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HOKKAIDO UNIVERSITY

DOCTORAL THESIS

**A Dynamic Model of Mergers and
Acquisitions: Optimal Payment Methods**

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HOKKAIDO UNIVERSITY

Abstract

Faculty of Economics and Business
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Doctor of Philosophy

A Dynamic Model of Mergers and Acquisitions: Optimal Payment Methods

by Wenjun CHEN

This dissertation develops dynamic models of joint takeovers to determine the optimal payment strategy and the optimal timing to acquire a target firm. We first establish a pure cash-payment model, which the bidder pays in cash to buy all the shares of the target firm. And then we extend the pure cash-payment model into three models using different payment strategies: a cash-share mixed-payment model, an expand-sell model, and a debt-share mixed-payment model.

In a cash-share mixed-payment model, the bidder and the target firm exchange parts of their share and the bidder also pays a cash premium payment to the target to gain high post-merger management control. The model relates the acquisition premium payment and the merger threshold to the growth rate, volatility, and correlation coefficient of the bidder and target. The result indicates the mixed-payment method will outperform the pure cash-payment method when the growth rate of the bidder is high, the businesses of the participating firms are low risky or the correlation coefficient of the participating company is low because of the diversification of the business of the two companies.

An expand-sell model considers an expansion offer that is motivated by the synergy gains and a contraction offer that is prompted by efficiency liquidation. The bidder can choose an expansion strategy to acquire the target when their market value increases, and determine a contraction strategy to sell the asset to the target when their market value decreases. The result indicates that the bidder prefers to expand their business when the growth rate of bidder's business is high and to sell their asset when the growth rate of the opposite firm is high. The expansion process is longer than the contraction process when the participating companies are highly risky.

A debt-share mixed-payment model extends the pure cash-payment which is also considered as the equity finance takeover to the debt finance takeover, which assumes that the bidder issues a revenue bond. The results indicate that the takeover execution speed of the debt finance model is faster than which of the equity finance model when the participating firms are highly risky.

The three main contributions of this study are as follows. First, we compare each method with the pure cash-payment method to find the relationship between the participating firm's business condition and the payment method decision. Second, we analyses the terms, assuming that the bidder and target will negotiate the terms of the merged enterprise, which we solve via a Nash bargaining solution (Nash [61]). Finally, we assume that both the bidder and target will probably mis-estimate the synergy generated, and that the managers of both firms can take advantage of this. The dissertation analyses the abnormal returns from the announcement.

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List of Abbreviations

S_X , the stock market value of the bidder;
 S_Y , the stock market value of the target;
 S_M , the stock market value of the post-merger firm;
 K_X , the capital stocks of the bidder;
 K_Y , the capital stocks of the target;
 X_t , the per unit price of bidder's capital at time t ;
 Y_t , the per unit price of target's capital at time t ;
 R_t , the ratio of per unit capital price at time t ;
 μ_X , the expected growth rate of the bidder;
 μ_Y , the expected growth rate of the target;
 σ_X , the volatility of the bidder;
 σ_Y , the volatility of the target;
 ρ , the correlation coefficient;
 α , the synergy parameter;
 c , per unit merger cost;
 r , risk-free rate;
 ξ , the friction of the post-merger company to the bidder;
 $1 - \xi$, the friction of the post-merger company to the target;
 τ , the timing of mergers and acquisitions;
 p , the cash payment ratio, which is a portion of the market value of the bidder;
 q , the debt payment ratio, which is a portion of the market value of the target;
 λ , the cash premium ratio, which is a portion of the market value of the target.

Chapter 1

Introduction

1.1 The Background of M&As

We are now in a new technological revolution with the development of artificial intelligence. Many transitional companies are seeking the business innovation and diversification. Mergers and acquisitions are useful strategies for the company to extend business scale or to begin a new business. In 2016, the volumes of the global M&As market demonstrated as 3.9 trillions USD, in line with the third best year on record.¹ Therefore, mergers and acquisitions are more important research theme for enterprise than even.

1.1.1 The History

Basic on the economists' common viewpoints, the twentieth century has seen five periods of high merger activities, also considered as merger waves. We are in the sixth merger wave nowadays synchronizing with the development of the Internet technology. Lambrecht [39] illustrates that waves typically coincided with economic expansion, and merger activity usually slowed down during economic recessions.

According to Patrick [65], five M&As waves occurred between 1887 and 1904, 1916 and 1929, 1965 and 1969, 1984 and 1989, and in the early 1990s. The first wave happened in the time of the Second Industrial Revolution. The merger activity was majorly horizontal, happening in the area of the principal steel, telephone, oil, mining, railroad and other giants of the primary manufacturing and transportation industries. The First World is viewed as the ending of the first wave.

The second period began during the first war (approximately 1916) and continued until the stock market crash. The vertical integration was significantly increased in this period. George [26] considered the first wave as "merging for monopoly" and the second wave as "merging for oligopoly". The primary reason for the second wave was the post-World War I economics boom.² And this wave was ended due to the 1929 Crash and the Great Depression.

The third merger wave was synchronous with a period of economic prosperity in the United State. Conglomerate mergers to diversify the business area characterized this merger wave. Many major established companies expanded their business into new industries and regions. Because of the conglomerate stocks crashed in 1970, diversification could not provide companies any other benefits.

¹According to "2017 M&As Global Outlook: Finding opportunities in a dynamic market" published by J.P. Morgan.

²See Patrick [65] Chapter two for further discussion.

The fourth merger wave, from 1984 to 1989, happened with the presidency of Ronald Reagan, who made the supply-side economic policies that led to the economic growth. In this wave, hostile mergers dominated the mergers and acquisitions market. The most famous case is, on behalf of Morgan Stanley, the transaction between Inco and ESB (Electric Storage Battery). This successful hostile bid case opened the door for investment banks to make hostile takeover bids. The volumes of mergers in this wave were seen to be much larger than those in earlier waves. The debt was also more widely used to finance mergers.

The fifth merger wave was approximately in the early 1990s, followed the economic recession of 1990. Lots of mega deals happened in this wave. Different from the fourth wave, the hostile takeover activity diminished in this wave. Because of a leverage risk in the fourth merger wave, the debt was less commonly used to finance in this wave. During this wave, companies were expanded to unprecedented size in order to maintain their competitive strength.

Many factors, such as the economic cycle, government, and the stock market, influence merger activities in the five waves. Government competition policy plays a significant role in most of merger activities. It can promote, retard or maybe prohibit mergers. With the increasing of the international transactions, currencies are also the critical factor in the merger market. Fluctuations in currencies have an impact on cross-border deals. Companies with stable currencies have an advantage in acquiring companies in countries with weak currencies. Japanese Yen appreciation may lead to a boom of cross-border merger activities by Japanese enterprise. Also, several liquidity mergers happened because of the cash flow and liquidity shocks. If the firm is hit by a liquidity shock that is larger than its pledgeable value, the company might not be able to raise the extra capital it needs. Liquidity merger is one solution. Arbitrage is a significant factor in merger activities. Arbitrageurs, sometimes, for their own purposes, encourage a company to seek a merger or to make a bid for a company even if this company is not that satisfied. Besides these factors, the economic cycle is the most critical reason for merger waves. Most merger waves happened or ended due to the economic shocks. Receptive equity and debt markets are essential factors in merger activities.

1.1.2 The Classification

Horizontal, Vertical, and Conglomerate M&As

The categories of the mergers and acquisitions activities can be divided by several ways. Based on relationships between the acquiring firm and target firm, we divide mergers and acquisitions into three types: horizontal, vertical, and conglomerate.

A horizontal merger occurs in the same industry, always among the competing firms. The bidder and the target firm offer similar, or compatible products or services. The motivation for a horizontal merger is to achieve higher market share, to increase the diversity through widening the product range, or to open a new market. Recently, with the popularity of the electronic vehicle, mergers and acquisitions activities aiming to diversify the products, such as Tesla, Inc. and Perbix Machine Company, Geely Automobile and Emerald Automotive, are increasing in the electric vehicle market and battery market. Also in 2017, the transaction that 7-Eleven Inc. paid 3.3 billion USD to acquire 1,110 U.S. stores under Sunoco LP to explore their business to the U.S is considered as a horizontal deal.

Vertical mergers generally happen between the buyer-seller relationships. Enterprises have several motives to combine vertically. The common reasons are to reduce

the cost or to reduce the uncertainty over the availability or quality of products. One example is the acquisition of AT&A and Time Warner. AT&T is a company, which provides mobile telephone services, fixed telephone services, and broadband subscription television services in the United States. And Time Warner is a mass media company. The combination of two companies may decrease the price to gain higher market share.

The mergers and acquisitions activities happen between the participating companies, which are not in the same industry, and without buy-seller relationships are considered as conglomerate deals. One motive of conglomerate transactions is to promote the innovation of the business and thereafter to diversify the products or the services, such as the acquisitions of Amazon and Whole Foods. Traditionally, it is difficult for a net-shopping site to extend their business to the fresh food industry. However, Amazon may take advantage of their delivery system to diversify the business.

Growth and Disinvestment M&As

Based on the motivations for the participating firms, Lambrecht and Myers [41] divides mergers and acquisitions into two broad categories: one is to gain the synergies and growth opportunities; and another is to seek higher efficiency through layoffs, consolidation, and disinvestment. As for the aspect of the growth M&As, according to Brouthers, Hastenburg and Ven [12], there are three accepted categories, the economic motives such as economies of scale, risk spreading, diversification, the personal incentives such as sales benchmark, material challenge, and finally the strategic motives such as acquisitions of the competitor or raw materials. In this dissertation, we establish the model of mergers and acquisitions economically motivated by synergy gains.

Friendly and Hostile M&As

We can also classify M&As activities as friendly or hostile. Friendly M&As happen with the agreement between the acquiring firm and the target firm, while hostile M&As are without agreement and always accomplished by a tender offer.

1.1.3 Type of Transactions

The mergers and acquisitions can include several different transactions. A general definition is given as follows.

Merger

In a merger transaction, the shareholders of two participating companies agree on the combination of their firms. Both the shareholders of the acquiring firm and the target firm hold the control power of the combined company after the merger.

Acquisitions

In an acquisition transaction, the acquiring firm buys most of the target firm's ownership (generally, more than 50% ownership of the target). The acquiring firm will control the combined firm after the transaction.

Tender Offer

In a tender offer, the acquiring firm writes an offer to purchase the outstanding stock of the target firm. The transaction price is determined at the announcement day and always higher than the market price. In this type of transaction, the acquiring firm buys the share from the shareholders directly without the agreement of the boards of directors.

Management acquisitions

The management acquisitions also called for a management-led buyout (MBO), is happening among the executives of the company. The managers purchase the assets of the company and hold the ownership after MBO. The motivation is the more significant potential rewards to be the owner of the company comparing with being an employee because of the insider information.

Consolidation

In a consolidation, the shareholders of both participating firms approve the transaction. Two firms combine to a new company. The shareholders receive the common equity shares of the combined company.

1.2 The Motivations of M&As

We can divide the motivations of mergers and acquisitions into three categories: the strategy motivations, the financial motivations, and the managerial motivations.

Strategic motives focus on the improvement and the development the business or on the competitive advantages. Mallikarjunappa and Nayak [51] illustrate that M&As are always a long-term strategy for the corporate sector. The synergistic gains from M&As may result from more efficient management, economies of scale, more profitable use of the assets, exploitation of market power, and use of complementary resources. Rizvi [70] studies 85% of M&As among Indian companies and found that M&As are important growth strategies for the companies. Kishore and Ravi [38] represent that takeovers are business strategies of directly or indirectly acquiring control over the management of the target firm. The strategic motives include the growth of the company, economies of scale, competition advantages, market shares, synergy gains, and products diversification or disinvestment efficiency.

The financial motives include tax saving, costs reducing or earning per share (EPS) increasing. The managerial benefits are self-interests of managers, such as sales benchmark, material challenge, which may not equal to the best strategy for the shareholders.

1.2.1 The Synergy

Several well-known studies have analyzed the mergers and acquisitions model considering the synergy gains. Andrade, Mitchell and Stafford [3] and Andrade and Stafford [4] provide the evidences that resource of mergers gains is generated from possible economies of scale, greater efficiency of resource using and the market power. Lambrecht [39] studies the timing and terms of mergers motivated by economies of scale and shows that merger activities are positively correlated with markets, meaning that firms are willing to merge during economic expansions. In the study,

he assumes a Cobb-Douglas production function, which displays increasing returns to scale. The increase therefore is called synergy in the model. Based on Lambrecht [39], Thijssen [77] builds a two-uncertainty model that optimizes the timing considering both efficiency gains and diversification benefits. The results show that mergers and acquisitions will happen during both economic upswings and downswings.

While Zhu et al. [80] develop a model to analyze the timing of bank mergers and show that the mergers motivated by the incentive to obtain too-big-to-fail (TBTF) status from the government may occur even in the absence of scale economies, which shows different results with Lambrecht [39]. Hackbarth and Morellec [30], Morellec and Zhdanov [58] and Shleifer and Vishny [75] assume a linear combination of the participating firms. In those models, the synergy assumptions show that the acquiring firm has a higher Tobin's q than the target, which also means the acquiring firm better performs than the target. The assumption also follows Andrade and Stafford [4] and Maksimovic and Phillips [50].

According to Pradeep [67], synergy gains include manufacturing synergy, operating synergy, marketing synergy and financial synergy. In this dissertation, we divide the synergy as managerial synergy, operating synergy, marketing synergy and financial synergy.

Managerial Synergy

Manne [49] recognizes that efficient management of the target firm's assets is the most critical reason for the acquisitions. Jarrell, Brickley and Netter [35] and Martin and McConenell [54] give supportive evidence proving that changing of the management because of the acquisitions generates the abnormal stock returns.

Operating Synergy

Operating synergy comes from greater pricing power or higher employee skills that can help the company gain the market shares. The company can choose the strategy to acquire their competitor directly to stable the market position, strengthen the market power and also decrease the risk of being bought. The company also can choose to merge with their supplier to reduce the cost and to increase the quality of the products therefore to win the competition.

Ashenfelter, Hosken and Weinberg [5] discuss 49 studies focusing on the airlines, banking, hospital petroleum industries. The studies illustrate the relationships between the price and the market share changes and provide the evidence that the firms increase market power through the mergers and acquisitions activities except for the petroleum sector. Bruce and Justin [13] estimate the effects of mergers and acquisitions on productivities and markups of the plants across all the United State manufacturing industries. The study finds the evidence that the profits of the firm will increase after mergers and acquisitions.

Barney [8] define resources as "All assets, capabilities, organizational processes, firm attributes, information, knowledge controlled by a firm that enables the firm to conceive of and implement strategies that improve its efficiency and effectiveness."

A more efficient utilization of resources also generates operating synergy. The combination of complementary resources is one of the benefits to reduce the cost or to improve the efficiency. In Teece, Rumelt, Dosi and Winter [76], complementary resources are considered as complementary product lines, technologies, know-how, geographical markets and customer groups. Therefore, a more efficient utilization of resources promotes the economies of scale if both the acquiring company and

the target produce the same product, and the economies of scope if they produce multiple products. Seth [71] and Severiens [72] also study the economies of scale and economies of scope.

Marketing Synergy

The combination of two firms can expand the marketing network or generate new marketing technologies after that to gain the marketing synergy. Weber and Dhoklakia [79] study the marketing synergy in the acquisitions and consider the marketing synergy as a more relevant factor in determining the ultimate success or failure of contemporary mergers and acquisitions.

Financial Synergy

Financial synergy denotes the improvement in the financial metrics such as debt capacity, cost of capital, profitability. Lewellen [44] illustrates that the companies increase their size through mergers and acquisitions and have more assets. More assets equivalently mean a higher debt capacity. The tax synergy is also considered as a one-time financial benefit from M&As. Hayn [31] study the tax synergy which promotes the mergers. Devos, Kadapakkam and Krishnamurthy [19] give the numerical examples of synergy gains and estimate that the average synergy gains are 10.03% of the combined equity value of the merging firms. The result shows that that tax savings contribute only 1.64% in additional value, while operating synergies account for the remaining 8.38%.

1.2.2 Disinvestment efficiency

As for the aspect of disinvestment efficiency, Lambrecht and Myers [41] focus on the disinvestment with takeover and absent takeover in declining industries. Almeida, Campello and Hackbarth [2] imply that the firms who are facing financial distress are more likely to be acquired by other firms. In their model, the mergers and acquisitions will happen even without synergy gains. In terms of energy industry, Lin and Huang [45] use real options approach to analyze the timing of entry and exit the energy-saving investment. Keswani and Shackleton [37] test the project value changing with future decision of investment and disinvestment. The result shows that the exit option to disinvest is as important as the entry option to invest.

1.2.3 Abnormal Returns

Abnormal returns represent the differences between the actual returns and the normal returns. Abnormal returns are referred to as positive when the actual returns exceeds the normal returns. Normal returns exceeding the actual returns leads to negative abnormal returns. In the mergers and acquisitions, abnormal returns are always occurred because of the asymmetric of the information.

Morellec and Zhdanov [58] find that acquiring firms earn low or negative abnormal returns, while target firms earn substantially positive abnormal returns around the announcement date of the takeover. Franks, Harris and Titman [24], Dodd and Ruback [20], Jensen and Ruback [36] give empirical studies which indicate that the

target firms earn a significant abnormal return in most of the markets in M&As announcement. Campa and Hernando [16] indicate that the acquiring firms yield insignificantly different from zero returns. In Huang and Walking [33], the results indicate that cash acquisitions generated higher positive abnormal returns than stock offers because of the tax-exemption.

1.3 The Payment Method

Pawlina [66] says "Mergers may be paid for in several ways. Transactions may use all cash, all securities or a combination of cash and securities. ". In this dissertation, we consider the payment method as pure cash-payment, cash-share mixed-payment and debt-payment.

1.3.1 Pure Cash-payment

In a pure cash merger, the bidder pays an equivalent cash amount to the target and buys the whole target company. As a result, the bidder holds all the shares of the merged firm. Lukas and Welling [47] and Lukas, Reuer and Welling [46] develop two-stage models analyzing the price and timing of merger and acquisitions. Offenberg and Pirinsky [63] prove the bidders who prefer a faster execution would tend to structure the acquisitions as a tender offer. Tender offers also come with a higher cost. The bidders hope for a trade-off between the execution speed benefits of tender offers and the lower premium benefits of mergers.

1.3.2 Mixed-payment

In a mixed-payment deal, the bidder pays both cash and shares to the target, and shareholders of both firms maintain ownership in the new firm. Compared with pure cash and pure share mergers, mixed-payment mergers are increasing in importance. Goergen and Renneboog [27] analyze 156 takeover bid samples in Europe during the 1990s; of the sample, 93 and 37 were pure cash and pure share, respectively, with 18 cases of the mixed-payment type. Pure share offers trigger much larger share price reactions than other two types.

A study by Faccio and Masulis [22] shows that 11.3% of a sample of European 3,667 mergers or acquisitions are mixed-payment mergers, and these deals always have a larger transaction size. In Martynova and Renneboog [55], the proportion of the mixed-payment mergers increased to 19% in a sample of 1,361 European acquisitions. Hubertde de La Bruslerie [34] examines the combination of cash and share payments in the context of an acquisitions process. For the bidder, the cash-payment portion increases with expectation of acquisitions gains and synergy.

1.3.3 Debt-payment

In a debt finance takeover, the bidder issues a revenue bond secured only by the revenues generated from the target and also pays cash payment using parts of their capital.

1.4 The Risks

Though M&As generate lots of benefits for the enterprise, they still are risky strategies with the risk ranging from the overpaying for the deals to the failure of combination of the company culture. Fang, Fridh and Schultzberg [23] study the fail mergers case of Telia-Telenor and find that historical sentiments, feelings and emotions can cause fatal damage business. Even the mergers and acquisitions success, the shareholders may fail to benefit. Meyer [57] divides the reasons for the leakage of the shareholder value in the post-mergers integration processes into two categories. One is that internal stakeholders reduce gains, and another is that the costs lead to reductions or reallocations of effort. A central question for the M&As analysis is the financing decisions to start an acquisition.

Several studies develop the model of financial structure in the irreversible investment. Graham [28] shows that large, liquid and profitable firms with low expected distress costs use debt conservatively. Most of the literatures are based on Leland [43], which examines debt value and establish an optimal capital structure. Broadie and Kaya [11] extend Leland [43] to the finite maturity case. Tserlukevich [78] develops a dynamic model of optimal financial structure with fixed costs and irreversibility of capital investment and shows that profitability is negatively correlated with leverage. Lambrecht and Myers [40] analyze the debt and equity financing in a real options model and develop a strategy to maximize the overall value of the firm including both the managers and outside shareholders. Agliardi and Koussis [1] develop an investment options model in finite horizon for the analysis of the optimal capital structure.

1.5 Contributions of the Dissertation

In this dissertation, we aim to establish a joint merger model of timing, acquisition premiums, and terms. We base our analysis on Morellec and Zhdanov [58]'s model of a joint determination of timing and terms of takeovers under competition and imperfect information. The model set-up is closely related to Hackbarth and Morellec [30] and Shleifer and Vishny [75], who develop a model based on the stock market mis-valuation of the merged firms and compares the stock returns of the participating firms in both the long- and short-run.

One main contribution of this dissertation is that we focus on the payment methods and give the comparison of different payment methods. The payment methods decision is the most important strategy to control the risk in the M&As transaction. In the transaction, the target firm, which is also the seller, always is willing to ask a higher price while the bidder always wants to pay as low price as possible. Therefore, the optimal payment will exist to satisfy the both side in the transaction.

Another main contribution is that we compare the abnormal returns of each model. We assume that both the bidder and target will probably mis-estimate the synergy generated, and that the managers of both firms can take advantage of the mis-estimation. In Morellec and Zhdanov [58], asymmetric information occurs between the participating firms and investors. We extend the model by assuming asymmetric information between the two participating firms. The dissertation analyses the abnormal returns from the announcement, which follows Morellec and Zhdanov [58].

Patrick [65] explained that mergers may be paid for in several ways. In this dissertation, transactions involving all cash, a combination of cash and securities,

or a combination of cash and debt are termed pure cash-payment mergers, mixed-payment mergers, and debt-payment mergers, respectively.

The pure cash-payment model is well studied in the previous studies. Several studies show that cash is usually preferred. Faccio and Masulis [22] illustrates that the cash is better perform if the target firm has a concentrated distribution of ownership or if the bidder worries about retaining control. Goergen and Renneboog [27] analyze 156 takeover bid samples in Europe during the 1990s; of the sample, 93 and 37 were pure cash and pure share, respectively. Faccio and Masulis [22] also study 3667 mergers and acquisitions of European firms at the end of the 1990s. In their study, 80.2% of the transactions are processed by the pure cash-payment method. Comparing with other payment methods, the pure cash-payment method frequently happened when the target firms are comparatively small size. Martynova and Renneboog [55] find that 54% of 1721 European take over transactions happened between 1993 and 2001 are paid by all-cash. Ben-Amar and André [9] examine 293 M&As in Canada during 1998 and 2002 and give the result that 58% of the transactions use pure cash-payment.

In the reality, several famous transactions are considered as pure cash deals. For example, Google acquired Apigee, a cloud software company, for 17.40 USD per share in cash, with a approximately total value of 625 million USD. The deal has completed in 2016. In 2017, German drugs and pesticides group Bayer has planned to acquire Monacnto, a U.S. seeds firm, in 128 USD per share. The deal is considered as the largest cash deal in the history with a total value of 66 billion USD. And also happened in 2017, MaxLinear, a U.S. hardware company, has agreed to acquire Exar, a U.S. semiconductor manufacturer, for 13 USD per share in cash. Therefore, the pure cash-payment method has an important position in the mergers and acquisitions transactions. In our model, we assume that the bidder use parts of their assets to pay the cash payment. The contribution in this model is that we give an optimal payment to acquire the target, which is represented as an optimal percentage of the bidder's assets.

In the mixed-payment transactions, the bidder pays both cash and shares to the target, and shareholders of both firms maintain ownership in the new firm. Compared with pure cash and pure share mergers, mixed-payment mergers are increasing in importance, particularly when the transaction size is relatively large. Goergen and Renneboog [27] analyze 156 takeover bid samples in Europe during the 1990s; of the sample, 18 cases were the mixed-payment type. A study by Faccio and Masulis [22] shows that 11.3% of a sample of European 3,667 mergers or acquisitions are mixed-payment mergers, and these deals always have a larger transaction size. The average size of a mixed-payment transaction, roughly 1.1 billion USD, was five times greater than which of a pure cash-payment transaction, approximately 209 million USD. In Martynova and Renneboog [55], the proposition of the mixed-payment mergers increased to 19% in a sample of 1,361 European acquisitions. In Ben-Amar and André [9], 22% were mixed-payment deals, with 32% of the total value of the transactions. The proportion of the mixed-payment transaction is increasing so that the academically study of the mixed-payment transaction is importance.

Two main contributions are given in the mixed-payment model. First, we consider a cash premium, which Morellec and Zhdanov [58] do not include. We establish the model using a non-cooperative game in which the bidder provides a tender offer, and the target can either accept the offer or wait. The study is also closely related to Lukas and Welling [47], who develop a two-stage model analyzing the

pricing and timing of mergers and acquisitions. Second, we analyse the terms, assuming that the bidder and target will negotiate the terms of the merged enterprise, which we solve via a Nash bargaining solution (Nash [61]). Several studies combine game theory and real options theory. Azevedo and Paxson [6] discuss the discrete- and continuous-time frameworks of a standard real options game and review two decades of academic research on standard and non-standard real options games. Lukas, Reuer and Welling [46] use a game-theoretic option approach to model the value of contingent earn-outs, finding that the firm will tend to postpone the investment under larger transaction costs, greater uncertainty in cash flows, a longer earn-out period, and higher performance targets.

We extend the pure cash-payment model into an expand-sell model. Lambrecht and Myers [41] generally divides mergers and acquisitions into two broad categories: one is in order to gain the synergies and growth opportunities; and another is to seek greater efficiency through layoffs, consolidation and disinvestment. For the layoffs purpose, AOL and Yahoo combined into a new company called Oath and is laying off 500 employees. For another instance, Disney acquires 21st Century Fox's film and TV studios and expects a synergy of 2 billion USD by cost savings. The transaction is considered as a standard horizontal consolidation. Several previous studies focus on the exit models. Almeida, Campello and Hackbarth [2] imply that the firms who are facing financial distress are more likely to be acquired by other Firms. Keswani and Shackleton [37] test the project value changing with future decision of investment and disinvestment. The result shows that the exit option to disinvest is as important as the entry option to invest. Therefore, we combine both two types of mergers and acquisitions which are defined in Lambrecht and Myers [41] and develop a model that the enterprise has the option to acquire a new business because of the synergy gains or liquidate the asset and re-allocate the resources (to more productive business). The main contributions of the expand-sell model are as following. First, we develop two basic models to determine the optimal price to acquire a company and the optimal price to sell the asset to another company. The execution process is close to Lukas and Welling [47] and Lukas, Reuer and Welling [46], who develop two-stage models analyzing the price and timing of mergers and acquisitions. Second, we establish the model of the optimal timing to start an offer to acquire a target or to sell the asset according to the market value of both participating firm.

Debt is one of the most important financing methods. For the bidder, debt financing has lower cost of capital than the equity. This payment method also can benefit the target firm's shareholders because they can delay the taxes payment until receiving the debt payment. In 2017, Amazon issued 16 billion USD of debt to acquire Whole Foods Market. In the transaction of AppLovin's and Orient Hontai, AppLovin is getting 841 million USD in debt financing from their buyer Orient Hontai Capital. A central question for the M&A analysis is the financing decisions to start an acquisition. Therefore we also focus on the model of financing with debt to acquire the target, which is called as the debt-payment model in this dissertation. The main contributions of this model are as following. First, this model develops models of joint takeovers to determine the timing, acquisitions payment using different finance methods. The model considers an equity finance takeover, which assumes that the bidder use parts of their capital to buy the target, and then extend to a debt finance takeover, which assumes that the bidder issues a revenue bond secured only by the revenues generated from the target and also pays a cash payment using parts of their capital. Second, we compare the equity finance model with the debt finance model and reveal the impact of the debt payment on the strategy decisions.

This dissertation is organized as follows. In Chapter 2, we first establish a pure cash-payment model, which the bidder pays in cash to buy all the shares of the target firm. Section 2.1 briefly introduces the background of the pure cash-payment model. In Section 2.2, we illustrate the model set-up. And then analyze the optimal strategy in Section 2.3. We finally give several numerical studies in Section 2.4. In the Chapter 3, we extend the pure cash-payment model into a cash-share mixed-payment model. The structure of Chapter 3 is similar as which of Chapter 2, given as background introduction in Section 3.1, model set-up in Section 3.2, optimal strategy analysis in Section 3.3 and numerical studies in Section 3.4. In Chapter 4, extend the pure cash-payment model into an expand-sell model. Section 4.1 and 4.2 give the background and the model set-up. In Section 4.3, we analyze the expansion option and sell option separately and then make the optimal decision based on the result of two options. Finally, we give the numerical studies in Section 4.4. In Chapter 5, we introduce the debt-payment model. The process is similar as the pure cash-payment model. Chapter 6 extends each model into the imperfect information models and then focus on the abnormal returns study. Chapter 7 gives the conclusion and future works.

Chapter 2

A Pure Cash-Payment Model

2.1 Background

Generally, enterprises can grow in two ways: the first is by expanding production, which is internal reinvestment; the second is by acquisition and reorganization. Acquisitions will create synergies from cost savings, customer expansion, or other financial benefits resulting from the cooperation of two firms.

The optimal timing and post-merger ownership structure are two keys in the analysis of merger and acquisition strategies. Several well-known studies have analyzed the timing and terms of mergers and acquisitions. Lambrecht [39] studies the timing and terms of mergers motivated by economies of scale and shows that merger activities are positively correlated with markets, meaning that firms are willing to merge during economic expansions. Thijssen [77] builds on Lambrecht [39] to build a two-uncertainty model that optimizes the timing considering both efficiency gains and diversification benefits. The results show that mergers and acquisitions will happen during both economic upswings and downswings. Bernile, Lyandres and Zhdanov [10], Hackbarth and Morellec [30], and Lambrecht and Myers [41] also develop models featuring optimal timing. Hackbarth and Miao [29] develop a joint model of oligopolistic industries that determines the industry's product equilibrium, as well as the timing and terms of takeovers. The result shows the relationship between the return from merging and firm size. In terms of firm-size analysis, Moeller, Schlingemann, and Stulz [60] show the firm-size effect in acquisition announcement returns.

Patrick [65] explained that mergers may be paid for in several ways. In this dissertation, transactions involving all cash, all securities, or a combination of cash and securities are termed pure cash mergers, pure share (stock-for-stock) mergers, and mixed-payment mergers, respectively. The studies described above assume pure share (stock-for-stock) merger conditions in their models, with no cash-payment made. In stock-for-stock mergers, both participating firms remain shareholders in the continuing combined enterprise. They negotiate the post-merger structure based on the pre-transaction ratio of the firms' market value.

In the pure cash mergers, the bidder pays an equivalent cash amount to the target and buys the whole target company. As a result, the bidder holds all the shares of the merged firm. Lukas and Welling [47] and Lukas, Reuer and Welling [46] develop two-stage models analyzing the price and timing of merger and acquisition. Offenberg and Pirinsky [63] prove the bidders who prefer a faster execution would tend to structure the acquisition as a tender offer. Tender offers also come with a higher cost. The bidders hope for a trade-off between the execution speed benefits of tender offers and the lower premium benefits of mergers.

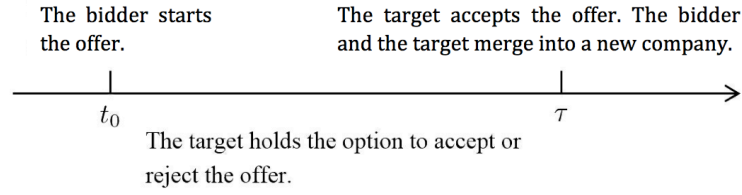


FIGURE 2.1: The acquisition process of a pure cash-payment M&A

In this Chapter, we develop a pure cash merger model based on Lukas and Welling [47]. Section 2.2 develops the model to determine the optimal timing and payment. Section 2.4 gives the numerical studies.

2.2 The Model Set-up

We construct the framework based on Morellec and Zhdanov [58]. Consider two firms: an bidder and a target, which operate in the same market. We assume capital stocks of K_B for the bidder and K_T for the target. The stock market valuation of each firm, denoted by $S_B(X_t)$ and $S_T(Y_t)$, respectively, before takeover is

$$S_B(X_t) = K_B X_t, \quad S_T(Y_t) = K_T Y_t, \quad (2.1)$$

where X_t and Y_t denote the per unit value of capital, which follows a geometric Brownian motion, given by

$$\begin{aligned} dX_t &= \mu_X X_t dt + \sigma_X X_t dW_X, \\ dY_t &= \mu_Y Y_t dt + \sigma_Y Y_t dW_Y, \end{aligned} \quad (2.2)$$

where the expected growth rates $\mu_X, \mu_Y > 0$, and volatilities $\sigma_X, \sigma_Y > 0$ are constant parameters. W_X and W_Y are standard Brownian motions. The correlation coefficient between W_X and W_Y is constant, represented as $\rho \in (-1, 1)$. We assume that all participants are risk neutral, and the risk-free interest rate is $r (\geq \mu_i, i = X, Y)$.

As shown in 2.1, we suppose the acquisition process proceeds in two steps. At time t_0 , the bidder makes an offer to acquire the target. The target firm need not decide immediately upon receiving the offer, that is, it can postpone the decision. Hence, the target holds the option to accept or reject the offer from time t_0 onwards. The horizon of the option which the target holds is infinite. The bidder is not looking for an immediate merger, which is generally associated with a higher cost. (see Offenbergh and Pirinsky [63] for the supporting evidence.) Suppose the target accepts the offer at time τ . Accepting the offer leads to an immediate merger of the two firms at time τ .

Following Hackbarth and Morellec [30] and Shleifer and Vishny [75], we assume a linear combination of pre-takeover values in terms of per unit value of capital. The post-merger value of the firm is

$$S_M(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G(X_t, Y_t), \quad (2.3)$$

where $G(X_t, Y_t)$ is net synergy gains generated from the merger, given by

$$G(X_t, Y_t) = K_T \left(\alpha(X_t - Y_t) - cY_t \right), \quad (\alpha, c) \in \mathbb{R}_{++}^2, \quad (2.4)$$

where α is the synergy parameter, which all participants can observe. c denotes the per unit mergers cost of the capital value of the target. The post-mergers per unit value of capital which the target has before mergers changes to $\alpha X_t + (1 - \alpha)Y_t$. Therefore, the post-mergers value of the target's capital increases to $S_T(Y_t) + K_T\alpha(X_t - Y_t)$. Considering the cost paid at the time of the mergers, the synergy generated thus is given by (2.4). This assumption indicates that the synergy will be positive only when the bidder outperforms the target, which has the same meaning as $X_t > Y_t$. This is equivalent to saying that the bidder generally has a higher Tobin's q than the target. Raua and Vermaelen [69] provide the supporting evidence. The target's resources are more efficiently allocated after the mergers.

2.3 The Optimal Strategy

2.3.1 The Optimal Timing in Pure Cash-payment Model

For a pure cash-payment M&A, the bidder pays an amount of cash to the target based on the target's market value and buys the whole firm. There is no share exchange in the process. The bidder is the only shareholder of the merged firm. Suppose the bidder will use parts of their firm's value, which is denoted as portion p , to pay the cash payment. Receiving the offer at t_0 , the target decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OMC(X_t, Y_t) = \max_{\tau} \mathbb{E} \left\{ e^{-r\tau} \left[pS_B(X_{\tau}) - S_T(Y_{\tau}) \right] \right\}. \quad (2.5)$$

At the optimal timing τ_c , the target receives the offer. They will receive a cash payment, worth $pS_B(X_{\tau_c})$ and give up their claim, worth $S_T(Y_{\tau_c})$. Maximizing the function (2.5) yields Proposition 1.

Proposition 1 (The optimal threshold under a pure cash-payment method) *Based on the value-maximizing strategy, the target firm will accept the offer and merge with the bidder when the ratio of per unit capital price, denoted by $R_t = X_t/Y_t$, reaches the level*

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B} \frac{1}{p}. \quad (2.6)$$

Value of the option that the target holds is given by,

$$OMC(X_t, Y_t) = \begin{cases} Y_t [pK_B R_t - K_T], & R_c \leq R_t, \\ Y_t [pK_B R_c - K_T] \left(\frac{R_t}{R_c} \right)^{\vartheta_1}, & R_t < R_c, \end{cases} \quad (2.7)$$

and the first passing time is

$$\tau_c = \inf \{ t > 0 : R_t \geq R_c \}. \quad (2.8)$$

$\vartheta_1 > 1$ is the positive root of the quadratic equation

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y \right) \vartheta (\vartheta - 1) + (\mu_X - \mu_Y) \vartheta - (r - \mu_Y) = 0. \quad (2.9)$$

(Appendix A.1 contains the proof.)

2.3.2 The Optimal Payment in Pure Cash-payment Model

As soon as the target accepts the offer, the two participating firms will merge. The bidder gives up the claim, worth $S_B(X_{\tau_c})$, and pays a cash amount of $pS_B(X_{\tau_c})$ to the target at time τ_c . In return, the bidder receives ownership of the merged firm, worth $S_M(X_{\tau_c}, Y_{\tau_c})$. The optimization function for the bidder thereafter is given by

$$OTC(X_t, Y_t) = \max_p \mathbb{E} \left\{ e^{-r\tau_c} \left[S_M(X_{\tau_c}, Y_{\tau_c}) - pS_B(X_{\tau_c}) - S_B(X_{\tau_c}) \right] \right\}. \quad (2.10)$$

Proposition 2 (Optimal cash payment in a pure cash-payment model) *Maximizing the payoff function (2.10) yields the optimal offered portion p_c for the bidder, given as*

$$p_c = \frac{\alpha(\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (2.11)$$

Substituting result (2.11) into (2.6) yields

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1}{\alpha} \left(\alpha + c - 1 + \frac{\vartheta_1}{\vartheta_1 - 1} \right). \quad (2.12)$$

(Appendix A.2 contains the proof.)

According to threshold (2.6), the higher p_c is, the lower the threshold will be. The merging process will be accelerated if the bidder uses a high portion p_c of their firm value to pay the target. If the bidder chooses an optimal portion p_c , which is given by (2.11), the target will accept the offer when the ratio of per unit capital value R_t reaches (2.12). According to (2.6), p_c positively relates to ϑ_1 as $\partial p_c / \partial \vartheta_1 > 0$, and negatively relates to the firm-size ratio, which is represented as K_B/K_T . A higher synergy parameter α will increase the payment portion p_c and then decrease the threshold R_c . While a higher cost c will decrease the payment and increase the threshold.

2.4 Numerical Studies

In this section, we provide several numerical results. The decision-making of mergers and acquisitions activities largely depends on the expected growth rate and volatility of the participating firm's business valuations, and also on the firm-size, synergy generated. Table 2.1 summarizes the basic parameter values. We assume the expected growth rates of the bidder and target are 0.035 and 0.02 respectively. It follows that the bidder generally outperforms the target. The volatility of the bidder and target are set to 20% and 30% which means the target has higher risk than the bidder. We focus on mergers of equal-size by assuming that $K_B = K_T = 1$ and study the impact of the debt level.

TABLE 2.1: Basic parameter values.

Parameter		Value
Expected growth rate of the bidder	μ_X	0.035
Expected growth rate of the target	μ_Y	0.02
Volatility of the bidder	σ_X	0.2
Volatility of the target	σ_Y	0.3
Correlation coefficient	ρ	0.5
Discount rate	r	0.06
Firm size of the bidder	K_B	1
Firm size of the target	K_T	1
Synergy parameter	α	0.6
Per unit merger cost	c	0.1

Figure 2.2 represents the relationship between the expected growth rate of the bidder and the threshold which is determined by the target and the payment which is acquiring firm's strategy. In the pure cash model, the bidder offers an optimal payment portion p_c which is given by Proposition 2. The target accepts the offer at time τ_c and the ratio of the per unit capital price $R_c = X_{\tau_c}/Y_{\tau_c}$ is given by Proposition 1. Therefore, the vertical axis of the second sub-figure in Figure 2.2, $p_c R_c = p_c X_{\tau_c}/Y_{\tau_c}$, holds the meaning that the bidder should pay $p_c X_{\tau_c}$ for one unit the target's capital, which is Y_{τ_c} , at time τ_c . We call $p_c R_c$ the exchange rate in the pure cash-payment model.

According to Proposition 2, $\partial p_c / \partial \theta_1 > 0$ and parameter θ_1 , which is given by (2.9), holds a negative relationship with μ_X . Hence, the optimal payment portion p_c negatively relates to the expected growth rate μ_X . Accordingly, in Figure 2.2, the bidder will offer a lower payment portion p_c to target firm when the bidder's growth rate is higher. For the target, they has two motivations to accept the offer, one is the increase of the per unit capital price of the bidder X_t , and another is the decrease of the per unit price of their own capital Y_t . When the optimal payment portion p_c is lower, target firm aspires to a much higher X_t or a much smaller Y_t to accept the offer. As a result, a negative relationship between p_c and growth rate μ_X leads to a positive relationship between the threshold R_c and growth rate μ_X which is represented in the first sub-figure of Figure 2.2. The bidder will consequently pay more for each unit of target firm's capital, and the exchange rate $p_c R_c$ positively relates to the expected growth rate μ_X shown in the Figure 2.2.

[Insert Figures 2.2 and 2.3 here]

As in Figure 2.4, when the volatility of the bidder is high, they will offer a low payment portion p_c which follows Proposition 2. Hence, it represents a reverse relationship between the threshold R_c and σ_X . The parameter θ_1 has a positive relationship with volatility σ_X when $\sigma_X < \rho\sigma_Y$, and vice versa. Thus, the acquisitions payment will increase with volatility σ_X and then decrease if $\rho > 0$. If $\rho \leq 0$, σ_X will always negative relates to θ_1 and then also negative with p_c . The same relationship between p_c and σ_Y in Figure 2.5. In both Figures 2.4 and 2.5, the increase of the threshold R_c causes the bidder pay more to the target for each unit of their capital, which is the exchange rate $p_c R_c$.

[Insert Figures 2.4 and 2.5 here]

In Figure 2.6, synergy parameter α will also increase the acquisition payment portion p_c offered by the bidder according to Proposition 2. According to the synergy assumption (2.4), the synergy generated due to merger is positive related to the synergy parameter α . The bidder is willing to pay a higher acquisition payment because of a high synergy when α is high. With a higher p_c , the target will accept the offer at a lower threshold R_c . According to Proposition 2, the exchange rate $p_c R_c$ is independent with the synergy parameter α .

[Insert Figure 2.6 here]

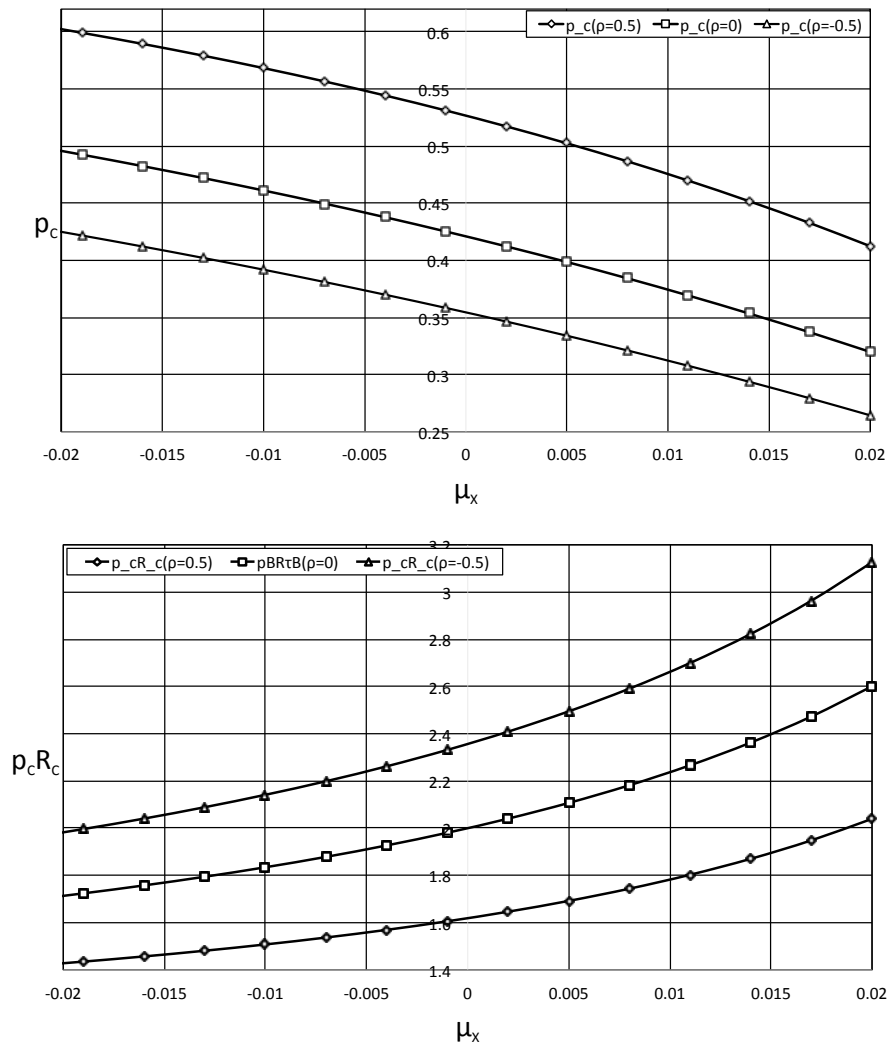


FIGURE 2.2: Impact of the expected growth rate of the bidder on the pure cash-payment.

