The International Journal of
Business and Finance RESEARCH

VOLUME 5 NUMBER 2 2011

CONTENTS

Does Multi-Dimensional Ownership Structure Matter in Firm Performance? A Dynamic Firm's Life Cycle Perspective 1
Chiung-Ju Liang, Ying-Li Lin, Tzu-Tsang Huang

The Long-Term Wealth Effect of Share Repurchases Evidence from Taiwan 21
Tai-Yuan Chen, Lie-Jane Kao, Hsing-Yu Lin

The Liquidity Effect in Option Pricing: An Empirical Analysis 35
Shih-Ping Feng

A Comparison of Non-Price Terms of Lending for Small Business and Farm Loans 45
Raymond Posey, Alan K. Reichert

Long-Run Operating Performance of Preferred Stock Issuers 61
Devrim Yaman

The Capital Asset Pricing Model's Risk-Free Rate 75
Sandip Mukherji

Equity Market Timing and Subsequent Delisting Likelihood 85
Frank D'souza, Harold Fletcher, Octavian Ionici

The Valuation of Reset Options When Underlying Assets Are Autocorrelated 95
Yu-Hong Liu, I-Ming Jiang, Shih-Cheng Lee, Yu-Ting Chen

Implied Index and Option Pricing Errors: Evidence from the Taiwan Option Market 115
Ching-Ping Wang, Hung-Hsi Huang, Chien-Chia Hung

DOES MULTI-DIMENSIONAL OWNERSHIP STRUCTURE MATTER IN FIRM PERFORMANCE? A DYNAMIC FIRM'S LIFE CYCLE PERSPECTIVE

Chiung-Ju Liang, National Taiwan University
Ying-Li Lin, Asia University
Tzu-Tsang Huang, National Taiwan University

ABSTRACT

Prior studies on the relationship between ownership and firm performance have produced mixed results; hence, this paper re-examines the relationship using an unbalanced panel pooled sample of 4,443 observations listed in the emerging Taiwanese market. We adopt a dynamic perspective to explore the persistence of the relationship across the life cycle stages of firms over time. Does the impact of ownership on firm performance vary at different life cycle stages? Does it persist across the stages over time? Our empirical results suggest a potential nonlinear relationship between ownership and performance. Furthermore, evidence shows that the impact of ownership on performance is a function of the life cycle effect, where the impact is more pronounced among mature firms over the same period. However, the case is not the same across different periods. To alleviate a potential simultaneity issue, we lag all measures of ownership structure by one year in the fixed-effect regressions framework of panel data. Overall, this paper contributes to ongoing research by extending the importance of the life cycle stages of firms in assessing the impact of ownership on firm performance over time.

JEL：C31; C33; G34

KEYWORDS：Multi-dimensional ownership structure, Performance, Life-cycle stage, Unbalanced panel, Taiwanese market

INTRODUCTION

The Asian Financial Crisis in 1997, the two largest bankruptcies in US history, Enron in December 2001 and WorldCom in July 2002, and the global financial distress in 2008 all point to the importance of corporate governance. Ownership structure is usually considered one of the core internal mechanisms of corporate governance. Does ownership structure affect firm performance? The relationship between ownership structure and corporate performance has received considerable attention in the finance literature. According to the literature, diffuse ownership places significant power in the hands of managers whose interests are not necessarily consistent with—and may even be detrimental to—the shareholders' wealth maximization principle. To constrain or to mitigate managerial opportunism, shareholders use various corporate governance mechanisms to align the interests of managers with those of the shareholders. One mechanism is giving managers equity stakes in firms. The level of the equity stake in the firm explains the positive or adverse relationship between ownership structure and performance, thus giving rise to the convergence-of-interest hypothesis and the managerial entrenchment hypothesis (Jensen and Meckling, 1976; Jensen and Ruback, 1983).

Following Jensen and Meckling (1976), numerous studies have focused on mitigating the conflict of interest between managers and shareholders. Some studies support the existence of a linear relationship, whereas others endorse a non-monotonic relationship between ownership and performance (Morck et al., 1988; McConnell and Servaes, 1990; Adams and Santos, 2006; McConnell et al., 2008). There is a growing consensus that boards have not been sufficiently efficient in monitoring the management, whereas institutional investors have become increasingly willing to use their ownership rights to pressure managers to act in the best interest of the shareholders.

Previous empirical studies on the nature of the relationship between ownership and performance seem to produce mixed results. To extend prior studies**,** this paper specifically explores the effect of the life cycle of firms on the link between ownership structure and firm performance. We further focus on the role of the dimensions of ownership structure: insider ownership, including the members of the board, managers, and block holders; and institutional investor ownership, including pressure-sensitive and pressure-insensitive investors (Brickley et al., 1988; Almazan et al., 2005; Cornett et al., 2007). Less attention has been given to the impact of ownership on performance across the life cycle of firms. In this paper, we assume not only that the sensitivity of ownership structure to firm performance is likely to vary across firms, but it is also likely to undergo important changes across different life-cycle stages over time. Based on these views, this paper extends previous studies by shedding light on several major topics. We first examine the relationship between ownership and performance in the emerging Taiwanese market. By adopting a dynamic perspective, this study further tests the persistence of the relationship across different stages over time.

The empirical results lead us to confirm a potential nonlinear and positive relationship between ownership structure and firm performance. Interestingly, evidence on ownership mechanism from Taiwanese listed firms shows that given a change in shareholding by insiders, there may be a mutually responsive change in institutional investor ownership or in others. This indicates that an increase in insider ownership increases firm values, whereas a decrease in insider ownership before the turning point may coincide with a simultaneous increase in institutional ownership, filling the gap and maintaining improved performance. Furthermore, evidence shows that the impact of ownership on performance is a function of a firm's life-cycle effect; the impact is more pronounced in mature firms over the same period. However, over time, the impact of ownership on firm performance is also driven by the period effect, implying that the impact is a function not only of the life cycle effect but also of the period effect over more than one period.

Our findings are generally robust in using alternative specifications and econometric techniques. We lag all measures of ownership structure in the fixed-effect regressions framework of panel data to alleviate a potential simultaneity issue, finding the robustness of our main results. This paper potentially contributes to the literature in several aspects. Notably, through dynamic specification, the life-cycle stages of firms play an important role in the relationship between ownership structure and firm performance. In the succeeding sections of this paper, we review the literature, propose the conceptual issues, and develop the hypotheses. We describe the methodology used, including the selection criteria of the sample, the categorization of the life-cycle stages of firms, the construction of variables, and the empirical models. We report the empirical findings and discuss robustness tests. Finally, we conclude the paper and present its implications.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Ownership structure is considered one of the core internal mechanisms of corporate governance; hence, the relationship between ownership structure and performance has been widely debated in the finance literature. Numerous studies, mainly based on the assumption that ownership is exogenous, document a causal relationship between ownership and performance. Some support the existence of a linear relationship (Jensen and Meckling, 1976), whereas others endorse a non-monotonic relationship. For instance, to capture possible nonlinearity, Morck et al. (1988) first apply a piecewise linear regression model and find a significant non-monotonic relationship between managerial ownership and performance. Following Morck et al. (1988), several studies (e.g., Hermalin and Weisbach, 1991; Holderness et al., 1999) demonstrate the low-level positive relationship between performance and insider ownership, and the high-level negative relationship between performance and ownership concentration, implicitly suggesting that the negative effects of concentrated ownership outweigh its beneficial effects. Recently, some studies (e.g., Anderson and Reeb, 2003; Adams and Santos, 2006) have documented the significant cross-sectional relationship between insider share ownership and corporate value. Contrary to the belief that managerial control is purely detrimental, these studies find that it has positive effects on the performance of financial institutions over at least some range. McConnell et al. (2008) first account for the endogeneity of ownership structure and finally find that cross-sectional changes in firm value are characterized by a curvilinear relationship. The results are consistent with a causal interpretation of the empirical relationship between insider ownership and firm value.

Some papers discuss the impact of institutional investor ownership on corporate performance. Pound (1988) proposes three hypotheses on the relationship between the shareholding of institutional investor ownership and corporate performance: the efficient monitoring hypothesis, the conflict of interest hypothesis, and the strategic alignment hypothesis. These hypotheses all suggest a positive or negative effect. Subsequent studies examine the relationship but provide a distinct point of view. McConnell and Servaes (1990) examine the cross-sectional relationship between Tobin's Q and management equity ownership; they find a significant curvilinear relationship for insider ownership and a positive relationship for block holders and institutional investor ownership, consistent with the efficient monitoring hypothesis. In contrast, other studies (e.g., Barnhart and Rosenstein, 1998; Faccio and Lasfer, 2000) find the opposite or show the absence of such significant relationship. Interestingly, Cornett et al. (2007) find a significant relationship between operating cash flow returns and institutional stock ownership. However, this relationship is found only for a subset of institutional investors (i.e., those less likely to have business relationships with the firm).

