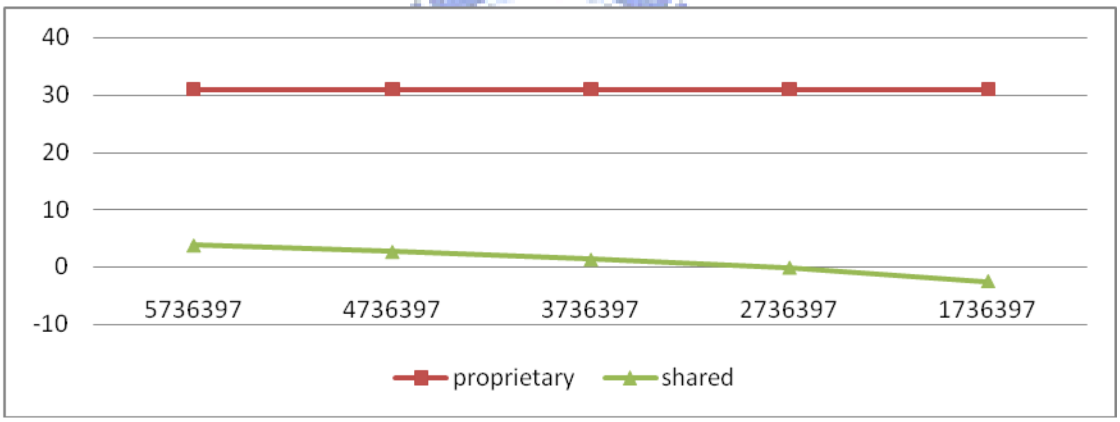
	The Expand NPV			Flexibility		Strategic Value	
θ	base case	proprietary	shared	proprietary	shared	proprietary	shared
5736397	85.27	114.61	97.24	30.94	3.8	-0.64	8.16
4736397	74.04	103.37	83.64	30.94	2.66	-0.64	6.94
3736397	62.81	93.1	70.76	30.94	1.28	-0.64	6.67
2736397	51.56	80.9	55.89	30.94	-0.15	-0.64	4.48
1736397	40.32	69.66	52.16	30.94	-2.56	-0.64	14.39

Panel A. Foxcoon's Expanded NPV versus Different Market Demand



	5736397	4736397	3736397	2736397	1736397
bace case	85.27	74.04	62.81	51.56	40.32
proprietary	114.61	103.37	93.1	80.9	69.66
shared	97.24	83.64	70.76	55.89	52.16

Panel B. The Value of Flexibility versus Different Market Demand



Panel C. The Strategic Value versus Different Market Demand

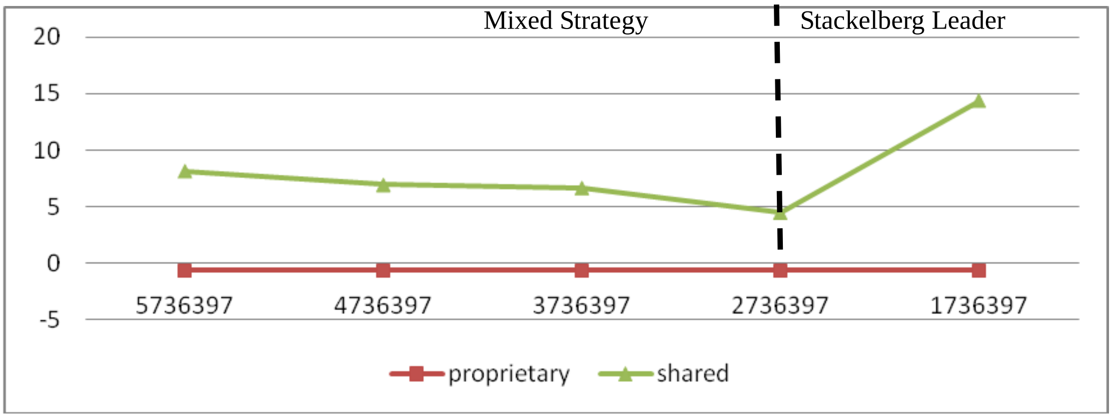


Figure 5.6 Strategic Value and Flexibility under Different Market Demand

The strategic value in low market demand is smaller than the high market demand, and show the trade-off between the flexibility effect and the strategic effect. When the market demand is lower than 2,736,397, Foxconn may change the action in the subgame. The changes from mixed strategy to Stackelberg leader would add the value of the expanded NPV and the strategic value.