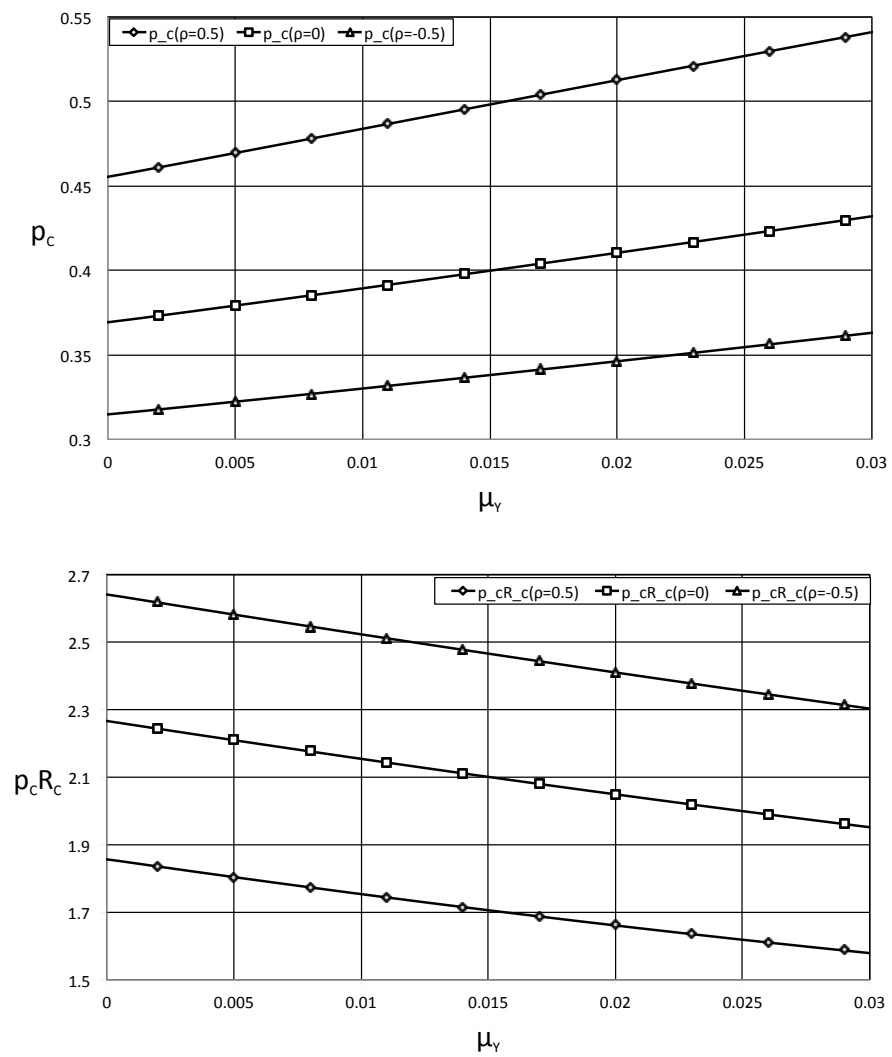


FIGURE 2.3: Impact of the expected growth rate of the target on the pure cash-payment.

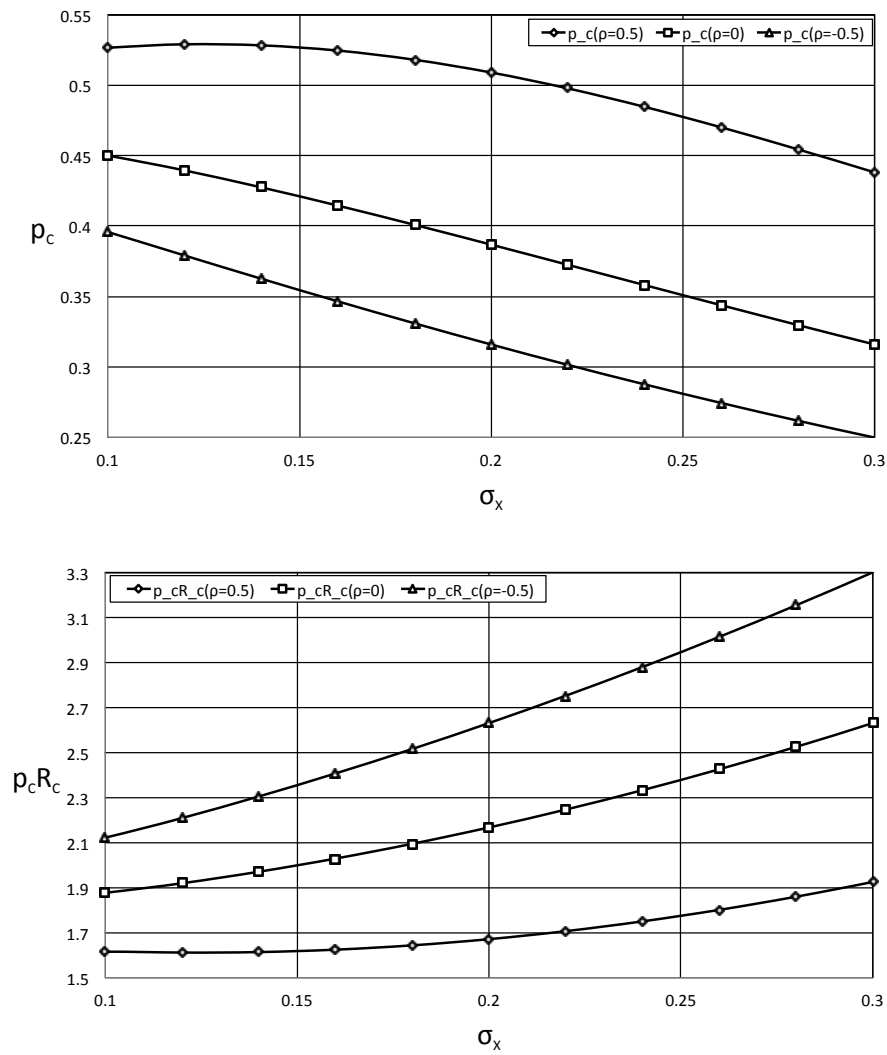


FIGURE 2.4: Impact of the volatility of the bidder on the pure cash-payment.

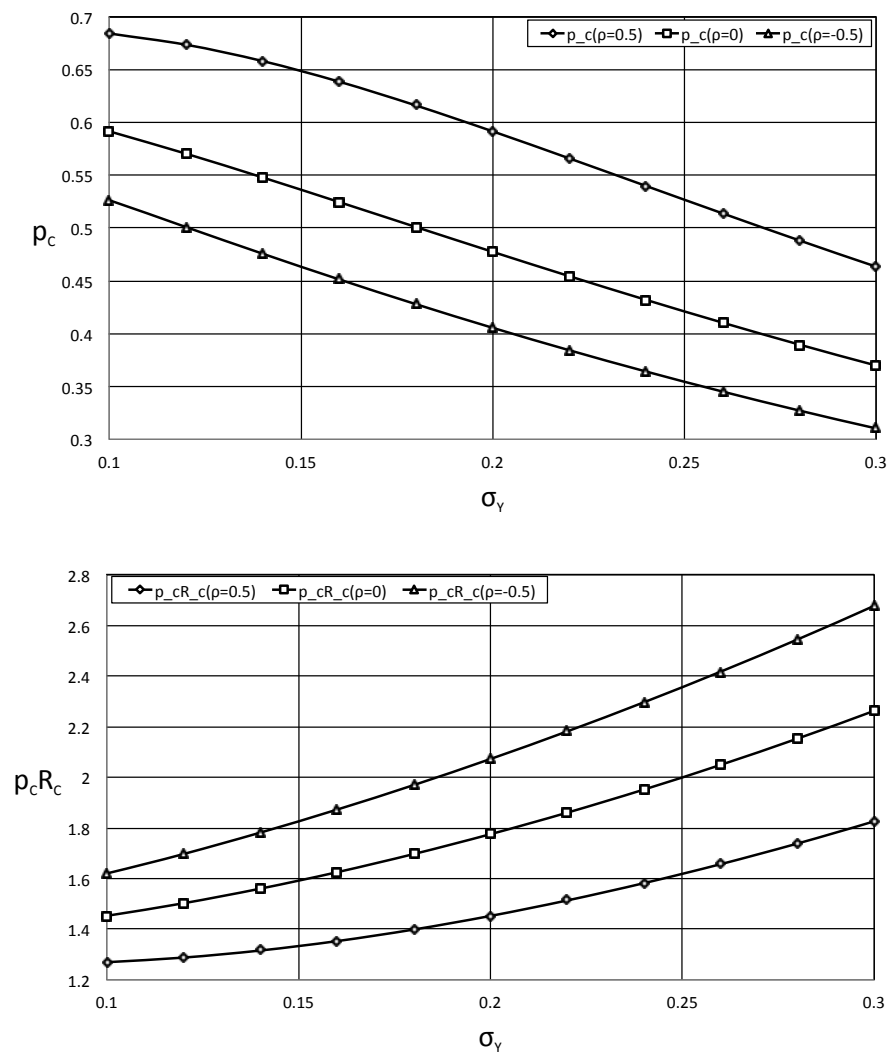


FIGURE 2.5: Impact of the volatility of the target on the pure cash-payment.

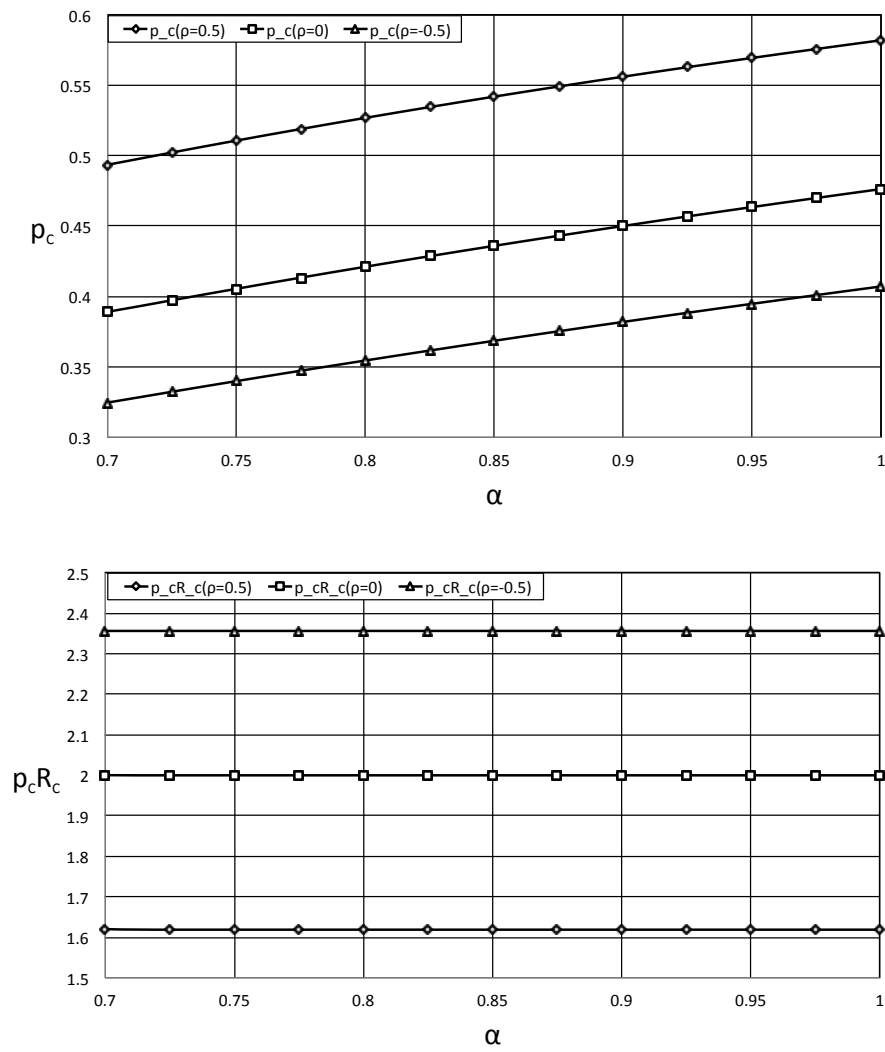


FIGURE 2.6: Synergy impact on the pure cash-payment.

Chapter 3

A Mixed-payment Model

3.1 Background

In this chapter, we develop a mixed-payment model of optimal timing, terms and cash acquisition premium. In the mixed-payment type, the bidder pays both cash and shares to the target, and shareholders of both firms maintain ownership in the new firm. Compared with pure cash and pure share mergers, mixed-payment mergers are increasing in importance. Goergen and Renneboog [27] analyse 156 takeover bid samples in Europe during the 1990s; of the sample, 93 and 37 were pure cash and pure share, respectively, with 18 cases of the mixed-payment type. Pure share offers trigger much larger share price reactions than other two types. A study by Faccio and Masulis [22] shows that 11.3% of a sample of European 3,667 mergers or acquisitions are mixed-payment mergers, and these deals always have a larger transaction size. In Martynova and Renneboog [55], the proportion of the mixed-payment mergers increased to 19% in a sample of 1,361 European acquisitions. Hubert de La Bruslerie [34] examines the combination of cash and share payments in the context of an acquisition process. For the bidder, the cash-payment portion increases with expectation of acquisition gains and synergy.

This study develops a model of mixed-payment mergers in which both the bidder and target remain shareholders of the new combined enterprise and negotiate over the post-merger terms. The bidder pays a cash premium to the target. bidders may have many motivations to pay a cash premium. In this chapter, we assume that the bidder pays a cash premium to negotiate better post-merger terms in the new firm. This study aims to establish a joint merger model of timing, cash acquisition premium, and terms in markets with perfect.

In this study, we base our analysis on Morellec and Zhdanov [58]’s model of a joint determination of timing and terms of takeovers under competition and imperfect information. The model set-up is closely related to Hackbarth and Morellec [30] and Shleifer and Vishny [75], who develop a model based on the stock market misvaluation of the merged firms and compares the stock returns of the participating firms in both the long- and short-run.

The result also differs from previous studies in several important dimensions. The two main contributions of this study are as follows. First, we consider a cash premium, which Morellec and Zhdanov [58] do not include. We establish the model using a non-cooperative game in which the bidder provides a tender offer, and the target can either accept the offer or wait. The study is also closely related to Lukas and Welling [47], who develop a two-stage model analyzing the pricing and timing of mergers and acquisitions.

Second, we analyse the terms, assuming that the bidder and target will negotiate the terms of the merged enterprise, which we solve via a Nash bargaining solution (Nash [61]). Several studies combine game theory and real options theory.

Azevedo and Paxson [6] discuss the discrete- and continuous-time frameworks of a standard real options game and review two decades of academic research on standard and non-standard real options games. Lukas, Reuer and Welling [46] use a game-theoretic option approach to model the value of contingent earn-outs, finding that the firm will tend to postpone the investment under larger transaction costs, greater uncertainty in cash flows, a longer earn-out period, and higher performance targets.

The chapter is organized as follows. In Section 3.2, we introduce the model's framework. In Section 3.3, we develop a basic model with full information. We will extend the basic model to one with imperfect information in Section 6.3. In Section 3.4, we give several numerical examples.

3.2 The Model Set-up

We construct the framework based on Morellec and Zhdanov [58]. Consider two firms: an bidder and a target, which operate in the same market. We assume capital stocks of K_B for the bidder and K_T for the target. The stock market valuation of each firm, denoted by $S_B(X_t)$ and $S_T(Y_t)$, respectively, before takeover is

$$S_B(X_t) = K_B X_t, \quad S_T(Y_t) = K_T Y_t, \quad (3.1)$$

where X_t and Y_t denote the per unit value of capital, which follows a geometric Brownian motion, given by

$$\begin{aligned} dX_t &= \mu_X X_t dt + \sigma_X X_t dW_X, \\ dY_t &= \mu_Y Y_t dt + \sigma_Y Y_t dW_Y, \end{aligned} \quad (3.2)$$

where the expected growth rates $\mu_X, \mu_Y > 0$, and volatilities $\sigma_X, \sigma_Y > 0$ are constant parameters. W_X and W_Y are standard Brownian motions. The correlation coefficient between W_X and W_Y is constant, represented as $\rho \in (-1, 1)$. We assume that all participants are risk neutral, and the risk-free interest rate is $r (\geq \mu_i, i = X, Y)$.

As shown in Figure 3.1, we suppose the acquisition process proceeds in two steps. At time t_0 , the bidder makes an offer to acquire the target. The target firm need not decide immediately upon receiving the offer, that is, it can postpone the decision. Hence, the target holds the option to accept or reject the offer from time t_0 onwards. The horizon of the option which the target holds is infinite. The bidder is not looking for an immediate merger, which is generally associated with a higher cost. (see Offenbergh and Pirinsky [63] for the supporting evidence.) Suppose the target accepts the offer at time τ . Accepting the offer leads to an immediate merger of the two firms at time τ .

Following Hackbarth and Morellec [30] and Shleifer and Vishny [75], we assume a linear combination of pre-takeover values in terms of per unit value of capital. The post-merger value of the firm is

$$S_M(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G(X_t, Y_t), \quad (3.3)$$

where $G(X_t, Y_t)$ is net synergy gains generated from the merger, given by

$$G(X_t, Y_t) = K_T (\alpha(X_t - Y_t) - cY_t), \quad (\alpha, c) \in \mathbb{R}_{++}^2, \quad (3.4)$$

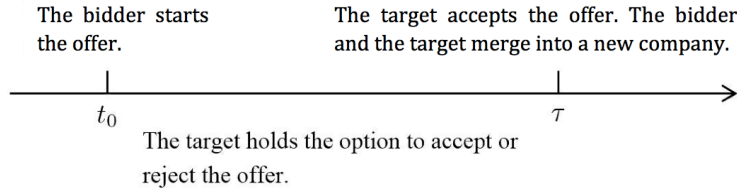


FIGURE 3.1: The acquisition process

where α is the synergy parameter, which all participants can observe. c denotes the per unit merger cost of the capital value of the target firm. The post-merger per unit value of capital which the target has before merger changes to $\alpha X_t + (1 - \alpha)Y_t$. Therefore, the post-merger value of the target's capital increases to $S_T(Y_t) + K_T\alpha(X_t - Y_t)$. Considering the cost paid at the time of the merger, the synergy generated thus is given by (3.4). This assumption indicates that the synergy will be positive only when the bidder outperforms the target, which has the same meaning as $X_t > Y_t$. (This is equivalent to saying that the bidder generally has a higher Tobin's q than the target. Raua and Vermaelen [69] provide the supporting evidence.) The target's resources are more efficiently allocated after the merger.

3.3 The Optimal Strategy

In a stock-for-stock M&A, the bidder and target generally determine the post-merger terms according to the ratio of their firm's market values. In a mixed-payment model, the bidder aims to hold a certain fraction of the merged firm in order to partly control or proportionally enjoy the business of the new firm. If the terms the bidder asks for are higher than the terms in the stock-for-stock M&A, the bidder has to pay a cash acquisition premium to the target in order to get a higher share. On the other hand, the bidder will ask for a cash acquisition premium from the target if the post-merger terms are low. We use parameter λ to denote the cash acquisition premium payment. This means that the bidder will pay $\lambda S_T(Y_t)$ to the target, where $S_T(Y_t)$ is the pre-merger market value of the acquired firm, given by equation (3.1). The bidder will receive terms $\xi (> 0)$ of the merged entity in return. Consequently, the target gets a cash acquisition premium payment of $\lambda S_T(Y_t)$ and receives $(1 - \xi)$ as the fraction of the merged firm. The parameter λ can even be negative, in which case, the target shareholders bargain for a higher post-merger ownership than the fraction they could get without the cash payment. The bidder asks the target to pay for the higher share. There is also the need to pay the transaction costs, denoted as $cS_T(Y_t)$, when the merging of firms occurs.

From the target's standpoint, the higher the $\lambda S_T(Y_t)$ is, the higher the cash acquisition premium payment they will receive upon selling. On the other hand, the fraction of ownership will decrease, and the target will therefore receive a lower share $(1 - \xi)$. From the bidder's perspective, if they provide a higher payment to the target, the cost will increase, though they will also gain a higher fraction ξ of the new entity. Therefore, there is an optimal payment strategy and terms (also called sharing-rule) ξ for both the bidder and target.

As shown in Figure 3.1, at time t_0 , the bidder offers a certain cash acquisition premium payment λ to the target, which can accept or reject the offer. At the time

τ , the target firm receives a cash acquisition premium payment of $\lambda S_T(Y_\tau)$ from the bidder and a fraction $(1 - \xi)$ of the merged firm, and in turn, has to give up a claim of $S_T(Y_\tau)$.

3.3.1 The Optimal Timing in Mixed-payment Model

In this section, we consider a scenario with perfect information and no competition in the process. As illustrated in the framework, there are two stages in the merger process. We use the Markov Perfect Nash Equilibrium to analyze the strategy, in which the bidder will provide an optimized cash acquisition premium payment of λ at stage one. The target receives this offer in stage one with a given λ and will accept the offer at the threshold of τ that maximizes their profit. The bidder and target will bargain about the terms according to the optimized cash payment portion λ and the threshold.

The target firm reacts to receiving the offer of the cash acquisition premium payment λ in stage one. They hold the option of accepting the offer. Conditional on the offered cash payment portion λ , the target will choose a threshold τ in stage two and accept the offer. The cash acquisition premium payment to accept the offer is $\lambda S_T(Y_\tau)$. Therefore, the target will give up their claim, worth $S_T(Y_{\tau_m})$, and receive both the cash payment value $\lambda S_T(Y_\tau)$ and a fraction $(1 - \xi)$ of the merged firm, worth $(1 - \xi)S_M(X_\tau, Y_\tau)$. The optimization function of the target at stage two is

$$OMM(X_t, Y_t) = \max_{\tau} \mathbb{E} \left\{ e^{-r\tau} \left[(1 - \xi)S_M(X_\tau, Y_\tau) + \lambda S_T(Y_\tau) - S_T(Y_\tau) \right] \right\}. \quad (3.5)$$

Proposition 3 (Optimal threshold in the mixed-payment model) *Based on the value-maximizing strategy, if offered cash acquisition premium payment satisfies $\lambda < (1 - \xi)(\alpha + c) + \xi$, the target firm will accept the offer and merge with the bidder when the ratio of per unit capital price R_t reaches the level*

$$R_m(\lambda, \xi) = \left((\alpha + c - 1) + \frac{1 - \lambda}{1 - \xi} \right) \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B + \alpha K_T}. \quad (3.6)$$

The value of the option that the target holds is

$$OMM(X_t, Y_t) = \begin{cases} Y_t \left[\frac{(1 - \xi)(\alpha + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T \right] \left(\frac{R_t}{R_m(\lambda, \xi)} \right)^{\vartheta_1}, & R_t < R_m(\lambda, \xi), \\ Y_t \left[(1 - \xi)(K_B + \alpha K_T) R_t + \left((1 - \xi)(1 - \alpha - c) - (1 - \lambda) \right) K_T \right], & R_t \geq R_m(\lambda, \xi). \end{cases} \quad (3.7)$$

The first passing time is

$$\tau_m = \inf \{ t > 0 : R_t \geq R_m(\lambda, \xi) \}. \quad (3.8)$$

And $\vartheta_1 > 1$ is the positive root of (2.9). (Appendix B.1 provides the proof.)

If the offered cash acquisition premium payment satisfies $\lambda \geq (1 - \xi)(\alpha + c) + \xi$, the target will accept the offer immediately because of a high cash acquisition premium payment. Otherwise the target will wait until the ratio of capital price first reaches the threshold (3.6), which is a reaction function of the cash acquisition premium payment λ and the bargain terms $(1 - \xi)$. Holding $(1 - \xi)$ constant, a

higher λ will decrease R_m and accelerate the merger. The threshold also largely relies on the ratio of firm size, represented by K_B/K_T . If given a constant λ , a higher ratio of firm size (K_B/K_T) will also accelerate the merger. While, λ provided by the bidder is also firm size (K_B/K_T) dependent that we will analyze in the next stage.

3.3.2 The Optimal Payment and Terms in Mixed-payment Model

At stage two, the bidder will give up their claims, worth $S_B(X_{\tau_m})$, and also pay the cash acquisition premium payment of $\lambda S_T(Y_{\tau_m})$. In return, they will receive a fraction ξ of the merged firm, worth $\xi S_M(X_{\tau_m}, Y_{\tau_m})$. The bidder will choose an optimal portion λ to maximize their benefit in stage one. The optimization function for the bidder is

$$OTM(X_t, Y_t) = \max_{\lambda} \mathbb{E} \left\{ e^{-r\tau_m} \left[\xi S_M(X_{\tau_m}, Y_{\tau_m}) - \lambda S_T(Y_{\tau_m}) - S_B(X_{\tau_m}) \right] \right\}. \quad (3.9)$$

Maximizing the payoff function (3.9) yields the following results.

Proposition 4 (Optimal tender offer in the mixed-payment model) *Based on the value maximizing strategy, the optimal cash acquisition premium payment λ_m that the bidder pays to the target is given as*

$$\lambda_m(\xi) = (\alpha + c)(1 - \xi) + \xi + \frac{\vartheta_1(\alpha + c)(1 - \xi)(K_B + \alpha K_T)}{(1 - \xi)K_B - \alpha(\vartheta_1 + \xi - 1)K_T}. \quad (3.10)$$

Substituting result (3.10) into (3.6) yields

$$R_m(\xi) = \frac{\vartheta_1^2}{\vartheta_1 - 1} \frac{(\alpha + c)K_T}{\alpha(\vartheta_1 + \xi - 1)K_T - (1 - \xi)K_B}. \quad (3.11)$$

Receiving the optimal offer of $\lambda_m(\xi)$, the target firm will accept the offer when the ratio of per unit capital price R_t satisfies (3.11). The bidder will immediately merge with the target after the target accepts the offer. (Appendix B.2 contains the proof.)

According the result from (3.10), $d\lambda_m(\xi)/d(1 - \xi) < 0$ (which is equivalent to $d\lambda_m(\xi)/d\xi > 0$), the cash payment parameter λ_m positively relates to the terms ξ . Hence, the bidder is willing to pay a higher cash acquisition premium to the target for greater post-merger management control ξ . On the other hand, a target's higher $(1 - \xi)$ requirement will decrease λ_m and increase the R_m , slowing the merging process.

We suppose the bidder and target will negotiate the post-merger terms at stage one. The post-merger terms is ξ for the bidder and $(1 - \xi)$ for the target. Having the results (3.10) and (3.11), the payoffs for the bidder and target which are given by (3.5) and (3.9) are reaction functions of the terms ξ . The bidder and target will negotiate the terms ξ in order to maximize the payoffs (3.5) and (3.9), which represent their benefits generated from the merger. We obtain the optimal ξ using the Nash bargaining approach. Banerjee, Güçbilmez and Pawlina [7] develop a model of the optimal real options exercise using the Nash bargaining approach. Based on Banerjee, Güçbilmez and Pawlina [7], we set the optimization function as

$$\Pi(X_t, Y_t) = \max_{\xi} \left[OT(X_t, Y_t; \xi) \right]^{\beta} \left[OM(X_t, Y_t; \xi) \right]^{1-\beta}, \quad (3.12)$$

TABLE 3.1: Parameter values.

Parameter		Value
Expected growth rate of the bidder	μ_X	0.035
Expected growth rate of the target	μ_Y	0.02
Volatility of the bidder	σ_X	0.20
Volatility of the target	σ_Y	0.30
Ratio of the firm size	K_B/K_T	1.00
Correlation coefficient	ρ	0.50
Synergy parameter	α	0.80
Per unit merger cost	c	0.01
Discount rate	r	0.06

where the bargain power parameter β is subject to $\beta \in (0, 1)$. Solving the maximization problem (3.12) yields the following.

Proposition 5 (Optimal bargain terms) *The bidder will pay the optimal offered portion λ_m and expect to receive the optimal terms ξ_m of the merged entity, where ξ_m satisfies*

$$\xi_m = 1 - \frac{(1 - \beta)\alpha K_T}{K_B + \alpha K_T}. \quad (3.13)$$

Receiving the optimal offered portion λ_m , the optimal strategy for the target is to require $(1 - \xi_m)$ as a fraction of the merged entity and choose to accept the offer at τ_m . The terms for the target are

$$1 - \xi_m = \frac{(1 - \beta)\alpha K_T}{K_B + \alpha K_T}. \quad (3.14)$$

(Appendix B.3 provides the proof.)

The optimal terms which is given by (3.13) under a Nash bargaining solution positively relates to the ratio of the firm size (K_B/K_T). With a higher firm size (K_B/K_T), the bidder is willing to require a higher ξ_m .

3.4 Numerical Studies

This section provides several numerical tests of the results. We first compare the pure cash-payment model and the mixed-payment model. Second, we examine the cash acquisition premium payment and the reaction threshold of merger changes with endogenous parameters. Table 3.1 summarizes the basic parameter values. We assume drifts of the bidder and target are 0.035 and 0.02. It follows that the bidder generally outperforms the target. The volatility of the bidder and target are set to 20% and 30% which means the target has higher risk than the bidder. We focus on mergers of equal-size by assuming that $K_B/K_T = 1$ and study the strategy of bargaining a high terms in order to have more management control.

3.4.1 Comparison between Pure Cash-payment Model and Mixed-payment Model

In a pure cash-payment model, the threshold for the target is given by (2.6), in Chapter 2. Accordingly, the cash-payment portion in the pure cash-payment model,

which is always constant, is given by

$$\lambda_c = \frac{pK_B X_{\tau_c}}{K_T Y_{\tau_c}} = \frac{\vartheta_1}{\vartheta_1 - 1}, \quad (3.15)$$

which means that at the time the target accepts the offer, the bidder will pay a cash amount of $\lambda_c S_T(Y_{\tau_c})$ to the target in order to buy it completely. In the mixed-payment model, the bidder will pay a cash acquisition premium amount of $\lambda_m S_T(Y_{\tau_m})$ and receive the terms which satisfies $\xi \in (0, 1]$ at τ_m . To compare the performance of two payment methods, we need compare the payoff generated. In the mixed-payment model, the payoff for the bidder $OTM(X_t, Y_t)$ is given by (3.9). $OTC(X_t, Y_t)$, which is given by (2.10), is the payoff for the bidder if the pure cash-payment method is used. We define the ratio of the payoff of the two payment methods as

$$\Gamma = \frac{OTM(X_t, Y_t)}{OTC(X_t, Y_t)}. \quad (3.16)$$

If $\Gamma > 1$, the mixed-payment method outperforms the pure cash-payment method, it is better to give up a portion of terms, which is equal to $(1 - \xi)$, and use the mixed-payment method.

[Insert Figure 3.2 here]

Figure 3.2 represents the ratio of the payoff which is given by (3.16). The dashed line represents $\Gamma = 1$. We assume that the bidder asks for 80% management control in the merged firm ($\xi = 0.8$) if they use a mixed-payment method. In Figure 3.2, $\Gamma > 1$ means payoff is higher if the bidder gives up 20% management control of the merged firm and therefore use a mixed-payment method. Γ decreases with the drift of the bidder. The mixed-payment method outperforms the pure cash-payment method when μ_X is low and under-performs the pure cash-payment method when μ_X is high. The bidder is willing to buy the whole firm of the target when the growth rate of the bidder's business is high because of a higher business benefits under the complete management control. By contrast, an increase in the growth rate of the target, which is μ_Y , leads to an increase in Γ . The higher the growth rate μ_Y is, the more beneficial the mixed-payment method is. The bidder will choose the pure cash-payment method when the risks of the business of the bidder itself or the target are high. When one of the participating firms faces high risks, a pure cash-payment method helps to distribute the risk because of an efficient allocation of the resources of the merged firm under complete management control. Γ increases with the correlation coefficient ρ . Mara and Ronald [52] illustrate that firms with more diversification have a lower probability of bankruptcy at a given leverage ratio and therefore proportionally lower expected bankruptcy costs. They also have better access to make debt financing. Thus, cash financing should be more feasible for well-diversified firms, which have a lower correlation coefficient. Therefore the pure cash-payment method is better than the mixed-payment method when ρ is low because of the diversification of the business of the two firms. Γ increases with the synergy parameter α . Recall that the synergy gain, which is given by the assumption (3.4), increases with α . In the situation when α is high, the bidder needs to pay more under a pure cash-payment method because the bidder expects 100% management control and enjoys all the synergy gain.

[Insert Figure 3.3 here]

The vertical axis of Figure 3.3 is R_m/R_c . R_m is the threshold in the mixed-payment model, which is given by (3.6) in Proposition 3. R_c , which is given by (2.6) in Proposition 1 is the threshold in the pure cash-payment model. The execution speed of the mixed-payment method is greater than that of the pure cash-payment method if $R_m/R_c < 1$. A higher threshold means the targets will demand a larger profits upon selling their assets before they make the decision. Figure 3.2 and Figure 3.3 represent a similar relationships. When R_m/R_c decreases, the execution speed of the mixed-payment method increases and the payoff of the mixed-payment method decreases, compared with the pure cash-payment method. Therefore, the bidders need to find a trade-off between the execution speed benefits and the synergy generated when they choose a mixed-payment method.

3.4.2 Relationship between Business Parameters and Decision Making

The merger's timing and acquisition premium depend on the growth rate and volatility of the firms' business valuations. We release the basic parameter values, which we want to test, and fix the others, as in Table 3.1.

[Insert Figures 3.4 and 3.5 here]

In Figure 3.4, λ_m is given by proposition 3. We assume that the bidder will negotiate for a high share and test the cash acquisition premium with the growth rate, volatility, correlation coefficient, and synergy parameter. R_m is given by Proposition 3. We again assume that the bidder will negotiate for a high share and test the acquisition premium with the growth rate, volatility, correlation coefficient, and synergy parameter. We find that the bidder will pay a lower acquisition premium when the bidder's growth rate is higher, and pay more when the target's growth rate is higher. According to Proposition 3, $\partial\lambda_m/\partial\theta_1 > 0$ and parameter θ_1 , which is given by (2.9), hold a negative relationship with μ_X . Hence, the cash payment portion λ_m is negatively related to the growth rate μ_X . Because $\partial\theta_1/\partial\mu_Y > 0$, the target's growth rate is positively related to the cash payment portion λ_m . As in the reaction function (3.6), the lower the acquisition premium is, the higher the threshold will be. Therefore, in Figure 3.5, an bidder's higher growth rate will decelerate the merger process, and a target's higher growth rate will accelerate it.

When the volatility of both firms is high, the bidder will pay a lower acquisition premium. Hence, it represent a reverse relationship in Figure 3.5. The parameter θ_1 has a positive relationship with volatility σ_X when $\sigma_X < \rho\sigma_Y$, and a positive relationship with volatility σ_X when $\sigma_X > \rho\sigma_Y$. Thus, the acquisition premium will, at first, increase with volatility σ_X and then decrease if $\rho > 0$. If $\rho \leq 0$, σ_X will always negative relates to θ_1 and then also negative with λ_m . In Figure 3.6, the black, blue and red lines correspond to the following information premium: $\rho = 0$, -0.99 and 0.99 . The red line which represents $\rho = 0.99$ in Figure 3.6, the maximum of λ_m is given when $\sigma_X = \rho\sigma_Y$. Because we set $\sigma_Y = 0.3$, as in Table 3.1, λ_m is maximized when $\sigma_X = 0.297$ on the red line of Figure 3.6 and the threshold R_m is minimized at the same point. The same relationship holds between λ_m , R_m and σ_Y . The lower the correlation coefficient ρ is, the less sensitive is the relation between volatility and the cash acquisition premium payment λ_m , according to Figure 3.6. The lower the correlation coefficient ρ is, the more sensitive is the relation between volatility and the threshold. As shown in Figure 3.4 and Figure 3.5, an increase in correlation coefficient ρ leads to an increase in the cash acquisition premium payment λ_m and a decrease in the threshold.

In Figure 3.4, synergy parameter α will also increase the cash acquisition premium. According to the synergy assumption (3.4), the synergy generated due to merger is positively related to the synergy parameter α . The bidder is willing to pay a higher cash acquisition premium because of a high synergy when α is high.

[Insert Figures 3.6 and 3.7 here]

Firm size equals K_B/K_T . We assume $\omega_T = 1$ and $\omega_B = 1$ in this figure and test the impacts of firm size of the bidder and target. Hence, the figure represents the relationship in a perfect information market. In Figure 3.7, The ratio of the two participating firms always decreases the acquisition premium. Assuming a constant K_B , K_T decreases when K_B/K_T increases. Therefore, a comparatively smaller target will generate a small synergy, according to the assumption in (3.4). The bidder will thereafter pay a lower cash acquisition premium. The threshold R_m is a reaction function of the acquisition premium λ_m , which is given by Proposition 3; therefore, a lower λ_m will increase the threshold and decelerate the process. As (3.11) in Proposition 3, the threshold R_m positive relates to K_B/K_T . The target has two sources of returns: the cash premium payment $\lambda K_T Y_{\tau_m}$, which decreases with an increase in K_B/K_T , assuming a constant K_B ; and the share payment $(1 - \xi)S_M(X_{\tau_m}, Y_{\tau_m})$, which also decreases because of a smaller synergy and thus a smaller $S_M(X_{\tau_m}, Y_{\tau_m})$. A lower return decelerates the decision of accepting the offer and merger with the bidder.

[Insert Figure 3.8 here]

In Figure 3.8, the left side represents the bidder's strategy and we set $\omega_T = 1$. The left side represents the target's strategy. Therefore, $\omega_B = 1$. If the bidder negotiates a higher post-merger share ξ , it needs to pay a higher acquisition premium. The result follows proposition 3. According to (3.10) in proposition 3, the cash acquisition premium payment λ_m is positively related to terms ξ because $d\lambda_m(\xi)/d\xi > 0$. The bidder may expect more management control after the merger and will provide the target with an additional cash payment to attain it. The target firm is willing to receive a higher cash payment; therefore, the merger threshold is also lower when ξ is higher. In the case of a small value of ξ , the acquiring firm is likely to receive lower business benefits after the merger because it has less management control in the target firm. The bidder may even ask for cash compensation, which means $\lambda_m < 0$. Therefore, the merger threshold is higher if the target needs to pay a cash compensation.

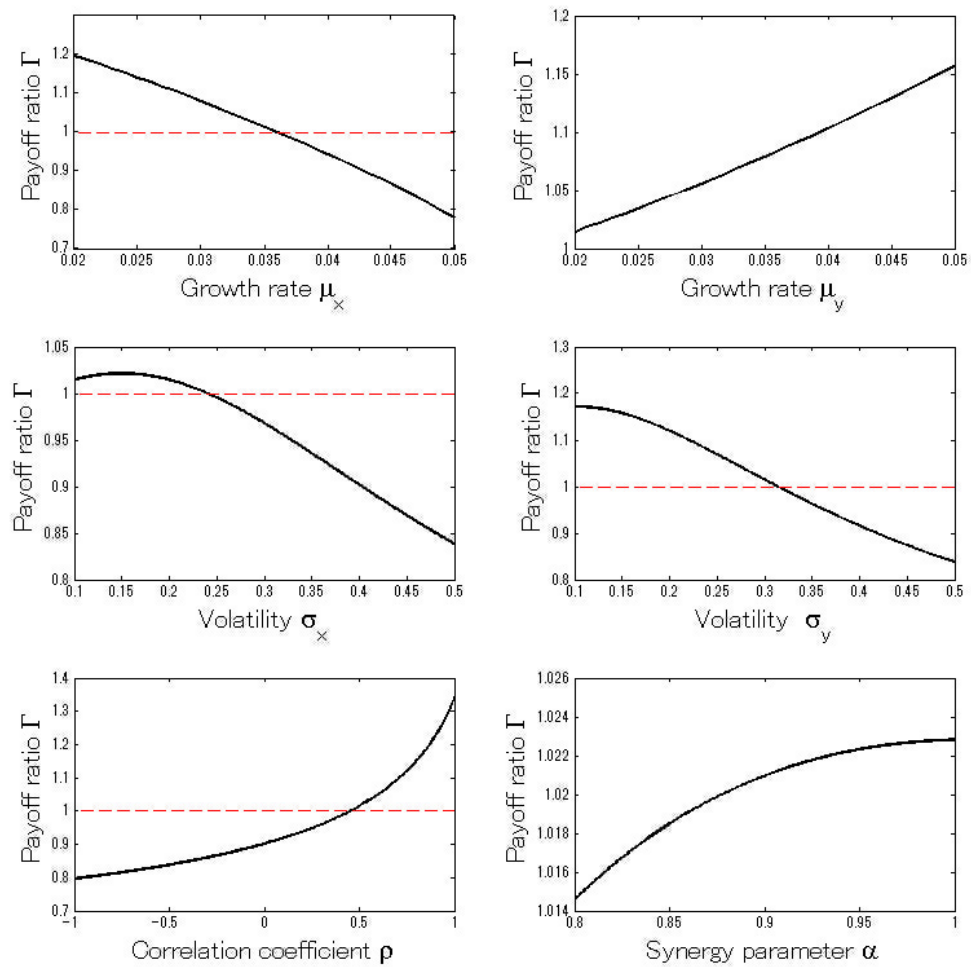


FIGURE 3.2: The ratio of the payoff of mixed-payment method and pure cash-payment method under $\xi = 0.8$.

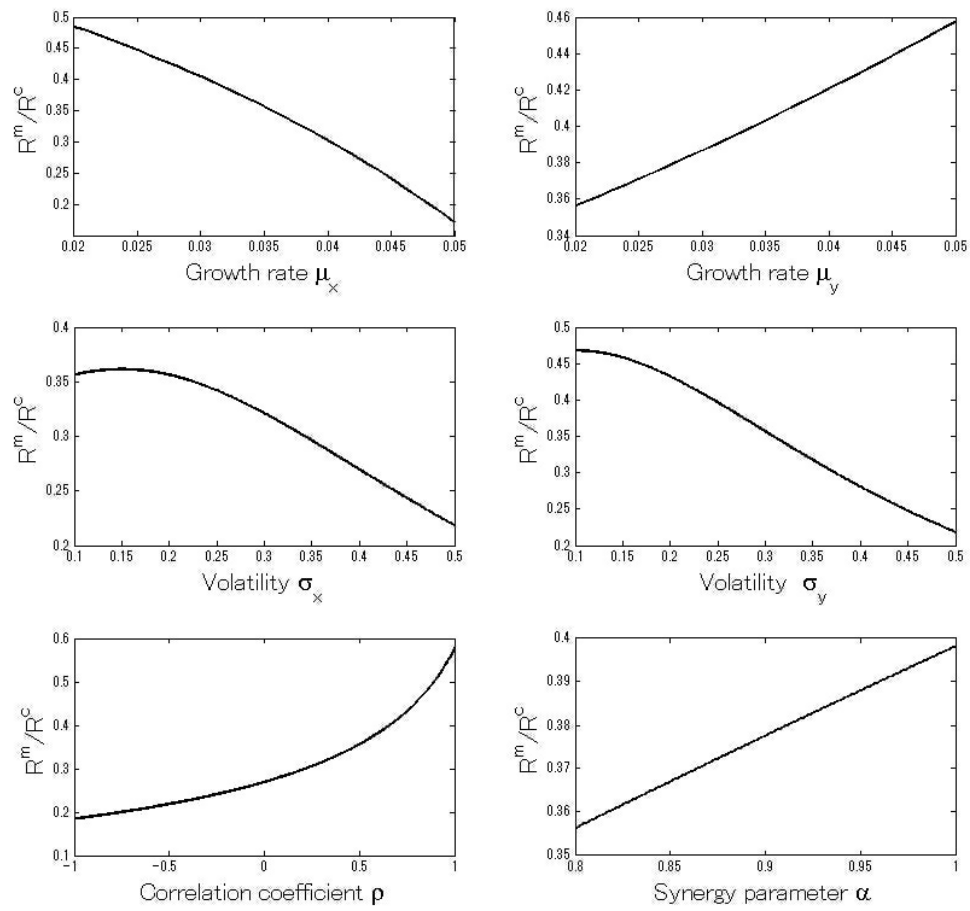


FIGURE 3.3: The comparison of the threshold of mixed-payment method and pure cash-payment method under $\xi = 0.8$.

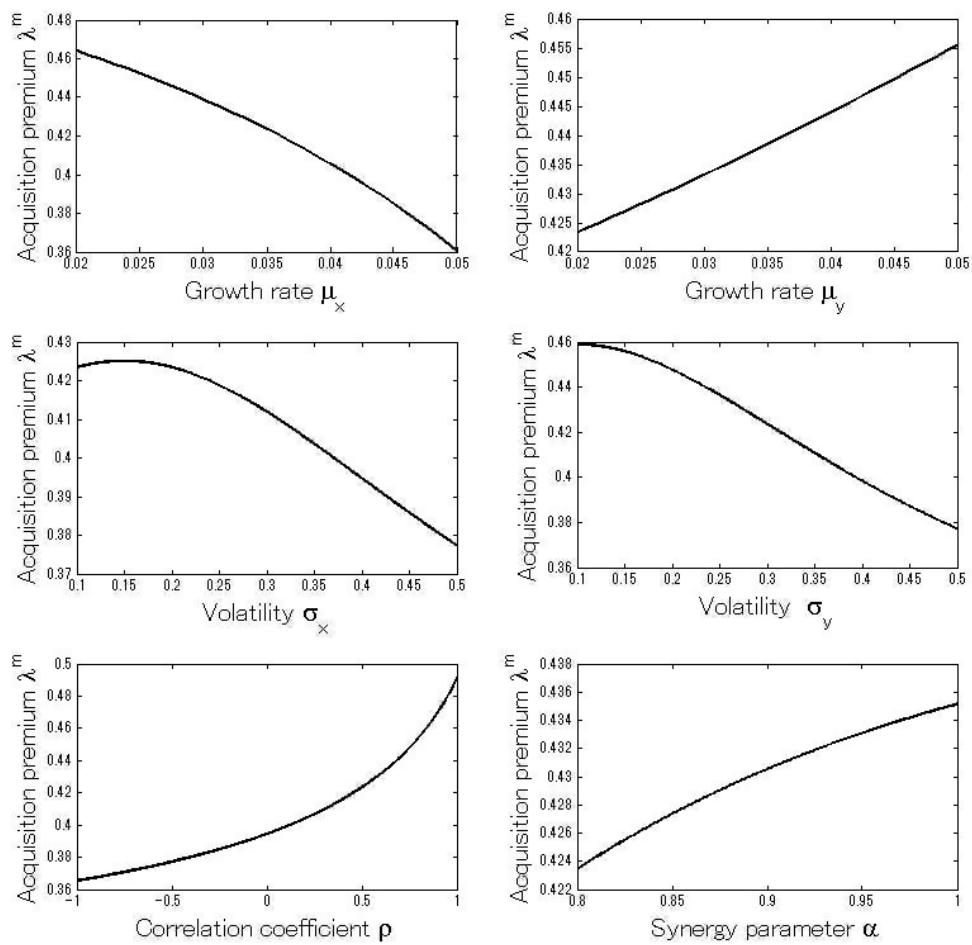


FIGURE 3.4: Parameter impacts on the acquisition premium λ_m under $\xi = 0.8$ in the mixed-payment model.