While the classic principal-agent conflict on dispersed ownership has been debated, empirical evidence reveals that a concentrated ownership structure is more universal (La Porta et al., 1999; Claessens et al., 2000; Yeh and Woidtke, 2005). Using a sample of listed firms in eight East Asian economies, Claessens et al. (2002) show that firm value is enhanced with the cash flow rights of the largest shareholder, consistent with the convergence-of-interest effect. However, there is evidence indicating that high divergence between control rights and cash flow rights, which allows the largest shareholder to control a firm's operations with a relatively small direct stake in its cash flow rights, can discount market valuation, which is consistent with the entrenchment effect (Morck et al., 1988; Lemmon and Lins, 2003; Baek et al., 2004). As a result of concentrated ownership, the main agency problem may turn out to be the principal-principal conflict of interest. This line of research is thus widely argued in the recent literature (Wiwattanakantang, 2001; Durnev and Kim, 2005; Maury, 2006; Villalonga and Amit, 2006).

Generally, the literature review on the relationship between ownership and performance seems to produce mixed results. Plausibly, this stems from the differences in the measurement of variables used (Demsetz and Villalonga, 2001). The previous studies all rely mainly on Tobin's Q or ROA as a measure of firm performance. As for the measure of ownership structure, studies that come after Demsetz and Lehn (1985) focus on insider shareholding, including shares owned by members of the board and of the managers. In contrast, several recent studies (e.g., Almazan et al., 2005; Cornett et al., 2007) suggest that institutional investors are better suited to monitor corporate managers. Moreover, differences in estimation techniques may also provide an explanation for the failure of the extant literature to reach a consensus. Studies that examine the linear or nonlinear relationship between ownership and performance usually apply ordinary least squares. Meanwhile, ownership endogeneity is also addressed by some studies using two-stage least squares or three-stage least squares to a set of simultaneous equations.

Hypotheses Development

Based on previous studies, this paper specifically explores the effect of the life-cycle of firms on the link between ownership structure and firm performance, and sheds light on several major hypotheses. Firms, like products, go through various life-cycle stages: start-up, growth, maturity, and stagnation. Accordingly, a company can be categorized into a corresponding life-cycle stage according to which stage its products are in [Black, 1998 (Fall)]. Previous studies apply the concept of life cycle in the analysis of operating strategy and performance (Smith et al., 1985; Miles et al., 1993; Beldona et al., 1997), and also in related topics (Adizes 1979; Dodge and Robins, 1992). Recent research shows that corporate governance parameters may be linked to strategic thresholds in the life cycle of firms (Filatotchev et al., 2006). More recently, Ramaswamy et al. (2008) study the relationship between firm growth, life-cycle stages, and corporate governance characteristics. The life cycle model suggests that companies move through a predictable sequence of various life cycle stages through their lifetime. Accordingly, each stage can be clearly isolated and is accompanied by a rebalancing in the activities and organizational structures of firms. In this paper, we focus on three stages: growth, maturity, and stagnation. The first hypothesis is as follows:

H1: The ownership structure and the performance of firms are significantly different across their life cycle stages.

Based on the agency theory, the study predicts that ownership concentration positively affects firm performance up to a certain point; thereafter, additional ownership actually reduces performance. This is consistent with the convergence-of-interest effect and the entrenchment effect. The central theme of this paper examines the impact of ownership structure on firm performance across the different life cycle stages of firms. The different stages involve suitable changes in the management of firms. For example, in the growth stage, investment in growth opportunities begins, and therefore strategies are constantly changing. Firms in the stage of maturity, having fully developed their market and their products, are commonly in a stage of moderate sales growth. This argument leads to the following hypothesis:
H2: The positive association between insider ownership and firm performance is more pronounced (mitigated) among firms in the growth (maturity) stage.

In addition to the concentration of insider ownership, this paper examines the impact of institutional ownership. Prior studies document that firm performance increases as institutional ownership grows. Moreover, it is claimed that institutional investor shareholdings are commonly higher in the stage of maturity (e.g., there is a high dividend payout rate), thereby increasing the incentive to monitor the management of firms. We separately examine whether the splits in ownership—the fractions of members of the board and managers, block holders, pressure-insensitive institutional investors, and pressure-sensitive institutional investors—are helpful in testing the ownership–performance relationship across the life cycle of firms.

H3: The impact of institutional ownership on firm performance is more pronounced (mitigated) among firms in the stage of maturity (growth).

H4: The split specifications of ownership structure are significantly associated with the impact of ownership on performance across the life cycle stages of firms.

To extend most of the prior studies, which focus only on one time period, we adopt a dynamic perspective to test the consistency of the impact of ownership on performance across the life cycle stages of firms over time (Beldona et al., 1997). We subdivide the research period into Period 1 (1999–2003) and Period 2 (2004–2008). Assuming no unusual regulatory changes in the firms, the impact of ownership on performance should not change over time. The hypotheses are as follows:

H5: The impact of ownership on performance will persist while firms characterized as a specific stage in period 1 go through the same stage in period 2.

H6: The impact of ownership on performance will persist while firms characterized as a specific stage in period 1 go through the same firms in the same stage in period 2.

DATA AND METHODOLOGY

Sample Selection

The Taiwanese market is a typical example of an Asian emerging economy in which controlling families dominate traditional firms, while high-tech companies increasingly demand for the separation of ownership and control (Yeh et al., 2001). This study concentrates on the case of Taiwan's publicly listed companies from 1999–2008 right before and after the two financial crisis periods over the decade. Financial data are obtained from the Taiwan Economic Journal Databank, a databank similar to COMPUSTAT, and China Credit Information Services, a databank company that collects data on business groups in Taiwan. Other data are collected from company prospectuses and annual reports. We exclude financial institutions because of their unique financial structure and regulatory requirements. We eliminate companies with insufficient data (missing values) and companies not listed before the end of 1999. To mitigate the influence of outlying values, we also trim extreme firm-year observations, dropping the top and bottom 1 percent of the observations (i.e., Tobin's Q value is censored at 1st and 99th percentiles as the cut-off point) for each variable. We end up with an unbalanced panel sample of 641 firms and 4,443 firm-year observations, representing 86.51 percent of the companies listed in the Taiwan Stock Exchange (TSE) in 2009.

Categorization of Life Cycle Stages

While previous academic studies use the life cycle of firms to analyze value relevance, we specifically explore the effect of the life cycle of firms on the relationship between ownership structure and firm performance. According to TSE regulation, a great majority of publicly listed companies have gone through the start-up period. We then categorize them into three stages: growth, maturity, and stagnation. Multiple financial indicators and firm age are used to classify the firm-year observations into one of the three life cycle stages. On average, sales growth, marketing expenditure, and capital expenditure are usually higher in the growth stage, forcing companies to apply more conservative dividend policies to keep more funds. However, in the stages of maturity and stagnation, capital and marketing expenditures gradually decrease along with reduced sales growth rates, enabling companies to pay higher dividends. Based on the discussion above, this study uses the classification method proposed by Anthony and Ramesh (1992) and Black [1998 (Fall)], along with marketing expenditure rates (Liang and Lin, 2008) to determine life cycle stages.

The indicators and measurement of life cycle stages are shown in Table 1. According to the results, we define the growth stage as 0, the stage of maturity as 1, and the stage of stagnation as 2 for the five life cycle stage indicators, respectively. The mean of the life cycle stage indicators for these three stages and the analysis of variance to test the reliability of the life cycle classification method are shown in Table 2.

Table 1: Indicator Description and Measurement of Life-cycle Stages

Indicator Variable	Description	Measurement	Score
Years of firm life (YL)	The growth stage occurs early in the life cycle.	The difference between the current year and the year the business was incorporated	2 if in top 33% 1 if in middle 33% 0 if in bottom 34%
Sales growth rate (SG)	A growth firm usually have higher sales growth rate.	The growth rate of net sales revenue	0 if in top 33% 1 if in middle 33% 2 if in bottom 34%
Dividend payout rate (DP)	A growth firm will likely apply more conservative dividend policies to keep funds.	The cash dividend of common stock divided by accounting earnings before extraordinary items	2 if in top 33% 1 if in middle 34% 0 if in bottom 33%
Capital expenditure rate (CE)	A growth firm will likely invest higher capital expenditure.	The capital expenditure divided by net asset	0 if in top 33% 1 if in middle 34% 2 if in bottom 33%
Marketing expenditure Rate (ME)	A growth firm will likely invest higher marketing expenditure.	The marketing expenses divided by net sales revenue	0 if in top 33% 1 if in middle 34% 2 if in bottom 33%

Note: The categorization of life cycle stages involves five life-cycle descriptors that divide the sample into three stages.