In scenario analysis, it can obviously appraisal the value of different strategies and decide the optimal strategy to Foxconn by separating flexibility value and strategic value from expanded NPV. Moreover, if market demand changed dramatically in the future, then Foxconn adopts proprietary investment strategy will be more advantageous. Finally, Foxconn will earn monopolist profit through adopting actions of law or tough M&A strategy to prevent BYD from obtaining the Korean mobile phone orders.

Panel A. Proprietary investment: flexible and inoffensive strategy

Panel B. Shared investment: committing and inoffensive strategy

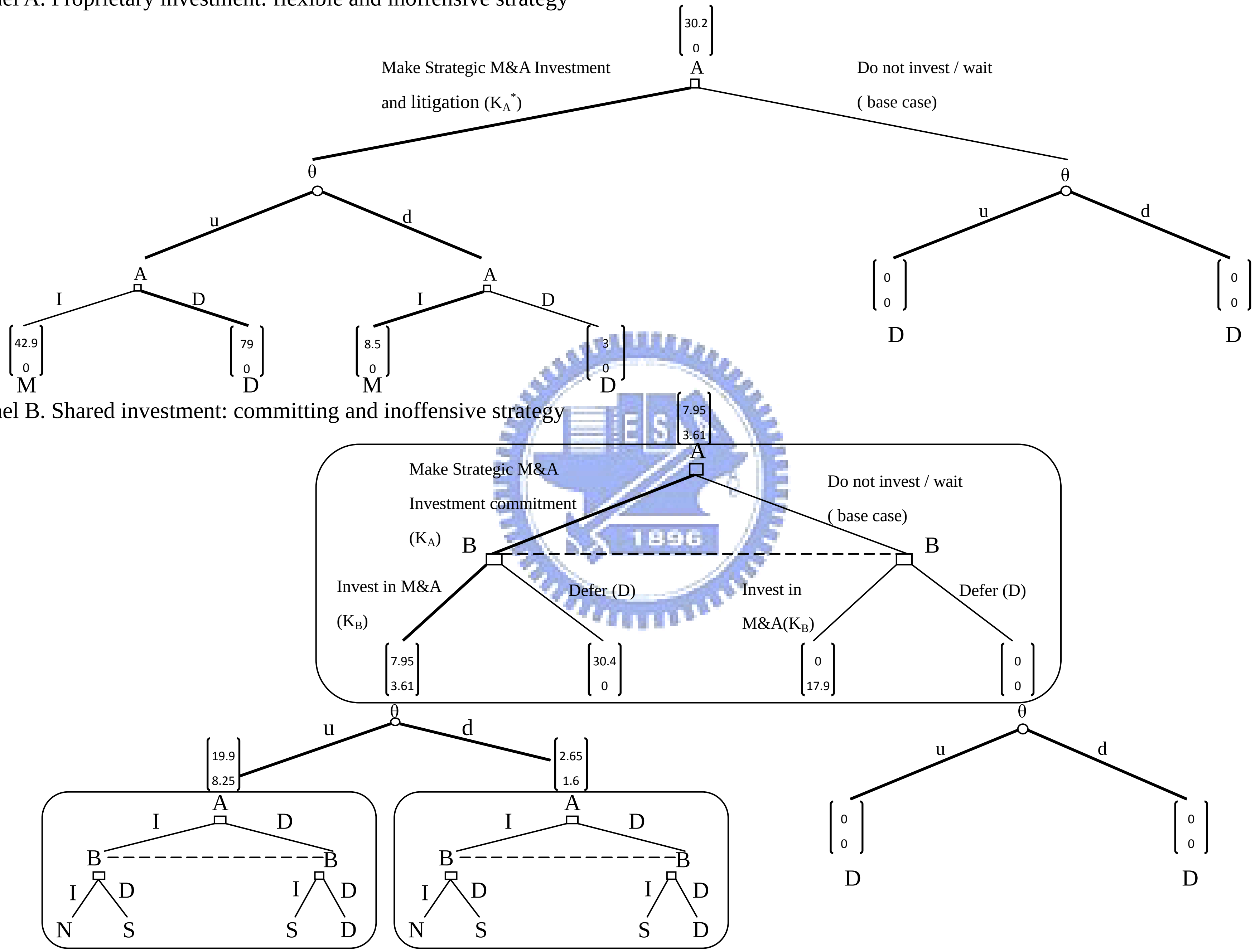
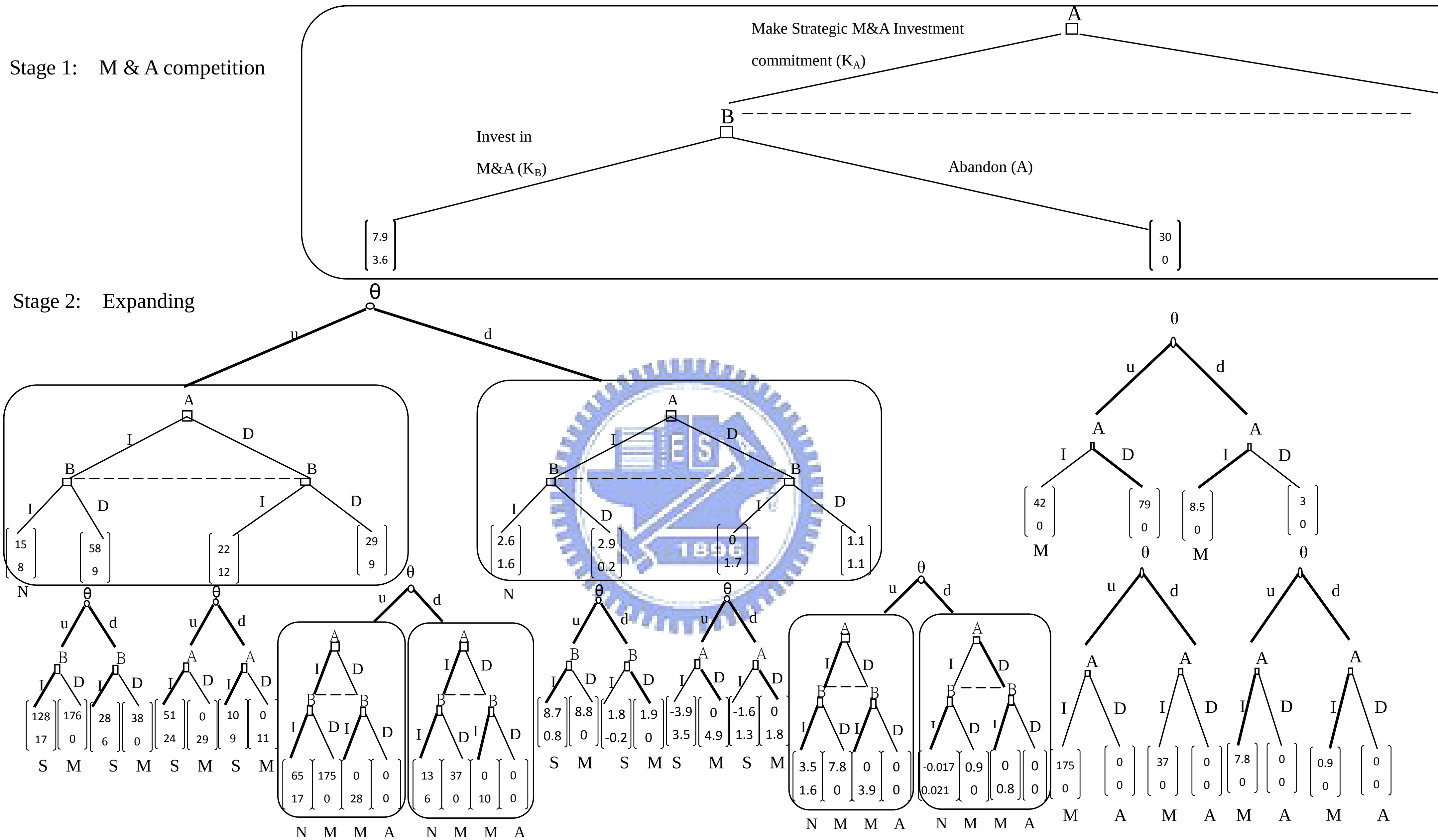