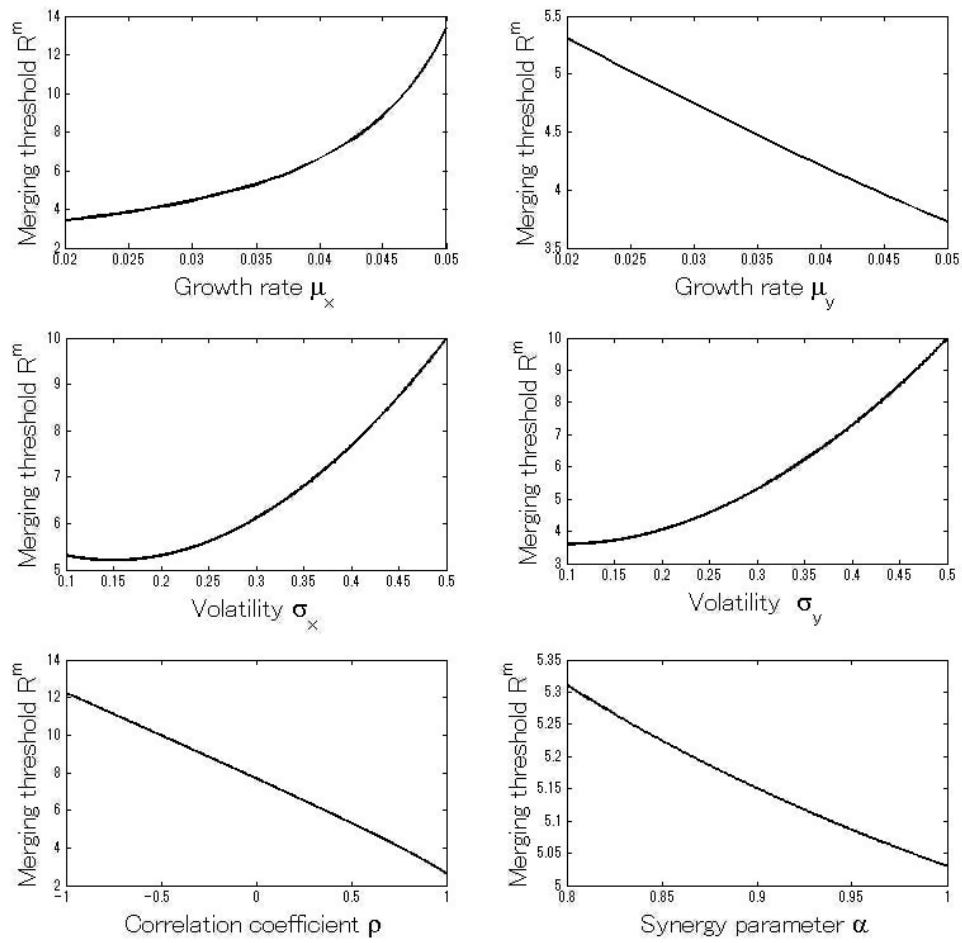


FIGURE 3.5: Parameter impacts on the threshold R_m under $\zeta = 0.8$ in the mixed-payment model.

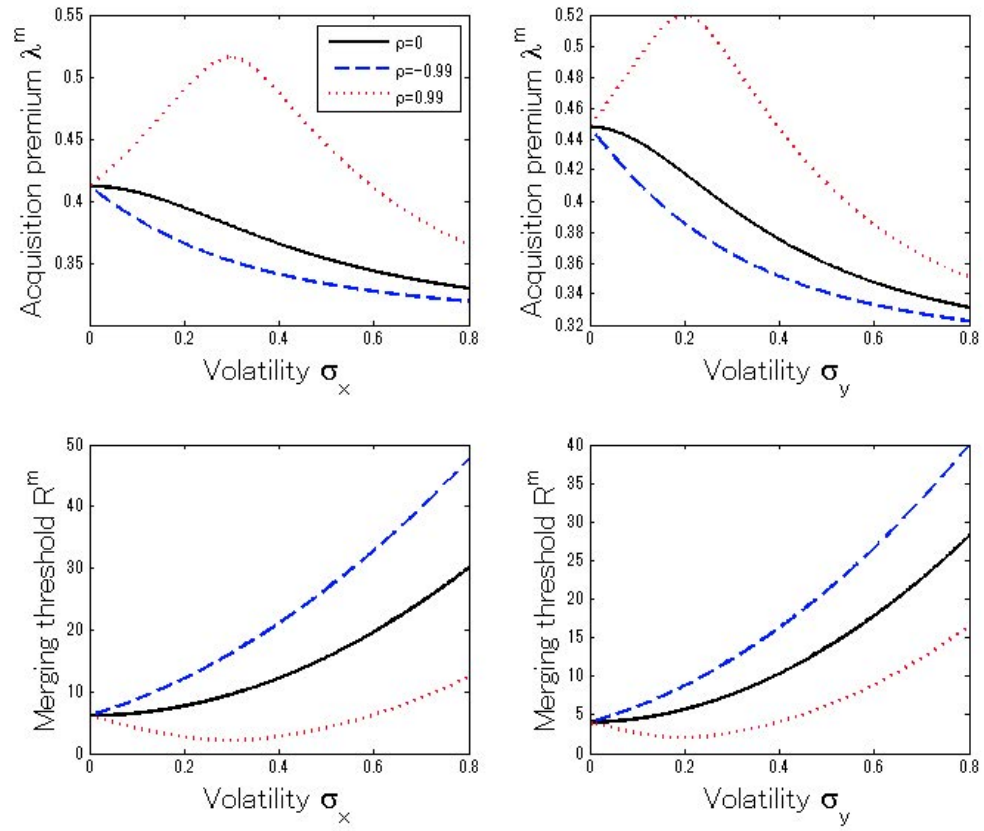


FIGURE 3.6: The impact of volatility on the cash acquisition premium and the threshold in the mixed-payment model. .

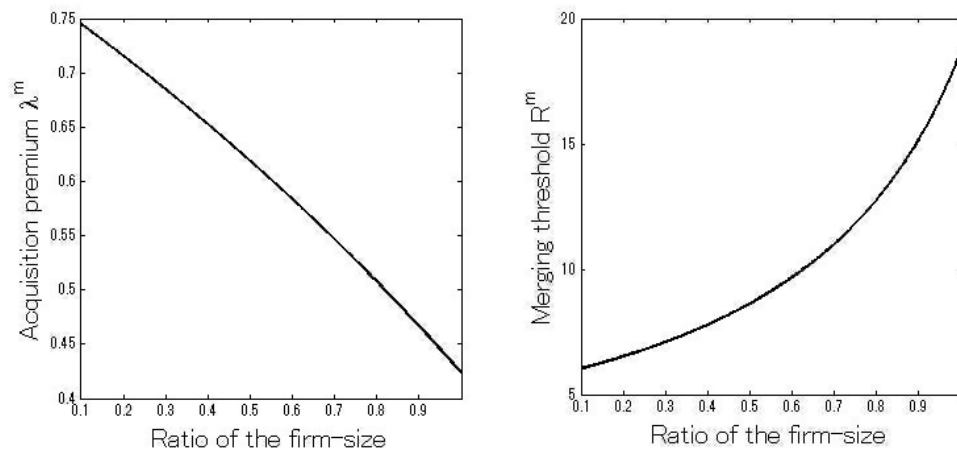


FIGURE 3.7: Effect of the firm size on strategy decision in the mixed-payment model. .

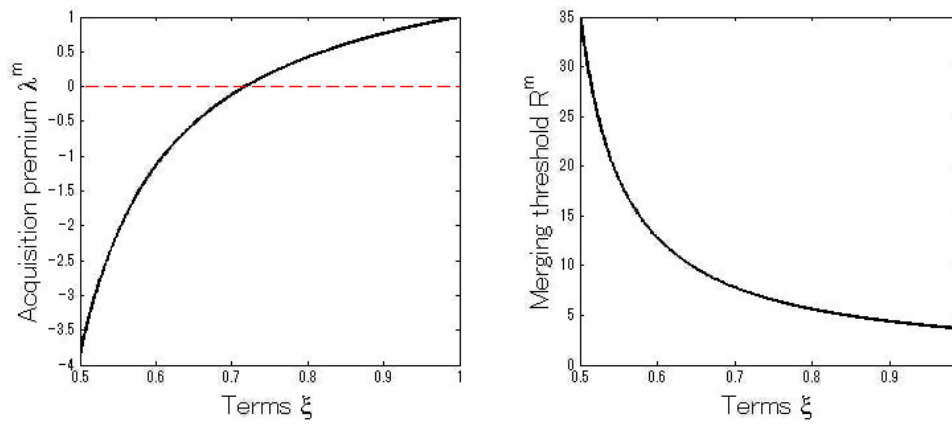


FIGURE 3.8: Relationship between the terms ξ , acquisition premium, and merger threshold in the mixed-payment model.

Chapter 4

An Expand-sell Model

4.1 Background

Mergers and acquisitions are useful strategies for the company to extend business scale or to begin a new business. The company can buy another enterprise to extend their business, or they can sell parts of their business to collect the capital to invest a new business. Lambrecht and Myers [41] generally divides mergers and acquisitions into two broad categories: one is in order to gain the synergies and growth opportunities; and another is to seek greater efficiency through layoffs, consolidation and disinvestment.

Several previous studies develop the M&A models that are motivated by synergy gains. Andrade, Mitchell and Stafford [3] and Andrade and Stafford [4] provide the evidence that resource of merger gains is generated from possible economies of scale, greater efficiency of resource using and market power. Lambrecht [39] studies the timing and terms of mergers motivated by economies of scale and shows that merger activities are positively correlated with markets, meaning that firms are willing to merge during economic expansions. In the study, he assumes a Cobb-Douglas production function, which displays increasing returns to scale. The increase therefore is called synergy in the model. Thijssen [77] extends Lambrecht [39] into a two-uncertainty model and divides the synergies into two types. One is the direct synergy, which are captured by the combination of deterministic profit flow. Another is the indirect synergy due to diversification. The results show that mergers and acquisitions will happen during both economic upswings and downswings. Hackbarth and Morellec [30], Morellec and Zhdanov [58] and Shleifer and Vishny [75] assume a linear combination of participating firms. In those models, the synergy assumptions show that the acquiring firm has a higher Tobin's q than the target, which also means the acquiring firm better performs than the target. The assumption follows Andrade and Stafford [4] and Maksimovic and Phillips [50]. Also, Hackbarth and Morellec [30] introduce the follow-up options of disinvestment and expansion.

As for the aspect of disinvestment efficiency, Lambrecht and Myers [41] focus on the disinvestment with takeover and absent takeover in declining industries. Almeida, Campello and Hackbarth [2] imply that the firms who are facing financial distress are more likely to be acquired by other firms. In their model, the mergers and acquisitions will happen even without synergy gains. In terms of energy industry, Lin and Huang [45] use real options approach to analyze the timing of entry and exit the energy-saving investment. Keswani and Shackleton [37] test the project value changing with future decision of investment and disinvestment. The result shows that the exit option to disinvest is as important as the entry option to invest.

This model combines both two types of mergers and acquisitions which are defined in Lambrecht and Myers [41]. We develop a model that the enterprise has the option to acquire a new business because of the synergy gains or liquidate the asset

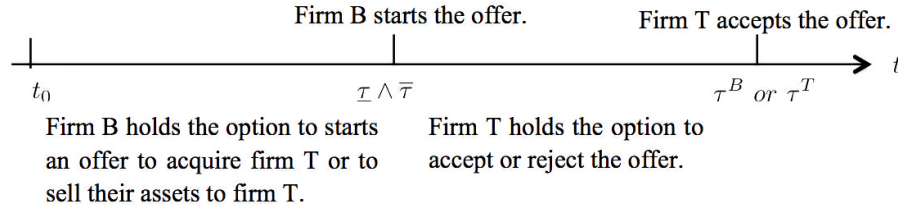


FIGURE 4.1: The acquisition process

and re-allocate the resources (to more productive business). Our synergy assumption is based on Hackbarth and Morellec [30]. And we extend this assumption to that the acquiring firm will be a bidder if they better perform than the target firm and then generate a positive synergy, and the target firm will be the bidder if the target firm is a better performer. In the second situation, the synergy will be positive under the management of the target firm.

The main contributions of this study are as follows. First, we develop two basic models to determine the optimal price to acquire a company and the optimal price to sell the asset to another company. The execution process is close to Lukas and Welling [47] and Lukas, Reuer and Welling [46], who develop two-stage models analyzing the price and timing of mergers and acquisitions. Second, we establish the model of the optimal timing to start an offer to acquire a target or to sell the asset according to the market value of both participating firms.

The Section is organized as follows. In Section 4.2, we introduce the model's framework. Section 4.3 is divided into three subsections to analyze the model of the option to acquire the target which we call the expansion option, the option to sell the asset which we call the contraction option, and the model to determine whether to expand or to contract. In Section 4.4, we give several numerical examples.

4.2 The Model Set-up

We construct the framework based on Morellec and Zhdanov [58]. Consider two firms: Firm B and Firm T, which operate in the same market. We assume capital stocks of K_B for Firm B and K_T for Firm T. The stock market valuation of each firm, denoted by $S_B(X_t)$ and $S_T(Y_t)$, respectively, without takeover is

$$S_B(X_t) = K_B X_t, \quad S_T(Y_t) = K_T Y_t, \quad (4.1)$$

where X_t and Y_t denote the per-unit value of capital, which follows a geometric Brownian motion,

$$\begin{aligned} dX_t &= \mu_X X_t dt + \sigma_X X_t dW_X, \\ dY_t &= \mu_Y Y_t dt + \sigma_Y Y_t dW_Y, \end{aligned} \quad (4.2)$$

where expected growth rates $\mu_X, \mu_Y > 0$, and volatilities $\sigma_X, \sigma_Y > 0$ are constant parameters. W_X and W_Y are standard Brownian motions. The correlation coefficient between W_X and W_Y is constant, represented as $\rho \in (-1, 1)$. We assume that all participants are risk neutral, and the risk-free interest rate is $r, r(\geq \mu_i, i = X, Y)$.

As shown in Figure 4.1, we suppose the acquisition process proceeds in three steps. At time t_0 , Firm B holds both an option to acquire the Firm T, and an option to

sell their Firm to Firm T. According to the market values of two participating Firms, Firm B will make an offer to acquire Firm T at time $\bar{\tau}$. Or they will make an offer to sell their asset at time $\underline{\tau}$. Firm T need not decide immediately upon receiving the offer, that is, it can postpone the decision. Hence, Firm T holds the option to accept or reject the offer from time $\bar{\tau} \wedge \underline{\tau}$ onwards. The horizon of the option which the target holds is infinite. Firm B is not looking for an immediate execution, which is generally associated with a higher cost. (see Offenberg and Pirinsky [63] for the supporting evidence.) Suppose Firm T accepts the offer at τ^B under an acquiring offer. Accepting the offer leads to an immediate merger of the two firms at time τ^B . The post-merger firm is under the control of Firm B. Similarly, suppose Firm T accepts the offer at τ^T under a selling offer and the post-merger firm is under the control of Firm T.

In the scenario that Firm B acquires Firm T and remains the shareholder of the post-merger enterprise, we assume a linear combination of pre-takeover values in terms of per-unit value of capital following Hackbarth and Morellec [30] and Shleifer and Vishny [75]. The post-merger value of the firm is

$$S_M^B(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G^B(X_t, Y_t), \quad (4.3)$$

where $G^B(X_t, Y_t)$ is net synergy gains generated from the merger for Firm B, given by

$$G^B(X_t, Y_t) = K_T(\alpha_B(X_t - Y_t) - c_B Y_t), \quad (\alpha_B, c_B) \in \mathbb{R}_{++}^2, \quad (4.4)$$

where α_B is the synergy parameter if the Firm B is the remaining shareholder of the post-merger enterprise, which all participants can observe. c_B denotes the per-unit merger cost of the capital value of the Firm T. The post-merger per-unit value of capital which the Firm T holds before merger changes to $\alpha_B X_t + (1 - \alpha_B)Y_t$. Therefore, the post-merger value of the Firm T's capital increased to $S_T(Y_t) + K_T \alpha_B(X_t - Y_t)$. Consider the cost paid at the time of merger, the synergy generated thus given by (4.4). This assumption indicates that the synergy will be positive only when the bidder outperforms the target, which has the same meaning as $X_t > Y_t$. (Equivalently, the bidder generally has a higher Tobin's q than the target. Rava and Vermaelen [69] give the supporting evidence.) The target's resources are more efficiently allocated after merger.

While if Firm B provides an offer to sell their assets, Firm T holds the whole share of the post-merger enterprise after they accept the offer. Under the management of Firm T, the post-merger value of the firm is

$$S_M^T(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G^T(X_t, Y_t), \quad (4.5)$$

where $G^T(X_t, Y_t)$ is net synergy gains generated from the merger, given by

$$G^T(X_t, Y_t) = K_B(\alpha_T(Y_t - X_t) - c_T X_t), \quad (\alpha_T, c_T) \in \mathbb{R}_{++}^2, \quad (4.6)$$

where α_T is the synergy parameter if the Firm T is the remaining shareholder of the post-merger enterprise, which all participants can observe. c_T denotes the per-unit merger cost of the capital value of the Firm B. The post-merger per-unit value of capital which the Firm B holds before merger changes to $\alpha_T Y_t + (1 - \alpha_T)X_t$. Therefore, the post-merger value of the Firm B's capital increased to $S_B(X_t) + K_B \alpha_T(Y_t - X_t)$. Consider the cost paid at the time of merger, the synergy generated thus given by (4.6). In this situation, Firm T more efficiently allocates resources of Firm B after

merger.

4.3 The Optimal Strategy

In this section, we first develop the model that Firm B acquires Firm T's share and then the model that they sell their assets to Firm T. We denote the option to acquire Firm T as the expansion option, and the option to sell the assets as the contraction option. Both scenarios are pure cash-payment merger. For a pure cash-payment M&A, the bidder is assumed to pay an amount of cash to the target based on the target's market value and buys the whole firm. There is no share exchange in the process. The bidder is the only shareholder of the merged firm. We finally compare the expansion strategy and the contraction strategy to determine the optimal strategy to start the offer.

4.3.1 The Expansion Option

Under an expansion strategy, Firm B is going to acquire Firm T. According to (4.4), the synergy gains are positive if the per-unit capital value of Firm B is higher than which of Firm T. Therefore, Firm B is more willing to buy Firm T's asset and allocate their resources to gain the positive synergy when they better perform than Firm T. Suppose Firm B will use parts of their capital, which is denoted as portion p_B , to pay the cash payment. Hence, Firm B provides an offer to use p_B portion of their capital to buy the whole Firm T. Receiving the offer, the target (here is Firm T) decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OM^B(X_t, Y_t) = \max_{\tau^B} \mathbb{E} \left\{ e^{-r\tau^B} \left[p_B S_B(X_{\tau^B}) - S_T(Y_{\tau^B}) \right] \right\}. \quad (4.7)$$

At time τ^B , the target accepts the offer. They will receive a cash payment, worth $p_B S_B(X_{\tau^B})$ and give up their claim, worth $S_T(Y_{\tau^B})$. Maximizing the function (4.7) yields Proposition 6.

Proposition 6 (The optimal threshold for the target to sell the assets) *Based on the value-maximizing strategy, the target firm will accept the offer and merge with the bidder when the ratio of per unit capital price, denoted by $R_t = X_t/Y_t$, reaches the level*

$$R_{\tau^B} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B p_B}. \quad (4.8)$$

Value of the option that the target holds is given by

$$OM^B(X_t, Y_t) = \begin{cases} Y_t [p_B K_B R_t - K_T], & R_{\tau^B} \leq R_t, \\ Y_t [p_B K_B R_{\tau^B} - K_T] \left(\frac{R_t}{R_{\tau^B}} \right)^{\vartheta_1}, & R_t < R_{\tau^B}, \end{cases} \quad (4.9)$$

and the first passing time is

$$\tau^B = \inf \{ t > 0 : R_t \geq R_{\tau^B} \}. \quad (4.10)$$

$\vartheta_1 > 1$ is the positive root of the quadratic equation 2.9. Appendix C.1 contains the proof.

As soon as Firm T accepts the offer, two participating firms will merge. Firm B gives up the claim, worth $S_B(X_{\tau^B})$, and pays a cash amount of $p_B S_B(X_{\tau^B})$ to the target at time τ^B . In return, Firm B receives the whole ownership of the merged firm, worth $S_M(X_{\tau^B}, Y_{\tau^B})$. The optimization function for Firm B thereafter is given by

$$OT^B(X_t, Y_t) = \max_{p_B} \mathbb{E} \left\{ e^{-r\tau^B} \left[S_M^B(X_{\tau^B}, Y_{\tau^B}) - p_B S_B(X_{\tau^B}) - S_B(X_{\tau^B}) \right] \right\}. \quad (4.11)$$

Proposition 7 (Optimal payment for the bidder to buy the target) *Maximizing the payoff function (4.11) yields the optimal offered portion p_B if Firm B starts an expansion offer, given as*

$$p_B = \frac{\alpha_B(\vartheta_1 - 1)}{(\alpha_B + c_B - 1)(\vartheta_1 - 1) + \vartheta_1 K_B} \frac{K_T}{K_B}. \quad (4.12)$$

Substituting result (4.12) into (4.8) yields

$$R_{\tau^B} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1}{\alpha_B} \left(\alpha_B + c_B - 1 + \frac{\vartheta_1}{\vartheta_1 - 1} \right). \quad (4.13)$$

Appendix C.2 contains the proof.

According to (4.8), the higher p_B is, the lower the threshold will be. The merging process will be accelerated if the Firm B uses a high portion p_B to pay Firm T. If Firm B chooses an optimal portion p_B , which is given by (4.12), Firm T will accept the offer when the ratio of per unit capital value R_t reaches (4.13). According to (4.12), p_B positively relates to ϑ_1 as $\partial p_B / \partial \vartheta_1 > 0$, and negatively relates to the firm-size ratio, which is represented as K_B / K_T . A higher synergy parameter α_B will increase the payment and then decrease the threshold R_{τ^B} . While a higher cost c_B will decrease the payment and increase the threshold.

4.3.2 The Contraction Option

Under a contraction option, Firm B will ask Firm T to buy their asset. If the per-unit capital value of Firm T is higher than Firm B, the synergy gains given by (4.4) are always negative, while the synergy gains given by (4.6) will be positive. Firm B will not acquire Firm T because of a negative synergy in this scenario, which means the resources will not be efficiently allocated under Firm B's operation. While Firm T is willing to pay a cash payment to buy Firm B's assets because of a positive synergy gain under their operation. We still assume that the Firm B is first mover that they will start an offer to sell their assets. Firm B will ask a cash payment as selling price. We assume the cash payment is denoted as a p_T portion of Firm T's capital value, which means that Firm B asks Firm T to use their p_T portion of capital to buy their company. Receiving the offer, Firm T decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OM^T(X_t, Y_t) = \max_{\tau^T} \mathbb{E} \left\{ e^{-r\tau^T} \left[S_M^T(X_{\tau^T}, Y_{\tau^T}) - p_T S_T(Y_{\tau^T}) - S_T(Y_{\tau^T}) \right] \right\}. \quad (4.14)$$

When Firm T accepts the offer, they will receive the ownership of the post-merger company, worth $S_M^T(X_{\tau^T}, Y_{\tau^T})$. To buy the Firm B, Firm T will pay a cash payment of $p_T S_T(Y_{\tau^B})$. Firm T also needs to give up their claim, worth $S_T(Y_{\tau^B})$. Maximizing the function (4.14) yields Proposition 8.

Proposition 8 (The optimal threshold for the target to buy the assets) *Based on the value-maximizing strategy, the Firm T will accept the offer and merge with Firm B when the ratio of per unit capital price, which is $R_t = X_t/Y_t$, reaches the level*

$$R_{\tau^T} = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{p_T K_T - \alpha_T K_B}{(1 - \alpha_T - c_T) K_B}. \quad (4.15)$$

Value of the option that the target holds is given by

$$OM^T(X_t, Y_t) = \begin{cases} Y_t \left[(\alpha_T + (1 - \alpha_T - c_T) R_t) K_B - p_T K_T \right], & R_t \leq R_{\tau^T}, \\ Y_t \left[(\alpha_T + (1 - \alpha_T - c_T) R_{\tau^T}) K_B - p_T K_T \right] \left(\frac{R_t}{R_{\tau^T}} \right)^{\vartheta_2}, & R_t > R_{\tau^T}, \end{cases} \quad (4.16)$$

and the first passing time is

$$\tau^T = \inf\{t > 0 : R_t \leq R_{\tau^T}\}. \quad (4.17)$$

$\vartheta_2 < 0$ is the negative root of the quadratic equation of (2.9).

Appendix C.3 contains the proof.

As soon as Firm T accepts the offer, two participating firms will merge. Firm B gives up the claim, worth $S_B(X_{\tau^T})$, and receive a cash payment of $p_T S_T(Y_{\tau^T})$ from Firm T at time τ^T . The optimization function for the Firm B thereafter is given by

$$OT^T(X_t, Y_t) = \max_{p_T} \mathbb{E} \left\{ e^{-r\tau^T} \left[p_T S_T(Y_{\tau^T}) - S_B(X_{\tau^B}) \right] \right\}. \quad (4.18)$$

Proposition 9 (Optimal payment for the bidder to sell the company) *Maximizing the payoff function (4.18) yields the optimal offered portion p_T receiving from Firm T, given as*

$$p_T = \frac{(1 - \alpha_T - c_T) + \vartheta_2}{(1 - \vartheta_2)(1 - \alpha_T - c_T) + \vartheta_2} \frac{\alpha_T K_B}{K_T}. \quad (4.19)$$

Substituting result (4.19) into (4.15) yields

$$R_{\tau^T} = \frac{\vartheta_2^2}{\vartheta_2 - 1} \frac{\alpha_T}{(1 - \vartheta_2)(1 - \alpha_T - c_T) + \vartheta_2}. \quad (4.20)$$

Appendix C.4 contains the proof.

According to (4.15), the higher p_T is, the higher the threshold will be. The merging process will be decelerated if the Firm B asks a higher portion p_T which causes Firm T to pay a higher cash amount if accepting the offer. If Firm B chooses an optimal portion p_T , which is given by (4.19), Firm T will accept the offer when the

ratio of per unit capital value R_t reaches (4.20). A higher synergy parameter α_T will increase the payment and then decrease the threshold R_{τ^T} .

4.3.3 The Optimal Decision

In this subsection, we will analyze the optimal decision from Firm B's perspective. At time t_0 , Firm B has two optional strategies. They hold the option to acquire Firm T so as to expand their business and also the option to sell their own company so as to collect the cash.

We assume the cost to start an expansion option to acquire Firm T is $c_e S_B(X_t)$. If Firm B choose the expansion option, the shareholder's value is $S_B(X_t) + OT^B(X_t, Y_t) - c_e S_B(X_t)$. Similarly, we assume the cost to start a contraction option to sell Firm B is $c_a S_B(Y_t)$. If Firm B choose the option to sell their firm, the shareholder's value is $S_B(X_t) + OT^T(X_t, Y_t) - c_a S_B(X_t)$.

When the ratio of per-unit capital price R_t increases, Firm B is more willing to exercise the expansion option because of a higher synergy given by (4.4). On the other hand, they will exercise the contraction option and ask an optimal payment when the ratio of per-unit capital price R_t decreases. Firm T will be more willing to pay $p_T S_T(Y_t)$ because of a high synergy given by (4.6) if the ratio of per-unit capital price R_t decreases. We denote $\bar{\tau}$ the first passage time to starts the expansion option and $\underline{\tau}$ the first passage time to starts the contraction option. The value-maximizing strategy can be characterized by two constant thresholds $R_{\bar{\tau}}$ and $R_{\underline{\tau}}$. Firm B will starts an expansion offer to acquire Firm T if the ratio of per-unit capital price R_t reaches $R_{\bar{\tau}}$ before $R_{\underline{\tau}}$ or they will starts a contraction offer to sell their asset to Firm T when R_t reaches $R_{\underline{\tau}}$ before $R_{\bar{\tau}}$. The optimization function for Firm B is

$$OB(X_t, Y_t) = \max_{\{\bar{\tau}, \underline{\tau}\}} \mathbb{E} \left\{ \mathbf{1}_{\{\bar{\tau} < \underline{\tau}\}} \left[e^{-r\bar{\tau}} \left\{ S_B(X_{\bar{\tau}}) + OT^B(X_{\bar{\tau}}, Y_{\bar{\tau}}) - c_e S_B(X_{\bar{\tau}}) \right\} \right] \right. \\ \left. + \mathbf{1}_{\{\bar{\tau} > \underline{\tau}\}} \left[e^{-r\underline{\tau}} \left\{ S_B(X_{\underline{\tau}}) + OT^T(X_{\underline{\tau}}, Y_{\underline{\tau}}) - c_a S_B(X_{\underline{\tau}}) \right\} \right] \right\}, \quad (4.21)$$

where $\mathbf{1}_\Omega$ is the indicator function of Ω . The first term in (4.21) is the option value if Firm B exercises the expansion option, given by (4.11), and the second term includes the option value if Firm B exercises the contraction option, given by (4.18).

Proposition 10 (The optimal strategy for Firm B) *Following the previous study by Hackbarth and Morellec [30], the thresholds to start the expansion offer and the contraction offer which are represented as $R_{\bar{\tau}}$ and $R_{\underline{\tau}}$ are defined by $R_{\bar{\tau}} = y R_{\underline{\tau}}$, where $y > 1$ is*

$$y = \left(\frac{(1 - \vartheta_2)(1 - c_e)K_B}{(1 - \vartheta_2)(1 - c_a)K_B - (\vartheta_1 - \vartheta_2)\mathcal{B}(R_{\tau^B})R_{\underline{\tau}}^{\vartheta_1 - 1}} \right)^{\frac{1}{\vartheta_1 - 1}}. \quad (4.22)$$

The threshold to start the contraction offer, $R_{\underline{\tau}}$, is the solution of

$$\begin{aligned} & \left(\frac{(\vartheta_1 - 1)(1 - c_e)K_B}{(\vartheta_1 - \vartheta_2)\mathcal{A}(R_{\tau^T})R_{\underline{\tau}}^{\vartheta_2 - 1} + (\vartheta_1 - 1)(1 - c_a)K_B} \right)^{\frac{1}{\vartheta_2 - 1}} \\ &= \left(\frac{(1 - \vartheta_2)(1 - c_e)K_B}{(1 - \vartheta_2)(1 - c_a)K_B - (\vartheta_1 - \vartheta_2)\mathcal{B}(R_{\tau^B})R_{\underline{\tau}}^{\vartheta_1 - 1}} \right)^{\frac{1}{\vartheta_1 - 1}}, \end{aligned} \quad (4.23)$$

where $\mathcal{A}(R_{\tau^T})$ and $\mathcal{B}(R_{\tau^B})$ are denoted as

$$\mathcal{A}(R_{\tau^T}) = (p_T K_T - K_B R_{\tau^T}) R_{\tau^T}^{-\vartheta_2}, \quad (4.24)$$

$$\mathcal{B}(R_{\tau^B}) = \left[K_T (\alpha_B R_{\tau^B} - \alpha_B - c_B + 1) - p_B K_B R_{\tau^B} \right] R_{\tau^B}^{-\vartheta_1}. \quad (4.25)$$

Value of the option is given by

$$OB(X_t, Y_t) = \begin{cases} Y_t \left[\mathcal{A}(R_{\tau^T}) R_t^{\vartheta_2} + K_B R_t \right], & R_t < R_{\underline{\tau}}, \\ Y_t \left[\mathcal{H}(R_t) \left(\mathcal{B}(R_{\tau^B}) R_{\bar{\tau}}^{\vartheta_1} + K_B R_{\bar{\tau}} \right) \right. \\ \quad \left. + \mathcal{L}(R_t) \left(\mathcal{A}(R_{\tau^T}) R_{\underline{\tau}}^{\vartheta_2} + K_B R_{\underline{\tau}} \right) \right], & R_{\underline{\tau}} \leq R_t \leq R_{\bar{\tau}}, \\ Y_t \left[\mathcal{B}(R_{\tau^B}) R_t^{\vartheta_1} + K_B R_t \right], & R_{\bar{\tau}} < R_t, \end{cases} \quad (4.26)$$

where $\mathcal{H}(R_t)$ and $\mathcal{L}(R_t)$ are stochastic discount, which are defined by

$$\mathcal{H}(R_t) = \frac{R_{\underline{\tau}}^{\vartheta_2} R_t^{\vartheta_1} - R_{\underline{\tau}}^{\vartheta_1} R_t^{\vartheta_2}}{R_{\bar{\tau}}^{\vartheta_1} R_{\underline{\tau}}^{\vartheta_2} - R_{\underline{\tau}}^{\vartheta_1} R_{\bar{\tau}}^{\vartheta_2}}, \quad \mathcal{L}(R_t) = \frac{R_{\bar{\tau}}^{\vartheta_1} R_t^{\vartheta_2} - R_{\bar{\tau}}^{\vartheta_2} R_t^{\vartheta_1}}{R_{\bar{\tau}}^{\vartheta_1} R_{\underline{\tau}}^{\vartheta_2} - R_{\underline{\tau}}^{\vartheta_1} R_{\bar{\tau}}^{\vartheta_2}}. \quad (4.27)$$

Given as (4.26), if the ratio of per unit capital price is lower than $R_{\underline{\tau}}$, Firm B will immediately start a contraction offer to sell their assets. If the ratio of per unit capital price is high than $R_{\bar{\tau}}$, Firm B will immediately start an expansion offer to acquire Firm T. If the ratio of per unit capital price is in the range of $(R_{\underline{\tau}}, R_{\bar{\tau}})$, Firm B will wait to start an optimal offer until the ratio reaches one of the thresholds. In the next section, we further examine the threshold given by (4.23).

4.4 Numerical Studies

In this section, we provide several numerical results. The decision-making of mergers and acquisitions activities largely depends on the growth rate and volatility of the participating firm's business valuations, and also on the synergy generated. Accordingly, we first illustrate the impact of the business growth rate on the decision-making. Second, we examine the impact of the volatility. Third, we study synergy impact. Table 4.1 summarizes the basic parameter values. We assume drifts of Firm B and Firm T are 0 and 0.025. The volatility of Firm B and Firm T are set to 20% and 25%. We examine the situation that the growth rate of Firm B is zero and Firm B seeks a strategy to stimulate the business. The execution target Firm T has a higher

TABLE 4.1: Parameter values.

Parameter		Value
Expected growth rate of the Firm B	μ_X	0.00
Expected growth rate of the Firm T	μ_Y	0.025
Volatility of the Firm B	σ_X	0.20
Volatility of the Firm T	σ_Y	0.25
Correlation coefficient	ρ	0.50
Ratio of the Firm-size	K_B/K_T	1.00
Synergy parameter under control of Firm B	α_B	0.80
Synergy parameter under control of Firm T	α_T	0.80
Per unit merger cost for Firm B	c_B	0.10
Per unit merger cost for Firm T	c_T	0.10
Per unit expansion offer cost	c_e	0.10
Per unit contraction offer cost	c_a	0.05
Risk-free rate	r	0.06

growth rate and also a higher risk. We also focus on mergers of equal-size by assuming that $K_B/K_T = 1$. In the following subsections, we release the basic parameter values, which we want to test, and fix the others, as in Table 1.

4.4.1 Impact of the Growth Rate on the Decision-making

Figure 4.2 represents the relationship between the growth rate of Firm B and the payment if Firm B decide to use an expansion strategy. In the expansion model, Firm B offers an optimal payment portion p_B which is given by Proposition 7. Firm T accepts the offer at time τ^B and the ratio of the per unit capital price $R_{\tau^B} = X_{\tau^B}/Y_{\tau^B}$ is given by Proposition 6. Therefore, the vertical axis $p_B R_{\tau^B} = p_B X_{\tau^B}/Y_{\tau^B}$ holds the meaning that Firm B should pay $p_B X_{\tau^B}$ for one unit Firm T's capital, which is Y_{τ^B} , at time τ^B . We call $p_B R_{\tau^B}$ the exchange rate in the expansion offer.

According to Proposition 7, $\partial p_B / \partial \theta_1 > 0$ and parameter θ_1 , which is given by (2.9), holds a negative relationship with μ_X . Hence, the optimal payment portion p_B negatively relates to the growth rate μ_X . Accordingly, in Figure 4.2, Firm B will offer a lower payment portion p_B to Firm T when Firm B's growth rate is higher. In the expansion model, Firm T will accept the offer when the per unit price of Firm B's capital X_t increase or the per unit price of their own capital Y_t decrease. When the optimal payment portion p_B is lower, Firm T aspires to a higher X_t or a smaller Y_t to accept the offer. Hence, a negative relationship between ∂p_B and growth rate μ_X leads to a positive relationship between the threshold R_{τ^B} and growth rate μ_X which is represented by the curve in omicron in Figure 4.6. Firm B will consequently pay more for each Firm T's capital, and the exchange rate $p_B R_{\tau^B}$ positive relates to the growth rate μ_X shown in Figure 4.2.

[Insert Figures 4.2 and 4.3 here]

Figure 4.3 represents the relationship between the growth rate of Firm B and the payment if Firm B decide to use a contraction strategy. In a contraction model, Firm B offers an optimal payment portion p_T which is given by Proposition 8. The motivation for Firm T to buy Firm B is the synergy gains given by (4.6), which increase if the ratio R_t decreases. Firm T accepts the offer at time τ^T and the ratio of the per

unit capital price $R_{\tau^T} = X_{\tau^T}/Y_{\tau^T}$ is given by Proposition 8. Similarly, the vertical axis $p_T/R_{\tau^T} = p_T Y_{\tau^T}/X_{\tau^T}$ holds the meaning that Firm T should pay $p_T Y_{\tau^T}$ for one unit Firm B's capital, which is X_{τ^T} , if they accept the offer at time τ^T . p_T/R_{τ^T} is the exchange rate in the contraction offer. Because $\partial p_T/\partial \vartheta_2 < 0$ and ϑ_2 positively relates to μ_X , p_T which is given by (4.19) negatively relates to the growth rate μ_X in Figure 4.3. With a lower p_T , Firm T can accept the offer even when the synergy gains are smaller because of a smaller cost. Synergy gains by (4.6) negatively relates to the ratio R_t . Therefore, a lower p_T leads to a higher threshold R_t , which is shown in Figure 4.6 as the curve in square. Firm T will consequently pay less for each Firm B's capital, and the exchange rate p_T/R_{τ^T} negatively relates to the growth rate μ_X shown in Figures 4.3. Figures 4.4 and 4.5 show reverse relationships with Figures 4.2 and 4.3. The threshold R_{τ^B} decreases and R_{τ^T} increase with μ_Y in Figure 4.2.

[Insert Figures 4.4 and 4.5 here]

In Figures 4.6 and 4.7, the curve in asterisk indicates the threshold for Firm B to start the expansion option and the curve in omicron show the threshold for Firm T to accept the expansion option. The curve in triangle indicates the threshold for Firm B to start the contraction option and the curve in square shows the threshold for Firm T to accept the contraction option. Because both the curve in asterisk and the curve in triangle decrease with the growth rate of Firm B μ_X , the decision to start an expansion offer is accelerated while the decision to start a contraction is decelerated. The movement of two curves equivalently means Firm B is more willing to acquire Firm T than to sell their asset to Firm T. In Figure 4.7, the curve in asterisk and the curve in triangle increase with the growth rate of Firm T μ_Y , the decision to start an expansion offer is decelerated while the decision to start a contraction is accelerated. Firm B is less willing to acquire Firm B than to sell their asset to Firm T when the growth rate of Firm T is high.

[Insert Figures 4.6 and 4.7 here]

Define the execution speed of the expansion process as $R_{\tau^B} - yR_{\tau^T}$ and the execution speed of the contraction process as $R_{\tau^T} - R_{\tau^B}$, where y and R_{τ^T} are given by Proposition 10. In Figures 4.6 and 4.7, the growth rate of Firm B μ_X slows down the execution speed of the expansion process and accelerate the contraction speed of the expansion process.

4.4.2 Impact of the Volatility on the Decision-making

As in Figure 4.8, when the volatility of Firm B is high, the Firm B offers a lower acquisition payment portion p_B . Hence, it represents a reverse relationship in Figure 4.12 as the curve in omicron. The parameter ϑ_1 has a positive relationship with volatility σ_X when $\sigma_X < \rho\sigma_Y$, and vice versa. Thus, the acquisition payment will increase with volatility σ_X and then decrease if $\rho > 0$. If $\rho \leq 0$, σ_X will always negative relates to ϑ_1 and then also negative with p_B . The same relationship between p_B and σ_Y in Figure 4.10. The exchange rate $p_B R_{\tau^B}$ increase because the threshold R_{τ^B} in both Figures 4.8 and 4.10. In both Figures 4.9 and 4.11, Firm B will ask a higher payment portion p_T when the volatilities of participating firms. Firm T will wait until a lower threshold R_t to reduce the cost. The exchange rate p_T/R_{τ^T} is high under a higher volatility.

[Insert Figures 4.8 and 4.9 here]

In Figure 4.12, a higher volatility of Firm B, σ_X , will increase the threshold to start an expansion offer and slightly decreases the threshold to start a contraction offer. Firm B is less willing to acquire Firm T and expanse the business or to contraction the assets when their volatility is high. A higher volatility of Firm B also decelerates the expansion speed because the threshold for Firm T to accept the expansion offer is more sensitive and increase with the volatility. When volatility σ_X is high, the expansion speed is slower than the contraction speed which means the expansion process is longer.

[Insert Figures 4.10 and 4.11 here]

A higher volatility of Firm T, σ_Y , will also increase the threshold to start an expansion offer in Figure 4.13 because of a higher exchange rate shown in Figure 4.10. While the contraction decision dependents on the correlation coefficient ρ . In Figure 4.11, the exchange rate for Firm B to sell their assets decreases with the ρ . The contraction threshold increases with σ_Y when the correlation coefficient ρ is positive and decreases when correlation coefficient ρ is zero or negative. The expansion speed exceeds the contraction speed with the increase of σ_X . When the volatility σ_Y is small, the expansion speed is fast because Firm B starts the expansion offer with a high payment portion p_B in Figure 4.10.

[Insert Figures 4.12 and 4.13 here]

4.4.3 Synergy Impact

In Figure 4.14, synergy parameter α_B will also increase the acquisition payment portion p_B offered by Firm B according to Proposition 7. According to the synergy assumption (4.4), the synergy generated due to merger is positive related to the synergy parameter α_B . The Firm B is willing to pay a higher acquisition payment because of a high synergy when α_B is high. With a higher p_B , Firm T will accept the expansion offer at a lower threshold R_{τ^B} . Therefore, the curve in omicron in Figure 4.16 shows a opposite relationship between the synergy parameter under control of Firm B and the threshold for Firm B to accept the expansion offer, which is R_{τ^B} given by (4.8). According to Proposition 7, the exchange rate $p_B R_{\tau^B}$ is independent with the synergy parameter α_B . In Figure 4.16, both the curve in asterisk and the curve in triangle decrease with the synergy parameter α_B , equivalently means Firm B is more willing to acquire Firm T than to sell their asset to Firm T.

[Insert Figures 4.14 and 4.15 here]

In Figure 4.15, synergy parameter α_T will decrease the acquisition payment portion p_T asked by Firm B, which will be paid by Firm T. In Figure 4.17, the threshold for Firm T to accept the contraction offer which is represented as the curve in square decrease with synergy parameter α_T . Therefore, the exchange rate p_T / R_{τ^T} linearly increases with α_T , which also following Proposition 9. In both Figures 4.16 and 4.17, while correlation coefficient ρ increases, the execution speed of expansion strategy becomes faster than the execution speed of contraction.

[Insert Figures 4.16 and 4.17 here]

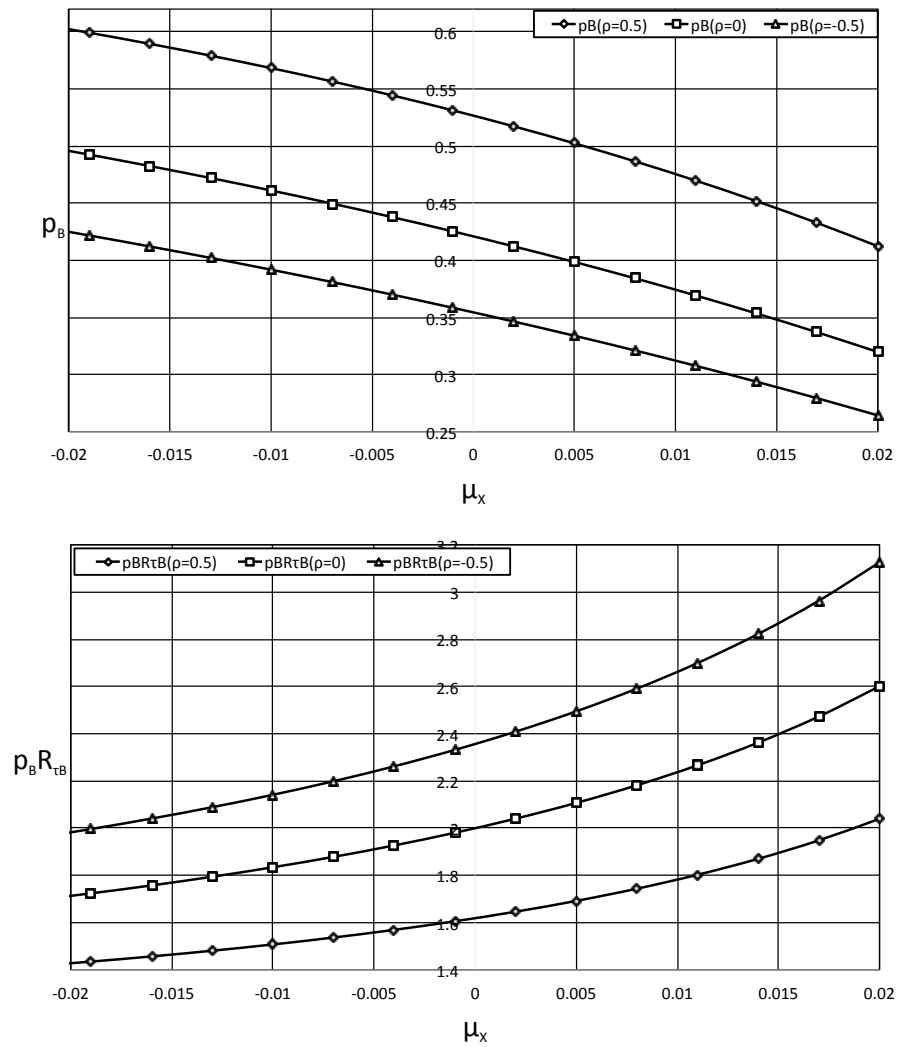


FIGURE 4.2: Impact of the growth rate of Firm B on the payment of the expansion offer.