Table 2: The ANOVA-test of Life-cycle Stage's Indicators in Mean (1999-2008)

Indicators	Growth stage	Mature stage	Stagnant stage	ANOVA test
Years of firm life(YL)	19.34	25.20	32.32	***
Sales growth rate(SG)	0.33	0.12	0.03	***
Dividend payout rate(DP)	0.73	1.88	3.29	***
Capital expenditure rate(CE)	0.36	0.24	0.14	***
Marketing expenditure rate(ME)	0.08	0.06	0.03	***

*Note: All indicators variables are defined in Table 1. The figure in each cell is the mean of life-cycle stage indicators for three stages, respectively. Analysis of variance is to test for the reliability of a life-cycle classification method. *, **, *** denote significance at the 10%, 5% and 1% level, respectively.*

Results show that companies in the growth stage have the highest mean sales growth rate, capital expenditure rate, and marketing expenditure rate (significant at 0.33, 0.36, 0.08, respectively), and the lowest dividend payout rate and firm age (0.73 and 19.34, respectively) over the period 1999–2008. Therefore, the categorization of these samples is perfectly in accordance with the characteristics of the three life cycle stages. Based on the aforementioned definition, we calculate the composite score of each sample by adding the five indicator values. We obtain the following composite scores for each stage as follows: growth stage (between 0 and 3), stage of maturity (between 4 and 6), and stage of stagnation (between 7 and 10). In sum, the categorization of life cycle stages involves five life cycle descriptors, dividing the sample into the stages of growth, maturity, and stagnation. Consequently, 907 firm-year observations are in the growth stage, 2,654 are in the stage of maturity, and 882 are in the stage of stagnation.

Definition and Statistics of Variables

Most studies (e.g., Holderness et al., 1999; McConnell and Servaes, 1990; Morck et al., 1988) use Tobin's Q to proxy for firm value, whereas Demsetz (1983) and Demsetz and Lehn (1985) employ profit rate (e.g., ROA and ROE) as a measure of firm performance. Demsetz and Villalonga (2001) and Brown and Caylor (2009) apply both Tobin's Q and profit rate for comparison. Does it matter whether one uses Tobin's Q or profit rate as a measure of firm performance? As a measure of firm performance, each has some defects. The profit rate may not be absolutely accurate in measuring the performance of firms in developing countries where accounting standards are not well established (Wiwattanakantang, 2001), whereas Tobin's Q regressions on ownership are more susceptible to endogeneity problems (Cornett et al., 2007). This study thus uses industry-adjusted ROA (IAROA) to proxy for firm performance. IAROA is defined as a firm's ROA less the average ROA for firms in the same industry according to the TSE's industry classification. The IAROA allows us to examine firm-specific performance regardless of any industry-wide effects that may affect ROA.

The primary multi-dimensional ownership structure variables are collected in the study. As a proxy for ownership concentration, the fraction of shares held by insiders (labeled as INSID) is used. Insiders refer to a group of shareholders who manage the company, such as members of the board and managers (the fraction of shares is labeled as BMO), and block holders (BLOCK) who may not be part of the management team or of the board. We also use insider squares (INSID^2) to test if there is a nonlinear ownership–performance relationship as reported by prior studies. Prior studies claim that an increase in share ownership by insiders gives rise to an increase in firm value up to a certain point; thereafter, firm value declines with further increases in insider share ownership. On the other hand, institutional ownership is measured by the percentage of shares held by institutional investors (INS). Several recent studies further categorize INS into pressure-sensitive and pressure-insensitive investors (Almazan et al., 2005; Cornett et al., 2007). The fractions of shares held by pressure-insensitive and pressure-sensitive institutional investors (INSPRI and INSPRS) are employed. We test whether the type of grouping is useful in examining the ownership–performance relationship across the life cycle stages of firms.

Aside from the abovementioned variables, certain control variables in the model are those that are commonly included in previous studies. Corporate efficiency is associated with firm size; hence, we use the natural logarithm of total assets (NLA) to control for firm size. That firm size and performance are negatively related to each another is possible. To control for firm leverage, liabilities to equity ratio (LER) is used to control for long-term financial structure. Firm leverage accounts for the possibility of lessening agency conflicts through additional monitoring by creditors, which may increase firm performance, whereas the pecking order theory assumes a negative relationship between debt levels and firm performance.

Furthermore, the fraction of seats in the board held by controlling shareholders (SEATR) and the difference between the control rights and the cash-flow rights held by the largest shareholder (VC) measure the entrenchment effect of excessive control rights. Other control variables include R&D (RD), marketing expenditure rate (ME), and asset growth rate (AG). The definitions and statistics of the variables are presented in Table 3.

Table 3: Description of Variables and Summary Statistics (1999-2008)

Variable	Symbol	Variable description	Mean	Max.	Min.	S. D.
Dependent variable :						
Performance	ROA	Return on asset	0.016	0.204	- 0.457	0.040
Performance	IAROA	Industry-adjusted return on asset	0.000	0.182	- 0.478	0.039
Ownership variable :						
Insider ownership concentration	INSID	Fraction of shares held by the members of the	0.416	0.991	0.026	0.160
Board and manager ownership concentration	BMO	Fraction of shares held by the members of the	0.249	0.953	0.001	0.138
Block holder ownership concentration	BLOCK	Fraction of shares held by block holders	0.100	0.700	0.000	0.100
Institutional ownership concentration	INS	Fraction of shares held by institutional investors	0.373	0.999	0.000	0.220
Pressure-insensitive institutional investors ownership	INSPRI	Fraction of shares held by foreign investors, investment companies,	0.089	0.972	0.000	0.133
Pressure-sensitive institutional investors ownership	INSPRS	Fraction of shares held by banks, insurance companies	0.016	0.622	0.000	0.032
Control variable:						
Controlling board- seat ratio	SEATR	Fraction of seats in board held by controlling shareholders	0.641	1.000	0.100	0.213
Deviation of cash flow right	VC	The difference between the control rights and the cash-flow rights held	0.055	0.746	0.000	0.096
Firm size	NLA	Natural logarithm of asset	15.659	20.290	12.584	1.249
Leverage	LER	Liabilities to equity ratio	0.850	32.600	0.010	1.290
Research expenditures rate	RD	Research and development expenditures to sales	0.028	6.287	- 0.082	0.124
Asset growth rate	AG	Asset growth divided by current net asset	0.061	2.228	- 0.281	0.093

Note: This table shows definitions and statistics of the variables. The paper ends up with an unbalanced panel sample of 641 firms for 4,443 firm-year observations listed on the Taiwan Stock Exchange (TSE) during the period 1999–2008. The figure in each cell is the mean, maximum, minimum, and standard deviation of variables, respectively.

While the mean of the dependent variable, ROA**,** is relatively low, mean industry-adjusted ROA is, as expected, nearly zero. The mean insider and institutional ownerships represent 41.63% and 37.35% of the total shares, respectively. Other variables of interest include firm size, debt ratio, R&D, ME, and AG. Using the natural logarithm of total assets, we obtain the mean firm size (15.66). The average debt to equity ratio is close to 85%. Average research expenditure is low at 2.83%, while marketing expenditure represents 6.14% of the net sales. Finally, the mean value of asset growth constitutes 9.35% of the total assets.

Table 4 shows descriptive statistics pertaining to the stages of growth, maturity, and stagnation for 907, 2,654, and 882 observations, respectively, over the period 1999–2008. The table shows that on average, growing firms are smaller than mature and stagnant firms in firm size. Average ROA is not significantly different between mature and stagnant firms, whereas it is lower among growing firms. Mean insider and institutional investor ownerships are more concentrated at the stages of growth and stagnation than at the stage of maturity, indicating that ownership shareholdings first decline and then elevate through the life cycle. The descriptive statistics confirm H1.