Figure 5.1 The Additional Value of Proprietary Investment and Shared Investment



Notes: The combination of competitive decisions (A or B) and market demand moves (θ) may result in one of the following market structure game outcomes:

N: Cournot Nash price competitive equilibrium outcome; S: Stackelberg leder / follower outcome;

M: Monopolist outcome; A: Abandon (0); D: Defer / stay flexible (option value)

Figure 5.2 Shared Investment of Foxconn

Table 5.4 The Net Present Value under Different Risk Free Rate and Different Volatility

Risk-free Rate Outlay	Volatility σ	Market Structure $\theta_{F,1} = u\theta_{F,0}$	Type NPV			Flexibility		Strategic Value	
			Base case	Proprietary	Market Shared	Proprietary	Market Shared	Proprietary	Market Shared
2.5%	0.9 (u=2.5)	Mix	67.56	96.86	76.65	29.93	2.89	-0.64	6.19
	0.81(u=2.25)	Mix	62.25	91.21	70.26	29.6	1.82	-0.64	6.19
	0.76(u=2.14)	**Mix**	**60.08**	**88.89**	**67.73**	**29.44**	**1.36**	**-0.64**	**6.19**
	0.56(u=1.75)	Mix	52.45	80.57	58.16	28.76	-0.48	-0.64	6.19
	0.4 (u=1.5)	Stackelberg	48.27	75.89	62.86	28.25	-1.83	-0.64	16.51
4.06%	0.9 (u=2.5)	Mix	70.62	101.41	80.18	31.43	2.9	-0.64	6.67
	0.81(u=2.25)	Mix	65.06	95.51	73.5	31.09	1.77	-0.64	6.67
	0.76(u=2.14)	**Mix**	**62.81**	**93.1**	**70.76**	**30.93**	**1.28**	**-0.64**	**6.67**
	0.56(u=1.75)	Mix	54.82	84.41	60.82	30.24	-0.67	-0.64	6.67
	0.4 (u=1.5)	Stackelberg	50.45	79.53	65.78	29.72	-2.08	-0.64	17.41
7.5%	0.9 (u=2.5)	Mix	77.8	112.05	88.48	34.9	2.95	-0.64	7.73
	0.81(u=2.25)	Mix	71.68	105.57	81.09	34.53	1.68	-0.64	7.73
	0.76(u=2.14)	**Mix**	**69.18**	**102.9**	**78.05**	**34.36**	**1.13**	**-0.64**	**7.73**
	0.56(u=1.75)	Mix	60.39	93.38	67.04	33.63	-1.09	-0.64	7.73
	0.4 (u=1.5)	Stackelberg	55.58	88.02	72.65	33.08	-2.79	-0.64	20.02

6. Conclusions

The investments between enterprises often interact with one another, as illustrated by the Foxconn case discussed above, in which a two stage decision tree is built using the options-game approach. In the first stage, Foxconn uses the M&A investment as the strategy to acquire the product ability of LG; in the second stage, Foxconn builds an industrial park in northeastern China as the options to expand. We analyze the investments between Foxconn and BYD using the game theory, which not only correctly estimates the cash flow from the time they start to invest but also eliminate the problem of underestimating the value of investment by the traditional NPV method. Indeed, Foxconn delayed BYD Electronic from being listed in Hong Kong by accusing BYD of obtaining confidential information from its former employees. The delay caused BYD to be unable to collect enough money to make M&A investment. Next, Foxconn acquired the property rights of Diabell, which is one of LG's component suppliers. Therefore, the strategy which Foxconn has adopted is the same as our empirical and closely coincides with the result from our analysis.