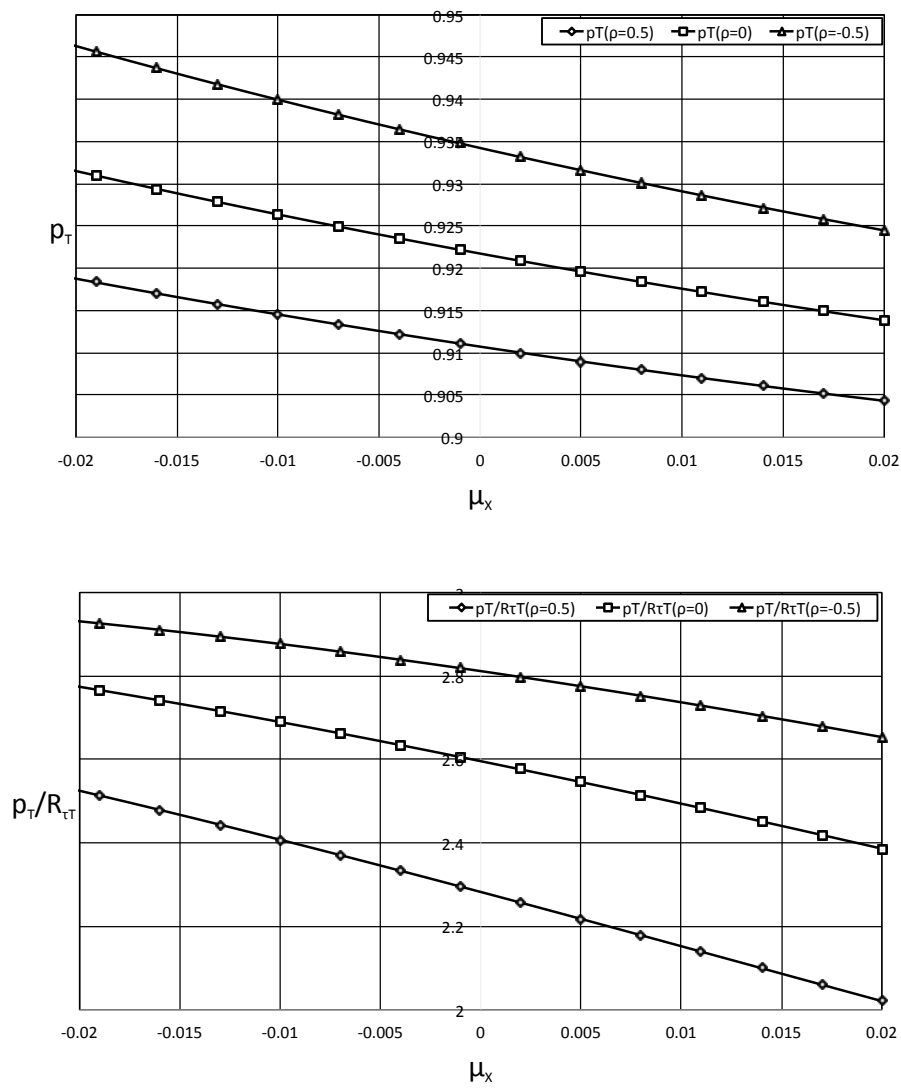


FIGURE 4.3: Impact of the growth rate of Firm B on the payment of the contraction offer.

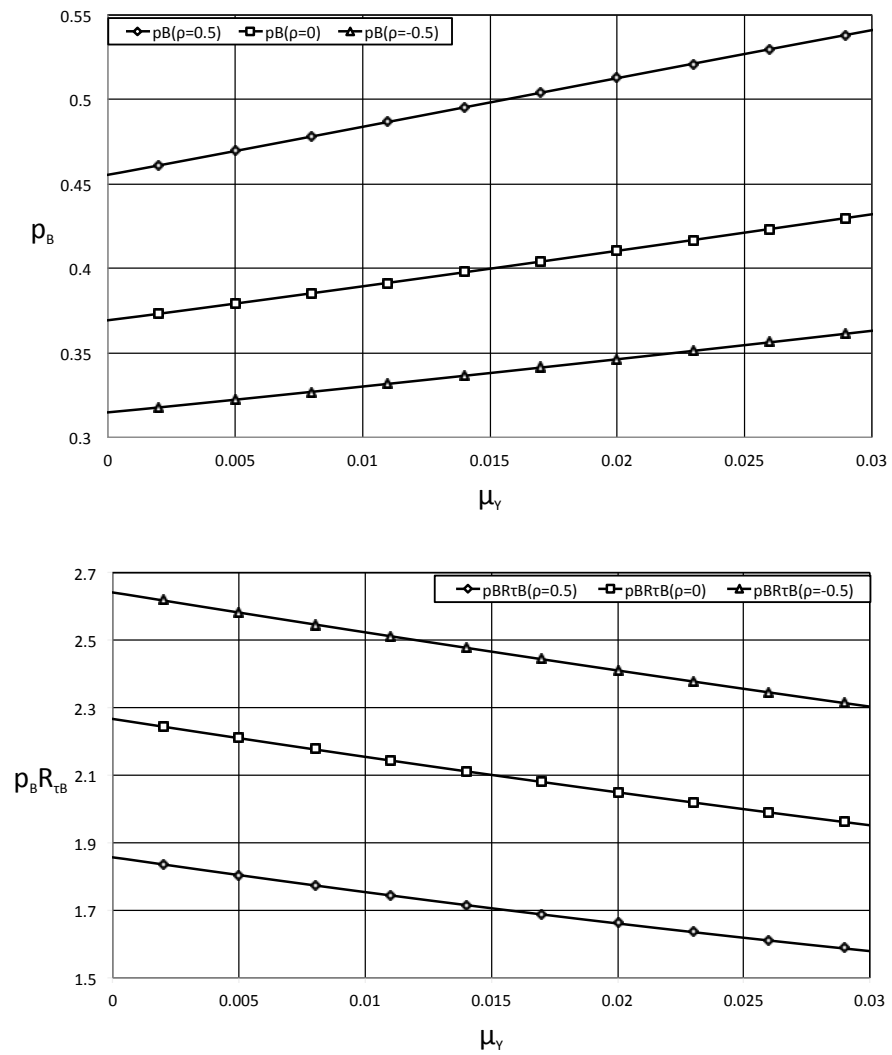


FIGURE 4.4: Impact of the growth rate of Firm T on the payment of the expansion offer.

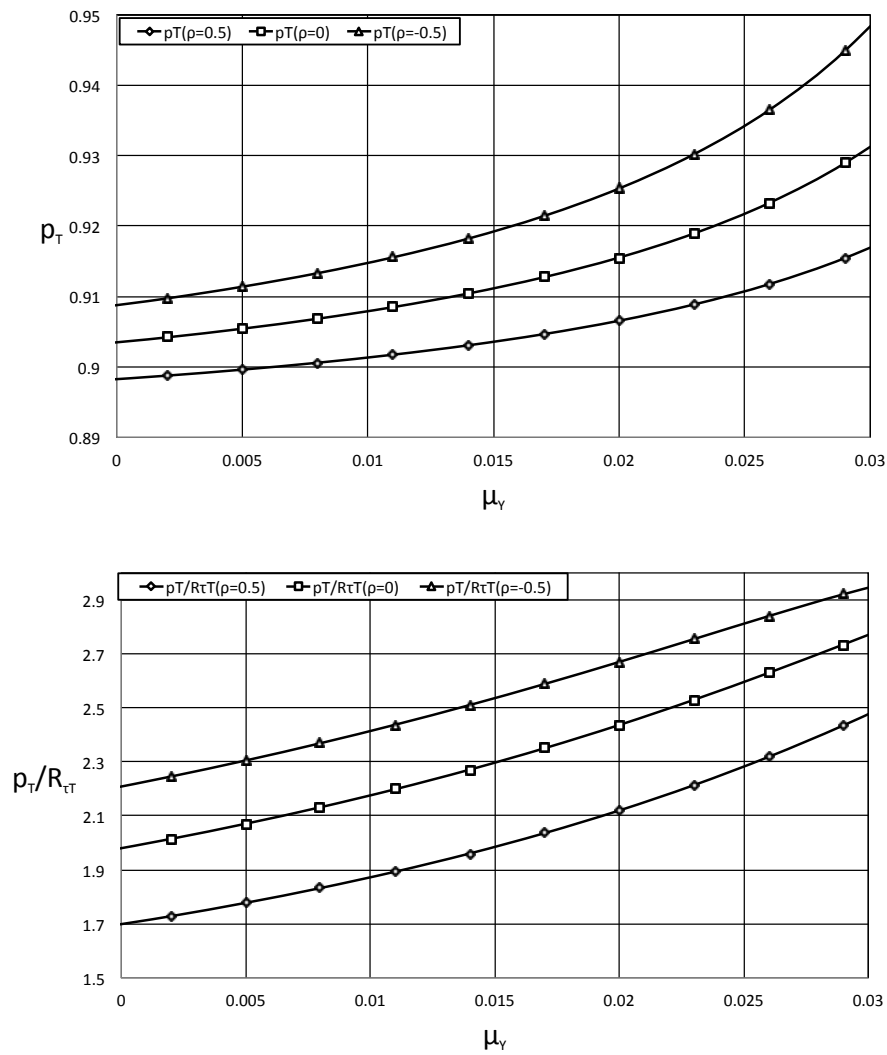


FIGURE 4.5: Impact of the growth rate of Firm T on the payment of the contraction offer.

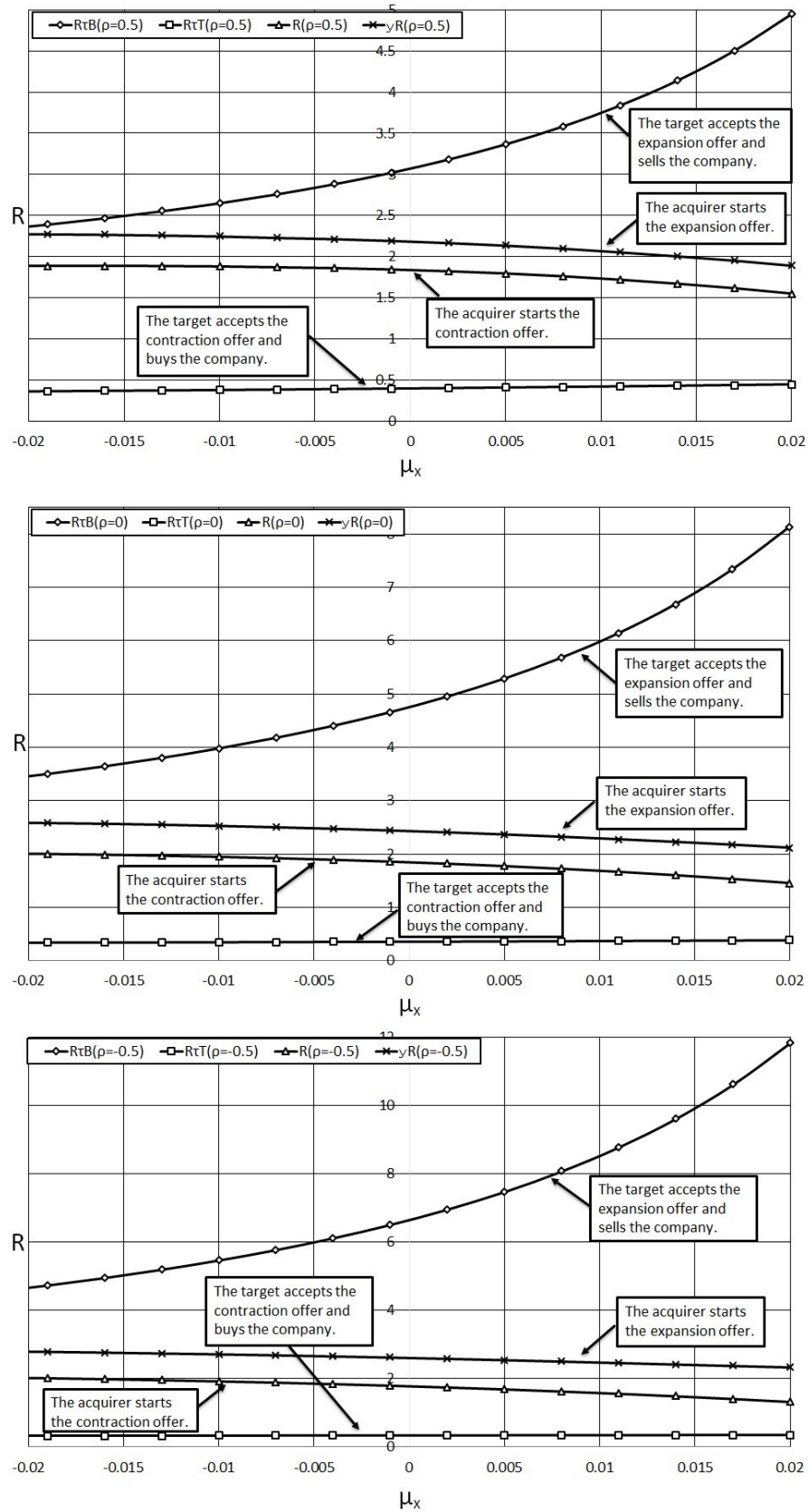


FIGURE 4.6: Impact of the growth rate of Firm B on the threshold.

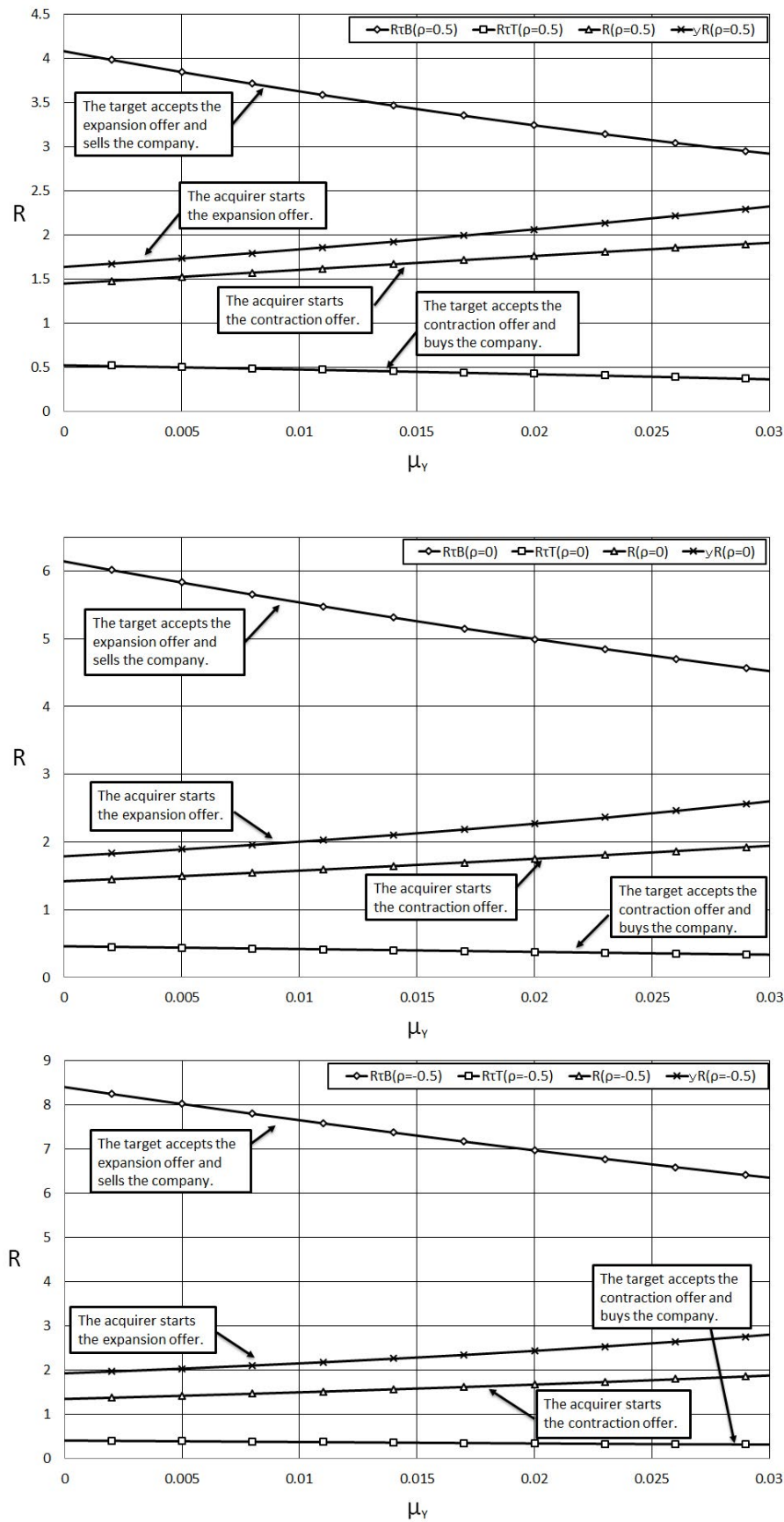


FIGURE 4.7: Impact of the growth rate of Firm T on the threshold.

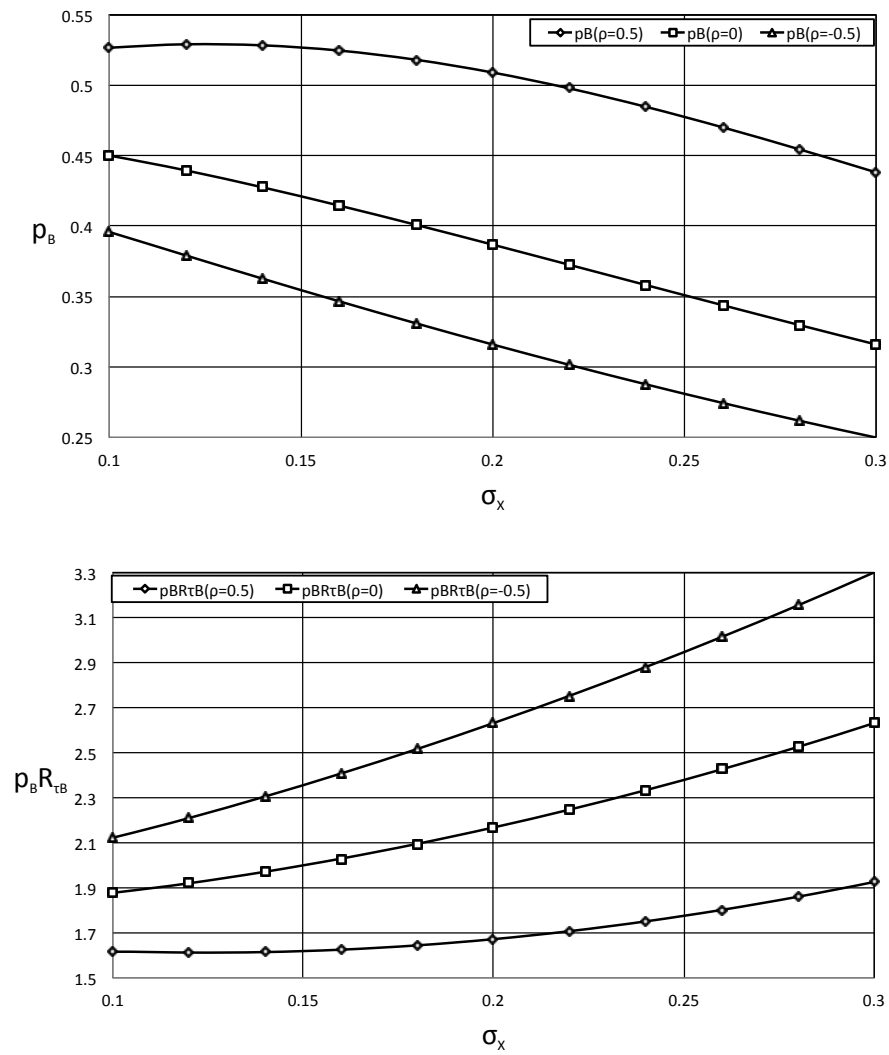


FIGURE 4.8: Impact of the volatility of Firm B on the payment of the expansion offer.

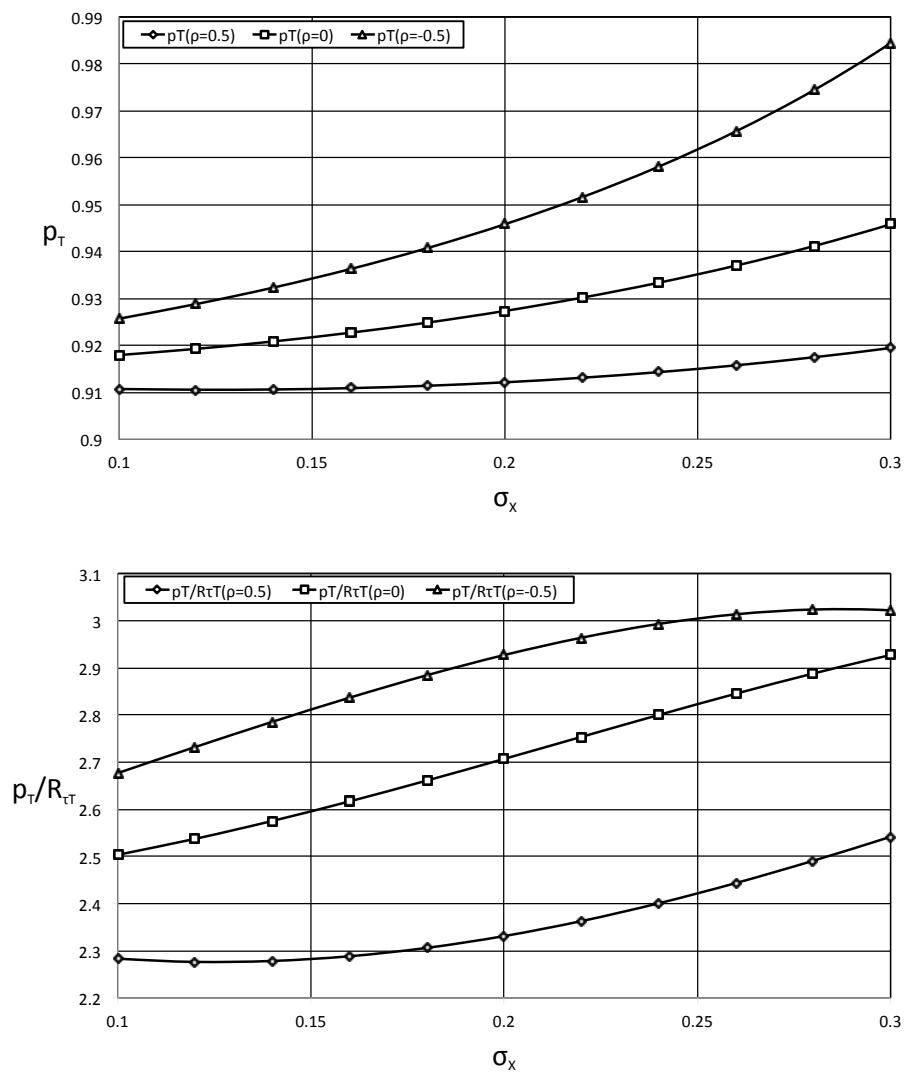


FIGURE 4.9: Impact of the volatility of Firm B on the payment of the contraction offer.

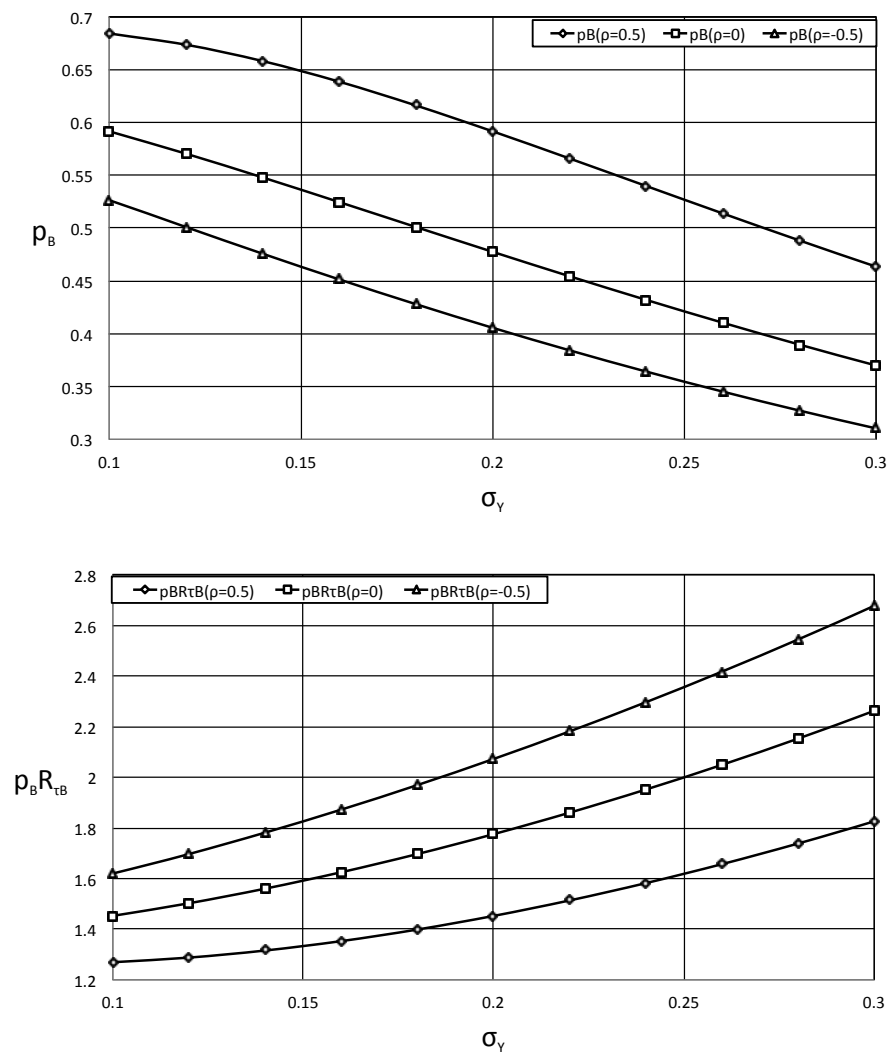


FIGURE 4.10: Impact of the volatility of Firm T on the payment of the expansion offer.

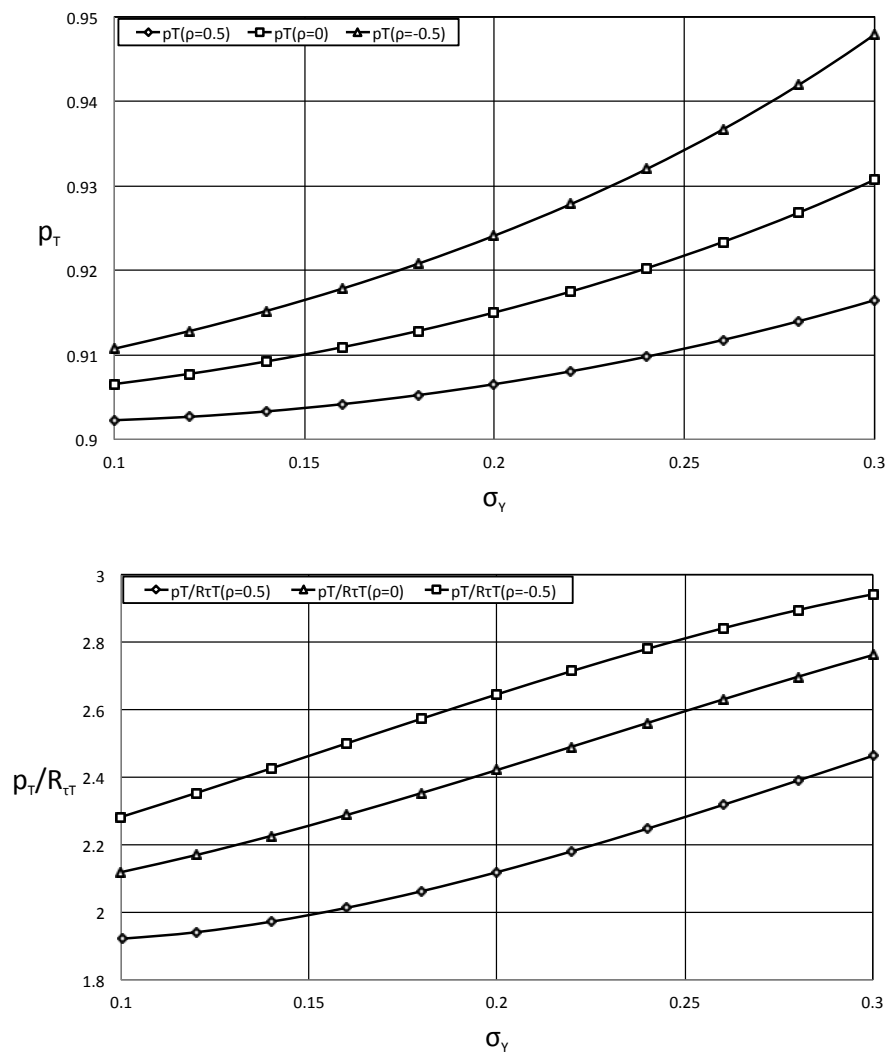


FIGURE 4.11: Impact of the volatility of Firm T on the payment of the contraction offer.

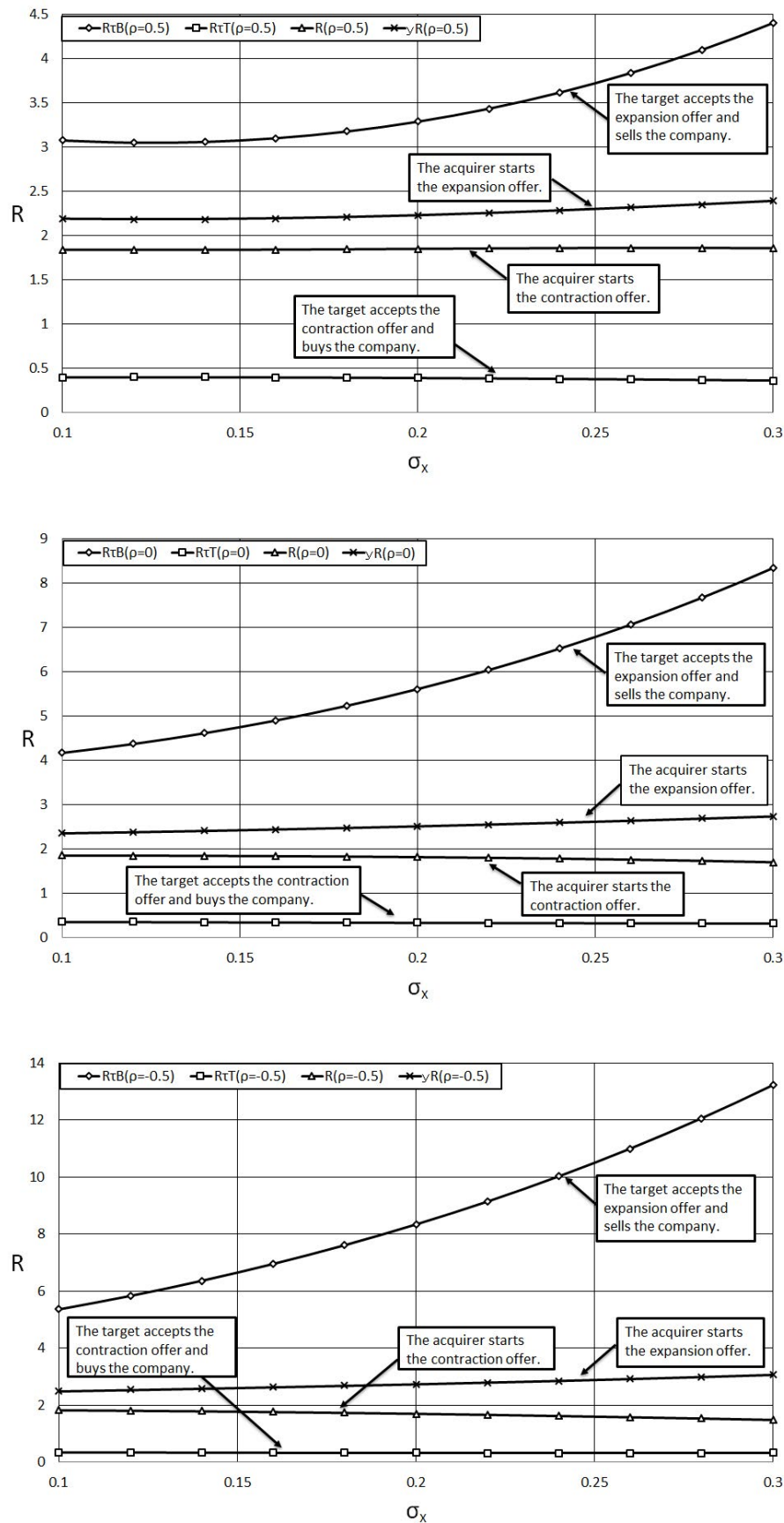


FIGURE 4.12: Impact of the volatility of Firm B on the threshold.

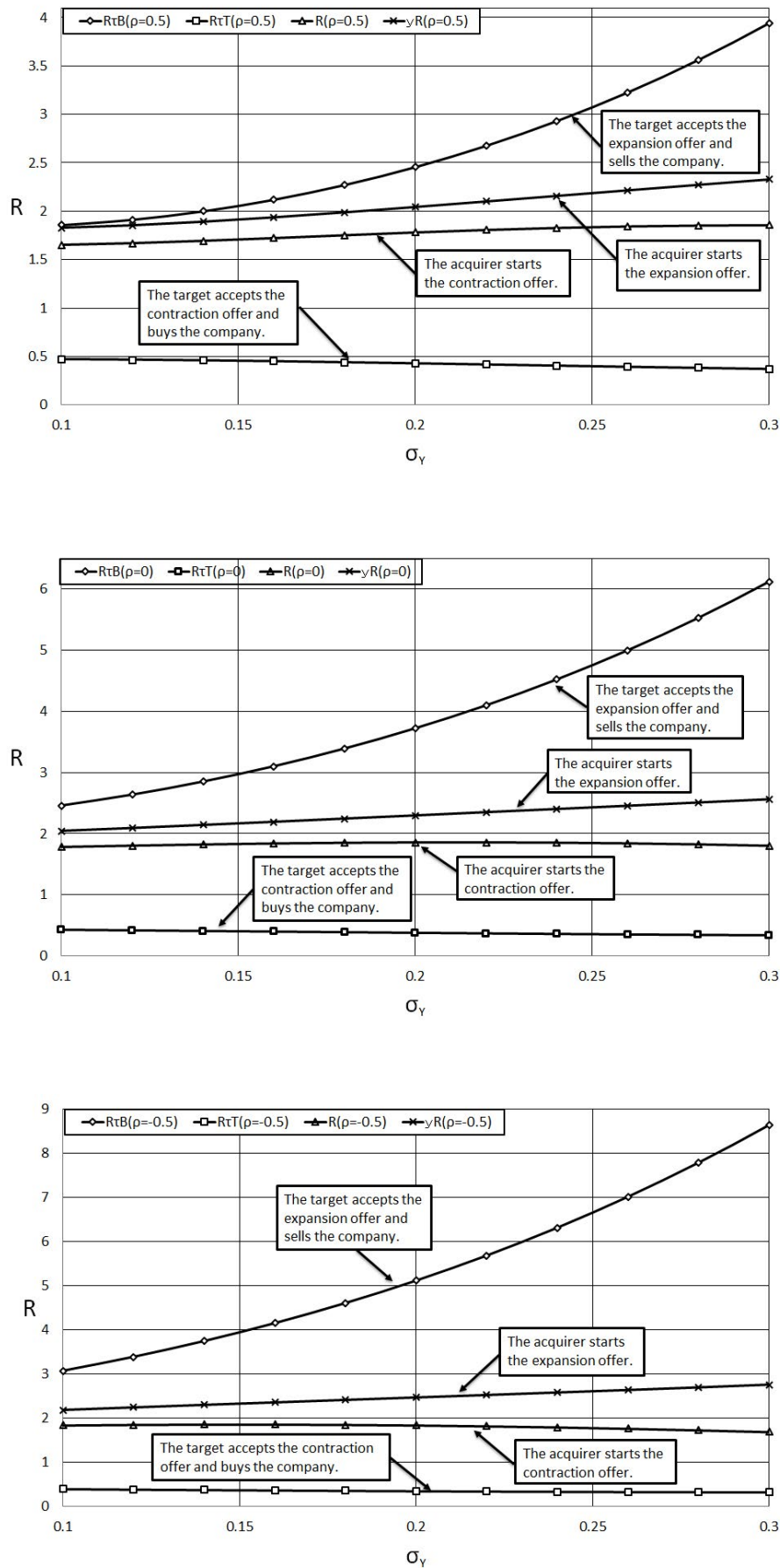


FIGURE 4.13: Impact of the volatility of Firm T on the threshold.

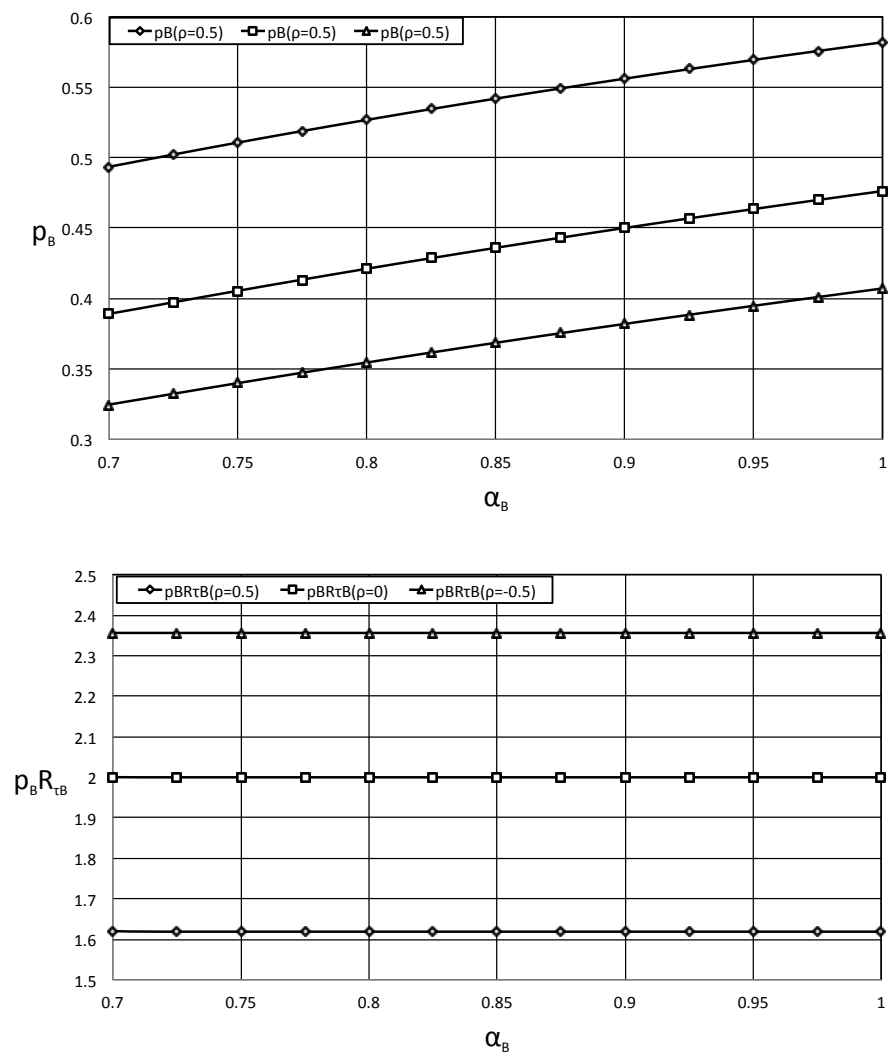


FIGURE 4.14: Synergy impact on the payment of the expansion offer.

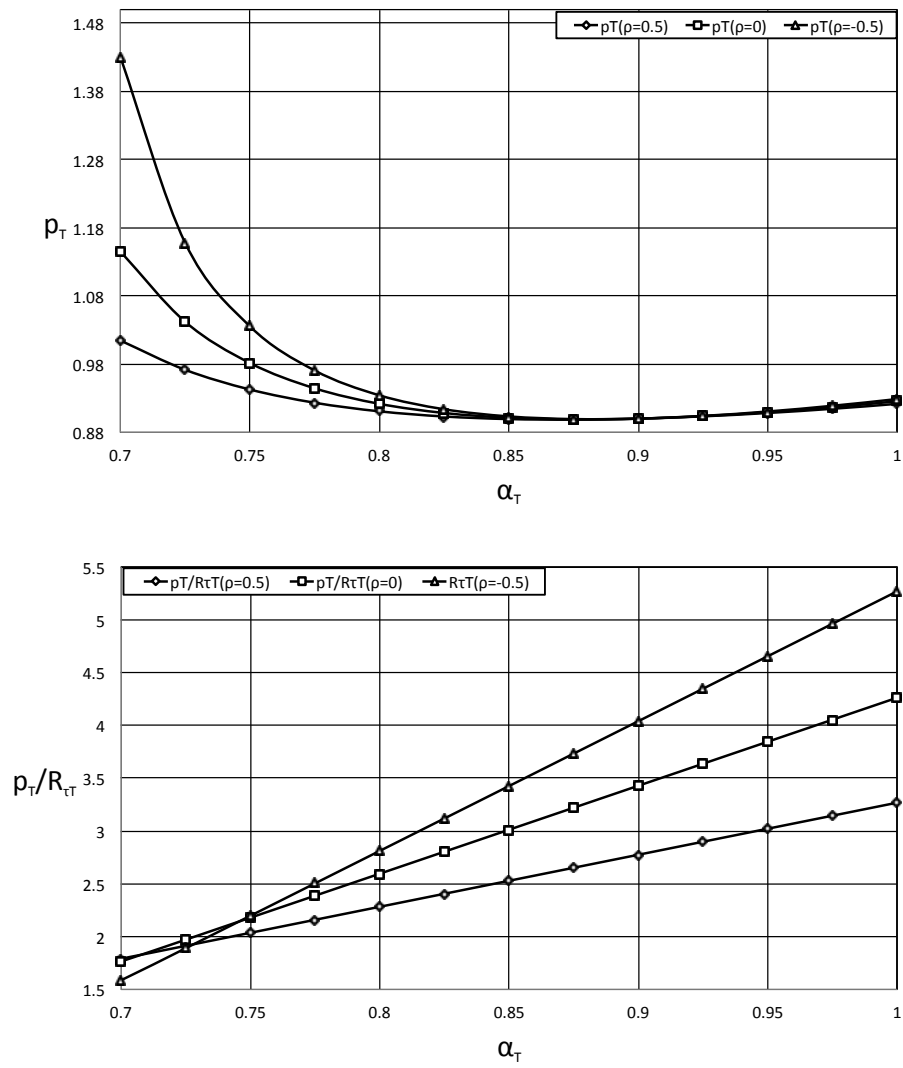


FIGURE 4.15: Synergy impact on the payment of the contraction offer.

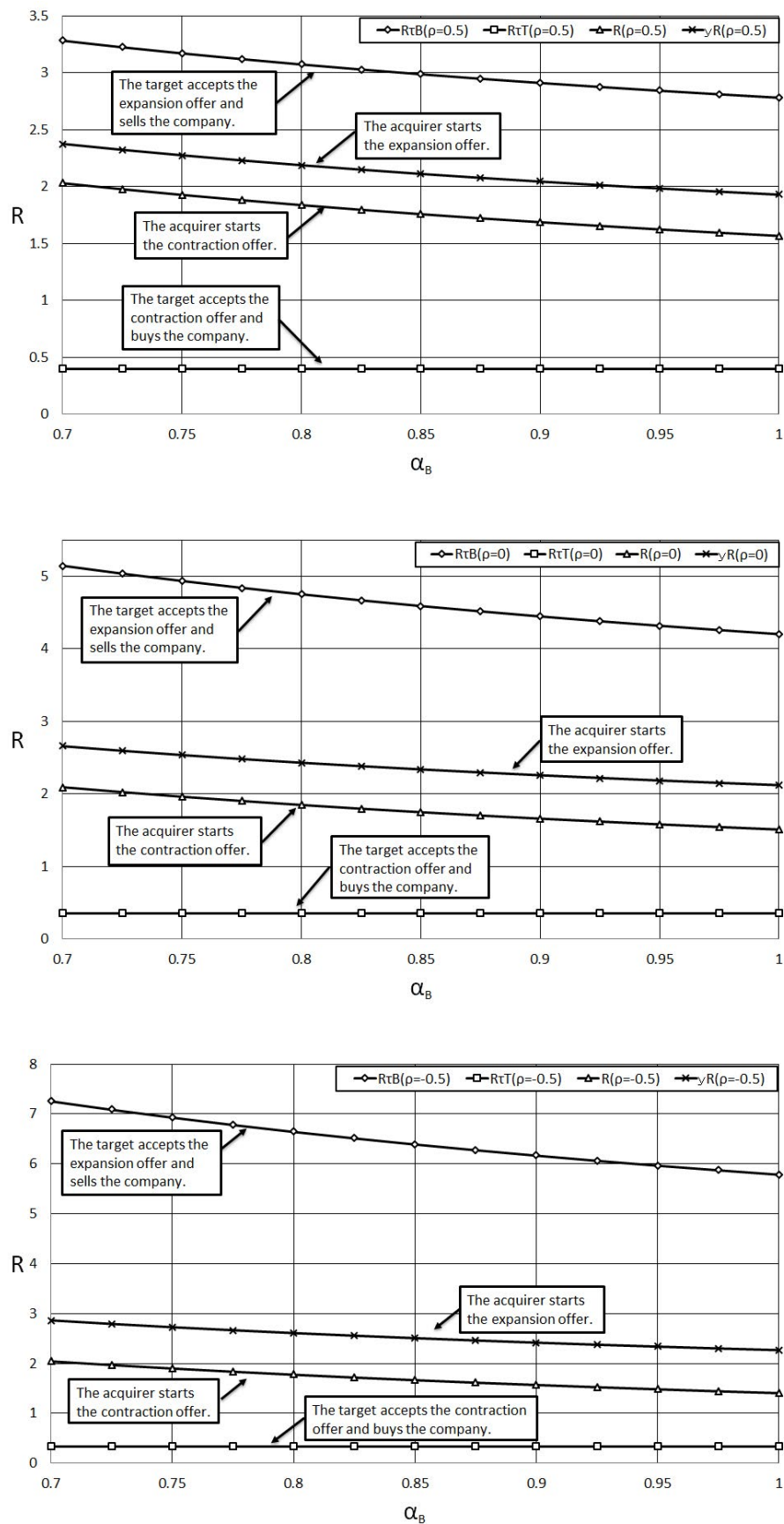


FIGURE 4.16: Impact of the synergy under control of Firm B on the threshold.