To ensure that multicollinearity does not exist in the regressions, we calculate variance inflation factors (VIF) for the selected variables in the models (not reported). The standard specification tests whether the correlations between the explanatory variables exceed 0.9 or the variance inflation factors for any of the variables exceed 10. We do not find that this is the case.

Table 4: Descriptive Statistics for Firms of Life-Cycle Stages (1999-2008)

	Growing firms		**Mature firms**		**Stagnant firms**	
Variable Symbol	Mean	S.D.	Mean	S.D.	Mean	S.D.
IAROA	0.000	0.046	0.001	0.038	0.000	0.033
ROA	0.013	0.047	0.016	0.039	0.015	0.033
INSID	0.438	0.173	0.409	0.159	0.412	0.147
BMO	0.266	0.149	0.247	0.138	0.237	0.124
BLOCK	0.170	0.110	0.160	0.100	0.170	0.100
INS	0.388	0.237	0.359	0.218	0.400	0.203
INSPRI	0.065	0.114	0.086	0.131	0.119	0.152
INSPRS	0.015	0.027	0.017	0.035	0.016	0.027
SEATR	0.614	0.212	0.642	0.215	0.664	0.206
NLA	15.551	1.441	15.557	1.132	16.079	1.285
LER	0.833	1.500	0.850	1.353	0.700	0.500
RD	0.030	0.051	0.030	0.157	0.018	0.030
ME	0.087	0.122	0.061	0.091	0.033	0.041
AG	0.117	0.306	0.089	0.233	0.080	0.294

Note: This table shows the descriptive statistics of growing, mature and stagnant firms during the period 1999–2008. The sub-samples are 907 firm-year observations for the growth stage, 2,654 for the mature stage, and 882 for the stagnant stage. The dependent variable is industry-adjusted return of asset (IAROA). The independent variables are insider (INSID) and institutional ownership (INS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME) and asset growth (AG). All other variables are defined in Table 3. The figure in each cell is the mean (Mean) and standard deviation (S.D.) of variables for growing firms, mature firms, and stagnant firms, respectively.

Model Specification

To assess the relationship between ownership and performance, we first model the pooled least square regressions in the main results and use fixed-effect models to test for robustness. The IAROA is a function of the multi-dimensional ownership structure and various control variables (1). Particularly, we examine the associations across the life cycle stages of firms over the periods 1999–2008, 1999–2003, and 2004–2008. To reassess the impacts, we exploit an interaction between insider ownership and the dummy variables of each of the stages (2). Further, the same specifications with the split of ownership structure are also shown for reference purposes (3). Thus, our main econometric models are presented as follows:

$$Performance = \beta_0 + \beta_1(INSID) + \beta_2(INSID)^2 + \beta_3(INS) + \beta_4(SEATR) + \beta_5(VC) + \beta_6(NLA) + \beta_7(LER)$$

$$+\beta_8(RD)+\beta_9(ME)+\beta_{10}(AG)+\varepsilon \quad (1)$$

$$Performance = \beta_0+\beta_1(INSID)+\beta_2(INSID)^2+\beta_3(INSID)*(Cycle_k)+\beta_4(INS)+\beta_5(SEATR)+\beta_6(VC)+\beta_7(NLA)$$
$$+\beta_8(LER)+\beta_9(RD)+\beta_{10}(ME)+\beta_{11}(AG)+\varepsilon \quad (2)$$

$$Performance = \beta_0+\beta_1(BMO)+\beta_2(BLOCK)+\beta_3(INSPRI)+\beta_4(INSPRS)+\beta_5(SEATR)+\beta_6(VC)+\beta_7(NLA)$$
$$+\beta_8(LER)+\beta_9(RD)+\beta_{10}(ME)+\beta_{11}(AG)+\varepsilon \quad (3)$$

Variable definitions are given in Table 3.

Cycle dummies: $Cycle_k$ k=1,2: $Cycle_1$= 1, for growth stage, otherwise Cycle $_1$=0；

$Cycle_2$= 1, for mature stage, otherwise Cycle $_2$=0.

EMPIRICAL RESULTS

Based on the hypotheses presented Section Hypotheses Development, this section answers the following questions: Does the impact vary at different stages in the life cycle of firms? Does it persist across the stages over time? We provide the main results of the pooled least square regressions. The fixed-effect models of panel data are left for robustness tests.

Impact of Ownership on Firm Value (1999-2008)

In constructing the tests, we consider the potential non-linear relationship between ownership and firm value documented by McConnell and Servaes (1990), among others. The first column of Table 5 reports the results of pooled least square regressions by regressing IAROA on ownership concentrations held by insiders and institutions.

While the coefficient on insider ownership concentration (0.073) is significant at the 1% level and is positively related to firm performance (t-statistic = 4.770), the coefficient on insider ownership squared (-0.059) is significantly and negatively related to firm performance (t-statistic = -3.406). This result is consistent with the causal interpretation by some previous papers, and it may reflect the fact that higher ownership concentrations are linked to higher firm values up to a certain point, after which additional ownership reduces firm performance (i.e., entrenchment effect). An inverted U-shaped non-linear relationship is suggested between insider ownership and firm performance. Ceteris paribus, the turning point is 61.86% and 61.38% for IAROA and ROA, respectively.

The mean shareholding by insiders (41.63%) is under the turning point; hence, higher ownership may be linked to higher firm values, consistent with the convergence-of-interests hypothesis. On the other hand, it is worth noting that institutional investors are increasingly becoming more important in emerging economies. The coefficient on ownership by institutional investors is significant and positive at 0.018, giving these investors a strong incentive to monitor the management, which is consistent with the efficient monitoring hypothesis.

Table 5: Estimates of Panel Pooled Multiple Regressions across Stages (1999~2008)

	All Firms	Growing Firms	Mature Firms	Stagnant Firms
Dependable Variable IAROA				
Independent Variables				
INSID	0.073***	0.051	0.066***	0.087***
	(4.770)	(1.273)	(3.450)	(2.725)
INSID^2	-0.059***	-0.052	-0.041*	-0.088**
	(-3.406)	(-1.189)	(-1.885)	(-2.470)
INS	0.018***	0.019**	0.016***	0.013*
	(5.660)	(2.358)	(3.899)	(2.020)
SEATR	-0.014***	-0.020***	-0.012***	-0.019***
	(-5.215)	(-2.976)	(-3.549)	(-3.385)
VC	-0.043*	-0.030	-0.072**	-0.020
	(-1.942)	(-0.640)	(-2.299)	(-0.409)
NLA	0.002***	0.002	0.002**	0.003***
	(3.430)	(1.287)	(2.569)	(2.887)
LER	-0.040***	-0.004***	-0.003***	-0.013***
	(-8.748)	(-4.209)	(-6.210)	(-6.547)
RD	-0.100**	-0.101***	-0.005	-0.086**
	(-2.260)	(-3.676)	(-1.221)	(-2.396)
ME	-0.026***	-0.030***	-0.017**	-0.108***
	(-4.553)	(-2.724)	(-2.307)	(-4.225)
AG	0.054***	0.061***	0.065***	0.027***
	(26.308)	(13.477)	(22.125)	(7.566)
Observations	4,443	907	2,654	882
Adjusted R-squared	0.310	0.245	0.336	0.264

*Note: $IAROA=\beta_0+\beta_1(INSID)+\beta_2(INSID)^2+\beta_3(INS)+\beta_4(SEATR)+\beta_5(VC)+\beta_6(NLA)+\beta_7(LER)+\beta_8(RD)+\beta_9(ME)+\beta_{10}(AG)+\varepsilon$. This table shows the panel pooled regression estimates of the equation. The model includes the full sample of 641 firms for 4,443 firm-year observations, representing 86.51% of the companies listed on the TSE during the period 1999–2008. The sub-samples are 907 firm-year observations for the growth stage, 2,654 for the mature stage, and 882 for the stagnant stage. The independent variables are insider (INSID) and institutional ownership (INS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME), and asset growth (AG). All other variables are defined in Table 3. The T-statistics are reported in parentheses below the estimate coefficients in each cell; *, **, *** denote significance at the 10%, 5%, and 1% level, respectively.*

The coefficient on deviation of cash flow right (VC) and the fraction of board seats held by controlling shareholders (SEATR) are significantly but only marginally and negatively related to performance, consistent with most prior studies. However, the negative sign of the coefficient on liability to equity (LER), consistent with the pecking order theory, is contrary to our expectations. The coefficient on firm size (NLA) has a significantly positive effect on IAROA, indicating that bigger firms have better performance. Other variables of interest include R&D and AG, showing negative and positive signs, respectively.