As demonstrated, using the options-game approach can distinguish the flexibility value and strategic value from the current decision-making method under uncertainty. The methodology adequately considers the uncertainty of market demand, and decides whether to invest immediately or defer to the next period. Using the expansion options to appraise the effects of an investment project, managers can manipulate different strategies in each stage. Moreover, they can analyze the feasibility of investment in each stage (including growth option, option to defer, option to abandon and option to switch), and link the game theory (dynamic or static game) to assay the effects from the response of rival. Finally, the optimal investment strategy is the one which has the maximum sum of flexibility value and strategic value. This research combines the real option model and game theory to investigate EMS industry investment types by taking competitor responses into consideration. Firms may take benefits from employing this options-game framework since they can more accurately evaluate their projects by considering the flexibility and strategic reactions.

To make a comprehensive survey of this paper, when we did this study, have referred to many materials of industries, and then chosen Foxconn to be the object of my study since the keen competition of Foxconn and BYD deserves to be surveyed. However, this paper is not meant to be a perfect and accurate description of the introduction of other investment in Foxconn but an application of our models. According to the annual report of Foxconn in 2008, Foxconn makes R&D investment in smart phone, if it has ability to manufacture smart phone, then it will become the new largest manufacturer of high-tech mobile phone or the competitor to HTC Crop., which manufactures smart phones, and mobile computer devices. Therefore, the further research can consider the above-mentioned to create new monograph.

Appendices

A. Mixed Strategy Equilibrium

Let the decision nodes labeled by an indicator set $I = \{1, 2, 3..., n\}$. At node *i*, the action set is $\mathrm{A}_i = \{a_1^i, a_2^i, a_3^i ..., a_n^i\}$. An individual's behavior at node *i* is determined by a probability vector $\mathrm{IP}_i = \left(p(a_1^i), p(a_2^i), p(a_3^i)..., p(a_n^i)\right)$, and the set of pure strategies is given by the cross-product of all the action sets: $s_i = A_1 \times A_2 \times \cdots \times A_n$.When there is only a single decision to be made, the sets of actions and pure strategies are identical. However, if there is more than one decision to be made, the action sets and pure strategies are no longer identical and there are now two. To distinguish between them we shall call one a "mixed strategy" and the other a "behavioural strategy".

A mixed strategy δ specifies the probability $p(s)$ with which each of the pure strategies $s \in \mathrm{S}$. Suppose the set of strategies is $\mathrm{S}=\{\mathrm{s_a}, \mathrm{s_b}, \mathrm{s_c}, \cdots\}$, then a mixed strategy can be represented as a vector of probabilities: $\delta = \left(\mathrm{p(s_a)}, \mathrm{p(s_b)}, \mathrm{p(s_c)}, \cdots\right)$.

Consider a two player two action game with arbitrary payoffs:

		P2	
		I	D
P1	I	(a, b)	(c, d)
	D	(e, f)	(g, h)

Usually, we will denote the probability of using the pure strategies s by $p(s)$ for player 1 and $q(s)$ for player 2. The payoffs for mixed strategies are then given by

$$\pi_i(\delta_1, \delta_2) = \sum_{s_1 \in \mathrm{S}_1} \sum_{s_1 \in \mathrm{S}_1} \mathrm{p(s_1)q(s_2)} \pi_i(s_1, s_2)$$

In this game, we look for a mixed strategies Nash equilibrium using the Equality of Payoffs: Let (δ_1, δ_2) be a Nash equilibrium, and let S_1^* be the support of δ_1^*. Then

$\pi_i(s_1, \delta_2^*) = \pi_i(\delta_1^*, \delta_2^*) \quad \forall s \in S_1^*$.