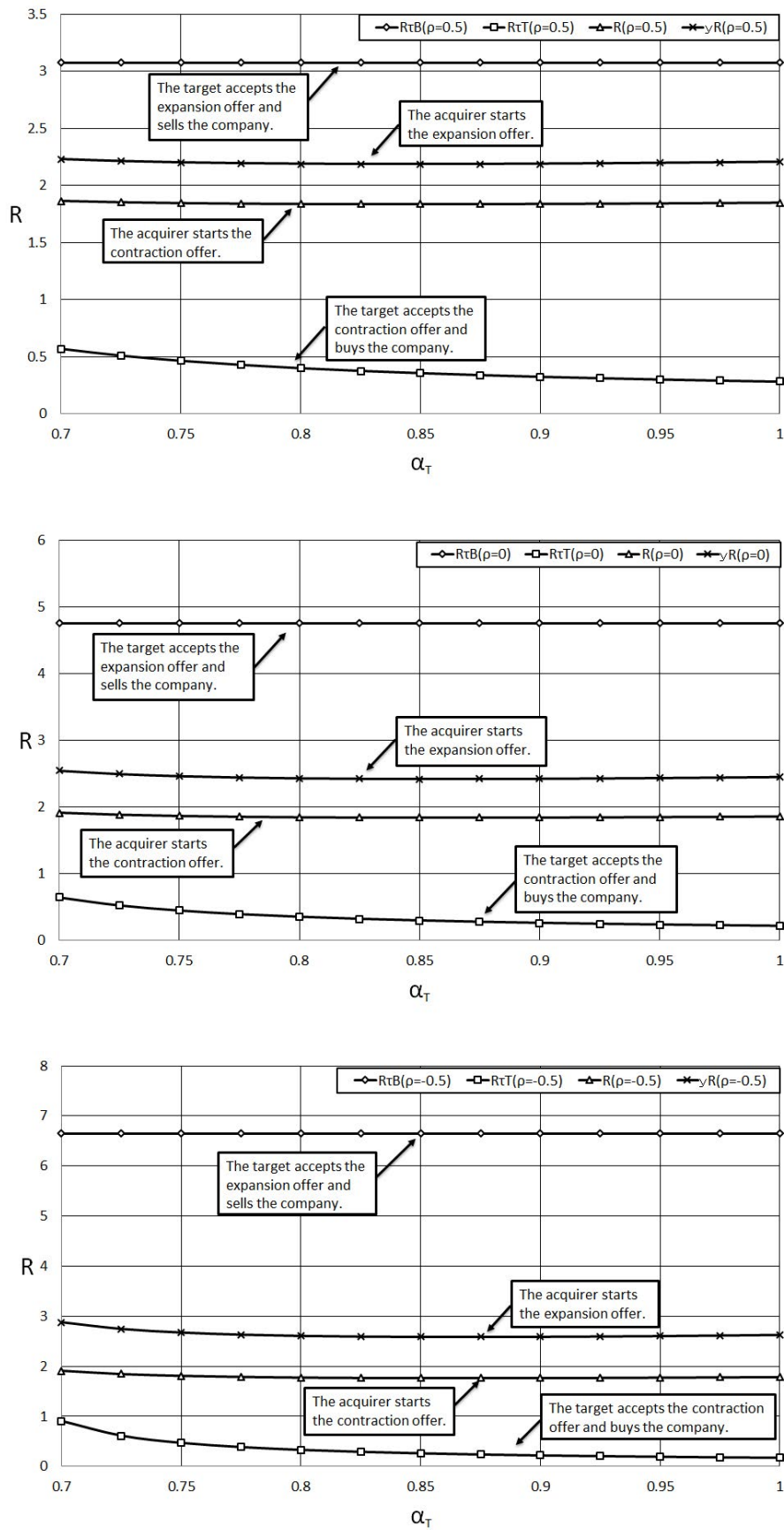


FIGURE 4.17: Impact of the synergy under control of Firm T on the threshold.

Chapter 5

A Debt-payment Model

5.1 Background

According to Brouthers, Hastenburg and Ven [12], there are three generally accepted categories of mergers motives, the economic motives such as economies of scale, risk spreading, diversification, the personal motives such as sales benchmark, material challenge, and finally the strategic motives such as acquisitions of the competitor or raw materials. In this model, we establish the model of mergers and acquisitions economically motivated by synergy gains.

Several well-known studies have analyzed the mergers and acquisitions model with the synergy gains. Andrade, Mitchell and Stafford [3] and Andrade and Stafford [4] provide the evidence that resource of mergers gains is generated from possible economies of scale, greater efficiency of resource using and market power. Lambrecht [39] studies the timing and terms of mergers motivated by economies of scale and shows that mergers activities are positively correlated with markets, meaning that firms are willing to merge during economic expansions. In the study, he assumes a Cobb-Douglas production function, which display increasing returns to scale. The increase therefore is called synergy in the model. Based on Lambrecht [39], Thijssen [77] builds a two-uncertainty model that optimizes the timing considering both efficiency gains and diversification benefits. The results show that mergers and acquisitions will happen during both economic upswings and downswings. While Zhu et al. [80] develop a model to analyze the timing of bank mergers and show that the mergers motivated by the incentive to obtain too-big-to-fail (TBTF) status from the government may occur even in the absence of scale economies, which is different from Lambrecht [39]. Hackbarth and Morellec [30], Morellec and Zhdanov [58] and Shleifer and Vishny [75] assume a linear combination of participating firms. In those models, the synergy assumptions show that the acquiring firm has a higher Tobin's q than the target, which also means the acquiring firm better performs than the target. The assumption follows Andrade and Stafford [4] and Maksimovic and Phillips [50].

Though M&As generate lots of benefits for the enterprise, they still are risky strategies with the risk ranging from the overpaying for the deals to the failure of combination of the company culture. Fang, Fridh and Schultzberg [23] study the fail mergers case of Telia-Telenor and find that historical sentiments, feelings and emotions can cause fatal damage business. Even the mergers and acquisitions success, the shareholders may fail to benefit. Meyer [57] divides the reasons for the leakage of the shareholder value in the post-mergers integration processes into two categories. One is that gains are reduced by internal stakeholders, and another is that the costs lead to reductions or reallocations of effort. A central question for the M&A analysis is the financing decisions to start an acquisitions. This dissertation therefore focuses on the model of financing with debt to acquire the target.

Several studies develop the model of financial structure in the irreversible investment. Graham [28] shows that large, liquid and profitable firms with low expected distress costs use debt conservatively. Most of the literatures are based on Leland [43], which examines debt value and establish an optimal capital structure. Broadie and Kaya [11] extend Leland [43] to the finite maturity case. Tserlukevich [78] develops a dynamic model of optimal financial structure with fixed costs and irreversibility of capital investment and shows that profitability is negatively correlated with leverage. Lambrecht and Myers [40] analyze the debt and equity financing in a real options model and develop a strategy to maximize the overall value of the firm including both the managers and outside shareholders. Agliardi and Kousis [1] develop an investment options model in finite horizon for the analysis of the optimal capital structure.

This dissertation determines the optimal timing and price for the mergers and acquisitions under both equity and debt finance. Our synergy assumption is based on Hackbarth and Morellec [30]. The execution process is close to Lukas and Welling [47] and Lukas, Reuer and Welling [46], who develop two-stage models analyzing the price and timing of mergers and acquisitions. The main contributions of this study are as following. First, this thesis develops models of joint takeovers to determine the timing, acquisitions payment using different finance methods. The model considers an equity finance takeover, which assumes that the bidder use parts of their capital to buy the target, and then extend to a debt finance takeover, which assumes that the bidder issues a revenue bond secured only by the revenues generated from the target and also pays a cash payment using parts of their capital. Second, we compare the equity finance model with the debt finance model and reveal the impact of the debt payment on the strategy decisions.

The Chapter is organized as follows. In Section 5.2, we introduce the model's framework. Section 5.3 is divided into two subsection to separately analyze the model of the equity financed mergers and the model including the debt finance. In Section 5.4, we give several numerical examples.

5.2 The Model Set-up

We construct the framework based on Morellec and Zhdanov [58]. Consider two firms: an bidder and a target, which operate in the same market. We assume capital stocks of K_B for the bidder and K_T for the target. The stock market valuation of each firm, denoted by $S_B(X_t)$ and $S_T(Y_t)$, respectively, before takeover is

$$S_B(X_t) = K_B X_t, \quad S_T(Y_t) = K_T Y_t, \quad (5.1)$$

where X_t and Y_t denote the per unit value of capital, which follows a geometric Brownian motion, given by

$$\begin{aligned} dX_t &= \mu_X X_t dt + \sigma_X X_t dW_X, \\ dY_t &= \mu_Y Y_t dt + \sigma_Y Y_t dW_Y, \end{aligned} \quad (5.2)$$

where the expected growth rates $\mu_X, \mu_Y > 0$, and volatilities $\sigma_X, \sigma_Y > 0$ are constant parameters. W_X and W_Y are standard Brownian motions. The correlation coefficient between W_X and W_Y is constant, represented as $\rho \in (-1, 1)$. We assume that all participants are risk neutral, and the risk-free interest rate is $r (\geq \mu_i, i = X, Y)$.

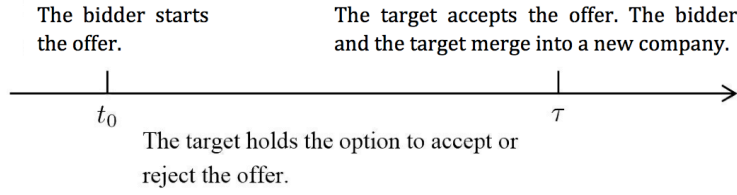


FIGURE 5.1: The acquisitions process

As shown in Figure 5.1, we suppose the acquisitions process proceeds in two steps. At time t_0 , the bidder makes an offer to acquire the target. The target need not decide immediately upon receiving the offer, that is, it can postpone the decision. Hence, the target holds the option to accept or reject the offer from time t_0 onwards. The horizon of the option which the target holds is infinite. The bidder is not looking for an immediate mergers, which is generally associated with a higher cost. (see Offenbergh and Pirinsky [63] for the supporting evidence.) Suppose the target accepts the offer at time τ . Accepting the offer leads to an immediate mergers of the two firms at time τ .

Following Hackbarth and Morellec [30] and Shleifer and Vishny [75], we assume a linear combination of pre-takeover values in terms of per unit value of capital. The post-mergers value of the firm is

$$S_M(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G(X_t, Y_t), \quad (5.3)$$

where $G(X_t, Y_t)$ is net synergy gains generated from the mergers, given by

$$G(X_t, Y_t) = K_T(\alpha(X_t - Y_t) - cY_t), \quad (\alpha, c) \in \mathbb{R}_{++}^2, \quad (5.4)$$

where α is the synergy parameter, which all participants can observe. c denotes the per unit mergers cost of the capital value of the target. The post-mergers per unit value of capital which the target has before mergers changes to $\alpha X_t + (1 - \alpha)Y_t$. Therefore, the post-mergers value of the target's capital increases to $S_T(Y_t) + K_T\alpha(X_t - Y_t)$. Considering the cost paid at the time of the mergers, the synergy generated thus is given by (5.4). This assumption indicates that the synergy will be positive only when the bidder outperforms the target, which has the same meaning as $X_t > Y_t$. This is equivalent to saying that the bidder generally has a higher Tobin's q than the target. Rauh and Vermaelen [69] provide the supporting evidence. The target's resources are more efficiently allocated after the mergers.

5.3 The Optimal Strategy

5.3.1 Equity Finance

In this section, we develop an equity finance model and will compare it with a debt finance model in the numerical examples section. For an equity finance model, the bidder is assumed to pay an amount of cash to the target based on the target's market value and buys the whole firm. There is no share exchange in the process. The bidder is the only shareholder of the merged firm. Suppose the bidder will use parts of their firm's capital value, which is denoted as portion p_c , to pay the cash payment.

Receiving the offer at t_0 , the target decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OMC(X_t, Y_t) = \max_{\tau_c} \mathbb{E} \left\{ e^{-r\tau_c} \left[p_c S_B(X_{\tau_c}) - S_T(Y_{\tau_c}) \right] \right\}. \quad (5.5)$$

At the time τ_c , the target receives the offer. They will receive a cash payment, worth $pS_B(X_{\tau_c})$ and give up their claim, worth $S_T(Y_{\tau_c})$. Maximizing the function (5.5) yields Proposition 11.

Proposition 11 (The optimal threshold under equity financing) *Based on the value-maximizing strategy, the target will accept the offer and merge with the bidder when the ratio of per unit capital price, denoted by $R_t = X_t/Y_t$, reaches the level*

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B} \frac{1}{p_c}. \quad (5.6)$$

Value of the option that the target holds is given by,

$$OMC(X_t, Y_t) = \begin{cases} Y_t \left[p_c K_B R_t - K_T \right], & R_c \leq R_t, \\ Y_t \left[p_c K_B R_c - K_T \right] \left(\frac{R_t}{R_c} \right)^{\vartheta_1}, & R_t < R_c, \end{cases} \quad (5.7)$$

and the first passing time is

$$\tau_c = \inf \{ t > 0 : R_t \geq R_c \}. \quad (5.8)$$

$\vartheta_1 > 1$ is the positive root of the quadratic equation 2.9. (Appendix D.1 contains the proof.)

As soon as the target accepts the offer, the two participating firms will merge. The bidder gives up the claim, worth $S_B(X_{\tau_c})$, and pays a cash amount of $p_c S_B(X_{\tau_c})$ to the target at time τ_c . In return, the bidder receives ownership of the merged firm, worth $S_M(X_{\tau_c}, Y_{\tau_c})$. The optimization function for the bidder thereafter is given by

$$OTC^c(X_t, Y_t) = \max_{p_c} \mathbb{E} \left\{ e^{-r\tau_c} \left[S_M(X_{\tau_c}, Y_{\tau_c}) - p_c S_B(X_{\tau_c}) - S_B(X_{\tau_c}) \right] \right\}. \quad (5.9)$$

Proposition 12 (Optimal cash payment under equity financing) *Maximizing the payoff function (5.9) yields the optimal offered portion p for the bidder, given as*

$$p_c = \frac{\alpha(\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (5.10)$$

Substituting result (5.10) into (5.6) yields

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1}{\alpha} \left(\alpha + c - 1 + \frac{\vartheta_1}{\vartheta_1 - 1} \right). \quad (5.11)$$

Appendix D.2 contains the proof.

According to threshold (5.6), the higher p_c is, the lower the threshold will be. The merging process will be accelerated if the bidder uses a high portion p_c of their firm

value to pay the target. If the bidder chooses an optimal portion p_c , which is given by (5.10), the target will accept the offer when the ratio of per unit capital value R_t reaches (5.11). According to (5.10), p_c positively relates to ϑ_1 as $\partial p_c / \partial \vartheta_1 > 0$, and negatively relates to the firm-size ratio, which is represented as K_B / K_T . A higher synergy parameter α will increase the payment portion p_c and then decrease the threshold R_c . While a higher cost c will decrease the payment and increase the threshold.

5.3.2 Debt Finance

Now we extend the model to the debt financing situation. In this case, the bidder issues a revenue bond secured only by the revenues generated from the target. That is, we can assume that the value of the debt is the portion q of the market value of the target, $qS_T(Y_t)$. The bidder pays the debt value to the target in addition to the cash amount $pS_B(X_t)$. Similar as the equity finance model, receiving the offer at t_0 , the target decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OMD(X_t, Y_t) = \max_{\tau_e} \mathbb{E} \left[\mathbb{E}^{-r\tau_e} (pS_B(X_{\tau_e}) + qS_T(Y_{\tau_e}) - S_T(Y_{\tau_e})) \right]. \quad (5.12)$$

At time τ_e , the target accepts the offer. They will receive a cash payment, worth $pS_B(X_{\tau_e})$ and also a debt worth $qS_T(Y_{\tau_e})$. They need to give up their claim, worth $S_T(Y_{\tau_e})$. Maximizing (5.12) yields Proposition 13.

Proposition 13 (The optimal threshold under debt financing) *Based on the value maximizing strategy, the target will accept the offer when the ratio of per unit capital price $R_t = X_t / Y_t$ reaches the level of*

$$R_e = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{p} \frac{K_T}{K_B}. \quad (5.13)$$

The option value of the target is given by

$$OMD(X_t, Y_t) = \begin{cases} Y_t (pK_B R_e - (1 - q)K_T) \left(\frac{R_t}{R_e} \right)^{\vartheta_1}, & R_t < R_e, \\ Y_t (pK_B R_t - (1 - q)K_T), & R_t \geq R_e, \end{cases} \quad (5.14)$$

and the first passage time is

$$\tau_e = \inf \{ t > 0 : R_t \geq R_e \}. \quad (5.15)$$

If $q = 0$, this Proposition coincides with Proposition 11.

As soon as the target accepts the offer, both firms will merge. At time τ_e , the bidder receives ownership of the merged firm $S_M^*(X_{\tau_e}, Y_{\tau_e})$, pays a cash amount of $pS_B(X_{\tau_e})$, and gives up the claim $S_B(X_{\tau_e})$. Note that the value of the debt should be subtracted from the value of ownership of the merged firm. And then, if the value of

net ownership falls down to zero, the merged firm will default. Therefore, we have

$$S_M^*(X_t, Y_t) = S_B(X_t) + (1 - q)S_T(Y_t) + G(X_t, Y_t) + \max_{\tau_d} \mathbb{E} [\mathbb{E}^{-r\tau_d} (-S_B(X_{\tau_d}) - (1 - q)S_T(Y_{\tau_d}) - G(X_{\tau_d}, Y_{\tau_d}))]. \quad (5.16)$$

The optimization function for the bidder thereafter given by

$$OTD(X_t, Y_t) = \max_p \mathbb{E} [\mathbb{E}^{-r\tau_e} (S_M^*(X_{\tau_e}, Y_{\tau_e}) - pS_B(X_{\tau_e}) - S_B(X_{\tau_e}))]. \quad (5.17)$$

Proposition 14 (The optimal default and cash payment under debt financing) *The merged firm will default when the ratio of per unit capital price $R_t = X_t/Y_t$ reaches the level of*

$$R_d = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha + c + q - 1)K_T}{K_B + \alpha K_T}, \quad (5.18)$$

where $\alpha + c + q > 1$. The option value of the merged firm is given by

$$S_M^*(X_t, Y_t) = \begin{cases} 0, & R_t \leq R_d, \\ Y_t ((K_B + \alpha K_T)R_t - (\alpha + c + q - 1)K_T) - Y_t A_d \left(\frac{R_t}{R_d} \right)^{\vartheta_2}, & R_t > R_d, \end{cases} \quad (5.19)$$

where

$$A_d = (K_B + \alpha K_T)R_d - (\alpha + c + q - 1)K_T \quad (5.20)$$

and the first passage time is

$$\tau_d = \inf\{t > 0 : R_t \leq R_d\}. \quad (5.21)$$

Then, maximizing value function yields the optimal offered portion p_d for the bidder, given as a positive root of

$$\frac{\vartheta_1 - \vartheta_2}{\vartheta_2 - 1} (\alpha + c + q - 1) \left(\frac{R_e}{R_d} \right)^{\vartheta_2} - \alpha(\vartheta_1 - 1)R_e + \vartheta_1 \left(\alpha + c + \frac{1 - q}{\vartheta_1 - 1} \right) = 0, \quad (5.22)$$

where

$$p_d = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{R_e} \frac{K_T}{K_B}. \quad (5.23)$$

According to the Proposition 13, when the debt payment portion q increases, the default threshold R_d increase. Because $\partial R_d / \partial \vartheta_2 < 0$, the default threshold negatively relates to ϑ_2 . Therefore the default threshold R_d negatively relates to the expected growth rate of the bidder and positively relates the expected growth rate of the target. Also, the relationship between the correlation coefficient ρ and the default threshold R_d is positive. In the next section, we further examine the threshold given by (5.22).

5.4 Numerical Studies

In this section, we provide several numerical results. The decision-making of mergers and acquisitions activities largely depends on the expected growth rate and volatility of the participating firm's core business valuations, and also on the firm-size, debt level, synergy generated. Accordingly, we first illustrate the impact of the

TABLE 5.1: Basic parameter values.

Parameter		Value
Expected growth rate of the bidder	μ_X	0.035
Expected growth rate of the target	μ_Y	0.02
Volatility of the bidder	σ_X	0.2
Volatility of the target	σ_Y	0.3
Correlation coefficient	ρ	0.5
Discount rate	r	0.06
Firm size of the bidder	K_B	1
Firm size of the target	K_T	1
Synergy parameter	α	0.6
Per unit mergers cost	c	0.1
Coupon rate of the revenue bond	q	0.3

business growth rates and volatilities on the decision-making. Second, we examine the impact of the firm-size. Third, we study the relationship between debt payment and the threshold. And then, we examine the synergy impact. Finally, we study the relationships between the parameters and the default threshold.

Table 5.1 summarises the basic parameter values. We assume the expected growth rates of the bidder and target are 0.035 and 0.02 respectively. It follows that the bidder generally outperforms the target. The volatility of the bidder and target are set to 20% and 30% which means the target has higher risk than the bidder. We focus on mergers of equal-size by assuming that $K_B = K_T = 1$ and study the impact of the debt level.

5.4.1 The Impact of Core Business Parameters

The mergers' timing and acquisitions payment depend on the expected growth rate and volatility of the firms' core business valuations. We release the basic parameter values, which we want to test, and fix the others, as in Table 5.1.

Figure 5.2 represents the relationship between the expected growth rate of the bidder and the threshold which is determined by the target and the payment which is acquiring firm's strategy. In the equity finance model, the bidder offers an optimal payment portion p_c which is given by Proposition 12. The target accepts the offer at time τ_c and the ratio of the per unit capital price $R_c = X_{\tau_c}/Y_{\tau_c}$ is given by Proposition 11. In the debt finance model, the optimal payment portion p_d is given by Proposition 13 and the threshold R_e is given by Proposition 14. Therefore, the vertical axis of the third sub-figure in Figure 5.2, $p_c R_c = p_c X_{\tau_c}/Y_{\tau_c}$, holds the meaning that the bidder should pay $p_c X_{\tau_c}$ for one unit the target's capital, which is Y_{τ_c} , at time τ_c . We call $p_c R_c$ the exchange rate in the equity finance model. Similarly, the exchange rate in the debt finance model is $p_d R_e$.

[Insert Figures 5.2 and 5.3 here]

According to Proposition 12, $\partial p_c / \partial \vartheta_1 > 0$ and parameter ϑ_1 , which is given by (2.9), holds a negative relationship with μ_X . Hence, the optimal payment portion p_c negatively relates to the expected growth rate μ_X . Accordingly, in Figure 5.2, the bidder will offer a lower payment portion p_c to target firm when the bidder's growth rate is higher. For the target, they has two motivations to accept the offer,

one is the increase of the per unit capital price of the bidder X_t , and another is the decrease of the per unit price of their own capital Y_t . When the optimal payment portion p_c is lower, target firm aspires to a much higher X_t or a much smaller Y_t to accept the offer. As a result, a negative relationship between p_c and growth rate μ_X leads to a positive relationship between the threshold R_c and growth rate μ_X which is represented in the first sub-figure of Figure 5.2. The bidder will consequently pay more for each unit of target firm's capital, and the exchange rate $p_c R_c$ positively relates to the expected growth rate μ_X shown in the Figure 5.2.

The debt finance payment and threshold show the same relationship with the expected growth rate μ_X as the equity finance model in Figure 5.2. Figure 5.3 shows reverse relationships between the strategies and the expected growth rate μ_Y . Therefore, an bidder's higher growth rate will decelerate the mergers process, and a target's higher growth rate will accelerate it. In both Figures 5.2 and 5.3, no matter what level the correlation coefficient ρ is, the threshold in the debt finance model R_e is always lower than which in the equity finance model R_c . Equivalently, the process of the debt finance model is faster than which of the equity finance model. The difference between the optimal payment portions of two models decrease with μ_X , while increases with μ_Y . The difference between the thresholds of two models increase with μ_X , while decreases with μ_Y . The higher the correlation coefficient ρ is, the larger the difference of two optimal payment portions is and the smaller the difference of two execution speed will be.

[Insert Figures 5.4 and 5.5 here]

As in Figure 5.4, when the volatility of the bidder is high, they will offer a low payment portion p_c which follows Proposition 12. Hence, it represents a reverse relationship between the threshold R_c and σ_X . The parameter θ_1 has a positive relationship with volatility σ_X when $\sigma_X < \rho\sigma_Y$, and vice versa. Thus, the acquisitions payment will increase with volatility σ_X and then decrease if $\rho > 0$. If $\rho \leq 0$, σ_X will always negative relates to θ_1 and then also negative with p_c . The same relationship between p_c and σ_Y in Figure 5.5. In both Figures 5.4 and 5.5, the increase of the threshold R_c causes the bidder pay more to the target for each unit of their capital, which is the exchange rate $p_c R_c$. According to Proposition 14, the threshold of a debt finance model, R_e , and the optimal payment portion p_d represent the same relationships with the volatilities σ_X and σ_Y as the equity finance model, which are as also shown in Figures 5.4 and 5.5. In both Figures 5.4 and 5.5, the process of the debt finance model is also faster than which of the equity finance model. The difference between the optimal payment portions of two models decrease with σ_X and σ_Y . The difference between the thresholds of two models increase with σ_X and σ_Y . When the volatilities of the participating firm are high, the debt finance will significantly accelerate the execution process. The correlation coefficient ρ positively relates to the difference of two optimal payment portions and negative relates to the difference of two execution speeds.

5.4.2 Relationship Between Firm-size And Decision-making

In Figure 5.6, the ratio of the size of the two participating firms always decreases the optimal acquisitions payment portion. Assuming a constant K_B , K_T decreases when the ratio K_B/K_T increases. Therefore, a comparatively smaller target will generate a small synergy, according to the assumption in (5.4). The bidder will thereafter offer a lower acquisitions portion p_c and p_d . While, the firm size has no impact on the

threshold which is determined by the target and they will finally receive more for each unit of their capital. As (5.6) in Proposition 11, the threshold R_c positive relates to K_B/K_T . Two motivations for target firm to accept the offer provided by the bidder: an decrease in K_B/K_T , assuming a constant K_B , which will increase the cash payment $K_T Y_{t_c}$; and increase in the payment portion which positively relates to the firm size K_T and negatively relates to the ratio K_B/K_T . As the result, the decision-making for the target has no change with the firm size which follow the (5.11) in Proposition 12. The firm size has greater impact on the difference of two optimal payment portions p_c and p_d when the target K_T is large or the ratio K_B/K_T is small.

[Insert Figure 5.6 here]

5.4.3 Debt And Synergy Impact

Figure 5.7 represents the relationship between the debt payment $qS_T(Y_t)$ and the decision making. When the debt payment portion q increases, the cash payment portion p_d or p_c decreases. The threshold for the target to accept offer decreases with the debt payment portion q . Therefore, the leverage ratio will accelerate the execution process. The impact of the debt payment on the execution speed is much more significant when the correlation coefficient ρ is lower. While the impact of the debt payment on the cash payment is greater when the correlation coefficient ρ is higher.

[Insert Figure 5.7 here]

In Figure 5.8, synergy parameter α will also increase the optimal payment portions p_d and p_c offered by the bidder according to Propositions 12 and 14. According to the synergy assumption (5.4), the synergy generated due to mergers is positive related to the synergy parameter α . The bidder is willing to pay a higher payment because of a high synergy when α is high. With a higher p_d or p_c , the target will accept the offer at a lower threshold R_e or R_c . Therefore, the first sub-figure in Figure 5.8 shows a opposite relationship between the synergy parameter under control of the bidder and the threshold for the target to accept the offer. According to propositions 12 and 14, the exchange rate $p_c R_c$ and $p_d R_e$ are independent with the synergy parameter α . In Figure 5.8, the execution speed of the debt finance model is faster than which of the equity finance model. And the speed difference of two models decreases with the synergy.

[Insert Figure 5.8 here]

5.4.4 Relationship Between The Default Threshold And Parameters

Figures 5.9 and 5.10 represent the relationship between the expected growth rate of the participating firms and the default threshold of the merged firm. As the expected growth rate of the bidder increases, the bidder will pay more to the target. The higher acquisition costs increase the threshold of the default in Figure 5.9. While, if the expected growth rate of the target increases, the acquire pays less, and the synergy gains after merger also increase. The default threshold thereafter decreases in Figure 5.10. No matter the expected growth rates of the participating firms increase or decrease, the higher the correlation coefficient ρ is, the higher the default threshold will be. Equivalently, the merged firm will be difficult to default if the

diversification between the bidder and the target is high. According to the Proposition 13, default threshold R_d negatively relates to ϑ_2 , which also follows the results in Figures 5.9 and 5.10.

[Insert Figures 5.9 and 5.10 here]

As in Figures 5.9 and 5.10, the merged firm is difficult to default if the volatilities of the participating firms are highly risky because the bidder can choose a lower payment portion p_d to acquire the target. The parameter ϑ_2 , which is given by (2.9), has a negative relationship with volatility σ_X when $\sigma_X < \rho\sigma_Y$, and a positive relationship with volatility σ_X when $\sigma_X > \rho\sigma_Y$. Because $\partial R_d / \partial \vartheta_2 < 0$, which is given in Proposition 13, default threshold R_d positively relates to the volatility σ_X when $\sigma_X < \rho\sigma_Y$ and negatively relates to the volatility σ_X when $\sigma_X > \rho\sigma_Y$. The same relationship is held between default threshold R_d and the volatility of the target σ_Y .

[Insert Figures 5.11 and 5.12 here]

The default threshold increases if the firm size of the target increase. The merged firm is easy to default if the target is a large-size company because the bidder should pay a higher acquisition payment which is shown in Figure 5.6. Therefore, Figure 5.13 shows a positively relationship between the default threshold R_d and the firm size of the target K_T . The default threshold also increases with the synergy parameter α in Figure 5.14. The bidder will provide a higher payment portion p_d if the synergy gain increases, which is shown in Figure 5.8. A higher payment portion p_d therefore increase the default threshold in Figure 5.14. The merged firm is easy to default if the debt parameter q is high, which is shown in Figure 5.15.

[Insert Figures 5.13, 5.14 and 5.15 here]

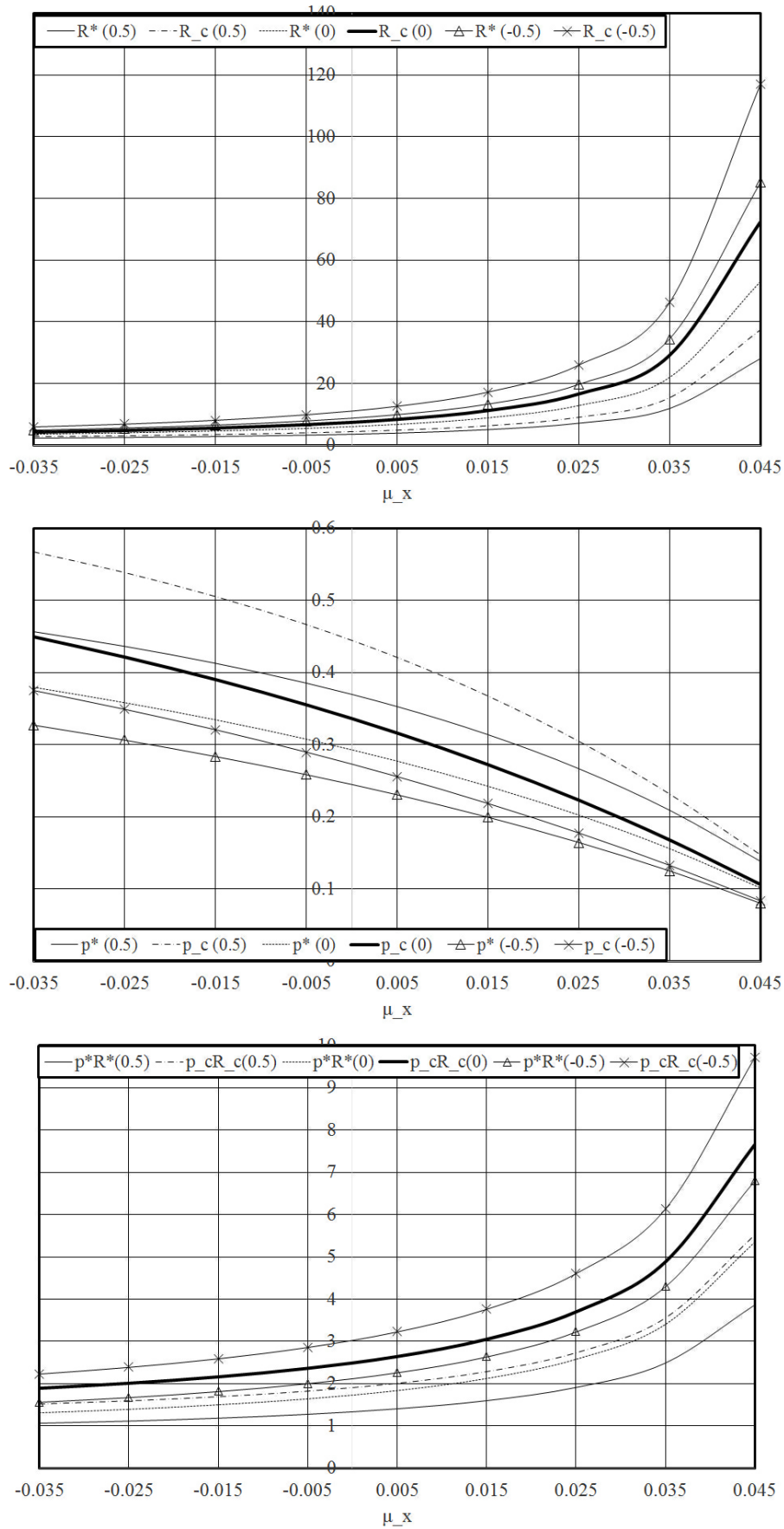


FIGURE 5.2: The impact of the expected growth rate of the bidder on the decision-making.

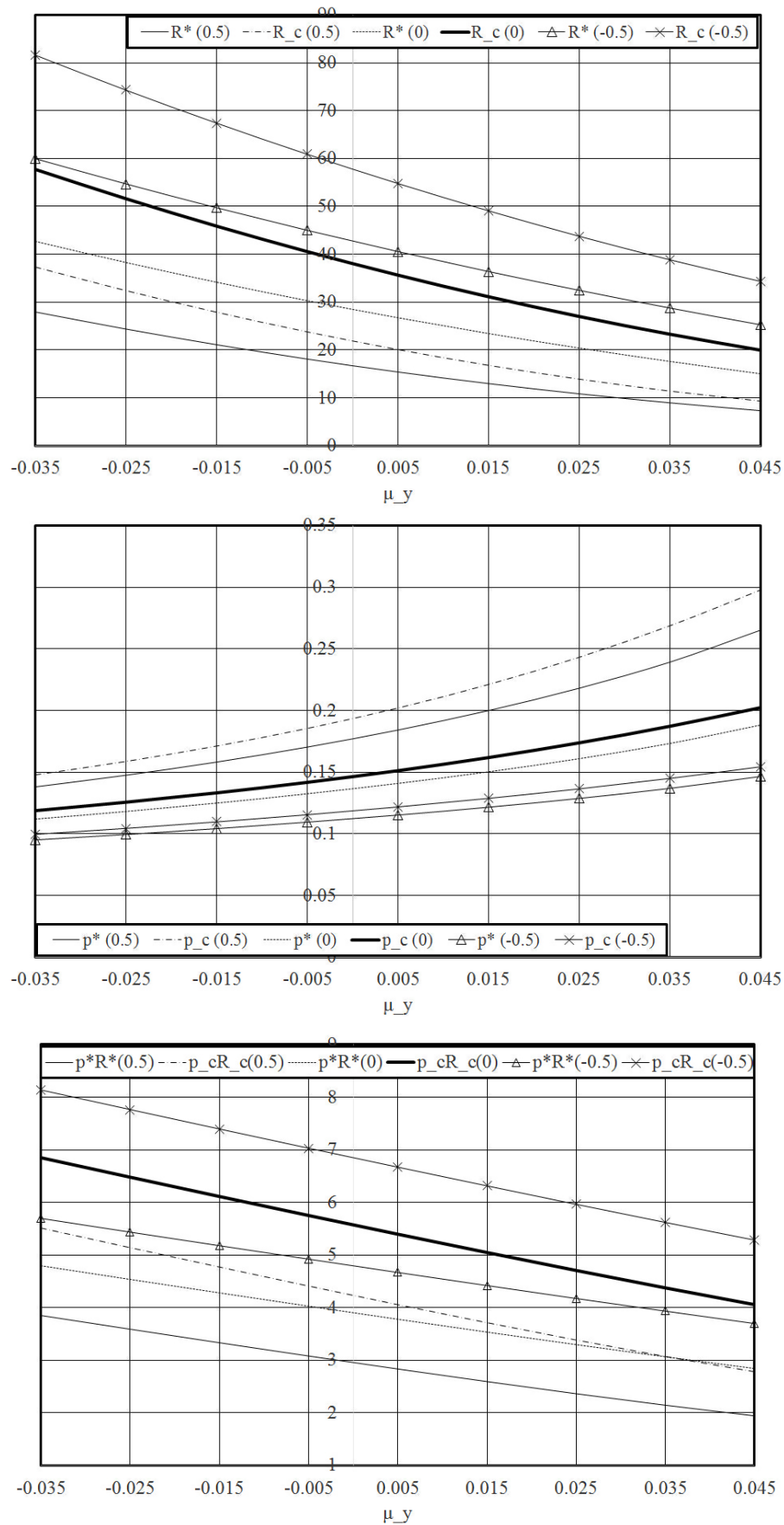


FIGURE 5.3: The impact of the expected growth rate of the target on the decision-making.

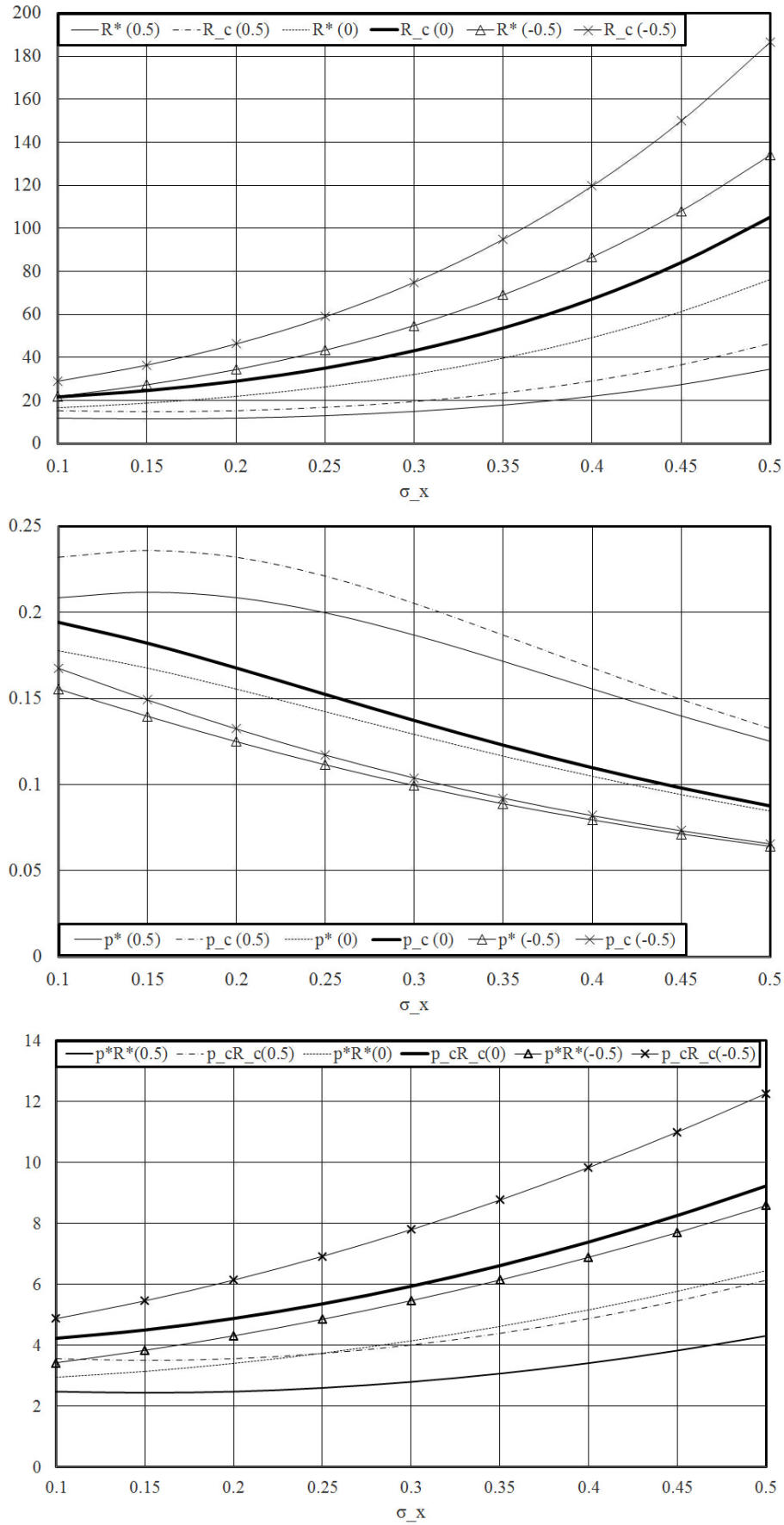


FIGURE 5.4: The impact of the volatility of the bidder on the decision-making.

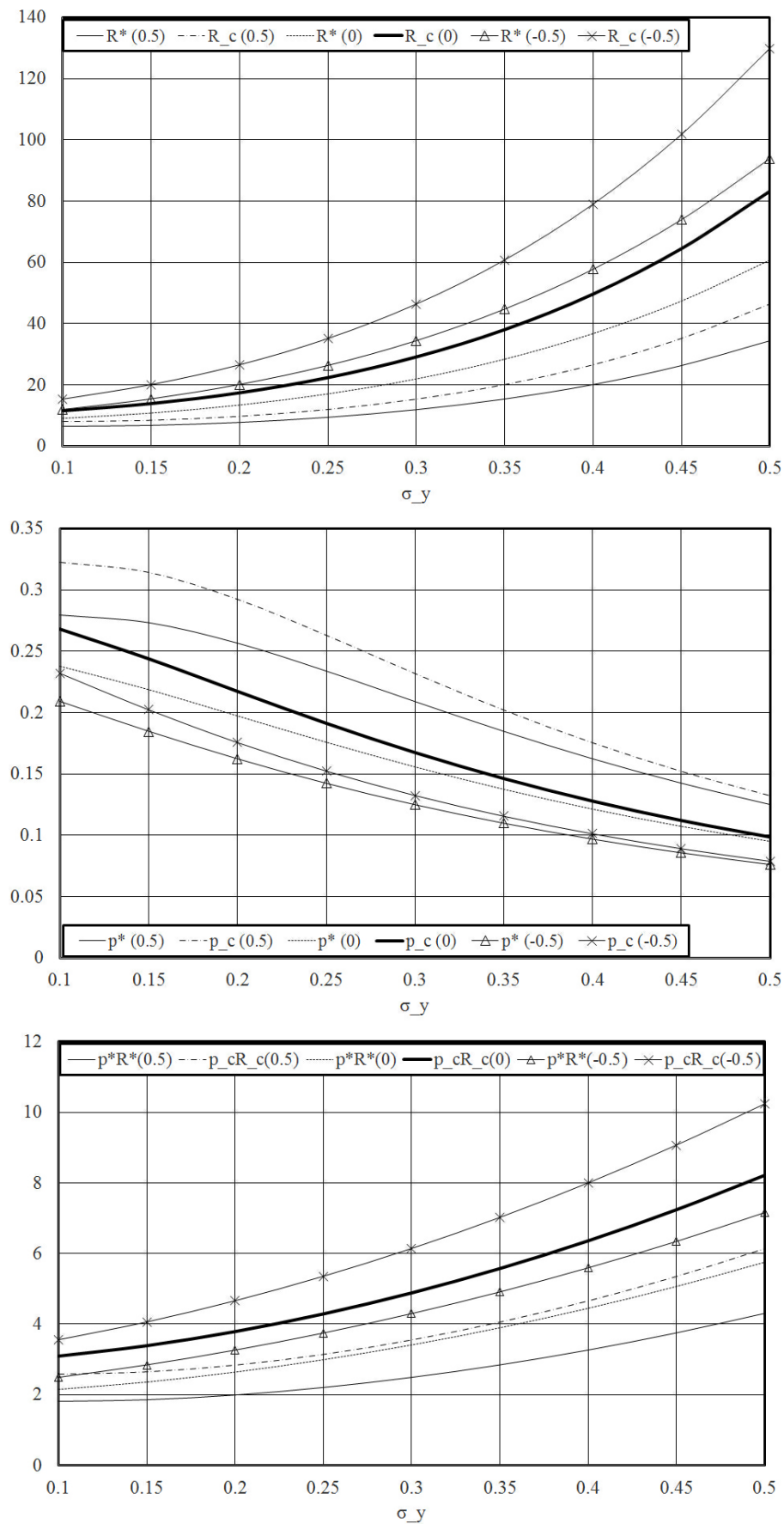


FIGURE 5.5: The impact of the volatility of the target on the decision-making.

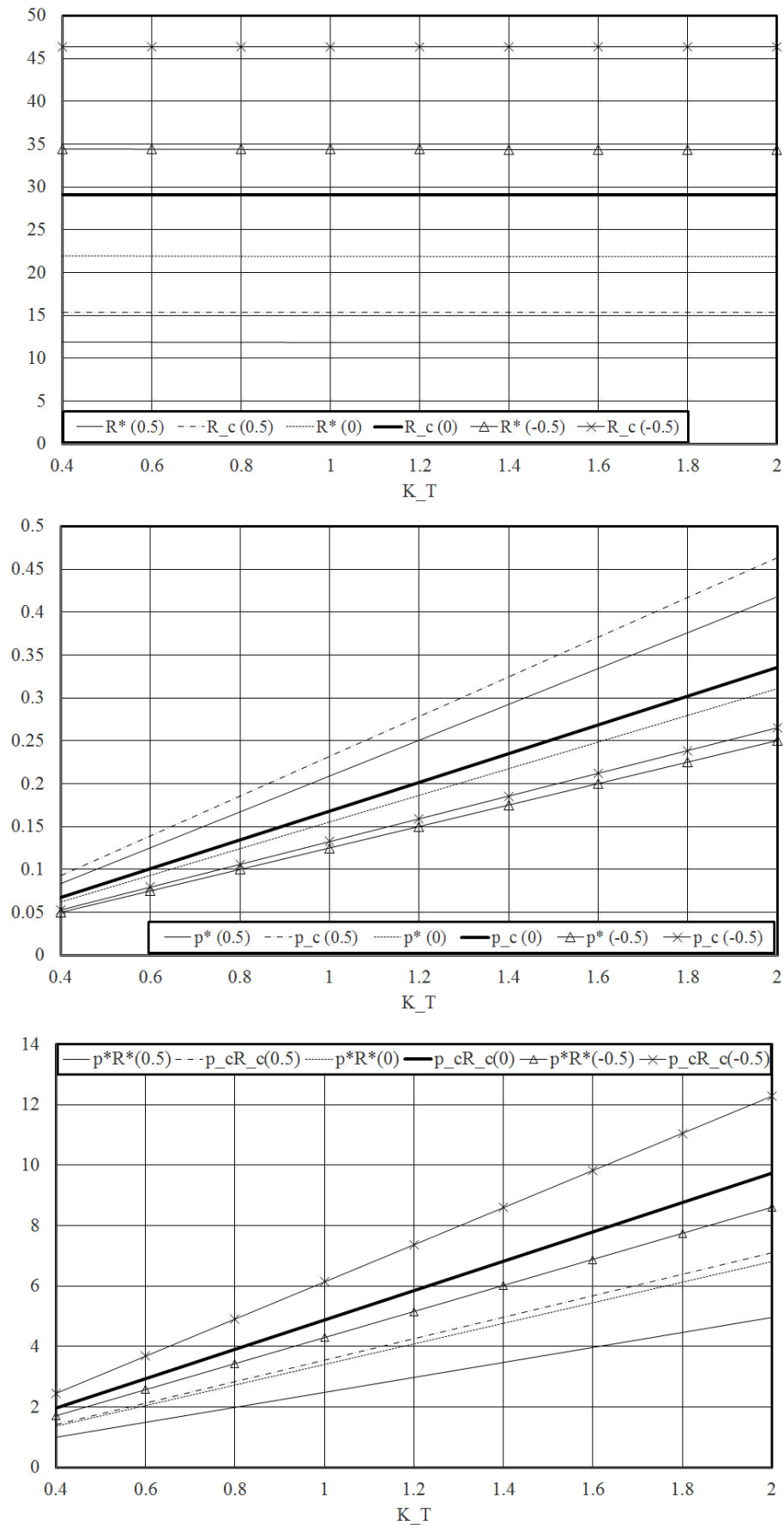


FIGURE 5.6: The impact of firm size on the decision-making.