Impact of Ownership on Firm Value Across Stages Over the Same Period (1999-2008)

To explore the influence and importance of the life cycle of firms, this study divides the full sample into growing, mature, and stagnant firms. Columns (2)–(4) of Table 5 provide results of the panel pooled regressions across different stages over the period 1999–2008. While insider ownership has positive and statistically significant coefficients for regressions of the mature and stagnant firms (0.066, t =3.451 and 0.087, t =2.725, respectively), the coefficient on growing firms (0.051) is positively but insignificantly related to performance. This indicates that the impacts of insider ownership on performance are stronger from growing through stagnant firms in the life cycle. The insider ownership squared has negative coefficients for firms in each of the stages, but again the coefficient on growing firms is not significant.

To reassess the impacts of insider ownership on performance across the life cycle stages of firms, we exploit an interaction between insider ownership and the dummy variables of each of the stages. In unreported results, we find that the coefficient on the interaction term for growing firms is negative but insignificant, while it is positive and significant at the 5% level for mature firms. These results (i.e., that the positive association between insider ownership and performance is more pronounced in firms in the stage of maturity but not in growing firms) seem to be contrary to H2.

On the other hand, the shareholding of institutional investors has positive and significant coefficients across each of the three stages (0.019, 0.016, and 0.013, respectively). In contrast to insider ownership, the impacts of institutional investors on performance are smaller through the life cycle stages for Taiwanese firms. The results provide evidence that the positive association between institutional ownership and firm performance is more pronounced in growing firms than in mature and stagnant firms, which is inconsistent with H3. Alternatively, we recall that the percentage of ownership by insiders is decreasing, while the percentage of institutional investor ownership is right at the opposite way from growth through the stagnant stage (Table 4). The mean insider ownership of the entire sample firms (41.63%) is lower than the turning point of an inverted U-shaped relation (i.e., approximately 62%); hence, insider ownership is positively related to performance. Interestingly, we thus have reason to believe the evidence on ownership mechanism among Taiwanese listed firms: given a change in shareholding by insiders, there may be a mutually responsive change in institutional ownership or in others. This indicates that an increase in insider ownership gives rise to higher firm values, whereas a decrease in insider ownership before the turning point coincides with a simultaneous increase in institutional ownership, filling the gap and sustaining improved performance.

As for the explanatory power of each of the panel models in Table 5, the adjusted R^2 (31%, 25%, 34%, 26%, respectively) are at reasonable levels for the performance equations of the full sample, growing firms, mature firms, and stagnant firms. Compared with similar studies in the literature, the adjusted R^2 seem to be quite acceptable.

Table 6 reports the same specifications but breaks down insider ownership into the fractions of BMO and BLOCK, and institutional investor ownership into INSPRI and INSPRS institutional investors. We separately examine whether the splits are helpful in testing the ownership–performance relationship across the life cycle stages of firms. The coefficients on the fraction of BMO for all firms (0.035, t-statistic = 7.586) and on BLOCK (0.022, t-statistic = 4.437) are both significant. The coefficient on the fraction of INSPRI (0.022) is significant at the 1% level (t-statistic = 4.683), while the coefficient on the fractions of INSPRS (0.028, t-statistic = 1.675) is significant but only marginally at the 10% level. Consistent with the arguments from prior studies, evidence shows that pressure-sensitive institutions (e.g., banks and insurance companies) having either existing or potential business relations with firms may on the margin be less important to incremental firm performance. On the other hand, for growing, mature, and stagnant firms, the coefficient on the BMO is positive and significant, while the other ownership coefficients are only significant for mature firms.

The findings imply that the split specifications of ownership structure may only be able to lessen the agency costs of managerial entrenchment in the mature stage of firms. We note that partly consistent with H4, the impacts of members of the board and pressure-insensitive institutions (e.g., foreign investors and pension fund advisors) are more pronounced in firms in the mature stage but are different from that of aggregate institutional ownership. The evidence addresses the importance of the life cycle stages in assessing the impact of ownership on firm performance. Clearly, for firms in the growth stage, corporate governance is a regulatory requirement, not a competitive tool. However, such is not the case in mature firms. Mature firms are in the stage of moderate sales growth and declining profit margins; hence, corporate governance is a competitive tool, not a regulatory requirement in the emerging Taiwanese market.

Table 6: Estimates of Panel Pooled Regressions Across Stages-the Split Specifications (1999~2008)

	All firms	**Growing firms**	**Mature firms**	**Stagnant firms**
Dependent V.				
IAROA				
Independent V.：				
BMO	0.034***	0.024**	0.041***	0.015*
	(7.586)	(2.233)	(7.291)	(1.647)
BLOCK	0.022***	-0.001	0.030***	0.015
	(4.437)	(-0.129)	(4.848)	(1.521)
INSPRI	0.022***	0.019	0.026***	0.012
	(4.683)	(1.410)	(4.391)	(1.502)
INSPRS	0.028*	-0.066	0.043**	-0.002
	(1.674)	(-1.295)	(2.264)	(-0.061)
SEATR	-0.011***	-0.021***	-0.008***	-0.018***
	(-4.392)	(-3.03)	(-2.666)	(-3.232)
VC	-0.009	-0.013	-0.013	0.006
	(-1.532)	(-0.972)	(-1.525)	(0.435)
NLA	0.001***	0.002*	0.000	0.003***
	(2.870)	(1.785)	(1.301)	(2.707)
LER	-0.003***	-0.003***	-0.002***	-0.013***
	(-8.563)	(-3.995)	(-5.936)	(-6.944)
RD	-0.011**	-0.114***	-0.006	-0.095**
	(-2.588)	(-4.077)	(-1.54)	(-2.597)
Observations	4,443	907	2,654	882
Adjusted R-squared	0.207	0.244	0.238	0.157

*Note: $IAROA=\beta_0+\beta_1(BMO)+\beta_2(BLOCK)+\beta_3(INSPRI)+\beta_4(INSPRS)+\beta_5(SEATR)+\beta_6(VC)+\beta_7(NLA)+\beta_8(LER)+\beta_9(RD)+\varepsilon$. This table shows the panel pooled regression estimates of the equation. The model includes the full sample of 641 firms for 4,443 firm-year observations, representing 86.51% of the companies listed on the TSE during the period 1999–2008. The sub-samples are 907 firm-year observations for the growth stage, 2,654 for the mature stage, and 882 for the stagnant stage. The dependent variable is industry-adjusted return of asset (IAROA). The independent variables are the board and managers and block holders ownership (BMO and BLOCK), pressure-insensitive and pressure-sensitive institutional ownership (INSPRI and INSPRS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME) and asset growth (AG). All other variables are defined in Table 3. The T-statistics are reported in parentheses below the estimate coefficients in each cell; *, **, *** denote significance at the 10%, 5% and 1% level, respectively.*

Impact of Ownership on Performance across Stages with Different Firms over Time

While most studies in the literature focus only on one time period, we adopt a dynamic perspective to test the consistency of the impact of ownership on performance across life cycle stages over time. We subdivide the full research period into Period 1 (1999–2003) and Period 2 (2004–2008). For example, we consider the possible impact on growing firms over Period 1 and on firms (i.e., they may be different from firms over Period 1) in the same stage over Period 2. In this section, we use IAROA as our dependent variable across periods. Separate results for the purpose of comparison are shown in Table

In Columns 1 and 2, while the estimates on ownership structure are less important to firm performance over Period 1, the coefficients on insider and institutional ownership for the full sample (i.e., all firms) and for firms across the stages are more important in both magnitude and significance over Period 2. Take the mature firms for example. The coefficients on the insiders and institutions ownership (0.025 and 0.003, respectively) are all insignificant over Period 1, whereas those in the same stage over Period 2 show a positive and significant relationship with performance. In light of the differences between periods, we re-estimate the regressions, although not reported, using the split specifications of ownership categories and find that the results are qualitatively similar to those mentioned above. Overall, the impacts of ownership on performance seem to be more mitigated over Period 1 (i.e., exactly in the environment of global financial distress) than over Period 2.

As such, this finding appears to account for the lack of persistence of the impacts of ownership on performance over time, inconsistent with H5. This may imply that the impact of ownership on performance depends mainly on whether there are unusual regulatory changes in firms between periods regardless of whether they are in the growing or stagnant stages.