Then

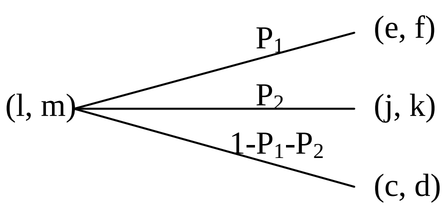
$$\pi_1(I, \delta_2^*) = \pi_1(D, \delta_2^*)$$
$$\Leftrightarrow aq^* + c(1-q^*) = eq^* + g(1-q^*)$$
$$\Leftrightarrow q^* = \frac{(c-g)}{(c-g)+(\mathrm{e}-a)}$$

and

$$\pi_2(\delta_1^*, I) = \pi_2(\delta_1^*, D)$$
$$\Leftrightarrow bp^* + f(1-p^*) = dp^* + h(1-p^*)$$
$$\Leftrightarrow p^* = \frac{(\mathrm{h}-f)}{(\mathrm{h}-f)+(\mathrm{b}-d)}$$

Accordingly, we have $0 < p^*, q^* < 1$ as required for a mixed strategy Nash equilibrium (James N. Webb, 2006, Game Theory).

In the real world, company never chooses mixed strategy, since the payoff from mixed strategy is less than both (D, I) and (I, D). Thus, we use the concept of trinomial method to compute the new payoff which higher than the payoff from mixed strategy.



Where (j, k) is the payoff from mixed strategy; P_1 and P_2 are risk-neutral probability.

Then, we suppose the following inequality:

$$e(P_1) + c(1-P_1-P_2) \le j(P_2)$$
$$f(P_1) + d(1-P_1-P_2) \le k(P_2)$$

Evaluate these two inequalities, we find the probabilities of three situations as:

$$P_1 = \frac{c(k+d)-d(j+c)}{(c-e)(k+d)+(j+c)(f-d)}$$
$$P_2 = \frac{c(f-d)-d(e-c)}{(c-e)(k+d)+(j+c)(f-d)}$$

We can calculate (l, m) through P_1 and P_2, and the new Nash equilibrium is:

$$l = e(P_1) + j(P_2) + c(1-P_1-P_2)$$
$$m = f(P_1) + k(P_2) + d(1-P_1-P_2)$$

B. Strategic Value and Flexibility Value

In this part, We want to illustrate how to compute the value of strategic and flexibility. At first, PVGO has two main effects on a company's value compared to M&A strategy: (1) strategic commitment effect (2) flexibility. In Foxconn case, when demand is up ($\theta_{\mathrm{F},1} = u\theta_{\mathrm{F},0}$), in which the result of subgame is Mixed strategy, yet if Foxconn does not have the option to defer, he will invest immediately and the value (BYD invests too) is 15.82 (the value is 2.65 when demand is down ($\theta_{\mathrm{F},1} = d\theta_{\mathrm{F},0}$)). Hence, the strategic commitment effect is 6.67 ($\frac{15.82(0.32)+2.65(0.68)}{1.0406}$). Furthermore, the flexibility value is the management's ability to wait to invest until demand develops sufficiently. As a result, the flexibility value is 1.283, which equals to the strategic commitment effect subtract from PVGO.

Second, the strategic commitment effect is the equal of initial investment K_a subtract from the sum of strategic reaction and strategic preemption. The strategic preemption is the value which the gap between the value of different market structure (Stackelberg Leader and Nash). To illustrate, when demand is up ($\theta_{\mathrm{F},1} = u\theta_{\mathrm{F},0}$), the gap in the subgame is 38.6 (58.55-15.82). When demand is down ($\theta_{\mathrm{F},1} = d\theta_{\mathrm{F},0}$), the gap in the subgame is 0.32 (2.97-2.65). Thus, the strategic preemption is 12.3 ($\frac{38.6(0.32)+0.32(0.68)}{1.0406}$), and the strategic reaction is -5.668 (6.62+0.012-12.3).

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