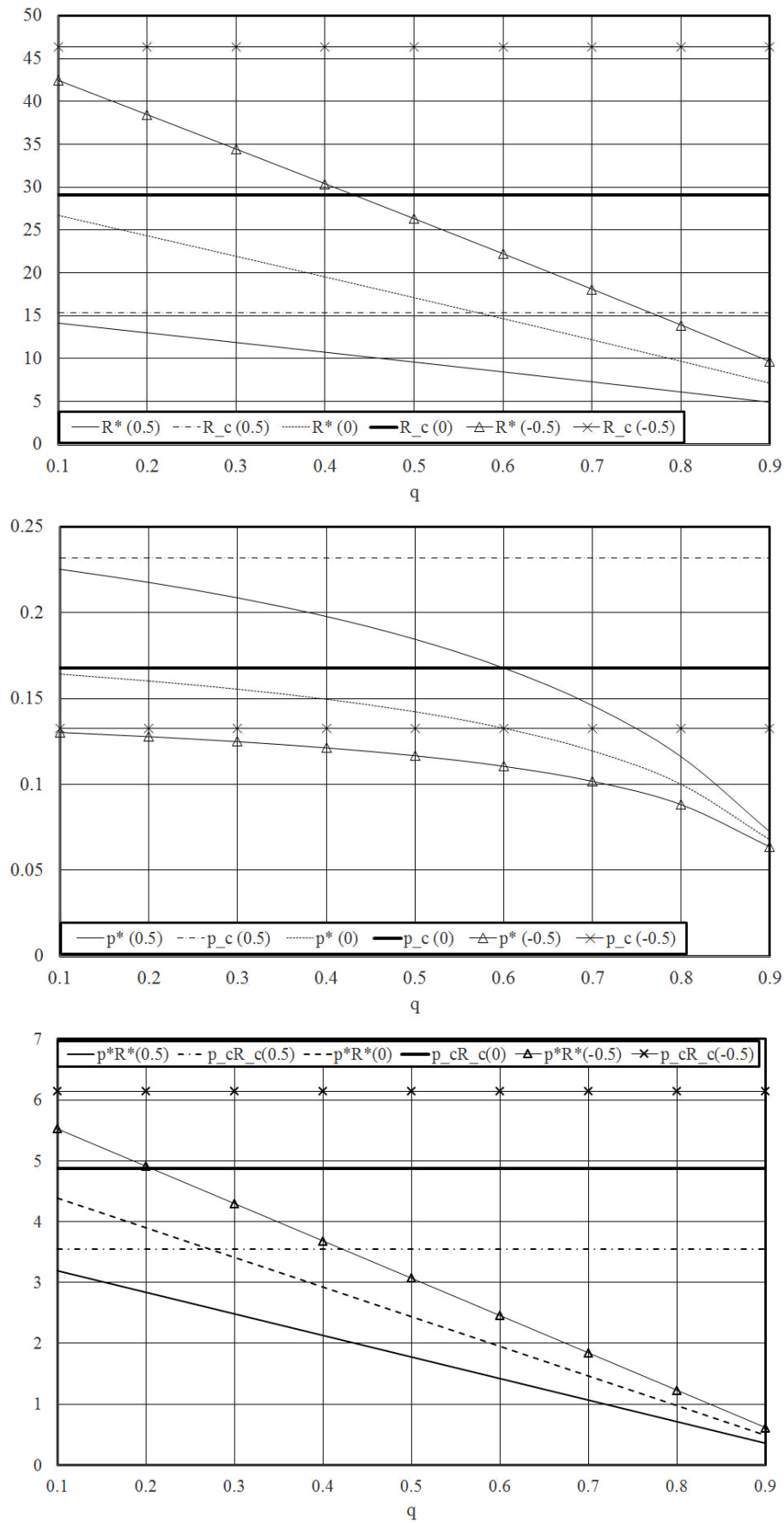


FIGURE 5.7: The impact of debt level on the decision-making.

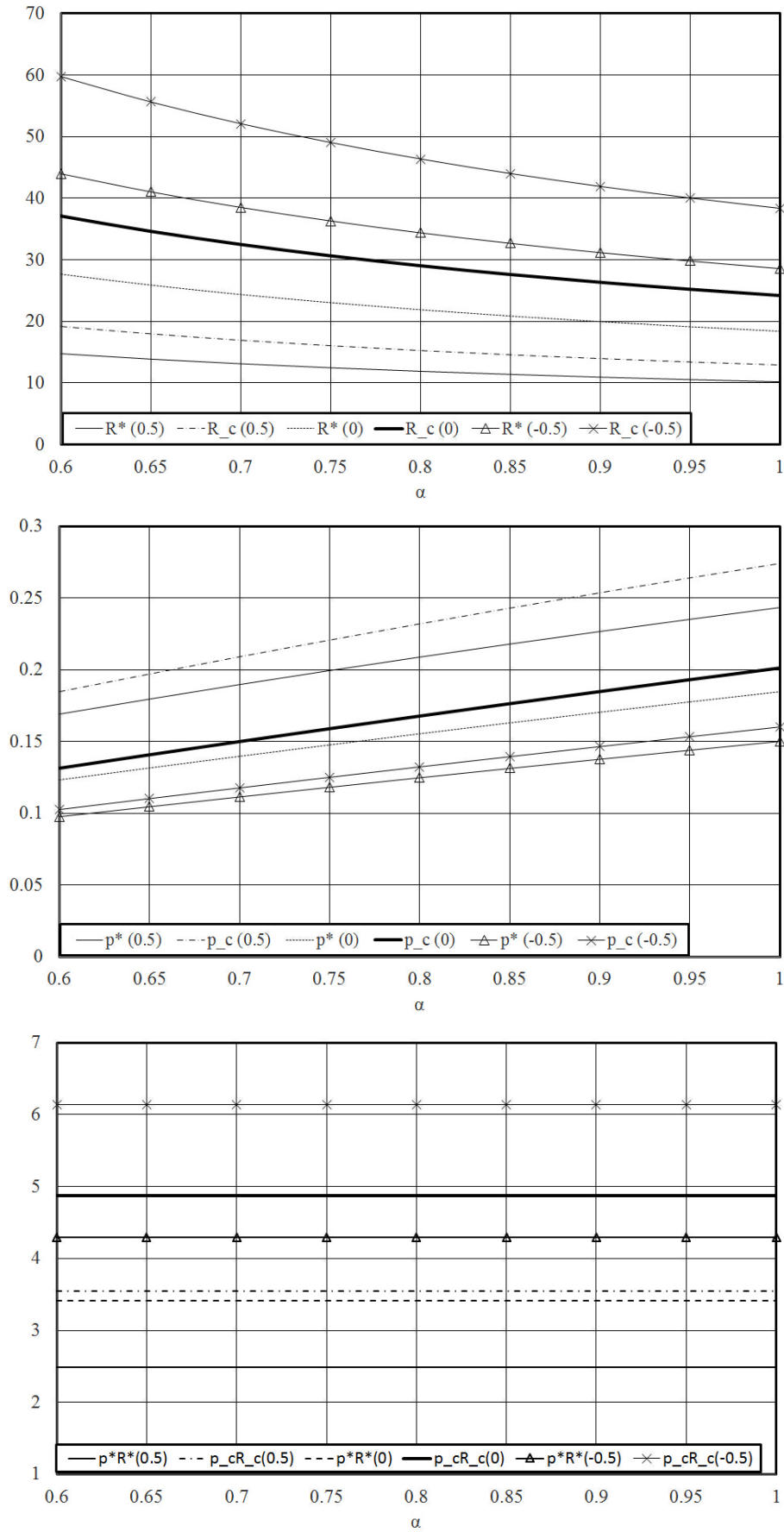


FIGURE 5.8: The impact of synergy on the decision-making.

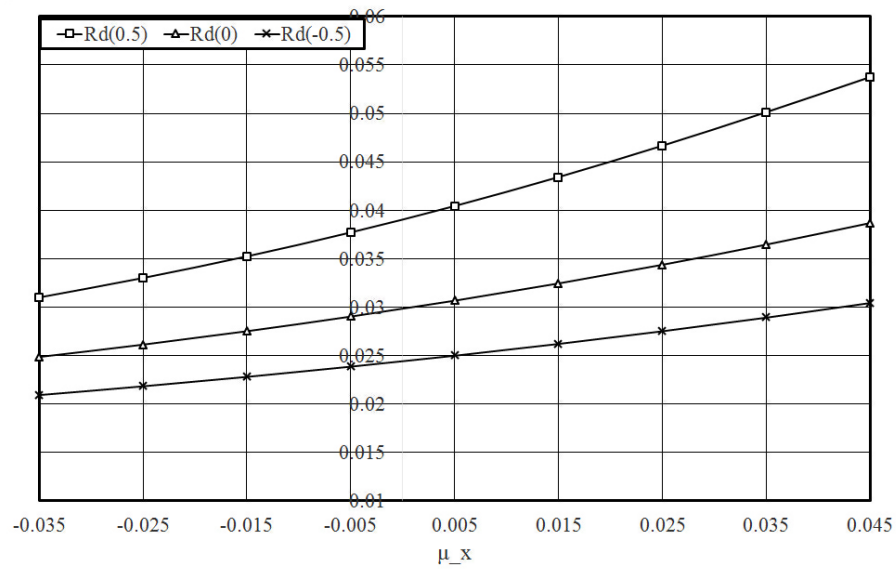


FIGURE 5.9: The impact of the expected growth rate of the bidder on the default threshold.

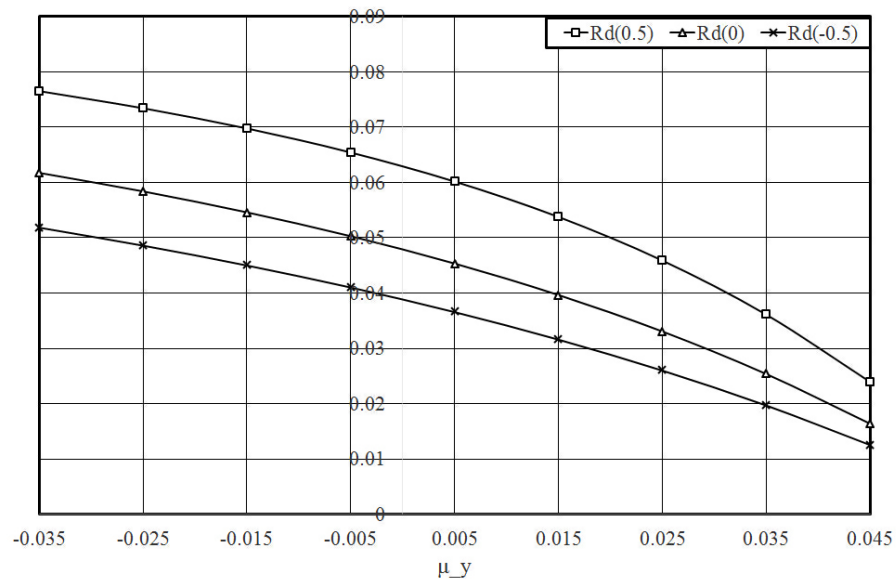


FIGURE 5.10: The impact of the expected growth rate of the target on the default threshold.

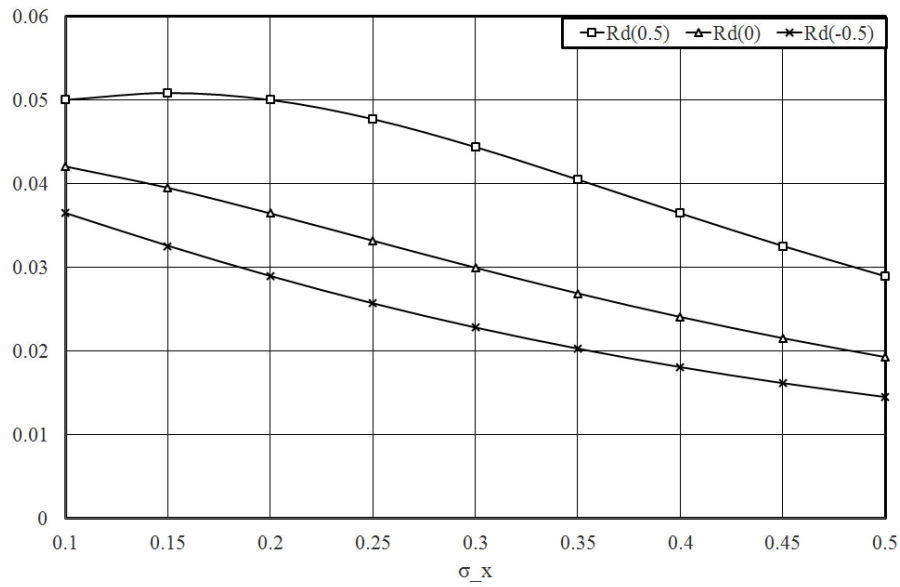


FIGURE 5.11: The impact of the volatility of the bidder on the default threshold.

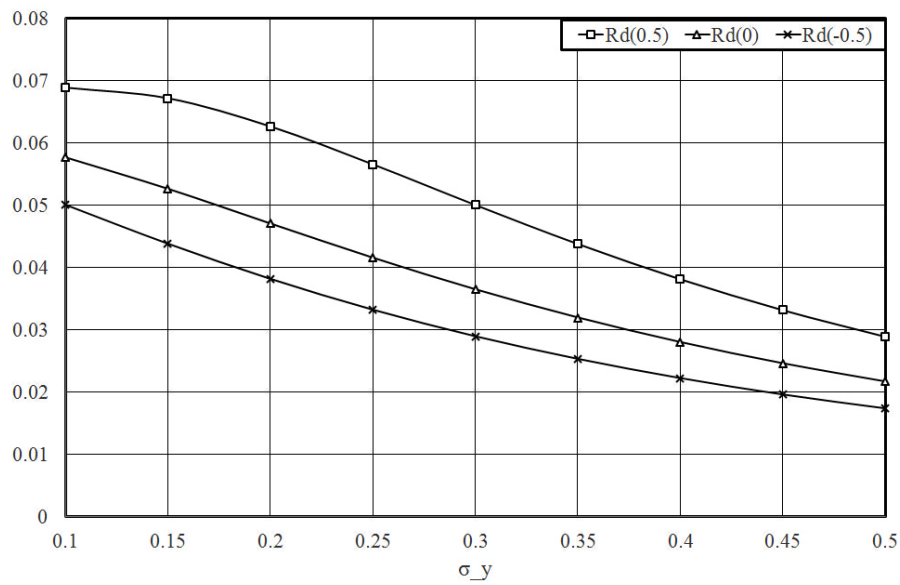


FIGURE 5.12: The impact of the volatility of the target on the default threshold.

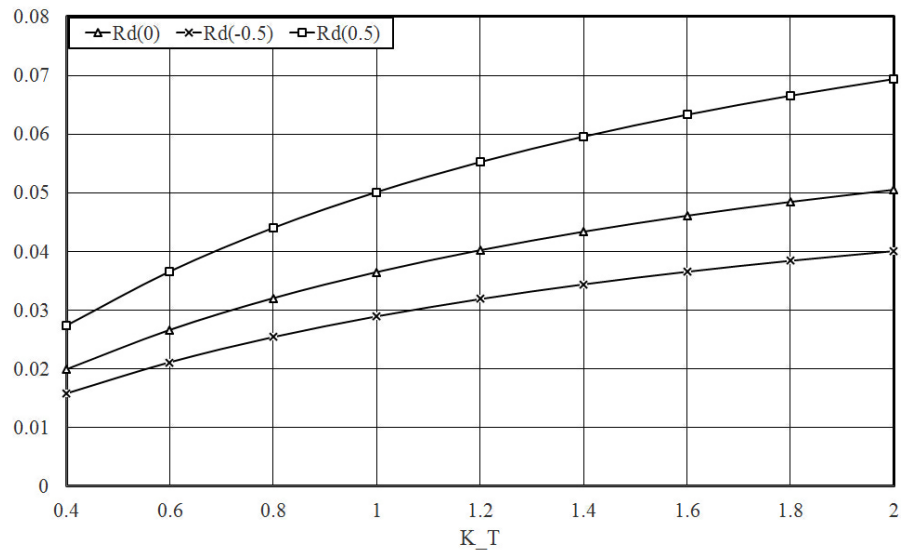


FIGURE 5.13: The impact of the firm size on the default threshold.

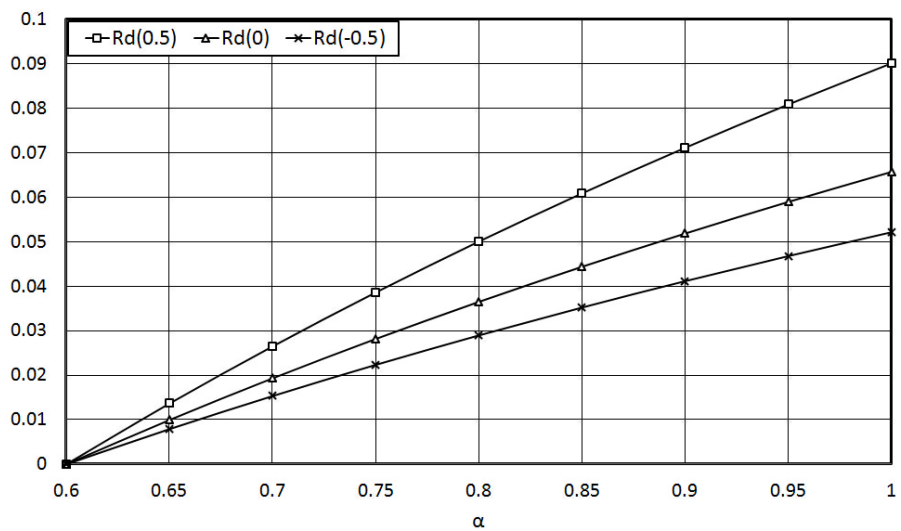


FIGURE 5.14: The impact of synergy on the default threshold.

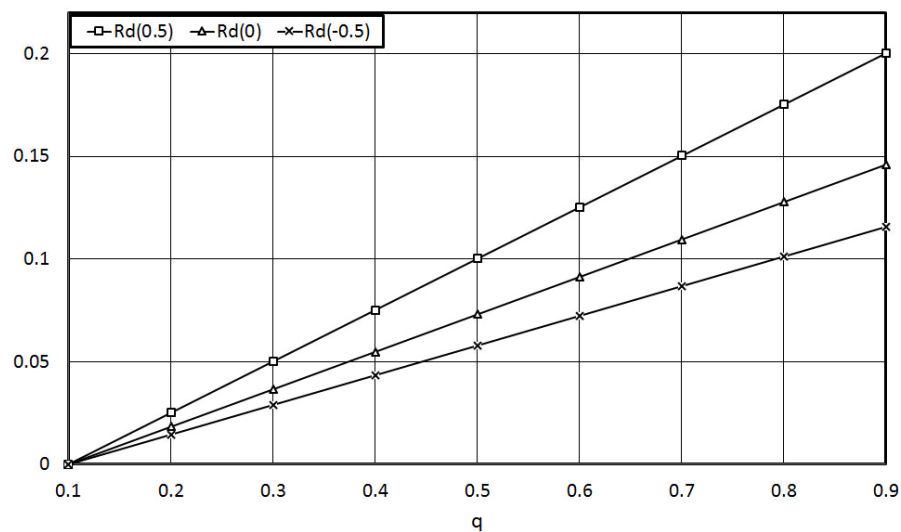


FIGURE 5.15: The impact of debt on the default threshold.

Chapter 6

The Imperfect Information Model

This dissertation develops dynamic models of joint takeovers to determine the optimal payment strategy and the optimal timing to acquire a target firm. We first establish a pure cash-payment model, which the bidder pays in cash to buy all the shares of the target firm. In Chapter 3, we extend the pure cash-payment model into a mixed-payment model, which both the bidder and target remain shareholders of the new combined enterprise and negotiate over the post-merger terms. Chapter 5 introduces the model, which determines the optimal timing and price for the mergers, and acquisitions under both equity and debt finance. In this section, we will extend those models into the situation that the information in the market is imperfect and compare the result with the perfect information results that we have already introduced. Furthermore, the model will examine the effect of information on the decision-making. In the Chapter 4, the transition, no matter the bidder choose an expand option or a sell option, is paid by the pure cash-payment. Therefore, in the section we extend the model in Chapter 2, Chapter 3 and Chapter 5.

In this study, we base our analysis on Morellec and Zhdanov [58]’s model of a joint determination of timing and terms of takeovers under competition and imperfect information. The model set-up is closely related to Hackbarth and Morellec [30] and Shleifer and Vishny [75], who develop a model based on the stock market misvaluation of the merged firms and compares the stock returns of the participating firms in both the long- and short-run. In the imperfect information market, we assume that both the bidder and target will probably mis-estimate the price and that the managers of both firms can take advantage of this. In Morellec and Zhdanov [58], asymmetric information occurs between the participating firms and investors. The dissertation analyses the abnormal returns from the announcement. We extend the model by assuming asymmetric information between the two participating firms.

The price of both the bidder and target may be mis-estimated, which means the market price may be higher or lower than the real price. However, both participating firms have complete information about their own firm. Therefore, they will generate an optimal strategy using the estimated parameters based on the available information. The merger and acquisition activities can increase information disclosure and push the market price towards the real value. Therefore, the model generates abnormal returns to both the bidder and the target of the merger.

6.1 The Model Set-up in a Market with Imperfect Information

In this section, we analyse the strategy in a market with asymmetric information. In this scenario, it is possible for the market value of per unit capital to be misjudged. In contrast to assumption (3.4), the net synergy gains generated from the merger

here are

$$G(X_t, Y_t) = K_T \left(\alpha (\omega_B X_t - \omega_T Y_t) - c Y_t \right), \quad (\alpha, c) \in \mathbb{R}_{++}^2, \quad (6.1)$$

where $\omega_B > 0$ and $\omega_T > 0$ are information parameters. The market value of per unit capital is underestimated if $\omega_i \in (1, \infty)$, ($i = B, T$), and overestimated if $\omega_i \in (0, 1)$. Morellec and Zhdanov [58] assume that the information parameter is only observable to the managers of participating firms and other market participants do not know this value. In this model, we assume that the information asymmetry exists between the bidder and target. Therefore ω_B is only observable to the managers of the bidder and ω_T is only observable to the managers of the target. Thus, managers know only the real value of their own firm. Additionally, managers cannot trade on their inside information due to legal prohibitions.

For the bidder, the net synergy gains generated from the merger are

$$G^B(X_t, Y_t) = K_T \left(\alpha (\omega_B X_t - Y_t) - c Y_t \right). \quad (6.2)$$

ω_T is not observable to the bidder, which believes that the target firm's market capital price is the real price. Based on the bidder's information, the post-merger value of the combined firm should be

$$S_M^B(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G^B(X_t, Y_t). \quad (6.3)$$

For the target, the net synergy gains generated from the merger are

$$G^T(X_t, Y_t) = K_T \left(\alpha (X_t - \omega_T Y_t) - c Y_t \right). \quad (6.4)$$

Based on the target firm's information, the post-merger value of the combined firm should be

$$S_M^T(X_t, Y_t) = S_B(X_t) + S_T(Y_t) + G^T(X_t, Y_t). \quad (6.5)$$

Asymmetric information will be disclosed after the merger. Therefore, the merger of the two firms will generate an abnormal return at the time of merger.

6.2 The Pure Cash-Payment Model in a Market with Imperfect Information

Similar to the model in the perfect information market which is introduced in Chapter 3, the bidder pays an amount of cash to the target based on the target's market value and buys the whole firm. The bidder is the only shareholder of the merged firm. Suppose the bidder will use parts of their firm's value, which is denoted as portion p , to pay the cash payment. Receiving the offer at t_0 , the target decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OMC^{im}(X_t, Y_t) = \max_{\tau_c^{im}} \mathbb{E} \left\{ e^{-r\tau_c^{im}} \left[p S_B(X_{\tau_c^{im}}) - S_T(Y_{\tau_c^{im}}) \right] \right\}. \quad (6.6)$$

Proposition 15 (The optimal threshold in the imperfect information market) *Based on the value-maximizing strategy, the target firm will accept the offer and merge with the bidder when the ratio of per unit capital price, denoted by $R_t = X_t/Y_t$, reaches the level*

$$R_c^{im} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B} \frac{1}{p}. \quad (6.7)$$

Value of the option that the target holds is given by,

$$OMC^{im}(X_t, Y_t) = \begin{cases} Y_t [pK_B R_t - K_T], & R_c \leq R_t \\ Y_t [pK_B R_c - K_T] \left(\frac{R_t}{R_c}\right)^{\vartheta_1}, & R_t < R_c \end{cases} \quad (6.8)$$

and the first passing time is

$$\tau_c^{im} = \inf\{t > 0 : R_t \geq R_c^{im}\}. \quad (6.9)$$

$\vartheta_1 > 1$ is the positive root of the quadratic equation (2.9).

As soon as the target accepts the offer, the two participating firms will merge. The bidder gives up the claim, worth $S_B(X_{\tau_c^{im}})$, and pays a cash amount of $p^{im} S_B(X_{\tau_c^{im}})$ to the target at time τ_c^{im} . In return, the bidder receives ownership of the merged firm, worth $S_M^B(X_{\tau_c^{im}}, Y_{\tau_c^{im}})$. The optimization function for the bidder thereafter is given by

$$OTC^{im}(X_t, Y_t) = \max_{p^{im}} \mathbb{E} \left\{ e^{-r\tau_c^{im}} \left[S_M^B(X_{\tau_c^{im}}, Y_{\tau_c^{im}}) - p^{im} S_B(X_{\tau_c^{im}}) - S_B(X_{\tau_c^{im}}) \right] \right\}. \quad (6.10)$$

Proposition 16 (Optimal cash payment in a pure cash-payment model) *Maximizing the payoff function (6.10) yields the optimal offered portion p_c^{im} for the bidder, given as*

$$p_c^{im} = \frac{\alpha \omega_B (\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (6.11)$$

Substituting result (6.11) into (6.7) yields

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1}{\alpha \omega_B} \left(\alpha + c - 1 + \frac{\vartheta_1}{\vartheta_1 - 1} \right). \quad (6.12)$$

(Appendix E.1 contains the proof.)

According to threshold (6.7), the higher p is, the lower the threshold will be. The merging process will be accelerated if the bidder uses a high portion p_c^{im} of their firm value to pay the target. If the bidder chooses an optimal portion p_c^{im} , which is given by (6.11), the target will accept the offer when the ratio of per unit capital value R_t reaches (6.12). According to (6.7), p_c^{im} positively relates to ϑ_1 as $\partial p_c^{im} / \partial \vartheta_1 > 0$, and negatively relates to the firm-size ratio, which is represented as K_B / K_T . A higher synergy parameter α will increase the payment portion p_c^{im} and then decrease the threshold R_c^{im} . While a higher cost c will decrease the payment and increase the threshold.

All the hidden information is revealed after the entire merging process is complete. After merging, the market value reflects the real value of the enterprise. Before merging, the participating firms know only their own real value and estimate their counterpart's value assuming that their value is equal to the market value. When the

bidder and target merge, they will receive a certain fraction of the merged firm under the real net synergy gain from merging, given by (6.1). We can write the pre-merger value of the bidder as

$$S_B(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-}) = K_B X_{\{\tau_c^{im}\}_-} + OTC^{im}(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-}; (\omega_B, 1)). \quad (6.13)$$

In addition, the pre-merger value of the target is

$$S_T(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-}) = K_T Y_{\{\tau_c^{im}\}_-} + OMC^{im}(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-}; (1, \omega_T)). \quad (6.14)$$

The abnormal returns of the pure cash-payment model satisfy

$$\begin{aligned} ARC_X &= \frac{OTC^{im}(X_{\tau_c^{im}}, Y_{\tau_c^{im}}; (\omega_B, \omega_T)) - OTC^{im}(X_{\tau_c^{im}}, Y_{\tau_c^{im}}; (\omega_B, 1))}{(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-})}; \\ &= \frac{\alpha(1 - \omega_T)K_T}{((1 - p_c^{im})K_B + \alpha\omega_B K_T)R_c^{im} + (1 - \alpha - c)K_T}. \end{aligned} \quad (6.15)$$

$$\begin{aligned} ARC_Y &= \frac{OMM^{im}(X_{\tau^{im}}, Y_{\tau^{im}}; (\omega_B, \omega_T)) - OMM^{im}(X_{\tau^{im}}, Y_{\tau^{im}}; (1, \omega_T))}{S_T(X_{\{\tau_c^{im}\}_-}, Y_{\{\tau_c^{im}\}_-})}; \\ &= 0. \end{aligned} \quad (6.16)$$

Because all the information will be revealed only after the success of the mergers and acquisitions, the imperfect information has the impact on the post-merger firm. The target firm will not remain, as the shareholder of the merged firm, the imperfect information, therefore, has no impact on the target firm. Thus, the imperfect information only impacts the return of the bidder which is represented as equation (6.15). The abnormal return for the target firm is zero.

6.3 The Mixed-payment Model in a Market with Imperfect Information

Similar to the model in the perfect information market, the optimization function of the reacting party (target firm) at stage two is

$$OMM^{im}(X_t, Y_t) = \max_{\tau_m^{im}} \mathbb{E} \left\{ e^{-r\tau^{im}} \left[(1 - \xi) S_M^T(X_{\tau_m^{im}}, Y_{\tau_m^{im}}) + \lambda S_T(Y_{\tau_m^{im}}) - S_T(Y_{\tau_m^{im}}) \right] \right\}. \quad (6.17)$$

Proposition 17 (Optimal threshold in a market with imperfect information) *If the offered cash acquisition premium payment satisfies $\lambda < \xi + (\alpha\omega_T + c)(1 - \xi)$, the target firm will accept the offer and merge with the bidder when the ratio of per unit capital value R_t reaches*

$$R_m^{im}(\lambda, \xi) = \left((\alpha\omega_T + c - 1) + \frac{1 - \lambda^{im}}{1 - \xi^{im}} \right) \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B + \alpha K_T}. \quad (6.18)$$

The value of merger option for the target is

$$OMM^{im}(X_t, Y_t) = \begin{cases} Y_t \left[\frac{(1-\xi)(\alpha\omega_T - c - 1) + (1-\lambda)}{\vartheta_1 - 1} K_T \right] \left(\frac{R_t}{R_m^{im}(\lambda, \xi)} \right)^{\vartheta_1}, & R_t < R_m^{im}(\lambda, \xi), \\ Y_t \left[(1-\xi)(K_B + \alpha K_T) R_t + \left((1-\xi)(1 - \alpha\omega_T - c) - (1-\lambda) \right) K_T \right], & R_t \geq R_m^{im}(\lambda, \xi), \end{cases} \quad (6.19)$$

and the first passing time is

$$\tau_m^{im} = \inf\{t > 0 : R_t \geq R_m^{im}(\lambda, \xi)\}. \quad (6.20)$$

$\vartheta_1 > 1$ is the positive root of equation (2.9). (Appendix E.2 provides the proof.)

At stage one, the bidder's optimization function, which is also similar to the model in the perfect information market, is

$$OTM^{im}(X_t, Y_t) = \max_{\lambda^{im}} \mathbb{E} \left\{ e^{-r\tau_m^{im}} \left[\xi S_M^B(X_{\tau_m^{im}}, Y_{\tau_m^{im}}) - \lambda^{im} S_T(Y_{\tau_m^{im}}) - S_B(X_{\tau_m^{im}}) \right] \right\}. \quad (6.21)$$

With the available information, the bidder will estimate the target firm's threshold as $R_m(\lambda^{im}, \xi)$, which is given by equation (3.6). After offering an optimal cash acquisition premium payment λ^{im} , the bidder will estimate that the target is willing to accept the offer when the ratio of per unit capital value R_t reaches $R_m(\lambda^{im}, \xi)$. While the real threshold that the target will choose is $R_m^{im}(\lambda^{im}, \xi)$, given by (6.18). We call the difference between the real threshold chosen by the target and the estimated threshold for the bidder as information distortion.

Proposition 18 (Optimal tender offer in a market with imperfect information) *The information parameter ω_T is not observable before τ^{im} , the bidder then optimizes the acquisition premium under a distorted estimation due to information distortion. The optimal cash acquisition premium payment λ^{im} the bidder chooses is*

$$\lambda^{im}(\xi) = (1-\xi)(\alpha + c) + \xi + \frac{\vartheta_1(\alpha + c)(1-\xi)(K_B + \alpha K_T)}{(1-\xi)K_B - \alpha \left((\vartheta_1 + \xi - 1) + \vartheta_1 \xi (\omega_B - 1) \right) K_T}. \quad (6.22)$$

Given $\lambda^{im}(\xi)$, the threshold finally is equal to $R_m^{im}(\xi)$. According to the result of (6.18), the optimal threshold to accept the offer is

$$R_m^{im}(\xi) = \frac{\vartheta_1}{\vartheta_1 - 1} \left(\frac{\alpha(\omega_T - 1)K_T}{K_B + \alpha K_T} + \frac{\vartheta_1(\alpha + c)K_T}{\alpha \left((\vartheta_1 + \xi - 1) + \vartheta_1 \xi (\omega_B - 1) \right) K_T - (1-\xi)K_B} \right). \quad (6.23)$$

(Appendix E.3 provides the proof.)

Similar to the model in the perfect information market, we use the Nash bargain approach to derive the optimal bargain terms. The optimization function of the

terms is

$$\Pi^{im}(X_t, Y_t) = \max_{\xi^{im}} \left[OM_m^{im}(X_t, Y_t; \xi^{im}) \right]^\beta \left[OT_m^{im}(X_t, Y_t; \xi^{im}) \right]^{1-\beta}, \quad (6.24)$$

where the bargaining power parameter β is subject to $\beta \in (0, 1)$. Solving the maximization problem (6.24) yields the following result.

Proposition 19 (Optimal post-merger terms in a market with imperfect information)

The bidder will pay the optimal acquisition premium payment λ^{im} and expect to receive the optimal fraction ξ^{im} of the merged entity. For receiving the optimal offered portion λ^{im} , the optimal strategy for the target is to require $(1 - \xi^{im})$ as a fraction of the merged entity and choose to accept the offer at τ_m^{im} . The optimal merger terms in a market with imperfect information satisfies

$$\frac{\alpha}{\alpha + c} \frac{K_T}{K_B + \alpha K_T} \frac{\omega_B}{1 - \xi^{im}} = \frac{\gamma_1}{\gamma_2^2} + \frac{(1 - \beta)\gamma_1}{\beta\vartheta_1\gamma_2^2 - (1 - \beta)(1 - \vartheta_1)\gamma_1\gamma_2}, \quad (6.25)$$

where

$$\gamma_1 = (1 - \xi^{im})(\alpha + c - 1) + (1 - \lambda^{im}(\xi^{im})); \quad (6.26)$$

$$\gamma_2 = (1 - \xi^{im})(\alpha\omega_T + c - 1) + (1 - \lambda^{im}(\xi^{im})). \quad (6.27)$$

(Appendix E.4 provides the proofs.)

The entire strategy will be decided in stage one; therefore, both the participating firms have no chance to adjust the strategy after the decision made. The optimal terms under a Nash bargaining approach in the imperfect information market is the solution to equation (6.25). For the bidder, the strategy will be (λ^{im}, ξ^{im}) . For the target, the strategy will be $(R_m^{im}, 1 - \xi^{im})$. In the next section, we analyze the impact of the information on the strategy.

All the hidden information is revealed after the entire merging process is complete. After merging, the market value reflects the real value of the enterprise. Before merging, the participating firms know only their own real value and estimate their counterpart's value assuming that their value is equal to the market value. When the bidder and target merge, they will receive a certain fraction of the merged firm under the real net synergy gain from merging, given by (6.1). We can write the pre-merger value of the bidder as

$$S_B(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}) = K_B X_{\{\tau_m^{im}\}_-} + OTM^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (\omega_B, 1)). \quad (6.28)$$

In addition, the pre-merger value of the target is

$$S_T(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}) = K_T Y_{\{\tau_m^{im}\}_-} + OM^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (1, \omega_T)). \quad (6.29)$$

The abnormal returns satisfy

$$\begin{aligned} ARM_X &= \frac{OT^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (\omega_B, \omega_T)) - OT^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (\omega_B, 1))}{S_B(\tau_-^{im})}; \\ &= \frac{\xi\alpha(1 - \omega_T)K_T}{\xi(K_B + \alpha\omega_B K_T)R_m^{im} + (\xi(1 - \alpha - c) - \lambda^{im})K_T}. \end{aligned} \quad (6.30)$$

$$\begin{aligned}
ARM_Y &= \frac{OM^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (\omega_B, \omega_T)) - OM^{im}(X_{\{\tau_m^{im}\}_-}, Y_{\{\tau_m^{im}\}_-}; (1, \omega_T))}{S_T(\tau_m^{im})}; \\
&= \frac{(1 - \xi)\alpha(\omega_B - 1)K_T R_m}{(1 - \xi)(K_B + \alpha K_T)R_m^{im} + ((1 - \xi)(1 - \omega_T\alpha - c) + \lambda^{im})K_T}.
\end{aligned} \tag{6.31}$$

Because the information parameter ω_T is unknown to the bidder until after the merger, ω_T has no impact on the decision, which is the optimal cash acquisition premium payment λ^{im} for the bidder. Comparing the results of (3.10) and (6.22), the higher the information parameter ω_B is, the higher the acquisition premium the bidder will provide. In the range $\omega_B \in (0, 1)$, $\lambda^{im} < \lambda^m$ and the reversal in the relationship occurs in the range $\omega_B \in (1, \infty)$.

Corollary 1 (Impact of information on the acquisition premium) *The bidder is willing to pay a higher acquisition premium if the target firm is underestimated, and versa lower one if it is overestimated. Therefore, a higher acquisition premium accelerates the merger process and the disclosure of underestimated information.*

The target will choose its strategy by following the reaction function (6.18); the effect of information on their function is as follows.

Corollary 2 (Impact of information on the threshold) *If the parameters satisfy*

$$(1 - \xi)\alpha(\omega_T - 1) > \lambda^{im} - \lambda^m, \tag{6.32}$$

this is equivalent to

$$\begin{aligned}
&\frac{\omega_T - 1}{\omega_B - 1} \\
&> \frac{\xi\theta_1^2(\alpha + c)(K_B + \alpha K_T)K_T}{\left((1 - \xi)K_B - \alpha(\theta_1 + \xi - 1)K_T\right)\left((1 - \xi)K_B - \alpha[(\theta_1 + \xi - 1) + \theta_1\xi(\omega_B - 1)]K_T\right)},
\end{aligned} \tag{6.33}$$

the threshold in the situation with imperfect information is higher than that with perfect information, which leads to

$$R_m^{im} > R_m. \tag{6.34}$$

If $\omega_B \in (0, 1)$ and $\omega_T \in (1, \infty)$, the left side of (6.32) is positive and the right side is negative. Thus, the inequality (6.32) will always be satisfied. If $\omega_B \in (1, \infty)$ and $\omega_T \in (0, 1)$, the inequality (6.32) will never be satisfied because of the different signs on the two sides. Therefore, if the target is overvalued and the bidder is undervalued, or vice versa, the inequality (6.32) will never be satisfied. If inequality (6.32) cannot be satisfied, the condition $R_m^{im} < R_m$ always holds. In this situation, the symmetric information will always accelerate the merger. On the other hand, if both the target and bidder are overestimated, which leads to $\omega_T \in (0, 1)$ and $\omega_B \in (0, 1)$, inequality (6.33) means that the greater the overestimation of the target, the higher is the threshold. Additionally, if both the target and bidder are underestimated, which leads to $\omega_T \in (1, \infty)$ and $\omega_B \in (1, \infty)$, inequality (6.33) means that the greater the underestimation of the target, the higher is the threshold. Therefore, if the misestimations of per unit market value of capital are in the same direction, the greater is the information distortion is and the slower the merger process will be.

6.4 The Debt-payment Model in a Market with Imperfect Information

In the debt-payment model, the bidder issues a revenue bond secured only by the revenues generated from the target. Similar as in the perfect information model, the value of the debt is the portion q^{im} of the market value of the target, $q^{im}S_T(Y_t)$. The bidder pays the debt value to the target in addition to the cash amount $p^{im}S_B(X_t)$. Receiving the offer at t_0 , the target decides the timing to accept the offer according to the benefits generated. The optimization function for the target is

$$OME^{im}(X_t, Y_t) = \max_{\tau_e^{im}} \mathbb{E} \left[\mathbb{E}^{-r\tau_e^{im}} \left(pS_B(X_{\tau_e^{im}}) + qS_T(Y_{\tau_e^{im}}) - S_T(Y_{\tau_e^{im}}) \right) \right]. \quad (6.35)$$

At time τ_e^{im} , the target accepts the offer. They will receive a cash payment, worth $pS_B(X_{\tau_e^{im}})$ and also a debt worth $qS_T(Y_{\tau_e^{im}})$. They need to give up their claim, worth $S_T(Y_{\tau_e^{im}})$. Maximizing (6.35) yields Proposition 20.

Proposition 20 (The optimal threshold under debt financing) *Based on the value maximizing strategy, the target will accept the offer when the ratio of per unit capital price $R_t = X_t/Y_t$ reaches the level of*

$$R_e^{im} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{p} \frac{K_T}{K_B}. \quad (6.36)$$

The option value of the target is given by

$$OME^{im}(X_t, Y_t) = \begin{cases} Y_t (pK_B R_e^{im} - (1 - q)K_T) \left(\frac{R_t}{R_e^{im}} \right)^{\vartheta_1}, & R_t < R_e^{im}, \\ Y_t (pK_B R_t - (1 - q)K_T), & R_t \geq R_e^{im}, \end{cases} \quad (6.37)$$

and the first passage time is

$$\tau_e^{im} = \inf\{t > 0 : R_t \geq R^*\}. \quad (6.38)$$

If $q = 0$, this Proposition coincides with Proposition 6.7.

As soon as the target accepts the offer, both firms will merge. At time τ_e^{im} , the bidder receives ownership of the merged firm $S_M^{im}(X_t, Y_t)$, pays a cash amount of $p^{im}S_B(X_{\tau_e^{im}})$, and gives up the claim $S_B(X_{\tau_e^{im}})$. Note that the value of the debt should be subtracted from the value of ownership of the merged firm. And then, if the value of net ownership falls down to zero, the merged firm will default. The bidder will determine the optimal payment based on the estimation of the default threshold. Before the merger, the bidder have no information of ω_T which is the information parameter of the target firm. Therefore, we have

$$S_M^{im}(X_t, Y_t) = S_B(X_t) + (1 - q)S_T(Y_t) + G^B(X_t, Y_t) + \max_{\tau_d^{im}} \mathbb{E} \left[\mathbb{E}^{-r\tau_d^{im}} \left(-S_B(X_{\tau_d^{im}}) - (1 - q)S_T(Y_{\tau_d^{im}}) - G^B(X_{\tau_d^{im}}, Y_{\tau_d^{im}}) \right) \right]. \quad (6.39)$$

The optimization function for the bidder thereafter given by

$$OTE^{im}(X_t, Y_t) = \max_{p_e^{im}} \mathbb{E} \left[\mathbb{E}^{-r\tau_d^{im}} \left(S_M^{im}(X_{\tau_d^{im}}, Y_{\tau_d^{im}}) - p_e^{im} S_B(X_{\tau_d^{im}}) - S_B(X_{\tau_d^{im}}) \right) \right]. \quad (6.40)$$

Proposition 21 (The optimal default and cash payment under debt financing) *The merged firm will default when the ratio of per unit capital price $R_t = X_t/Y_t$ reaches the level of*

$$R_d^{im} = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha + c + q - 1)K_T}{K_B + \alpha\omega_B K_T}, \quad (6.41)$$

where $\alpha + c + q > 1$. The option value of the merged firm is given by

$$S_M^{im}(X_t, Y_t) = \begin{cases} 0, & R_t \leq R_d^{im}, \\ Y_t ((K_B + \alpha\omega_B K_T)R_t - (\alpha + c + q - 1)K_T) - Y_t A_d^{im} \left(\frac{R_t}{R_d^{im}} \right)^{\vartheta_2}, & R_t > R_d^{im}, \end{cases} \quad (6.42)$$

where

$$A_d^{im} = (K_B + \alpha\omega_B K_T) R_d^{im} - (\alpha + c + q - 1)K_T, \quad (6.43)$$

and the first passage time is

$$\tau_d^{im} = \inf\{t > 0 : R_t \leq R_d^{im}\}. \quad (6.44)$$

Then, maximizing value function yields the optimal offered portion p^* for the bidder, given as a positive root of

$$\frac{\vartheta_1 - \vartheta_2}{\vartheta_2 - 1} (\alpha + c + q - 1) \left(\frac{R_e^{im}}{R_d^{im}} \right)^{\vartheta_2} - \alpha\omega_B (\vartheta_1 - 1) R_e^{im} + \vartheta_1 \left(\alpha + c + \frac{1 - q}{\vartheta_1 - 1} \right) = 0. \quad (6.45)$$

where

$$p_d^{im} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{R_e^{im}} \frac{K_T}{K_B}. \quad (6.46)$$

According to the Proposition 20, when the debt payment portion q increases, the default threshold R_d^{im} increase. Because $\partial R_d^{im} / \partial \vartheta_2 < 0$, the default threshold negatively relates to ϑ_2 . Therefore the default threshold R_d negatively relates to the expected growth rate of the bidder and positively relates the expected growth rate of the target. Also, the relationship between the correlation coefficient ρ and the default threshold R_d is positive. In the next section, we further examine the threshold given by (6.45).