Table 7: Estimates of Panel Pooled Regressions - across Stages over Time

	All firms		Growing firms		Mature firms		Stagnant firms	
	1999-2003	2004-2008	1999-2003	2004-2008	1999-2003	2004-2008	1999-2003	2004-2008
Dependent V.: IAROA								
Independent V.:								
INSID	0.025	0.088***	-0.010	0.070	0.025	0.091***	0.054	0.056
	(1.308)	(4.150)	(-0.226)	(1.245)	(1.070)	(3.340)	(1.101)	(1.361)
INSID^2	0.008	-0.085**	0.022	-0.070	0.016	-0.079**	-0.019	-0.070
	(0.402)	(-3.595)	(0.420)	(-1.158)	(0.623)	(-2.573)	(-0.328)	(-1.579)
INS	0.002	0.025***	0.007	0.020*	0.003	0.028***	-0.002	0.016*
	(0.616)	(5.625)	(0.805)	(1.737)	(0.67)	(4.986)	(-0.267)	(1.890)
SEATR	-0.020***	-0.011***	-0.008	-0.029***	-0.017***	-0.010**	-0.030***	-0.009
	(-5.628)	(-3.155)	(-1.110)	(-2.842)	(-3.627)	(-2.449)	(-3.87)	(-1.245)
VC	0.022	-0.070**	-0.000	-0.016	0.037	-0.123***	-0.033	0.009
	(0.688)	(-2.487)	(-0.07)	(-0.241)	(0.789)	(-3.046)	(-0.453)	(0.154)
NLA	0.002***	0.001*	0.001	0.001	0.003***	0.000	0.004***	0.002*
	(3.963)	(1.630)	(1.199)	(0.747)	(3.87)	(0.496)	(2.946)	(1.601)
LER	-0.010***	-0.002***	-0.013***	-0.002***	-0.009***	-0.001***	-0.021***	-0.009***
	(-11.969)	(-5.010)	(-6.384)	(-2.624)	(-8.769)	(-3.27)	(-6.961)	(-3.897)
RD	-0.031*	-0.006	-0.096***	-0.122***	0.001	-0.000	-0.046	-0.046
	(-1.705)	(-1.468)	(-3.426)	(-2.753)	(0.0432)	(-0.867)	(-0.596)	(-1.151)
ME	-0.041***	-0.015*	-0.033***	-0.021	-0.061***	-0.005	-0.026	-0.124***
	(-5.767)	(-1.915)	(-3.325)	(-1.075)	(-5.358)	(-0.561)	(-0.646)	(-4.023)
AG	0.030***	0.079***	0.037***	0.084***	0.043***	0.076***	0.012***	0.079***
	(13.867)	(23.403)	(8.596)	(10.840)	(11.848)	(17.88)	(3.504)	(9.511)
Observations	1,683	2,760	353	554	992	1,662	339	543
Adjusted R-squared	0.256	0.239	0.313	0.261	0.304	0.239	0.203	0.251

*Note: $IAROA=\beta_0+\beta_1(INSID)+\beta_2(INSID)^2+\beta_3(INS)+\beta_4(SEATR)+\beta_5(VC)+\beta_6(NLA)+\beta_7(LER)+\beta_8(RD)+\beta_9(ME)+\beta_{10}(AG)+\varepsilon$. This table shows the panel pooled regression estimates of the equation. The dependent variable is industry-adjusted return of asset (IAROA). The independent variables are insider (INSID) and institutional ownership (INS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME) and asset growth (AG). All other variables are defined in Table 3. The model includes the full sample of 641 firms for 4,443 firm-year observations, representing 86.51% of the companies listed on the TSE. The sub-samples are 907 firm-year observations for the growth stage, 2,654 for the mature stage, and 882 for the stagnant stage. The sample is further sub-divided into sub-samples of period 1 (1999-2003) and period 2 (2004-2008), respectively. The T-statistics are reported in parentheses below the estimate coefficients in each cell; *, **, *** denote significance at the 10%, 5% and 1%level, respectively.*

<u>Impact of Ownership on Performance across Stages with the Same Firms over time: A Dynamic Specification</u>

To explore further whether the impact of ownership on performance is driven mainly by the period effect, we adopt another dynamic specification to complement the findings reported above (Table 8).

Assuming there are no unusual regulatory changes in the firms, the impact of ownership on performance persists over time (i.e., the same firms across life cycle stages over the period 1999–2003 and 2004–2008). The results show, for example, that the coefficients on insider and institutional ownership for growing firms are insignificant and significant, respectively, over Period 1. Conversely, those of the same firms in the same stage over Period 2 are even more influential on IAROA. The coefficients are positive (0.247 and 0.044) and significant at the 5% level (t = 2.34 and 2.18, respectively), and they are also higher in magnitude. Other examples (not shown to conserve space) are in the same situation. These interesting findings demonstrate that given unusual changes in the environment of firms, the impact of ownership on performance changes over time, which is inconsistent with H6.

Table 8: Estimates of Panel Pooled Regressions-across Stages with the Same Firms over Time

	G→G		G→M		S→S		S→M	
	1999-2003	**2004-2008**	**1999-2003**	**2004-2008**	**1999-2003**	**2004-2008**	**1999-2003**	**2004-2008**
Dependent V.: IAROA Independent V:								
INSID	-0.083	0.247**	0.079	0.130*	-0.013	-0.141*	0.156*	0.060
	(-1.204)	(2.348)	(1.105)	(1.656)	(-0.221)	(-1.522)	(1.722)	(-1.127)
INSID^2	0.090	-0.236*	-0.070	-0.004	0.048	0.047	-0.128	-0.040
	(1.192)	(-1.941)	(-0.840)	(-0.041)	(0.683)	(0.616)	(-1.179)	(-0.460)
INS	0.042***	0.044**	-0.003	0.009	0.048	0.022**	-0.021	0.013
	(2.699)	(2.185)	(-0.324)	(0.637)	(0.683)	(2.240)	(-1.225)	(0.851)
SEATR	-0.014	-0.039**	-0.000	-0.014	0.003	-0.019**	-0.037***	-0.031**
	(-1.159)	(-2.447)	(-0.017)	(-1.231)	(0.284)	(-2.201)	(-2.650)	(-2.55)
VC	0.050	0.056	-0.047	-0.281***	-0.004	-0.041	-0.087	-0.027
	(0.458)	(0.448)	(-0.601)	(2.821)	(-0.502)	(-0.402)	(-0.706)	(-0.248)
NLA	-0.002	-0.000	0.001	0.004**	0.016	0.003**	0.006*	0.004
	(-1.069)	(-0.282)	(0.864)	(1.794)	(0.066)	(2.194)	(1.940)	(1.272)
LER	-0.013***	-0.001*	-0.010***	-0.025***	0.001	-0.017***	-0.025***	-0.015***
	(-4.565)	(-1.818)	(-3.411)	(-6.962)	(0.730)	(-4.070)	(-6.118)	(-4.016)
RD	-0.139***	-0.170***	-0.059*	-0.175***	-0.005	-0.054	-0.034	-0.750***
	(-3.891)	(-3.238)	(-1.786)	(2.910)	(-1.120)	(-0.865)	(-0.207)	(-3.992)
ME	-0.070**	-0.056*	-0.037***	-0.010	0.013	-0.115**	0.025	0.032
	(-2.454)	(-1.675)	(-3.424)	(-1.050)	(01554)	(-2.051)	(0.397)	(0.721)
AG	0.038***	0.076***	0.033**	0.014	0.009***	0.070***	0.042***	0.107***
	(3.431)	(6.254)	(6.907)	(-1.050)	(2.974)	(7.413)	(2.977)	(6.847)
Observations	133	211	221	317	206	260	143	172
Adjusted R-squared	0.340	0.310	0.291	0.265	0.256	0.272	0.320	0.417

Note: IAROA $=\beta_0+\beta_1(INSID)+\beta_2(INSID)^2+\beta_3(INS)+\beta_4(SEATR)+\beta_5(VC)+\beta_6(NLA)+\beta_7(LER)+\beta_8(RD)+\beta_9(ME)+\beta_{10}(AG)+\varepsilon$. *This table shows the panel pooled regression estimates of the equation with the dynamic specification of the same firms across life cycle stages over the period 1999-2003 and 2004-2008. The dependent variable is industry-adjusted return of asset (IAROA). The independent variables are insider (INSID) and institutional ownership (INS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME), and asset growth (AG). All other variables are defined in Table 3. The models are for the full sample, growing firms (G), mature firms (M), and stagnant firms (S). The notations G→G, G→G, S→S, and S→M, denote the stages over Period 1 that go through another stage with the same firms over Period 2, respectively. The T-statistics are reported in parentheses below the estimate coefficients in each cell; *, **, *** denote significance at the 10%, 5%, and 1% level, respectively.*

Robustness of the Results

In this section, we examine the sensitivity of our results to the use of alternative specifications and econometric techniques: fixed-effects panel data models and lagged specifications.

Test of Fixed or Random Effect Model for Panel Data **:** From the econometric view, there are two main regression models for panel data: fixed effects and random effects. In empirical application, several tests are applied to measure the usefulness of these models. For the equations in the study, the *F*-test and Hausman test reject the null hypothesis (p-value=0.000), confirming that the equations potentially and significantly possess the fixed effect.

Impact of Lagged Ownership on Firm Performance across Stages (1999-2008)

Prior studies usually raise questions on the issue: is ownership structure endogenously determined or is it an exogenous variable that affects performance? As such, we first apply the Granger causality test to examine the causal relationship between ownership structure and firm performance for reference purposes. The results fail to reach a strong consensus. To test for robustness, we then lag all measures of ownership structure and selected control variables in the fixed-effect regressions framework of panel data by one year to signify that ownership and performance do not affect one another contemporaneously. Lagged values of ownership structure alleviate potential simultaneity and endogeneity issues (Cornett et al., 2007). The lagged specification loses 831 observations in the full sample. We end up with an unbalanced panel sample of 3612 firm-year observations. Table 9 provides the robustness of our main results to the use of alternative specifications. Columns (1) and (2) show the results for the full sample with alternative econometric techniques. In Columns (3)–(8), the results for growing, mature, and stagnant firms are presented, respectively.

Table 9: The Lagged Specifications – panel pooled & fixed effects regressions (1999-2008)

	All firms		Growing firms		Mature firms		Stagnant firms	
Dependent V.: IAROA	**pooled OLS**	**fixed**	**pooled OLS**	**fixed**	**pooled OLS**	**fixed**	**pooled OLS**	**fixed**
Independent V.:								
INSID(-1)	0.044**	0.054**	0.065	0.063	-0.003	0.129***	0.102***	0.006
	(2.571)	(2.119)	(1.404)	(0.745)	(-0.149)	(3.985)	(2.747)	(0.092)
INSID(-1)^2	-0.029	-0.050*	-0.071	-0.104	0.036	-0.142**	-0.108***	-0.011
	(-1.481)	(-1.718)	-1.411	(-1.212)	(1.450)	(-2.399)	(-2.650)	(-0.162)
INS(-1)	0.015***	-0.006	0.019**	0.016	0.015***	0.002	0.012*	0.004
	(4.424)	(-0.903)	(2.015)	(0.425)	(3.336)	(0.276)	(1.641)	(0.020)
SEATR(-1)	-0.012***	-0.007	-0.020**	0.012	-0.010***	-0.021**	-0.017***	0.010
	(-4.428)	(-1.241)	(-2.552)	(0.627)	(-2.875)	(-2.536)	(-2.614)	(0.700)
VC(-1)	-0.064***	-0.128**	-0.039	0.032	-0.085**	-0.071	-0.026	-0.222
	(-2.580)	(-2.536)	(-0.710)	(0.244)	(-2.324)	(-0.946)	(-0.443)	(-1.466)
NLA	0.001***	0.001	0.001	0.004	0.001*	-0.002	0.003**	0.005
	(3.217)	(0.631)	(0.552)	(0.573)	(1.792)	(-0.677)	(2.405)	(0.811)
LER	-0.003***	-0.004***	-0.004***	0.002	-0.002***	-0.040***	-0.008***	-0.020***
	(-7.616)	(-3.166)	(-3.817)	(0.931)	(-5.273)	(-5.930)	(-3.575)	(-3.723)
RD	-0.008*	-0.045***	-0.128***	-0.270***	-0.003	-0.018	-0.054	-0.058
	(-1.703)	(-3.166)	(-3.679)	(-3.849)	(-0.767)	(-1.302)	(-1.262)	(-0.627)
ME	-0.021***	-0.046***	-0.018	-0.060***	-0.014*	-0.040***	-0.128***	-0.180***
	(-3.365)	(-5.662)	(-1.441)	(-3.406)	(-1.773)	(-3.655)	(-4.382)	(-4.435)
AG	0.059***	0.048***	0.076***	0.079***	0.078***	0.064***	0.004***	0.020***
	(23.319)	(18.221)	(11.890)	(8.222)	(20.62)	(16.181)	(5.483)	(4.435)
Observations	3,612	3,612	660	660	2,072	2,072	672	672
Adjusted R-squared	0.198	0.391	0.245	0.375	0.246	0.476	0.132	0.387

*Note: The models lag all measures of ownership structure and selected control variables in the fixed-effect regressions framework of panel data by one year to signify that ownership and performance do not affect one another contemporaneously. The lagged specifications lose 831 observations for the full sample, thereby ending up with an unbalanced panel sample of 3,612 firm-year observations during the period 1999 to 2008. The models are for the full sample, growing firms, mature firms, and stagnant firms. The dependent variable is industry-adjusted return of asset (IAROA). The independent variables are insiders and institutional ownership (INSID and INS), firm size (NLA), liabilities (LER), R&D (RD), marketing expenditure (ME) and asset growth (AG). All other variables are defined in Table 3. The T-statistics are reported in parentheses below the estimate coefficients in each cell; *, **, *** denote significance at the 10%, 5% and 1% level, respectively.*

The lagged insider ownership has positive and significant coefficients of the fixed effect regressions for the full sample and for mature firms (0.054, t =2.12 and 0.129, t =3.98, respectively). The coefficients on the lagged insider ownership squared are all negative but are significant only for the full sample and for mature firms, consistent with the finding of an inverted U-shaped non-linear relationship in the previous section. Overall, the impact of ownership on performance seems to be qualitatively unchanged when we use alternative specifications and econometric techniques. Other control variables (not shown) are mostly confirmed to be significant in the lagged fixed effect regressions. With regard to explanatory power, evidence shows that the adjusted R^2 is at a higher level (approximately 0.37–0.48) for each of the fixed effect models, respectively.

CONCLUSION

Previous empirical studies seem to have produced mixed results on the nature of the relationship between ownership and performance. To extend these studies, this paper specifically explores the effect of the life cycle of firms on the relationship between ownership structure and firm performance. What is the relationship between them? Does the relationship persist across different life cycle stages over time? Using an unbalanced panel pooled data of 4,443 observations listed in the emerging Taiwanese market, we adopt a dynamic perspective to explore the persistence of the relationship across stages over time. We first model the panel pooled least square regressions in the main results and use fixed-effect models of panel data for robustness tests.

The primary findings of this paper are worth elaborating. First, the evidence strongly indicates that higher insider ownership among Taiwanese firms is linked to higher firm performance up to a turning point, after which additional ownership actually reduces firm performance. The empirical results further reveal that over the same period, the positive association between insider ownership and performance is more pronounced in mature firms. In contrast, the positive association between institutional ownership and firm performance is more pronounced in growing firms than in mature and stagnant firms. Clearly, the life cycle stages of firms play an important role in the relationship between ownership structure and firm performance. Second, we adopt a dynamic specification to examine the impact of ownership on performance across stages and periods, and find that the impacts are significantly different between periods regardless of whether they are in the same life cycle stage with different firms or with the same firms. Third, we lag all measures of ownership structure in the fixed-effect regressions framework of panel data by one year to alleviate a potential simultaneity issues. Clearly, the impact of ownership on performance seems to be qualitatively unchanged, confirming the robustness of our main results.

Overall, this paper potentially contributes to the literature by extending the importance of the life cycle stages of firms, thus assessing the impact of ownership on firm performance. However, our paper has a number of limitations, which suggest areas for further research. For instance, there is a need to document relatively neglected life cycle stages (i.e., the start-up or the renewal firms) and to argue the endogeneity of ownership structure. Demsetz (1983) first argues that a firm's ownership structure may be endogenously determined. Except for insiders, institutional ownership is also susceptible to endogeneity problems. Further research is needed to examine empirically potential simultaneity issues and to enable meaningful comparisons.

REFERENCES

Adams, R., and Santos, J. A. C. (2006), Identifying the Effect of Managerial Control on Firm Performance. *Journal of Accounting and Economics, 41*, 55-85.

Adizes, I. (1979), Organizational Passages- diagnosing and Treating Life Cycle Problems of Organizations. *Organizational Dynamics, 8*, 3-24.