All the hidden information is revealed after the entire merging process is complete. The ownership of the merged firm that the acquirer can receive equals to,

$$S_M^*(X_t, Y_t) = S_B(X_t) + (1 - q)S_T(Y_t) + G(X_t, Y_t) + \max_{\tau_d^*} \mathbb{E} \left[\mathbb{E}^{-r\tau_d^*} \left(-S_B(X_{\tau_d^*}) - (1 - q)S_T(Y_{\tau_d^*}) - G(X_{\tau_d^*}, Y_{\tau_d^*}) \right) \right]. \quad (6.47)$$

Therefore, the true default threshold is

$$R_d^* = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha\omega_T + c + q - 1)K_T}{K_B + \alpha\omega_B K_T}. \quad (6.48)$$

$$(6.49)$$

After merging, the market value reflects the real value of the enterprise. Before merging, the participating firms know only their own real value and estimate their counterpart's value assuming that their value is equal to the market value. When the bidder and target merge, they will receive a certain fraction of the merged firm under the real net synergy gain from merging, given by (6.1). We can write the pre-merger value of the bidder as

$$S_B(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}) = K_B X_{\{\tau_e^{im}\}_-} + OTD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (\omega_B, 1)). \quad (6.50)$$

In addition, the pre-merger value of the target is

$$S_T(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}) = K_T Y_{\{\tau_e^{im}\}_-} + OMD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (1, \omega_T)). \quad (6.51)$$

The abnormal returns satisfy

$$ARD_X = \frac{OTD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (\omega_B, \omega_T)) - OTD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (\omega_B, 1))}{S_B(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-})}; \quad (6.52)$$

$$ARD_Y = \frac{OMD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (\omega_B, \omega_T)) - OMD^{im}(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-}; (1, \omega_T))}{S_T(X_{\{\tau_e^{im}\}_-}, Y_{\{\tau_e^{im}\}_-})}. \quad (6.53)$$

In the next section, we will give several numerical studies of the abnormal return.

6.5 Numerical studies

This section provides several numerical tests of the results. We first study the information impact on the optimal timing and payment of mergers and acquisitions. Second, the information impact on the information premium. Finally, we study the abnormal returns in this model and compare them with those reported in Morellec and Zhdanov [58]. They find that acquiring firms earn low or negative abnormal returns, while target firms earn substantially positive abnormal returns around the announcement date of the takeover.

Table 6.1 summarizes the basic parameter values. We assume Expected growth rates of the bidder and target are 0.035 and 0.02. It follows that the bidder generally outperforms the target. The volatility of the bidder and target are set to 20% and 30% which means the target has a higher risk than the bidder. We focus on mergers of equal-size by assuming that $K_B/K_T = 1$ and study the strategy of bargaining high terms in order to have more management control.

6.5.1 Information Impact on the Optimal Timing and Payment

In this section, we study the impact of information asymmetry on the cash payment p_c^{im} and p_c^{im} which is given by equation (6.11) and (6.45), the cash acquisition premium payment λ^{im} and the threshold R^{im} . We release the basic parameter values,

TABLE 6.1: Parameter values.

Parameter		Value
Expected growth rate of the bidder	μ_X	0.035
Expected growth rate of the target	μ_Y	0.02
Volatility of the bidder	σ_X	0.20
Volatility of the target	σ_Y	0.30
Ratio of the firm size	K_B/K_T	1.00
Correlation coefficient	ρ	0.50
Synergy parameter	α	0.80
Per unit merger cost	c	0.01
Coupon rate of the revenue bond	q	0.3.
Discount rate	r	0.06

which we want to test, and fix the others, as in Table 6.1.

[Insert Figure 6.1 here]

In Figure 6.1, an increase in the information parameter ω_B will increase in three models. The mixed-payment model has a comparatively sensitive reaction to the information parameter ω_B . The payment increase in the pure cash-payment model is larger than which in the debt-payment model. The higher correlation coefficient is, the more sensitive the reaction of payment to the information parameter ω_B .

In Figure 6.2, an increase in the information parameter ω_B will increase the cash acquisition premium λ^{im} . Recall that the bidder is underestimated when $\omega_B > 1$. Therefore the bidder is willing to provide a higher λ^{im} when their firm is underestimated. This result follows corollary 1. In the situation $\xi = 0.9$ which is represented as red line, the bidder always pays a positive cash acquisition premium payment λ^{im} no matter the bidder is overestimated or underestimated. The information asymmetry has less impact on λ^{im} when the bidder bargains a high terms ξ and has more impact when the terms ξ is low. The bidder will ask a cash payment from the target in the situation when the bidder is overestimated and the bargain terms is low. In Figure 6.2, λ^{im} is given by proposition 17 and R^{im} is given by Proposition 5. The black, blue and red lines correspond to the following information premium: $\xi = 0.7$, 0.8 and 0.9. According to corollary 2, the higher ω_T is, the easier the inequality (6.32) can be satisfied and the easier it is for the threshold in the imperfect information market to exceed that in the perfect information market. Therefore, R^{im} increases with the information parameter ω_T , as shown in Figure 6.2.

[Insert Figure 6.2 here]

6.5.2 Information Impact on the Payment Premium

In order to further study the impact on the payment. In this section, we study the premium caused by the information.

In the mixed-payment model, the definition of information premium is

$$\Delta\lambda = \lambda^{im} - \lambda^m. \quad (6.54)$$

where λ^{im} is given by (6.18) and λ^m is given by (6.22). $\Delta\lambda$ represents the increment or decrement because of the information asymmetry between the bidder and target.

In the pure cash-payment and debt-payment, the premium is denoted as $\Delta p_i = p_i^{im} - p_i^m, i = c, e$. Only the information parameter ω_B impacts the payment. Figure 6.3 shows the relationship between the information premium and ω_B . An increase in the information parameter ω_B will increase the information premium in three models.

[Insert Figure 6.3 here]

Figure 6.4 represent the information premium $\Delta\lambda$ when the bidder is underestimated and Figure 6.5 represent the information premium $\Delta\lambda$ when the bidder is overestimated. We assuming the post-merger terms $\zeta = 0.8$. In Figure 6.4, the black, blue and red lines correspond to the following information premium: $\omega_B = 2, 1.5$ and 1.2 . In Figure 6.5, the black, blue and red lines correspond to the following information premium: $\omega_B = 0.8, 0.6$ and 0.4 . $\Delta\lambda > 0$ means the bidder is willing to pay more because of the information asymmetry, and vice versa. Figure 6.4 and Figure 6.5 also follow corollary 1 as the result that the bidder will provide a higher λ^{im} when their firm is underestimated a lower λ^{im} when their firm is overestimated.

[Insert Figures 6.4 and 6.5 here]

In Figure 6.4, the black line above the other two lines represents the situation $\omega_B = 2$ which is also higher than other two information parameters set-up. It indicates that the bidder is more likely to pay a higher cash acquisition premium in order to decrease the threshold R^{im} (which is provided in Proposition ??), and thereafter, accelerate the merger process. As a result, the bidder is more willing to disclose the underestimated information.

Given a constant ω_B , the growth rate μ_X increases the information premium and the growth rate μ_Y decreases the information premium, as shown in Figure 6.4. The higher the growth rate of the bidder is, the more cash acquisition premium it will pay to accelerate the merger process, and therefore, accelerate the disclosure of the information. The volatility also increases the information premium in Figure 6.4. In Figure 3.4, the acquisition premium decreases with the volatility of both firms. As in Figure 6.4, the decrement of the acquisition premium when the bidder is underestimated is smaller than that with perfect information. The acquisition premium is less sensitive to the volatility when the bidder is underestimated. In Figure 3.4, the acquisition premium with perfect information increases with the correlation coefficient ρ . Figure 6.4 shows a decrease in information premium with an increase in the correlation coefficient ρ . The acquisition premium is less sensitive to ρ when the bidder is underestimated. Comparing Figure 6.4 and Figure 6.5, we find that the information has great impact when the bidder is overestimated.

6.5.3 Information Impact on the Abnormal Return

Figure 6.7 represents the abnormal return for the bidder. The bidder receives a positive abnormal return when the target firm is overestimated and receives a negative abnormal return when the target firm is underestimated. The abnormal return in the pure cash-payment model is the most sensitive to the information parameter ω_T .

[Insert Figure 6.6 here]

Figure 6.7 plots the abnormal returns as a function of the information parameters ω_B and ω_T , given as (6.52) and (6.53). The black and blue lines represent the

abnormal return of the bidder and target, respectively. We first test the abnormal return change with the information parameter ω_T , assuming $\omega_B = 1.5$ and $\omega_B = 0.5$, meaning that the bidder is under- or over-estimated. We then test the abnormal return change with the information parameter ω_B , assuming $\omega_T = 1.5$ and $\omega_T = 0.5$. In the figures, the participating firms' abnormal returns can be positive or negative, according to the relationship between ω_B and ω_T . Figure 6.7 shows a different result than that reported in Morellec and Zhdanov [58], in which the abnormal returns to the target shareholders are not always higher than those of the bidder. The abnormal return to the target shareholders, which is given by (6.53), is largely influenced by ω_B and increases with ω_B . The more the bidder is underestimated, the more the abnormal return to the target shareholders. The point of zero abnormal to the target shareholders is around $\omega_B = 1$. The impact of ω_T was observable prior to the merger, and hence, has less impact on the target's abnormal return. The abnormal return to the bidder shareholders, which is given by (6.52), is around zero and less influenced by the information parameter. The abnormal return to the bidder is slightly influenced by ω_T and increases with ω_T when the bidder is overestimated. For the bidder, ω_B was observable before the merger, and thus, has less influence.

[Insert Figure 6.7 here]

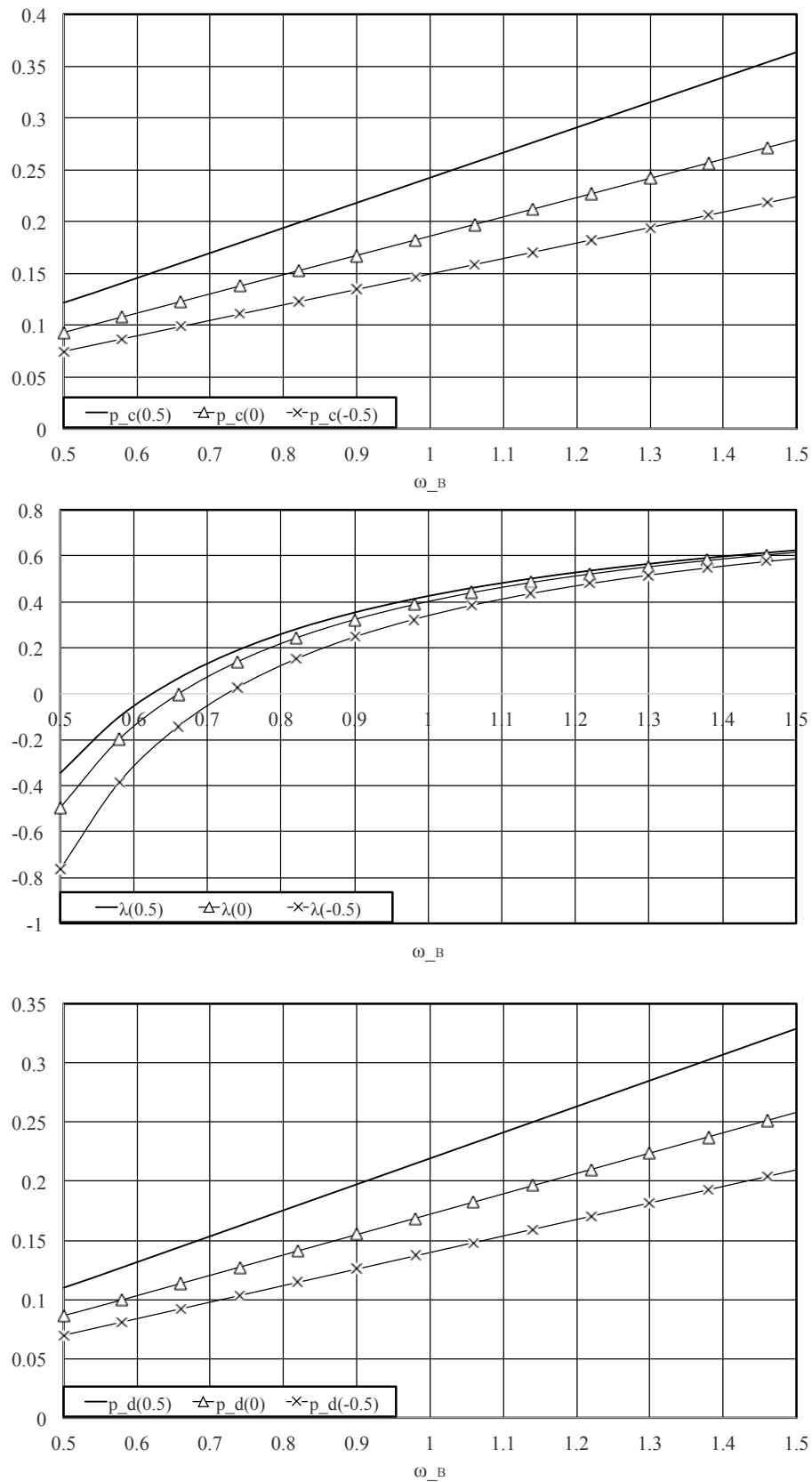


FIGURE 6.1: The impact of the information parameter of the bidder on the optimal payment.

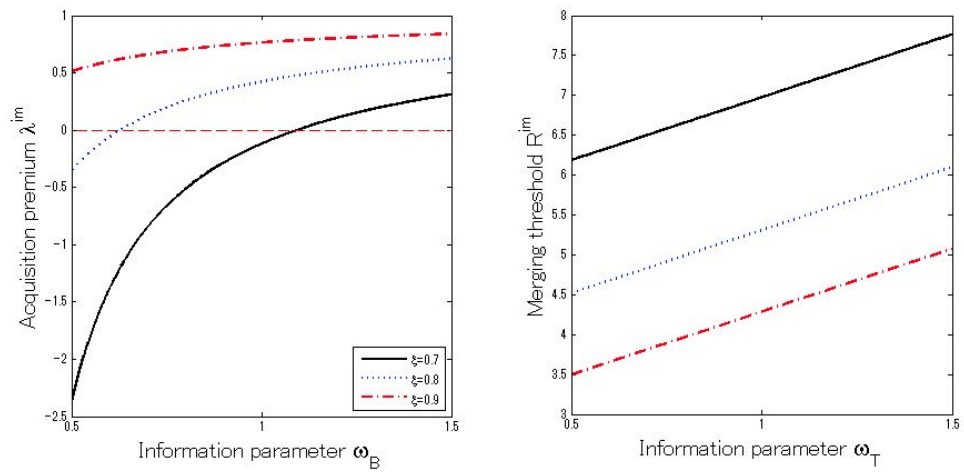


FIGURE 6.2: The impact of information asymmetry on the cash payment portion λ^{im} and the threshold R^{im} under the assumption of $\xi = 0.8$.

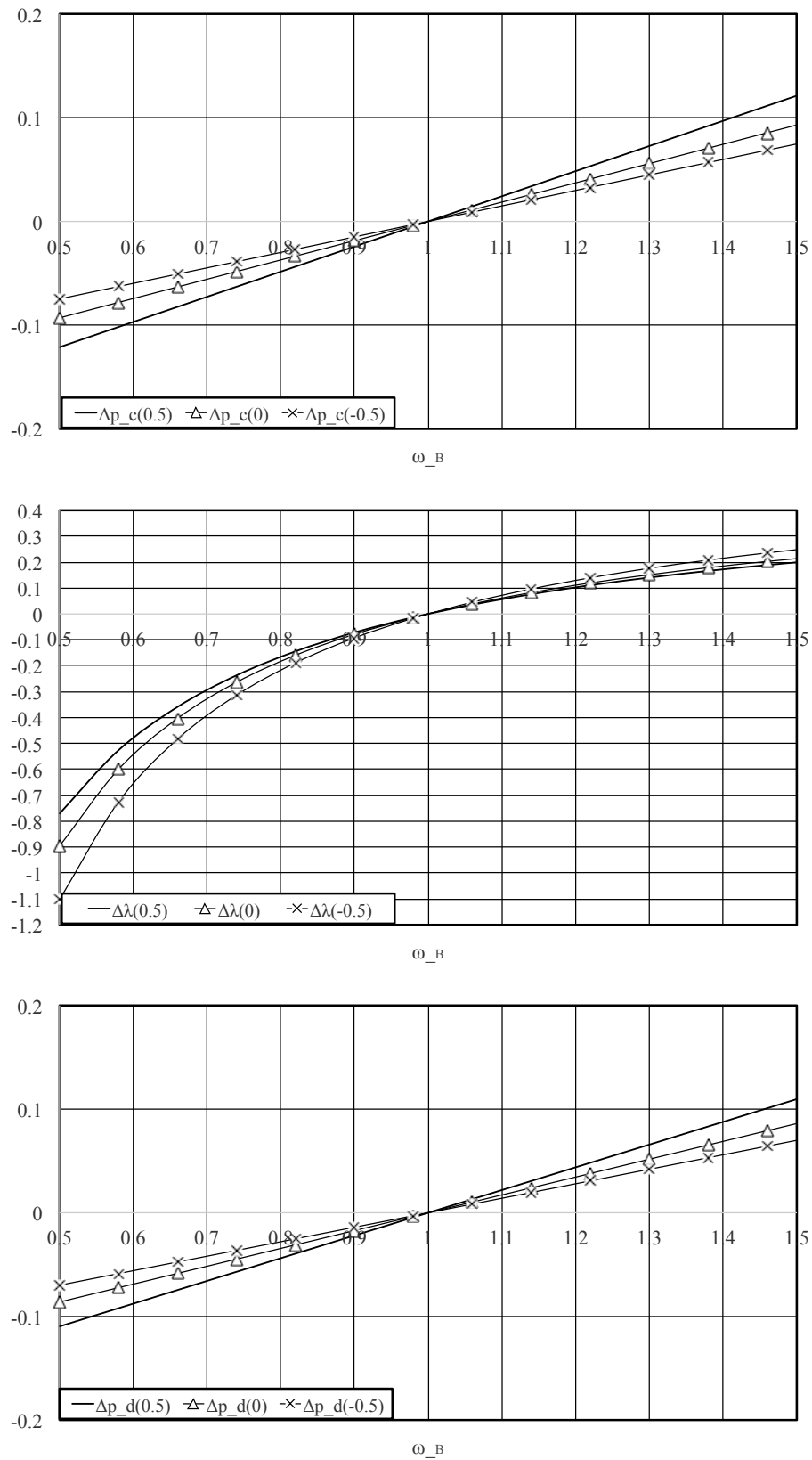


FIGURE 6.3: The impact of the information parameter of the bidder on the payment premium.

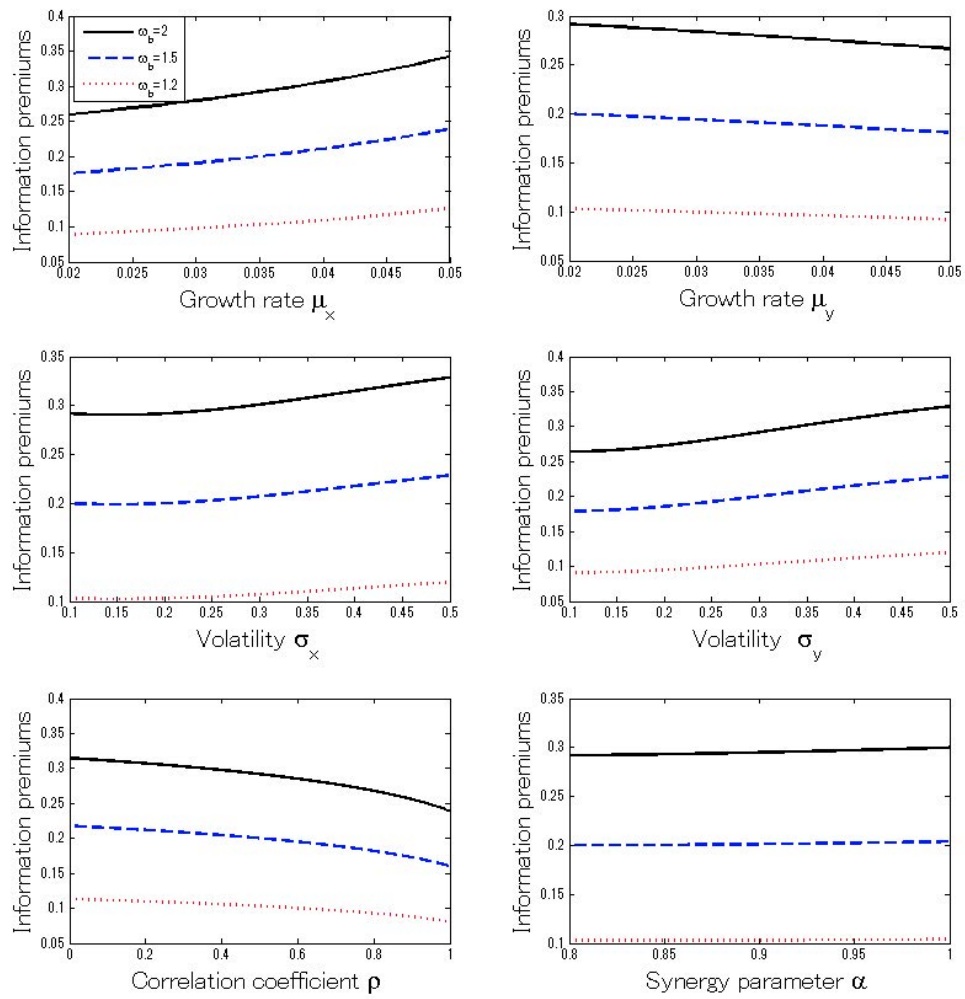


FIGURE 6.4: Information premium when the bidder is underestimated.

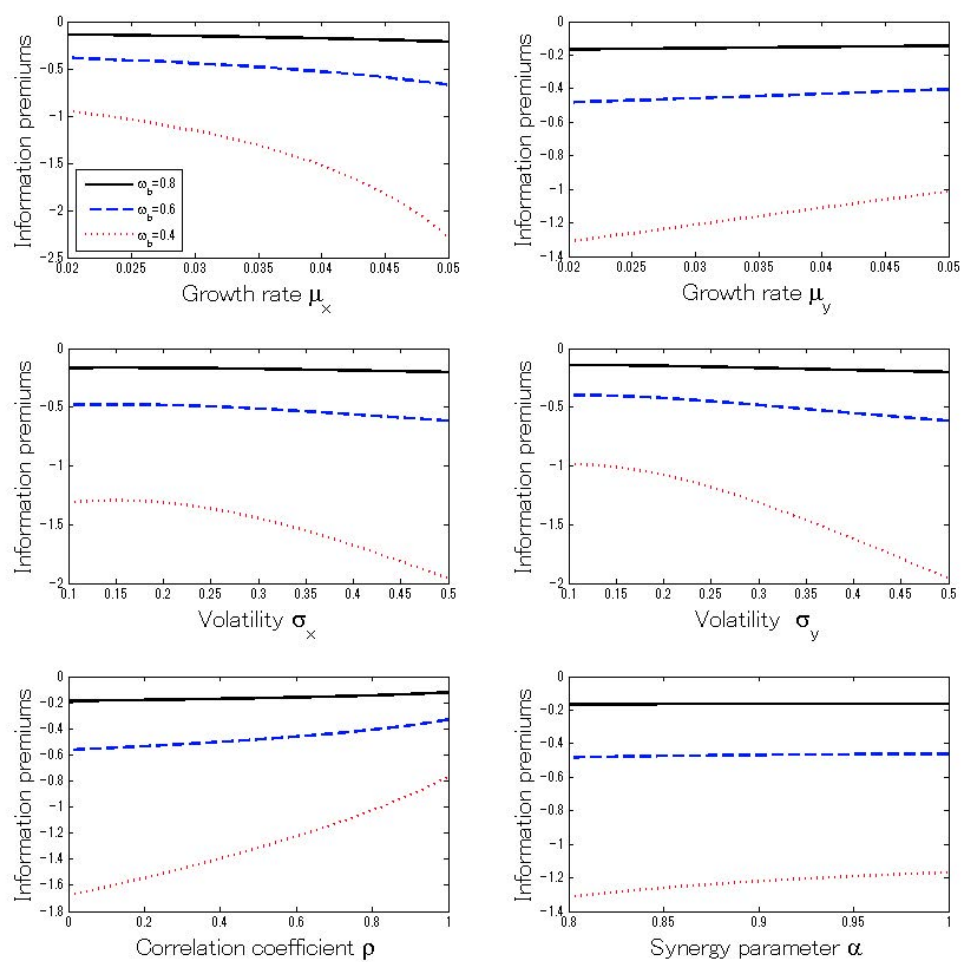


FIGURE 6.5: Information premium when the bidder is overestimated.

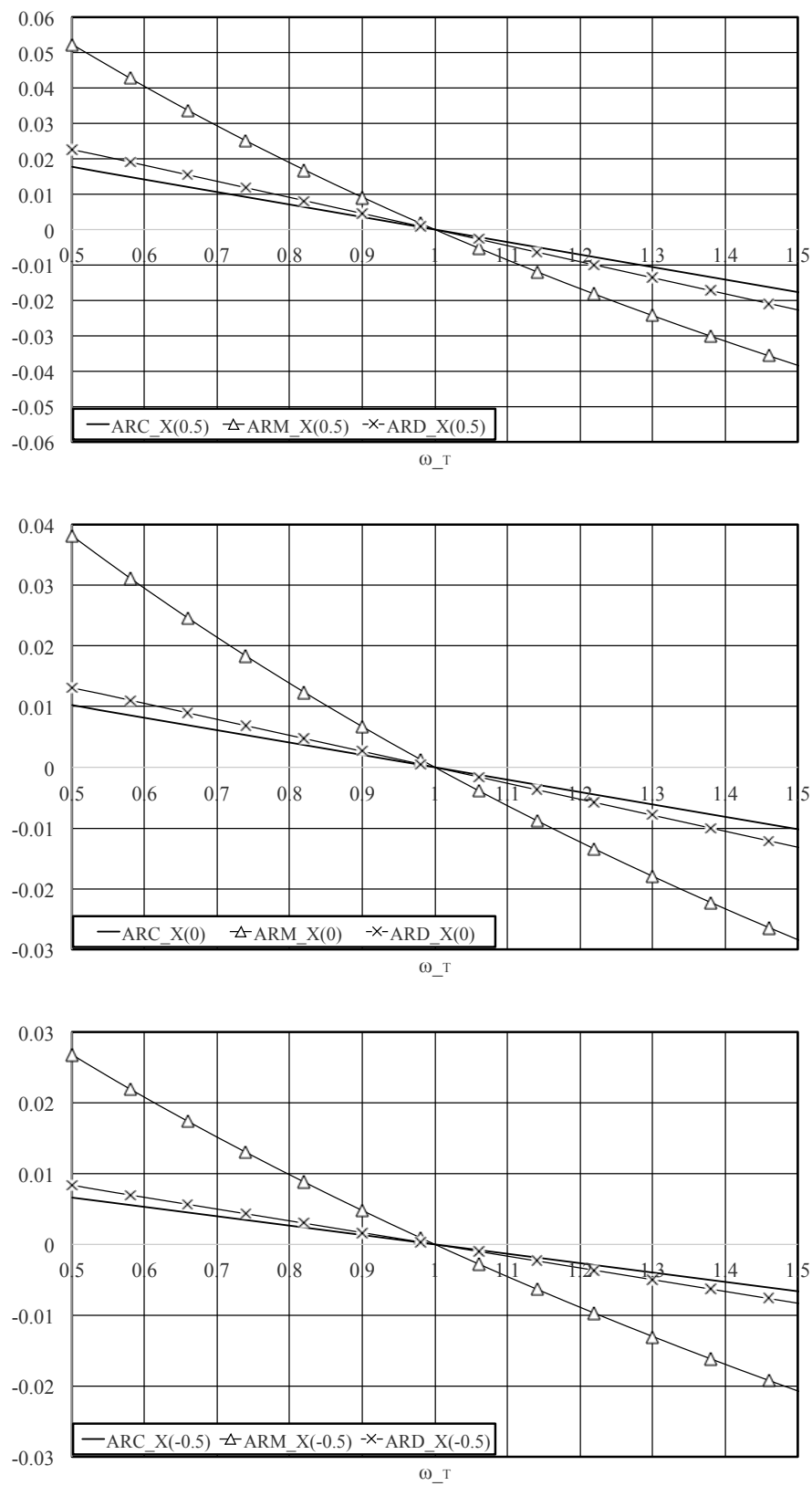


FIGURE 6.6: The impact of the information parameter of the bidder on the abnormal return.

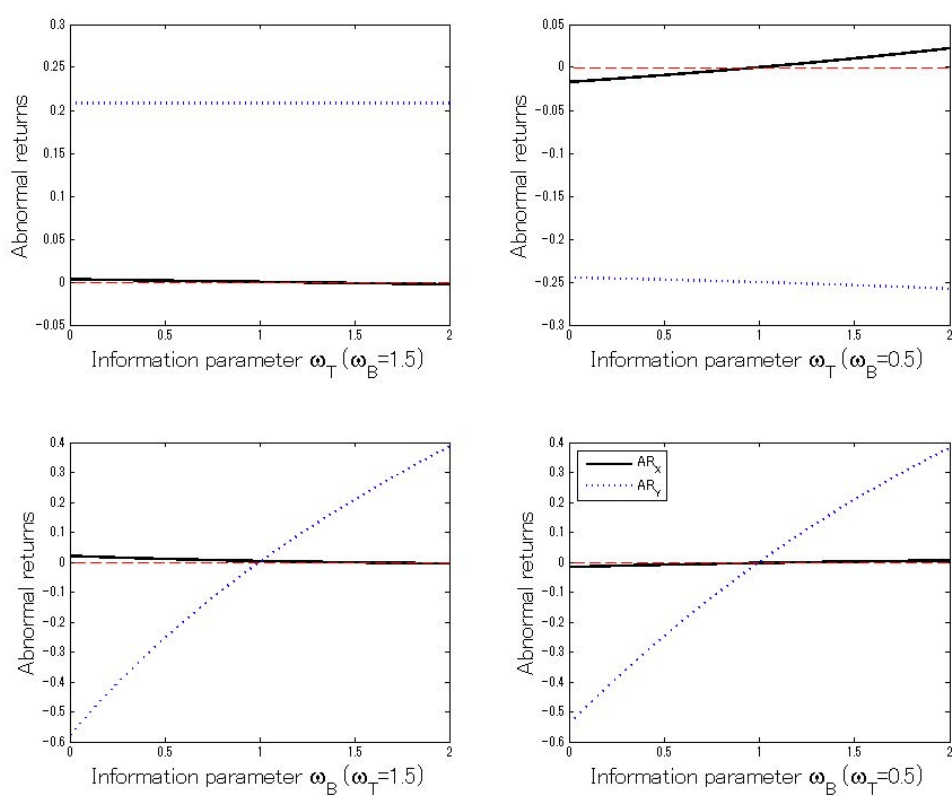


FIGURE 6.7: The effects of information on abnormal returns.

Chapter 7

Conclusion

This dissertation develops dynamic models of joint takeovers to determine the optimal payment strategy and the optimal timing to acquire a target firm. We first establish a pure cash-payment model, which the bidder pays in cash to buy all the shares of the target firm. In Chapter 3, we extend the pure cash-payment model into a mixed-payment model, which both the bidder and target remain shareholders of the new combined enterprise and negotiate over the post-merger terms. In Chapter 4, we develop a model that the enterprise has the option to acquire a new business because of the synergy gains or liquidate the asset and re-allocate the resources (to more productive business). Chapter 5 introduces the model, which determines the optimal timing and price for the mergers, and acquisitions under both equity and debt finance.

7.1 The Pure Cash-payment Model

In the pure cash-payment model, the bidder offers an optimal payment portion to the target firm. The target accepts the offer at a time when their benefits are maximized. The pure cash-payment model predicts that

1. the optimal payment negatively relates to the expected growth rate of the bidder. The bidder will offer a lower payment portion to target firm when the bidder's growth rate is higher;
2. when the volatility of the bidder is high, they will offer a low payment portion;
3. synergy gains will increase the acquisition payment portion offered by the bidder.

7.2 The Mixed-payment Model

In a mixed-payment model, the bidder and the target firm exchange parts of their share and the bidder also pays a cash premium payment to the target to gain high post-merger management control. The transaction, therefore, consists a share-payment and a cash-payment. The mixed-payment model differs from previous studies in several important dimensions. The three main contributions of this study are as follows. First, we consider a cash premium, which Morellec and Zhdanov [58] does not include. We establish the model using a non-cooperative game in which the bidder provides a tender offer, and the target can either accept the offer or wait. The study is also closely related to Lukas and Welling [47], who develop a two-stage model analyzing the pricing and timing of mergers and acquisitions.

Second, we analyze the terms, assuming that the bidder and target will negotiate the terms of the merged enterprise, which we solve via a Nash bargaining solution (Nash [61]). Several studies combine game theory and real options theory. Azevedo and Paxson [6] discuss the discrete- and continuous-time frameworks of a standard real options game and review two decades of academic research on standard and non-standard real options games. Lukas, Reuer and Welling [46] use a game-theoretic option approach to model the value of contingent earn-outs, finding that the firm will tend to postpone the investment under more significant transaction costs, higher uncertainty in cash flows, a more extended earn-out period, and more top performance targets.

Finally, we assume that both the bidder and target will probably mis-estimate the price and that the managers of both firms can take advantage of this. In Morellec and Zhdanov [58], asymmetric information occurs between the participating companies and investors. The dissertation analyses the abnormal returns from the announcement. We extend the model by assuming asymmetric information between the two participating firms.

The mixed-payment model predicts that

1. the mixed-payment method will outperform the pure cash-payment method when the growth rate of the bidder is high, the business is low risk or the correlation coefficient of the participating company is low because of the diversification of the business of the two firms;
2. in the situation when synergy parameter is high, the bidder needs to pay more under a pure cash-payment method because the bidder expects 100% management control and enjoys all the synergy gain;
3. the execution speed of the mixed-payment method increases and the payoff of the mixed-payment method decreases, compared with the pure cash-payment method. Therefore, the bidders need to find a trade-off between the execution speed benefits and the synergy generated when they choose a mixed-payment method;
4. the abnormal returns to the target's shareholders are negative when the bidder is overestimated and positive when the bidder is underestimated, the abnormal return to the target's shareholders can be higher or lower than those to the bidder's shareholders;
5. if the mis-estimations of per unit market value of capital are in the same direction, the greater is the information distortion is and the slower the merger process will be.
6. a higher acquisition premium will accelerate the merger process;
7. an undervalued bidder will accelerate the merger process and an underestimated target will decelerate the merger process.

7.3 The Expansion and contraction Offer

Lambrecht and Myers [41] generally divides mergers and acquisitions into two broad categories: one is in order to gain the synergies and growth opportunities; and another is to seek greater efficiency through layoffs, consolidation and disinvestment.

The expansion and contraction offer combines both two types of mergers and acquisitions which are defined in Lambrecht and Myers [41].

We develop a model that the enterprise has the option to acquire a new business because of the synergy gains or liquidate the asset and re-allocate the resources (to more productive business). Our synergy assumption is based on Hackbarth and Morellec [30]. And we extend this assumption to that the acquiring firm will be an bidder if they better perform than the target firm and then generates a positive synergy, and the target firm will be the bidder if the target firm is the better performer. In the second situation, the synergy will be positive under the management of the target firm.

The main contributions of this study are as follows. First, we develop two basic models to determine the optimal price to acquire a company and the optimal price to sell the asset to another company. The execution process is close to Lukas and Welling [47] and Lukas, Reuer and Welling [46], who develop two-stage models analyzing the price and timing of mergers and acquisitions. Second, we establish the model of the optimal timing to start an offer to acquire a target or to sell the asset according to the market value of both participating firms.

The model considers the expansion offer, which is motivated by the synergy gains, and the contraction offer which is motivated by an efficiency liquidation. The acquiring firm can choose to acquire the target firm when the ratio of per unit capital price increases, and choose to sell the asset to the target firm when the ratio decrease. The target firm decides the optimal timing to accept the offer according to the payment offered. The model predicts that

1. the acquiring firm will be more willing to acquire and expand the business than to sell the asset when the growth rate of business of the acquiring firm is high because of a high the synergy gains, and be more willing to sell the asset to the target than to expand the business when the growth rate of the target firm is high because the benefit from an efficiency liquidation is high;
2. the expansion process is longer than the contraction process when the participating firms are high risky;
3. both the expansion process and the contraction process is lengthened with the growth rate of the buy-side firm, and shortened with the growth rate of the sell-side firm.
4. the acquiring firm will delay the decision on both expansion and liquidation when their volatility is high.

7.4 The Equity and Debt Finance Takeover

The equity and debt finance model determines the optimal timing and price for the mergers and acquisitions under both equity and debt finance. The main contributions of this study are as follows. First, this dissertation develops models of joint takeovers to determine the timing, acquisitions payment using different finance methods. The model considers an equity finance takeover, which assumes that the bidder uses parts of their capital to buy the target. And then extend to a debt finance takeover, which assumes that the bidder issues a revenue bond secured only by the revenues generated from the target and also pays a cash payment using parts of their capital. Second, we compare the equity finance model with the debt finance model and reveal the impact of the debt payment on the strategic decisions.

In Chapter 5, we assume that the bidder uses parts of their capital to buy the target. And then we extend the model to a debt finance takeover, which assumes that the bidder issues a revenue bond secured only by the revenues generated from the target and also pays a cash payment using parts of their capital.

We compare the debt finance model with the equity finance model to test the impact of the debt. The model predicts that

1. the execution speed of the debt finance model is faster than which of the equity finance model, which equivalently means the debt issues will accelerate the decision for the target to sell their shares to the bidder,
2. the execution speed difference between two finance methods increases with the expected growth rate of the bidder and decreases with the expected growth rate of the target;
3. the execution speed of the debt finance method is much faster than which of the equity finance method when the participating firms are highly risky;
4. the leverage ratio will accelerate the execution process;
5. The default threshold increases if the firm size of the target increase. The merged firm is easy to default if the target is a large-size company because the bidder should pay a higher acquisition payment.

7.5 Future Work

With the development of the financial products, the payment of the mergers and acquisitions transactions will become much more complicated. The results of this dissertation also provide a strong foundation for future work in expanding other financial products into the model to diversify the payment method and reduce the risk in the mergers and acquisitions process. One area of future work is in combining the crypto currency with other traditional securities because crypto currency can be considered as a global payment method. Another area of future work is to examine the competition in the process to study how the payment method will impact the competition results.

Appendix A

Appendix of the Pure Cash-payment Model

A.1 Proof of Proposition 1

According to *Itô's Lemma*, the option value, $OMC(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOMC(X_t, Y_t) = & \mu_X X_t OMC_X(X_t, Y_t) + \mu_Y Y_t OMC_Y(X_t, Y_t) \\ & + \frac{1}{2} \sigma_X^2 X_t^2 OMC_{XX}(X_t, Y_t) + \frac{1}{2} \sigma_Y^2 Y_t^2 OMC_{YY}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OMC_{XY}(X_t, Y_t). \end{aligned} \quad (A.1)$$

Because $OMC(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t . We set the ratio of per unit capital of the bidder and target as

$$R_t = \frac{X_t}{Y_t}. \quad (A.2)$$

Therefore we rewrite the option function as

$$OMC(X_t, Y_t) = \max_{\tau} \mathbb{E} \left\{ e^{-r\tau} Y_{\tau} \left[p K_B R_{\tau} - K_T \right] \right\}. \quad (A.3)$$

According to (A.3), the payoff function increases with the ration R_t . When the ratio reaches a certain threshold R_c , target firm will obtain the offer and sell their shares. Accordingly, we assume,

$$OMC(X_t, Y_t) = Y_t g^c(R_t). \quad (A.4)$$

The successive differentiation equations of $OMC(X_t, Y_t)$ give

$$OMC(X_t, Y_t) = g_R^c(R_t), \quad (A.5)$$

$$OMC_Y(X_t, Y_t) = g^c(R_t) - R_t g_R^c(R_t), \quad (A.6)$$

$$OMC_{XX}(X_t, Y_t) = g_{RR}^c(R_t) / Y_t, \quad (A.7)$$

$$OMC_{YY}(X_t, Y_t) = R_t^2 g_{RR}^c(R_t) / Y_t, \quad (A.8)$$

$$OMC_{XY}(X_t, Y_t) = -R_t g_{RR}^c(R_t) / Y_t. \quad (A.9)$$

Substituting the successive differentiation equations above into the partial differential equation (A.1) yields the ordinary differential equation,

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y\right) R^2 g_{RR}^c(R_t) + (\mu_X - \mu_Y) R g_R^c(R_t) - (r - \mu_Y) g^c(R_t) = 0. \quad (\text{A.10})$$

Suppose a general solution $g^c(R_t) = AR_t^{\vartheta_1} + CR_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g_t^c = 0$, the solution of (A.10) is

$$g^c(R_t) = AR_t^{\vartheta_1}, \quad \vartheta_1 > 1. \quad (\text{A.11})$$

(A.11) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} A_c R_c^{\vartheta_1} &= pK_B R_c - K_T, \\ \vartheta_1 A_c R_c^{\vartheta_1-1} &= pK_B. \end{aligned} \quad (\text{A.12})$$

Solving the equations above yields the results

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B} \frac{1}{p}, \quad (\text{A.13})$$

$$A_c = (pK_B R_c - K_T) (R_c)^{-\vartheta_1}. \quad (\text{A.14})$$

A.2 Proof of Proposition 2

Submitting the results of Proposition 1 into the optimisation function (2.10) is given by

$$OTC(X_t, Y_t) = \max_p \left\{ Y_t \left[K_T \left(\alpha R_c - \alpha - c + 1 \right) - pK_B R_c \right] \left(\frac{R_t}{R_c} \right)^{\vartheta_1} \right\}. \quad (\text{A.15})$$

Suppose

$$OTC(X_t, Y_t) = Y_t g^{otc}(R_t), \quad (\text{A.16})$$

where

$$g^{otc}(R_t) = \max_p \left\{ \left[K_T \left(\alpha R_c - \alpha - c + 1 \right) - pK_B R_c \right] \left(\frac{R_t}{R_c} \right)^{\vartheta_1} \right\}. \quad (\text{A.17})$$

Maximizing function (A.17) yields,

$$p_c = \frac{\alpha(\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (\text{A.18})$$

Appendix B

Appendix of the Mixed-payment Model

B.1 Proof of Proposition 3

Substituting the firm's post-merger value given by equation (3.3) into the value of the option for the target, given by (3.5), yields

$$\begin{aligned} OMM(X_t, Y_t) \\ = \max_{\tau} \mathbb{E} \left\{ e^{-r\tau} \left[(1 - \xi) \left(S_B(X_{\tau}) + S_T(Y_{\tau}) + G(X_{\tau}, Y_{\tau}) \right) - (1 - \lambda) K_T Y_{\tau} \right] \right\}, \end{aligned} \quad (\text{B.1})$$

which is in the region for the two state variables. According to *Itô's Lemma*, the payoff function (B.1) satisfies the partial differential equation

$$\begin{aligned} rOMM(X_t, Y_t) &= \mu_X X_t OMM_X(X_t, Y_t) + \mu_Y Y_t OMM_Y(X_t, Y_t) \\ &+ \frac{1}{2} \sigma_X^2 X_t^2 OMM_{XX}(X_t, Y_t) + \frac{1}{2} \sigma_Y^2 Y_t^2 OMM_{YY}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OMM_{XY}(X_t, Y_t). \end{aligned} \quad (\text{B.2})$$

The synergy $G(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t according to assumption (3.4). We can rewrite the synergy equation (3.4) as

$$G(X_t, Y_t) = Y_t g_R^G(R_t), \quad (\text{B.3})$$

where

$$g_R^G(R_t) = K_T [\alpha (R_t - 1) - c]. \quad (\text{B.4})$$

Substituting equations (B.3) and (B.4) into (B.1) yields the payoff function

$$\begin{aligned} OM(X_t, Y_t) \\ = \max_{\tau} \mathbb{E} \left\{ e^{-r\tau} Y_{\tau} \left[(1 - \xi) (K_B + \alpha K_T) R_{\tau} + [(1 - \xi)(1 - \alpha - c) - (1 - \lambda)] K_T \right] \right\}. \end{aligned} \quad (\text{B.5})$$

The payoff function above increases with the ratio R_t . We can assume that when the ratio reaches a certain threshold R_m , the target firm will accept the offer and merge with the bidder. Suppose

$$OM(X_t, Y_t) = Y_t g^{omm}(R_t). \quad (\text{B.6})$$

Successive differentiation equations of (B.6) with respect to R_t give

$$OMM_X(X_t, Y_t) = g_R^{omm}(R_t), \quad (B.7)$$

$$OMM_Y(X_t, Y_t) = g^{omm}(R_t) - R_t g_R^{omm}(R_t), \quad (B.8)$$

$$OMM_{XX}(X_t, Y_t) = g_{RR}^{omm}(R_t) / Y_t, \quad (B.9)$$

$$OMM_{YY}(X_t, Y_t) = R_t^2 g_{RR}^{omm}(R_t) / Y_t, \quad (B.10)$$

$$OMM_{XY}(X_t, Y_t) = -R_t g_{RR}^{omm}(R_t) / Y_t. \quad (B.11)$$

Substituting equations (B.7) - (B.11) into (B.2) yields the ordinary differential equation

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^{omm}(R_t) + (\mu_X - \mu_Y) R g_R^{omm}(R_t) - (r - \mu_Y) g^{omm}(R_t) = 0. \quad (B.12)$$

Suppose the general solution of (B.12) is $g^{omm}(R_t) = A_m R_t^{\vartheta_1} + C_m R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g^{omm}(R_t) = 0$, we have the solution

$$g^{omm}(R_t) = A_m R_t^{\vartheta_1}, \vartheta_1 > 1. \quad (B.13)$$

We can solve $g^{omm}(R_t)$ subject to the value-matching and smoothing-pasting conditions

$$g^{omm}(R_t)|_{t=\tau_m} = g^G(R_t)|_{t=\tau_m}, \quad (B.14)$$

$$g_R^{omm}(R_t)|_{t=\tau_m} = g_R^G(R_t)|_{t=\tau_m}. \quad (B.15)$$

The target will accept the offer at τ_m and $R_t = R_m$ at τ_m . Substituting equations (B.5) and (B.13) into (B.14)-(B.15) yields

$$\begin{aligned} A_m (R_m)^{\vartheta_1} &= (1 - \xi)(K_B + \alpha K_T) R_m + [(1 - \xi)(1 - \alpha - c) - (1 - \lambda)] K_T, \\ \vartheta_1 A_m (R_m)^{\vartheta_1 - 1} &= (1 - \xi)(K_B + \alpha K_T). \end{aligned} \quad (B.16)$$

Solving the equations above yields

$$R_m(\lambda) = \left[(\alpha + c - 1) + \frac{1 - \lambda}{1 - \xi} \right] \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B + \alpha K_T}, \quad (B.17)$$

$$A_m = \frac{(1 - \xi)(\alpha + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T (R_m(\lambda))^{-\vartheta_1}. \quad (B.18)$$

Because $R_m(\lambda)$ is positive, the following inequality is satisfied,

$$\lambda < (\alpha + c)(1 - \xi) + \xi. \quad (B.19)$$

Substituting the results above into (B.13) yields

$$g^{omm}(R_t) = \frac{(1 - \xi)(\alpha + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T \left(\frac{R_t}{R_m(\lambda)} \right)^{\vartheta_1}. \quad (B.20)$$

Therefore,

$$OMM(X_t, Y_t) = Y_t \left(\frac{(1 - \xi)(\alpha + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T \right) \left(\frac{R_t}{R_m(\lambda)} \right)^{\vartheta_1}, \quad (\text{B.21})$$

where $R_t = X_t/Y_t$.

B.2 Proof of proposition 4

Submitting the result of Proposition 3 into the optimization function (3.9), we have

$$\begin{aligned} & OTM(X_t, Y_t) \\ &= \max_{\lambda} Y_t \left\{ \left[\left((\xi - 1)K_B + \xi\alpha K_T \right) R_m(\lambda) + \left(\xi(1 - \alpha - c) - \lambda \right) K_T \right] \left(\frac{R_t}{R_m(\lambda)} \right)^{\vartheta_1} \right\}. \end{aligned} \quad (\text{B.22})$$

The value function (B.22) is linearly homogeneous in X_t and Y_t ; thus, we assume

$$OTM(X_t, Y_t) = Y_t g^{otm}(R_t), \quad (\text{B.23})$$

where

$$\begin{aligned} & g^{otm}(R_t) \\ &= \max_{\lambda} \left\{ \left[\left((\xi - 1)K_B + \xi\alpha K_T \right) R_m(\lambda) + \left(\xi(1 - \alpha - c) - \lambda \right) K_T \right] \left(\frac{R_t}{R_m(\lambda)} \right)^{\vartheta_1} \right\}. \end{aligned} \quad (\text{B.24})$$

We can solve the optimization problem when

$$\frac{dg^{otm}(R_t)}{d\lambda} = 0. \quad (\text{B.25})$$

The result of condition (B.25) is

$$\lambda_m(\xi) = (\alpha + c)(1 - \xi) + \xi + \frac{\vartheta_1(\alpha + c)(1 - \xi)(K_B + \alpha K_T)}{(1 - \xi)K_B - \alpha(\vartheta_1 + \xi - 1)K_T}. \quad (\text{B.26})$$

Therefore,

$$R_m(\xi) = \frac{\vartheta_1^2}{\vartheta_1 - 1} \frac{(\alpha + c)K_T}{\alpha(\vartheta_1 + \xi - 1)K_T - (1 - \xi)K_B}. \quad (\text{B.27})$$

B.3 Proof of proposition 5

We can solve the maximization problem (3.12) when the terms satisfies

$$\beta \frac{dOTM(X_t, Y_t; \xi)}{d\xi} + (1 - \beta) \frac{OTM(X_t, Y_t; \xi)}{OMM(X_t, Y_t; \xi)} \frac{dOMM(X_t, Y_t; \xi)}{d\xi} = 0. \quad (\text{B.28})$$

According to equations (B.6) and (B.23), we can rewrite equation (B.28) as

$$\beta \frac{dg^{otm}(R_t; \xi)}{d\xi} + (1 - \beta) \frac{g^{otm}(R_t; \xi)}{g^{omm}(R_t; \xi)} \frac{dg^{omm}(R_t; \xi)}{d\xi} = 0. \quad (\text{B.29})$$

Substituting the optimal acquisition premium λ_m , given by (3.10), and the threshold (3.11) into the payoff function (B.24), yields

$$g^{otm}(R_t; \xi) = \frac{(\alpha + c)K_T}{\vartheta_1 - 1} \left(\frac{R_t}{R_m(\lambda_m; \xi)} \right)^{\vartheta_1}. \quad (\text{B.30})$$

The first-order derivative of equation (B.30) with respect to ξ is

$$\frac{dg^{otm}(R_t; \xi)}{d\xi} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{(\alpha + c)K_T(\alpha K_T + K_B)}{\alpha(\vartheta_1 + \xi - 1)K_T - (1 - \xi)K_B} \left(\frac{R_t}{R_m(\lambda_m; \xi)} \right)^{\vartheta_1}. \quad (\text{B.31})$$

Substituting (3.10) into (B.20) yields

$$g^{omm}(R_t; \xi) = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{(1 - \xi)(\alpha + c)(K_B + \alpha K_T)K_T}{\alpha\vartheta_1 K_T - (1 - \xi)(K_B + \alpha K_T)} \left(\frac{R_t}{R_m(\lambda_m; \xi)} \right)^{\vartheta_1}. \quad (\text{B.32})$$

The first-order derivative of equation (B.32) with respect to ξ is

$$\begin{aligned} & \frac{dg^{omm}(R_t; \xi)}{d\xi} \\ &= \frac{\vartheta_1^2}{\vartheta_1 - 1} \frac{(\alpha + c)((1 - \xi)(K_B + \alpha K_T) - \alpha K_T)(K_B + \alpha K_T)K_T}{[\alpha\vartheta_1 K_T - (1 - \xi)(K_B + \alpha K_T)]^2} \left(\frac{R_t}{R_m(\lambda_m; \xi)} \right)^{\vartheta_1}. \end{aligned} \quad (\text{B.33})$$

Substituting equations (B.30) - (B.33) into (B.29) gives

$$1 - \xi = \frac{(1 - \beta)\alpha K_T}{K_B + \alpha K_T}. \quad (\text{B.34})$$

Appendix C

Appendix of the Expand-sell Model

C.1 Proof of Proposition 6

According to *Itô's Lemma*, the option value, $OM^B(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOM^B(X_t, Y_t) = & \mu_X X_t OM_X^B(X_t, Y_t) + \mu_Y Y_t OM_Y^B(X_t, Y_t) + \frac{1}{2} \sigma_X^2 X_t^2 OM_{XX}^B(X_t, Y_t) \\ & + \frac{1}{2} \sigma_Y^2 Y_t^2 OM_{YY}^B(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OM_{XY}^B(X_t, Y_t). \end{aligned} \quad (C.1)$$

Because $OM^B(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t . We set the ratio of per unit capital of the bidder and target as

$$R_t = \frac{X_t}{Y_t}. \quad (C.2)$$

Therefore we rewrite the option function as

$$OM^B(X_t, Y_t) = \max_{\tau^B} \mathbb{E} \left\{ e^{-r\tau} Y_{\tau^B} \left[p_B K_B R_{\tau^B} - K_T \right] \right\}. \quad (C.3)$$

According to (C.3), the payoff function increases with the ratio R_t . When the ratio reaches a certain threshold R^c , target firm will obtain the offer and sell their shares. Accordingly, we assume,

$$OM^B(X_t, Y_t) = Y_t g^B(R_t). \quad (C.4)$$

The successive differentiation equations of $OM(X, Y)$ give

$$OM^B(X_t, Y_t) = g_R^B(R_t), \quad (C.5)$$

$$OM_Y^B(X_t, Y_t) = g^B(R_t) - R_t g_R^B(R_t), \quad (C.6)$$

$$OM_{XX}^B(X_t, Y_t) = g_{RR}^B(R_t) / Y, \quad (C.7)$$

$$OM_{YY}^B(X_t, Y_t) = R_t^2 g_{RR}^B(R_t) / Y, \quad (C.8)$$

$$OM_{XY}^B(X_t, Y_t) = -R_t g_{RR}^B(R_t) / Y. \quad (C.9)$$

Substituting the successive differentiation equations above into the partial differential equation (C.3) yields the ordinary differential equation,

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y \right) R^2 g_{RR}^B(R_t) + (\mu_X - \mu_Y) R g_R^B(R_t) - (r - \mu_Y) g^B(R_t) = 0. \quad (\text{C.10})$$

Suppose a general solution $g^B(R_t) = A_B R_t^{\vartheta_1} + C_B R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g_t^B = 0$, the solution of (C.10) is

$$g^B(R_t) = A_B R_t^{\vartheta_1}, \quad \vartheta_1 > 1. \quad (\text{C.11})$$

(C.11) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} A_B R_{\tau^B}^{\vartheta_1} &= p_B K_B R_{\tau^B} - K_T, \\ \vartheta_1 A_B R_{\tau^B}^{\vartheta_1-1} &= p_B K_B. \end{aligned} \quad (\text{C.12})$$

Solving the simultaneous equations above yields the results

$$R_{\tau^B} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B p_B}, \quad (\text{C.13})$$

$$A_B = (p_B K_B R_{\tau^B} - K_T) (R_{\tau^B})^{-\vartheta_1}. \quad (\text{C.14})$$

C.2 Proof of Proposition 7

Submitting the results of Proposition 6 into the optimization function (4.11) is given by

$$OT^B(X_t, Y_t) = \max_{p_B} \left\{ Y_t \left[K_T \left(\alpha_B R_{\tau^B} - \alpha_B - c + 1 \right) - p_B K_B R_{\tau^B} \right] \left(\frac{R_t}{R_{\tau^B}} \right)^{\vartheta_1} \right\}. \quad (\text{C.15})$$

Suppose

$$OT^B(X_t, Y_t) = Y_t g^{otc}(R_t), \quad (\text{C.16})$$

where

$$g^{otc}(R_t) = \max_{p_B} \left\{ \left[K_T \left(\alpha_B R_{\tau^B} - \alpha_B - c + 1 \right) - p_B K_B R_{\tau^B} \right] \left(\frac{R_t}{R_{\tau^B}} \right)^{\vartheta_1} \right\}. \quad (\text{C.17})$$

Maximizing function (C.17) yields,

$$p_B = \frac{(1 - \alpha_T - c_T) + \vartheta_2}{(1 - \vartheta_2)(1 - \alpha_T - c_T) + \vartheta_2} \frac{\alpha_T K_B}{K_T}. \quad (\text{C.18})$$

C.3 Proof of Proposition 8

According to *Itô's Lemma*, the option value, $OM^T(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOM^T(X_t, Y_t) = & \mu_X X_t OM_X^T(X_t, Y_t) + \mu_Y Y_t OM_Y^T(X_t, Y_t) + \frac{1}{2} \sigma_X^2 X_t^2 OM_{XX}^T(X_t, Y_t) \\ & + \frac{1}{2} \sigma_Y^2 Y_t^2 OM_{YY}^T(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OM_{XY}^T(X_t, Y_t). \end{aligned} \quad (C.19)$$

Because $OM^T(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t . We rewrite the option function as

$$OM^T(X_t, Y_t) = \max_{\tau^B} \mathbb{E} \left\{ e^{-r\tau^T} Y_{\tau^B} \left[K_B \left(\alpha_T - (\alpha_T + c_T - 1) R_{\tau^T} \right) - p_T K_T \right] \right\}. \quad (C.20)$$

According to (C.20), the payoff function decrease with the ration R_t . When the ratio reaches a certain threshold R^T , firm T will obtain the offer and buy firm B's shares. Accordingly, we assume,

$$OM^T(X_t, Y_t) = Y_t g^T(R_t). \quad (C.21)$$

The successive differentiation equations of $OM(X, Y)$ give

$$OM^T(X_t, Y_t) = g_R^T(R_t), \quad (C.22)$$

$$OM_Y^T(X_t, Y_t) = g^T(R_t) - R_t g_R^T(R_t), \quad (C.23)$$

$$OM_{XX}^T(X_t, Y_t) = g_{RR}^T(R_t) / Y, \quad (C.24)$$

$$OM_{YY}^T(X_t, Y_t) = R_t^2 g_{RR}^T(R_t) / Y, \quad (C.25)$$

$$OM_{XY}^T(X_t, Y_t) = -R_t g_{RR}^T(R_t) / Y. \quad (C.26)$$

Substituting the successive differentiation equations above into the partial differential equation (C.20) yields the ordinary differential equation,

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^T(R_t) + (\mu_X - \mu_Y) R g_R^T(R_t) - (r - \mu_Y) g^T(R_t) = 0. \quad (C.27)$$

Suppose a general solution $g^T(R_t) = A_T R_t^{\vartheta_1} + C_T R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow \infty} g_t^T = 0$, the solution of (C.27) is

$$g^T(R_t) = C_T R_t^{\vartheta_2}, \quad \vartheta_2 < 0. \quad (C.28)$$

(C.28) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} C_T R_{\tau^T}^{\vartheta_2} &= K_B \left(\alpha_T - (\alpha_T + c_T - 1) R_{\tau^T} \right) - p_T K_T, \\ \vartheta_2 C_T R_{\tau^T}^{\vartheta_2 - 1} &= -K_B (\alpha_T + c_T - 1). \end{aligned} \quad (C.29)$$

Solving the simultaneous equations above yields the results

$$R_{\tau^T} = \frac{\vartheta_2}{-1\vartheta_2(1 - \alpha_T - c_T)K_B'} \frac{p_T K_T - \alpha_T K_B}{-1\vartheta_2(1 - \alpha_T - c_T)K_B'} \quad (\text{C.30})$$

$$C_T = \left[\left(\alpha_T - (\alpha_T + c_T - 1)R_{\tau^T} \right) K_B - p_T K_T \right] (R_{\tau^T})^{-\vartheta_2}. \quad (\text{C.31})$$

C.4 Proof of Proposition 9

Submitting the results of Proposition 8 into the optimization function (4.18) is given by

$$OT^T(X_t, Y_t) = \max_{p_T} \left\{ Y_t \left[p_T K_T - K_B R_{\tau^T} \right] \left(\frac{R_t}{R_{\tau^T}} \right)^{\vartheta_2} \right\}. \quad (\text{C.32})$$

Suppose

$$OT^T(X_t, Y_t) = Y_t g^{ott}(R_t), \quad (\text{C.33})$$

where

$$g^{ott}(R_t) = \max_{p_T} \left\{ \left[p_T K_T - K_B R_{\tau^T} \right] \left(\frac{R_t}{R_{\tau^T}} \right)^{\vartheta_2} \right\}. \quad (\text{C.34})$$

Maximizing function (C.34) yields,

$$p_T = \frac{(1 - \alpha_T - c_T) + \vartheta_2}{(1 - \vartheta_2)(1 - \alpha_T - c_T) + \vartheta_2} \frac{\alpha_T K_B}{K_T}. \quad (\text{C.35})$$

C.5 Proof of Proposition 10

According to *Itô's Lemma*, the option value, $OB(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOB(X_t, Y_t) &= \mu_X X_t OB_X(X_t, Y_t) + \mu_Y Y_t OB_Y(X_t, Y_t) \\ &+ \frac{1}{2} \sigma_X^2 X_t^2 OB_{XX}(X_t, Y_t) + \frac{1}{2} \sigma_Y^2 Y_t^2 OB_{YY}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OB_{XY}(X_t, Y_t). \end{aligned} \quad (\text{C.36})$$

$OB(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$OB(X_t, Y_t) = Y_t g^{ob}(R_t), \quad (\text{C.37})$$

where $g^{ob}(R_t)$ satisfies the ordinary differential equation,

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^{ob}(R_t) + (\mu_X - \mu_Y) R g_R^{ob}(R_t) - (r - \mu_Y) g^{ob}(R_t) = 0. \quad (\text{C.38})$$

Suppose a general solution

$$g^{ob}(R_t) = F R_t^{\vartheta_1} + H R_t^{\vartheta_2}, \quad (\text{C.39})$$

where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). The option OB combines the value of the real option to sell the asset to the opposite and the real option to buy opposite's assets. The threshold to sell and buy denote as $\underline{\tau}$ and $\bar{\tau}$, which can be determined using the value-matching and smooth-pasting conditions:

$$g^{ob}(R_{\underline{\tau}}) = g^{ott}(R_{\underline{\tau}}) + (1 - \underline{c})K_B R_{\underline{\tau}}, \quad (\text{C.40})$$

$$g^{ob}(R_{\bar{\tau}}) = g^{otb}(R_{\bar{\tau}}) + (1 - \bar{c})K_B R_{\bar{\tau}}, \quad (\text{C.41})$$

$$g_R^{ob}(R_{\underline{\tau}}) = g_R^{ott}(R_{\underline{\tau}}) + (1 - \underline{c})K_B, \quad (\text{C.42})$$

$$g_R^{ob}(R_{\bar{\tau}}) = g_R^{otb}(R_{\bar{\tau}}) + (1 - \bar{c})K_B. \quad (\text{C.43})$$

where $g^{ott}(R_t)$ and $g^{otb}(R_t)$ is given in Appendices C.2 and C.4. Solving the simultaneous equations above yields Proposition 10.

Appendix D

Appendix of the Debt-payment Model

D.1 Proof of Proposition 11

According to *Itô's Lemma*, the option value, $OMC(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOMC(X_t, Y_t) = & \mu_X X_t OMC_X(X_t, Y_t) + \mu_Y Y_t OMC_Y(X_t, Y_t) + \frac{1}{2} \sigma_X^2 X_t^2 OMC_{XX}(X_t, Y_t) \\ & + \frac{1}{2} \sigma_Y^2 Y_t^2 OMC_{YY}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OMC_{XY}(X_t, Y_t). \end{aligned} \quad (D.1)$$

Because $OMC(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t . We set the ratio of per unit capital of the bidder and target as

$$R_t = \frac{X_t}{Y_t}. \quad (D.2)$$

Therefore we rewrite the option function as

$$OMC(X_t, Y_t) = \max_{\tau_c} \mathbb{E} \left\{ e^{-r\tau} Y_{\tau_c} \left[p K_B R_c - K_T \right] \right\}. \quad (D.3)$$

According to (D.3), the payoff function increases with the ration R_t . When the ratio reaches a certain threshold R_c , target firm will obtain the offer and sell their shares. Accordingly, we assume,

$$OMC(X_t, Y_t) = Y_t g^c(R_t). \quad (D.4)$$

The successive differentiation equations of $OMC(X, Y)$ give

$$OMC_X(X_t, Y_t) = g_R^c(R_t), \quad (D.5)$$

$$OMC_Y(X_t, Y_t) = g^c(R_t) - R_t g_R^c(R_t), \quad (D.6)$$

$$OMC_{XX}(X_t, Y_t) = g_{RR}^c(R_t)/Y, \quad (D.7)$$

$$OMC_{YY}(X_t, Y_t) = R_t^2 g_{RR}^c(R_t)/Y, \quad (D.8)$$

$$OMC_{XY}(X_t, Y_t) = -R_t g_{RR}^c(R_t)/Y. \quad (D.9)$$

Substituting the successive differentiation equations above into the partial differential equation (D.3) yields the ordinary differential equation,

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y\right) R^2 g_{RR}^c(R_t) + (\mu_X - \mu_Y) R g_R^c(R_t) - (r - \mu_Y) g^c(R_t) = 0. \quad (\text{D.10})$$

Suppose a general solution $g^c(R_t) = A_c R_t^{\vartheta_1} + C_c R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g_t^c = 0$, the solution of (D.10) is

$$g^c(R_t) = A_c R_t^{\vartheta_1}, \quad \vartheta_1 > 1. \quad (\text{D.11})$$

(D.11) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} A_c R_c^{\vartheta_1} &= p K_B R_c - K_T, \\ \vartheta_1 A_c R_c^{\vartheta_1-1} &= p K_B. \end{aligned} \quad (\text{D.12})$$

Solving the equations above yields the results

$$R_c = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B} \frac{1}{p}, \quad (\text{D.13})$$

$$A_c = (p K_B R_c - K_T) (R_c)^{-\vartheta_1}. \quad (\text{D.14})$$

D.2 Proof of Proposition 12

Submitting the results of Proposition 11 into the optimization function (5.9) is given by

$$OTC(X_t, Y_t) = \max_p \left\{ Y_t \left[K_T \left(\alpha R_c - \alpha - c + 1 \right) - p K_B R_c \right] \left(\frac{R_t}{R_c} \right)^{\vartheta_1} \right\}. \quad (\text{D.15})$$

Suppose

$$OTC(X_t, Y_t) = Y_t g^{otc}(R_t), \quad (\text{D.16})$$

where

$$g^{otc}(R_t) = \max_p \left\{ \left[K_T \left(\alpha R_c - \alpha - c + 1 \right) - p K_B R_c \right] \left(\frac{R_t}{R_c} \right)^{\vartheta_1} \right\}. \quad (\text{D.17})$$

Maximizing function (D.17) yields,

$$p_c = \frac{\alpha(\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (\text{D.18})$$

D.3 Proof of Proposition 13

According to *Itô's Lemma*, the option value, $OMD(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOMD(X_t, Y_t) = & \mu_X X_t OMD_X(X_t, Y_t) + \mu_Y Y_t OMD_Y(X_t, Y_t) + \frac{1}{2} \sigma_X^2 X_t^2 OMD_{XX}(X_t, Y_t) \\ & + \frac{1}{2} \sigma_Y^2 Y_t^2 OMD_{YY}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OMD_{XY}(X_t, Y_t). \end{aligned} \quad (D.19)$$

Because $OMD(X_t, Y_t)$ is also linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$OMD(X_t, Y_t) = \max_{\tau_e} \mathbb{E} \left[\mathbb{E}^{-r\tau_e} Y_{\tau_e} (pK_B R_{\tau_e} + qK_T - K_T) \right]. \quad (D.20)$$

According to (D.20), the payoff function increases with the ration R_t . When the ratio reaches a certain threshold R_e , target firm will obtain the offer and sell their shares. Accordingly, we assume,

$$OMD(X_t, Y_t) = Y_t g^d(R_t). \quad (D.21)$$

where $g^d(R_t)$ follows the ordinary differential equation,

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^d(R_t) + (\mu_X - \mu_Y) R g_R^d(R_t) - (r - \mu_Y) g^d(R_t) = 0. \quad (D.22)$$

Suppose a general solution $g^d(R_t) = DR_t^{\vartheta_1} + ER_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g_t^d = 0$, the solution of (D.22) is

$$g^d(R_t) = DR_t^{\vartheta_1}, \quad \vartheta_1 > 1. \quad (D.23)$$

(D.23) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} DR_{\tau_e}^{\vartheta_1} &= pK_B R_c + qK_T - K_T, \\ \vartheta_1 DR_{\tau_e}^{\vartheta_1-1} &= pK_B. \end{aligned} \quad (D.24)$$

Solving the equations above yields the results

$$R_{\tau_e} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{p} \frac{K_T}{K_B}, \quad (D.25)$$

$$D = (pK_B R_{\tau_e} - (1 - q) K_T) (R_{\tau_e})^{-\vartheta_1}. \quad (D.26)$$

D.4 Proof of Proposition 14

Because the value of the ownership of the merged firm $S_M^*(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$S_M^*(X_t, Y_t) = Y_t (K_B R_t + (1 - q)K_T + K_t (\alpha(R_t - 1) - c)) + \max_{\tau_d} \mathbb{E} [\mathbb{E}^{-r\tau_d} Y_{\tau_d} (-K_B R_t - (1 - q)K_T - K_t (\alpha(R_t - 1) - c))] . \quad (\text{D.27})$$

According to (D.27), the merged firm will default when the ratio decrease to a certain threshold R_d . Accordingly, we assume

$$\max_{\tau_d} \mathbb{E} [\mathbb{E}^{-r\tau_d} (-Y_{\tau_d}) (K_B R_t + (1 - q)K_T + K_T (\alpha(R_t - 1) - c))] = -Y_t g^d(R_t). \quad (\text{D.28})$$

where $g^d(R_t)$ yields the ordinary differential equation,

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^d(R_t) + (\mu_X - \mu_Y) R g_R^d(R_t) - (r - \mu_Y) g^d(R_t) = 0. \quad (\text{D.29})$$

Suppose a general solution $g^d(R_t) = C_d R_t^{\vartheta_1} + A_d R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow \infty} g_t^d = 0$, the solution of (D.29) is

$$g^d(R_t) = A_d R_t^{\vartheta_2}, \quad \vartheta_2 < 0. \quad (\text{D.30})$$

(D.30) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$A_d R_{\tau_d}^{\vartheta_2} = K_B R_{\tau_d} + (1 - q)K_T + K_T (\alpha(R_{\tau_d} - 1) - c), \quad (\text{D.31})$$

$$\vartheta_2 A_d R_{\tau_d}^{\vartheta_2 - 1} = K_B + \alpha K_T. \quad (\text{D.32})$$

Solving the equations above yields the results

$$R_d = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha + c + q - 1)K_T}{K_B + \alpha K_T}, \quad (\text{D.33})$$

$$A_d = ((K_B + \alpha K_T) R_d - (\alpha + c + q - 1)K_T) (R_{\tau_d})^{-\vartheta_1}. \quad (\text{D.34})$$

Substituting the results (D.33) and (D.34) into (6.40), we have

$$\begin{aligned} OTD(X_t, Y_t) = \max_p \left\{ Y_t \left(\frac{R_t}{R_e} \right)^{\vartheta_1} \left[(\alpha K_T - p K_B) R_e - (\alpha + c + q - 1) K_T \right. \right. \\ \left. \left. - \left((K_B + \alpha K_T) R_d - (\alpha + c + q - 1) K_T \right) \left(\frac{R_e}{R_d} \right)^{\vartheta_2} \right] \right\}. \end{aligned} \quad (\text{D.35})$$

Maximizing (D.35) yields

$$\frac{\vartheta_1 - \vartheta_2}{\vartheta_2 - 1} (\alpha + c + q - 1) \left(\frac{R_e}{R_d} \right)^{\vartheta_2} - \alpha (\vartheta_1 - 1) R_e + \vartheta_1 \left(\alpha + c + \frac{1 - q}{\vartheta_1 - 1} \right) = 0. \quad (\text{D.36})$$

Appendix E

Appendix of the Abnormal Return

E.1 Proof of Proposition 16

Submitting the results of Proposition 15 into the optimisation function (6.10) is given by

$$OTC^{im}(X_t, Y_t) = \max_{p^{im}} \left\{ Y_t \left[K_T \left(\alpha \omega_B R_{\tau^B} - \alpha_B - c + 1 \right) - p_B K_B R_{\tau^B} \right] \left(\frac{R_t}{R_{\tau^B}} \right)^{\vartheta_1} \right\}. \quad (E.1)$$

Suppose

$$OTC^{im}(X_t, Y_t) = Y_t g^{otci}(R_t), \quad (E.2)$$

where

$$g^{otci}(R_t) = \max_{p^{im}} \left\{ \left[K_T \left(\alpha \omega_B R_{\tau^B} - \alpha_B - c + 1 \right) - p_B K_B R_{\tau^B} \right] \left(\frac{R_t}{R_{\tau^B}} \right)^{\vartheta_1} \right\}. \quad (E.3)$$

Maximizing function (E.3) yields,

$$p_c^{im} = \frac{\alpha \omega_B (\vartheta_1 - 1)}{(\alpha + c - 1)(\vartheta_1 - 1) + \vartheta_1} \frac{K_T}{K_B}. \quad (E.4)$$

E.2 Proof of Proposition 17

We can simplify the target firm's value of the option, given by (6.17), as

$$\begin{aligned} & OMM^{im}(X_t, Y_t) \\ &= \max_{\tau^{im}} \mathbb{E} \left\{ e^{-r\tau^{im}} \left[(1 - \xi)(K_B + \alpha K_T) X_{\tau^{im}} + \left((1 - \xi)(1 - \alpha \omega_T - c) - (1 - \lambda) \right) K_T Y_{\tau^{im}} \right] \right\}. \end{aligned} \quad (E.5)$$

Assume $OMM^{im}(X_t, Y_t) = Y_t \tilde{g}^{om}(R_t)$, which satisfies the ordinary differential equation

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R_t^2 \tilde{g}_{RR}^{om}(R_t) + (\mu_X - \mu_Y) R_t \tilde{g}_R^{om}(R_t) - (r - \mu_Y) \tilde{g}^{om}(R_t) = 0. \quad (E.6)$$

Suppose $\tilde{g}^{om}(R_t) = FR_t^{\vartheta_1}$, where ϑ_1 is the positive root of equation (??). We can solve $\tilde{g}^{om}(R_t)$ subject to the value-matching and smoothing-pasting conditions below

$$\begin{aligned} F(R^{im})^{\vartheta_1} &= (1 - \xi)(K_B + \alpha K_T)R^{im} + \left((1 - \xi)(1 - \alpha\omega_T - c) - (1 - \lambda)\right)K_T, \\ \vartheta_1 F(R^{im})^{\vartheta_1 - 1} &= (1 - \xi)(K_B + \alpha K_T). \end{aligned} \quad (E.7)$$

Solving the equations above yields,

$$\begin{aligned} R^{im}(\lambda, \xi) &= \left(\alpha\omega_T + c - 1 + \frac{1 - \lambda}{1 - \xi}\right) \frac{\vartheta_1}{\vartheta_1 - 1} \frac{K_T}{K_B + \alpha K_T}, \\ F &= \frac{(1 - \xi)(\alpha\omega_T + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T (R^{im}(\lambda, \xi))^{-\vartheta_1}. \end{aligned} \quad (E.8)$$

where $R^{im}(\lambda, \xi)$ is positive, the following inequality is satisfied,

$$\lambda < \xi + (\alpha\omega_T + c)(1 - \xi) \quad (E.9)$$

And,

$$\tilde{g}^{om}(R_t) = \frac{(1 - \xi)(\alpha\omega_T + c - 1) + (1 - \lambda)}{\vartheta_1 - 1} K_T \left(\frac{R_t}{R^{im}(\lambda, \xi)}\right)^{\vartheta_1}, \quad (E.10)$$

where $R_t = X_t/Y_t$.

E.3 Proof of proposition 18

Substituting (3.1)-(3.4) into the optimization function (6.21) yields,

$$\begin{aligned} OT^{im}(X_t, Y_t) &= \max_{\lambda^{im}} Y_t \left\{ \left[((\xi - 1)K_B + \xi\alpha\omega_B K_T) R^m(\lambda^{im}, \xi) \right. \right. \\ &\quad \left. \left. + [\xi(1 - \alpha - c) - \lambda^{im}] K_T \right] \left(\frac{R_t}{R^m(\lambda^{im}, \xi)} \right)^{\vartheta_1} \right\}, \end{aligned} \quad (E.11)$$

where $R^m(\lambda^{im}, \xi)$ is given by (3.6). And suppose

$$OT^{im}(X_t, Y_t) = Y_t \tilde{g}^{ot}(R_t), \quad (E.12)$$

where $\tilde{g}^{ot}(R_t)$ is given by

$$\begin{aligned} \tilde{g}^{ot}(R_t) &= \max_{\lambda^{im}} \left\{ \left[((\xi - 1)K_B + \xi\alpha\omega_B K_T) R^m(\lambda^{im}, \xi) \right. \right. \\ &\quad \left. \left. + [\xi(1 - \alpha - c) - \lambda^{im}] K_T \right] \left(\frac{R_t}{R^m(\lambda^{im}, \xi)} \right)^{\vartheta_1} \right\}. \end{aligned} \quad (E.13)$$

The optimization problem is maximised when

$$\frac{d\tilde{g}^{ot}(R_t)}{d\lambda^{im}} = 0. \quad (E.14)$$

Therefore, the optimal offered portion satisfies

$$\begin{aligned}
 (\vartheta_1 - 1) \left((\xi - 1)K_B + \xi\alpha\omega_B K_T \right) \frac{dR^m(\lambda^{im}, \xi)}{d\lambda^{im}} \\
 + \vartheta_1 \left(\xi(1 - \alpha - c)K_T - \lambda^{im}K_T \right) \frac{1}{R^m(\lambda^{im}, \xi)} \frac{dR^m(\lambda^{im}, \xi)}{d\lambda^{im}} + K_T = 0.
 \end{aligned} \tag{E.15}$$

Solving the equation above yields

$$\lambda^{im} = (1 - \xi)(\alpha + c) + \xi + \frac{\vartheta_1(\alpha + c)(1 - \xi)(K_B + \alpha K_T)}{(1 - \xi)K_B - \alpha \left((\vartheta_1 + \xi - 1) + \vartheta_1 \xi(\omega_B - 1) \right) K_T}. \tag{E.16}$$

Substituting the result above into the equation (6.18) gives

$$R^{im} = \frac{\vartheta_1}{\vartheta_1 - 1} \left(\frac{\alpha(\omega_T - 1)K_T}{K_B + \alpha K_T} + \frac{\vartheta_1(\alpha + c)K_T}{\alpha \left((\vartheta_1 + \xi - 1) + \vartheta_1 \xi(\omega_B - 1) \right) K_T - (1 - \xi)K_B} \right). \tag{E.17}$$

E.4 Proof of proposition 19

According to the optimization function (6.24), the optimal terms satisfies

$$\beta \frac{d\tilde{g}^{ot}(R_t; \xi^{im})}{d\xi^{im}} + (1 - \beta) \frac{\tilde{g}^{ot}(R_t; \xi^{im})}{\tilde{g}^{om}(R_t; \xi^{im})} \frac{d\tilde{g}^{om}(R_t; \xi^{im})}{d\xi^{im}} = 0. \tag{E.18}$$

For the bidder firm, ω_T keeps unknown until the merger succeeds. Therefore, they will provide an optimal acquisition premium λ^{im} which is given by (6.22) and estimate that the threshold which the target will accept the offer is (3.6) which is the threshold in a market with perfect information. Substituting (3.6) and (6.22) into (E.13) yields

$$\begin{aligned}
 & \tilde{g}^{ot}(R_t; \xi) \\
 &= \left\{ \left(\xi(K_B + \alpha\omega_B K_T) - K_B \right) R_m(\lambda^{im}, \xi) + \left(\xi(1 - \alpha - c) - \lambda^{im} \right) K_T \right\} \left(\frac{R_t}{R_m(\lambda^{im}, \xi)} \right)^{\vartheta_1}, \\
 &= \frac{(\alpha + c)K_T}{\vartheta_1 - 1} \left(\frac{R_t}{R_m(\lambda^{im}, \xi)} \right)^{\vartheta_1}.
 \end{aligned} \tag{E.19}$$

According to the result of (3.6), $R_m(\lambda^{im}, \xi)$ satisfies

$$\frac{1}{R_m(\lambda^{im}, \xi)} \frac{dR_m(\lambda^{im}, \xi)}{d\xi} = \left(-\frac{d\lambda^{im}}{d\xi} + \frac{1 - \lambda^{im}}{1 - \xi} \right) \frac{1}{(1 - \xi)(\alpha + c - 1) + 1 - \lambda^{im}}. \tag{E.20}$$

The first-order derivative of equation (E.19) with respect to ξ is

$$\begin{aligned} \frac{d\tilde{g}^{ot}(R_t; \xi)}{d\xi} &= -(\alpha + c)K_T \frac{\vartheta_1}{\vartheta_1 - 1} \left(\frac{R_t}{R_m(\lambda^{im}, \xi)} \right)^{\vartheta_1} \frac{1}{R_m(\lambda^{im}, \xi)} \frac{dR_m(\lambda^{im}, \xi)}{d\xi}, \\ &= \frac{\vartheta_1}{\vartheta_1 - 1} \left(\frac{R_t}{R_m(\lambda^{im}, \xi)} \right)^{\vartheta_1} \left(\frac{d\lambda^{im}}{d\xi} - \frac{1 - \lambda^{im}}{1 - \xi} \right) \frac{(\alpha + c)K_T}{(1 - \xi)(\alpha + c - 1) + 1 - \lambda^{im}}. \end{aligned} \quad (\text{E.21})$$

Substituting (E.19) - (E.21) into the optimization function (E.18), we have

$$\begin{aligned} &\frac{\alpha}{\alpha + c} \frac{K_T}{K_B + \alpha K_T} \frac{\omega_B}{1 - \xi} \left((1 - \xi)(\alpha\omega_T + c - 1) + (1 - \lambda^{im}) \right)^2 \\ &= (1 - \xi)(\alpha + c - 1) + (1 - \lambda^{im}) \\ &+ \frac{(1 - \beta)}{\frac{\beta\vartheta_1}{(1 - \xi)(\alpha + c - 1) + (1 - \lambda^{im})} - \frac{(1 - \beta)(1 - \vartheta_1)}{(1 - \xi)(\alpha\omega_T + c - 1) + (1 - \lambda^{im})}}. \end{aligned} \quad (\text{E.22})$$

To simplify the equation, we set

$$\gamma_1 = (1 - \xi)(\alpha + c - 1) + (1 - \lambda^{im}) \quad (\text{E.23})$$

$$\gamma_2 = (1 - \xi)(\alpha\omega_T + c - 1) + (1 - \lambda^{im}) \quad (\text{E.24})$$

Therefore, the optimal terms satisfies

$$\frac{\alpha}{\alpha + c} \frac{K_T}{K_B + \alpha K_T} \frac{\omega_B}{1 - \xi} = \frac{\gamma_1}{\gamma_2^2} + \frac{(1 - \beta)\gamma_1}{\beta\vartheta_1\gamma_2^2 - (1 - \beta)(1 - \vartheta_1)\gamma_1\gamma_2} \quad (\text{E.25})$$

E.5 Proof of Proposition 20

According to *Itô's Lemma*, the option value, $OME^{im}(X_t, Y_t)$, satisfies the partial differential equation

$$\begin{aligned} rOME^{im}(X_t, Y_t) &= \mu_X X_t OME_X^{im}(X_t, Y_t) + \mu_Y Y_t OME_Y^{im}(X_t, Y_t) + \frac{1}{2} \sigma_X^2 X_t^2 OME_{XX}^{im}(X_t, Y_t) \\ &+ \frac{1}{2} \sigma_Y^2 Y_t^2 OME_{YY}^{im}(X_t, Y_t) + \rho \sigma_X \sigma_Y X_t Y_t OME_{XY}^{im}(X_t, Y_t). \end{aligned} \quad (\text{E.26})$$

Because $OME^{im}(X_t, Y_t)$ is also linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$OME^{im}(X_t, Y_t) = \max_{\tau_e^{im}} \mathbb{E} \left[\mathbb{E}^{-r\tau_e^{im}} Y_{\tau_e^{im}} \left(pK_B R_{\tau_e^{im}} + qK_T - K_T \right) \right]. \quad (\text{E.27})$$

According to (E.27), the payoff function increases with the ration R_t . When the ratio reaches a certain threshold R_e^{im} , target firm will obtain the offer and sell their shares. Accordingly, we assume,

$$OME^{im}(X_t, Y_t) = Y_t g^d(R_t). \quad (\text{E.28})$$

where $g^d(R_t)$ follows the ordinary differential equation,

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y\right) R^2 g_{RR}^d(R_t) + (\mu_X - \mu_Y) R g_R^d(R_t) - (r - \mu_Y) g^d(R_t) = 0. \quad (\text{E.29})$$

Suppose a general solution $g^d(R_t) = DR_t^{\vartheta_1} + ER_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow 0} g_t^d = 0$, the solution of (E.29) is

$$g^d(R_t) = DR_t^{\vartheta_1}, \quad \vartheta_1 > 1. \quad (\text{E.30})$$

(E.30) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$\begin{aligned} DR_{\tau_e^{im}}^{\vartheta_1} &= pK_B R_{\tau_e^{im}} + qK_T - K_T, \\ \vartheta_1 DR_{\tau_e^{im}}^{\vartheta_1-1} &= pK_B. \end{aligned} \quad (\text{E.31})$$

Solving the equations above yields the results

$$R_{\tau_e^{im}} = \frac{\vartheta_1}{\vartheta_1 - 1} \frac{1 - q}{p} \frac{K_T}{K_B}, \quad (\text{E.32})$$

$$D = (pK_B R_{\tau_e^{im}} - (1 - q) K_T) (R_{\tau_e^{im}})^{-\vartheta_1}. \quad (\text{E.33})$$

E.6 Proof of Proposition 21

Because the value of the ownership of the merged firm $S_M^{im}(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$\begin{aligned} S_M^{im}(X_t, Y_t) &= Y_t (K_B R_t + (1 - q) K_T + K_T (\alpha(\omega_B R_t - 1) - c)) \\ &\quad + \max_{\tau_d^{im}} \mathbb{E} [\mathbb{E}^{-r\tau_d^{im}} Y_{\tau_d} (-K_B R_t - (1 - q) K_T - K_T (\alpha(\omega_B R_t - 1) - c))]. \end{aligned} \quad (\text{E.34})$$

According to (E.34), the merged firm will default when the ratio decrease to a certain threshold R_d . Accordingly, we assume

$$\max_{\tau_d^{im}} \mathbb{E} [\mathbb{E}^{-r\tau_d^{im}} (-Y_{\tau_d}) (K_B R_t + (1 - q) K_T + K_T (\alpha(R_t - 1) - c))] = -Y_t g^d(R_t). \quad (\text{E.35})$$

where $g^d(R_t)$ yields the ordinary differential equation,

$$\left(\frac{1}{2}\sigma_X^2 + \frac{1}{2}\sigma_Y^2 - \rho\sigma_X\sigma_Y\right) R^2 g_{RR}^d(R_t) + (\mu_X - \mu_Y) R g_R^d(R_t) - (r - \mu_Y) g^d(R_t) = 0. \quad (\text{E.36})$$

Suppose a general solution $g^d(R_t) = C_d R_t^{\vartheta_1} + A_d R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow \infty} g^d(R_t) = 0$, the solution of (E.36) is

$$g^d(R_t) = A_d R_t^{\vartheta_2}, \quad \vartheta_2 < 0. \quad (\text{E.37})$$

(E.37) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$A_d(R_d^{im})^{\vartheta_2} = K_B R_d^{im} + (1 - q)K_T + K_T (\alpha(\omega_B R_d^{im} - 1) - c), \quad (\text{E.38})$$

$$\vartheta_2 A_d(R_d^{im})^{\vartheta_2-1} = K_B + \alpha\omega_B K_T. \quad (\text{E.39})$$

Solving the equations above yields the results

$$R_d^{im} = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha + c + q - 1)K_T}{K_B + \alpha\omega_B K_T}, \quad (\text{E.40})$$

$$A_d = \left((K_B + \alpha\omega_B K_T) R_d^{im} - (\alpha + c + q - 1)K_T \right) (R_d^{im})^{-\vartheta_1}. \quad (\text{E.41})$$

Substituting the results (E.40) and (E.41) into (6.40), we have

$$\begin{aligned} OTE^{im}(X_t, Y_t) = \max_{p^{im}} \left\{ Y_t \left(\frac{R_t}{R_d^{im}} \right)^{\vartheta_1} \left[(\alpha\omega_B K_T - p^{im} K_B) R_{de}^{im} - (\alpha + c + q - 1)K_T \right. \right. \\ \left. \left. - \left((K_B + \alpha\omega_B K_T) R_d^{im} - (\alpha + c + q - 1)K_T \right) \left(\frac{R_{de}^{im}}{R_d^{im}} \right)^{\vartheta_2} \right] \right\}. \end{aligned} \quad (\text{E.42})$$

Maximizing (E.42) yields

$$\frac{\vartheta_1 - \vartheta_2}{\vartheta_2 - 1} (\alpha + c + q - 1) \left(\frac{R_e^{im}}{R_d^{im}} \right)^{\vartheta_2} - \alpha\omega_B (\vartheta_1 - 1) R_e^{im} + \vartheta_1 \left(\alpha + c + \frac{1 - q}{\vartheta_1 - 1} \right) = 0. \quad (\text{E.43})$$

E.7 Proof of Equation 6.48

Because the value of the ownership of the merged firm $S_M^*(X_t, Y_t)$ is linearly homogeneous in X_t and Y_t , we rewrite the option function as

$$\begin{aligned} S_M^*(X_t, Y_t) = Y_t (K_B R_t + (1 - q)K_T + K_T (\alpha(\omega_B R_t - \omega_T) - c)) \\ + \max_{\tau_d^*} \mathbb{E} \left[\mathbb{E}^{-r\tau_d} Y_{\tau_d} (-K_B R_t - (1 - q)K_T - K_T (\alpha(\omega_B R_t - \omega_T) - c)) \right]. \end{aligned} \quad (\text{E.44})$$

According to (E.44), the merged firm will default when the ratio decrease to a certain threshold R_d . Accordingly, we assume

$$\max_{\tau_d^*} \mathbb{E} \left[\mathbb{E}^{-r\tau_d^{im}} (-Y_{\tau_d}) (K_B R_t + (1 - q)K_T + K_T (\alpha(R_t - \omega_T) - c)) \right] = -Y_t g^d(R_t). \quad (\text{E.45})$$

where $g^d(R_t)$ yields the ordinary differential equation,

$$\left(\frac{1}{2} \sigma_X^2 + \frac{1}{2} \sigma_Y^2 - \rho \sigma_X \sigma_Y \right) R^2 g_{RR}^d(R_t) + (\mu_X - \mu_Y) R g_R^d(R_t) - (r - \mu_Y) g^d(R_t) = 0. \quad (\text{E.46})$$

Again, we suppose a general solution $g^d(R_t) = C_d^* R_t^{\vartheta_1} + A_d^* R_t^{\vartheta_2}$, where $\vartheta_1 > 1$ and $\vartheta_2 < 0$ are roots of the quadratic equation of (2.9). As the no-bubble condition $\lim_{R_t \rightarrow \infty} g^d(R_t) = 0$, the solution of (E.46) is

$$g^d(R_t) = A_d^* R_t^{\vartheta_2}, \quad \vartheta_2 < 0. \quad (\text{E.47})$$

(??) can be solved subjecting to the value-matching and smoothing-pasting conditions as

$$A_d^* (R_d^*)^{\vartheta_2} = K_B R_d^* + (1 - q)K_T + K_T \left(\alpha(\omega_B R_d^* - \omega_T) - c \right), \quad (\text{E.48})$$

$$\vartheta_2 A_d^* (R_d^*)^{\vartheta_2 - 1} = K_B + \alpha \omega_B K_T. \quad (\text{E.49})$$

Solving the equations above yields the results

$$R_d^* = \frac{\vartheta_2}{\vartheta_2 - 1} \frac{(\alpha \omega_T + c + q - 1)K_T}{K_B + \alpha \omega_B K_T}, \quad (\text{E.50})$$

$$A_d^* = ((K_B + \alpha \omega_B K_T) R_d^* - (\alpha \omega_T + c + q - 1)K_T) (R_d^*)^{-\vartheta_1}. \quad (\text{E.51})$$

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