Almazan, A., Hartzell, J., and Starks, L. T. (2005), Active Institutional Shareholders and Cost of Monitoring: Evidence from Managerial Compensation. *Financial Management, 34*(4), 5-34.

Anderson, R. C., and Reeb, D. M. (2003), Founding-family Ownership and Firm Performance: Evidence from the S&P 500. *Journal of Finance, 58*, 1301-1328.

Anthony, J. H., and Ramesh, K. (1992), Association between Accounting Performance Measures and Stock Prices. *Journal of Accounting and Economics, 15*, 203-227.

Baek, J. S., Kang, J. K., and Park, K. S. (2004), Corporate Governance and Firm Value: Evidence from the Korean Financial Crisis. *Journal of Financial Economics, 71*(2), 265-313.

Barnhart, S. W., and Rosenstein, S. (1998), Board Composition, Managerial Ownership, and Firm

Performance: An Empirical Analysis. *The Financial Review, 33*(4), 1-16.

Beldona, S. R., Chaganti, M., Habib, M., and Inkpen, A. C. (1997), Industry Variety, Life-cycle Stages, and Performance: A Dynamic Perspective. *Competitive Intelligence Review, 8*(4), 65-74.

Black, E. L. (1998(Fall)), Life-cycle Impacts on the Incremental Value-relevance of Earnings and Cash Flow Measures. *The Journal of Financial Statement Analysis, 4*(1), 40-56.

Brickley, J. A., Lease, R. C., and Smith, C. W. (1988), Ownership Structure and Voting on Antitakeover Amendments. *Journal of Financial Economics, 20*, 267-292.

Brown, L. D., and Caylor, M. L. (2009), Corporate Governance and Firm Operating Performance. *Rev Quant Finan Acc, 32*, 129-144.

Claessens, S., Djankov, S., Fan, J. P. H., and Lang, L. H. P. (2002), Disentangling the Incentive and Entrenchment Effects of Large Shareholdings. *Journal of Finance, 57*(6), 2741-2771.

Claessens, S., Djankov, S., and Lang, L. H. P. (2000), The Separation of Ownership and Control in East Asian Corporations. *Journal of Financial Economics, 58*, 81-112.

Cornett, M. M., Marcus, A. J., Anthony, S., and Tehranian, H. (2007), The Impact of Institutional Ownership on Corporate Operating Performance. *Journal of Banking & Finance, 31*, 1771-1794.

Demsetz, H. (1983), The Structure of Corporate Ownership and the Theory of the Firm. *Journal of Law Economic, 26*(2), 375-390.

Demsetz, H., and Lehn, K. (1985), The Structure of Corporate Ownership: Causes and Consequences. *Journal of Political Economy, 93*(6), 1155-1177.

Demsetz, H., and Villalonga, B. (2001), Ownership Structure and Corporate Performance. *Journal of Corporate Finance, 7*(3), 209-233.

Dodge, H. R., and Robins, J. E. (1992), An Empirical Investigation of the Organizational Life Cycle Model for Small Business Development and Survival. *Journal of Small Business Management, 30*(1), 27-37.

Durnev, A., and Kim, E. (2005), To Steal or Not to Steal: Firm Attributes, Legal Environment, and Valuation. *Journal of Finance, 60*(3), 1461-1493.

Faccio, M., and Lasfer, M. A. (2000), Do Occupational Pension Funds Monitor Companies in which They Hold Large Stakes? *Journal of Corporate Finance, 6*(1), 71-110.

Filatotchev, I., Toms, S., and Wright, M. (2006), The Firm's Strategic Dynamics and Corporate Governance Life-cycle. *International Journal of Managerial Finance, 2*(4), 256-279.

Hermalin, B., Weisbach, M. (1991), The Effects of Board Compensation and Direct Incentives on Firm Performance. *Financial Management, 20*(4), 101-112.

Holderness, C., Kroszner, R., and Sheehan, D. (1999), Were the Good Old Days That Good? Changes in

Managerial Stock Ownership Since the Great Depression. *Journal of Finance, 54*(2), 435-469.

Jensen, M. C., and Meckling, W. H. (1976), Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure. *Journal of Financial Economics, 3*(4), 305-360.

Jensen, M. C., and Ruback, R. (1983), The Market for Corporate Control: The Scientific Evidence. *Journal of Financial Economics, 11*, 5-55.

La Porta, R., Lopez-De-Silanes, F., and Shleifer, A. (1999), Corporate Ownership Around the World. *Journal of Finance, 54*(2), 471-518.

Lemmon, M., and Lins, K. (2003), Ownership Structure, Corporate Governance, and Firm Value: Evidence from the East Asian Financial Crisis. *Journal of Finance, 58*(4), 1445-1468.

Liang, C. J., and Lin, Y. L. (2008), Which IC Is More Important? A Life-Cycle Perspective. *Journal of Intellectual Capital*, *9*(1), 62-76.

Maury, B. (2006), Family Ownership and Firm Performance: Empirical Evidence from Western European Corporations. *Journal of Corporate Finance, 12*, 321- 341.

McConnell, J., Henri, S., and Lins, K. (2008), Changes in Insider Ownership and Changes in the Market Value of the Firm. *Journal of Corporate Finance, 14*, 92-106.

McConnell, J. J., and Servaes, H. (1990), Additional Evidence on Equity Ownership and Corporate Value. *Jouranl of Financial Ecomonics, 27*(2), 595-612.

Miles, G., Snow, C. C., and Sharfman, M. P. (1993), Industry Variety and Performance. *Strategic Management Journal, 14*(3), 163-177.

Morck, R., Shleifer, A., and Vishny, R. W. (1988), Management Ownership and Market Valuation: An Empirical Analysis. *Journal of Financial Economics, 20*, 293-315.

Pound, J. (1988), Proxy Contests and the Efficiency of Shareholder Oversight. *Journal of Financial Economics, 20*, 237-265.

Ramaswamy, V., Ueng, C. J., and Carl, L. (2008), Corporate Governance Characteristics of Growth Companies: An Empirical Study. *Academy of Strategic Management Journal, 7*, 21-33.

Smith, K. G., Mitchell, T. R., and Summer, C. E. (1985), Top Level Management Priorities in Different Stages of the Organization Life Cycle. *Academy of Management Journal, 28*(4), 779-820.

Villalonga, B., and Amit, R. (2006), How Do Family Ownership, Control, and Management Affect Firm Value? *Jouranl of Financial Ecomonics, 80*(2), 385-417.

Wiwattanakantang, Y. (2001), Controlling Shareholders and Corporate Value: Evidence from Thailand. *Pacific-Basin Finance Journal, 9*, 323-362.

Yeh, Y. H., Lee, T. S., and Woidtk, T. (2001), Family Control and Corporate Governance: Evidence from Taiwan. *International Review of Finance, 2:1/2*, 21-48.

Yeh, Y. H., and Woidtke, T. (2005), Commitment or Entrenchment? Controlling Shareholders and Board Composition. *Journal of Banking and Finance, 29*(7), 1857-1885.

ACKNOWLEDGEMENT

The authors would like to thank the editor and anonymous reviewers for their valuable and constructive comments, which have led to a significant improvement in the manuscript. This research was supported by National Science Council of the Republic of China under grant NSC 98-2410-H-468-006.

BIOGRAPHY

Chiung-Ju Liang majored in capital market and performance evaluation research. She is currently a finance associate professor at the National Taiwan University of Science and Technology. Professor Liang can be contacted at Graduate Institute of Finance, National Taiwan University of Science and Technology, No.43, Sec. 4, Keelung Rd., Da-an District, Taipei City 106, Taiwan, R.O.C.
Tel: +886-2-27376915, E-mail: cjliang@mail.ntust.edu.tw

Ying-Li Lin majored in economic theory and financial management research. He is currently a finance assistant professor at the Department of Finance, Asia University. Professor Lin can be contacted at Department of Finance, Asia University, 500, Lioufeng Rd., Wufeng, Taichung 41354, Taiwan, R.O.C.
Tel: +886-935641319, E-mail: yllin@asia.edu.tw

Tzu-Tsang Huang, corresponding author, is a doctoral student at the Graduate Institute of Finance, National Taiwan University of Science and Technology. He is also an instructor at the Department of Finance, Hsing Wu University of Science and Technology. Mr. Huang can be contacted at Graduate Institute of Finance, National Taiwan University of Science and Technology No.43, Sec. 4, Keelung Rd., Da-an District, Taipei City 106, Taiwan, R.O.C. Tel: +886-933802852, Fax: +886-2-27376744, E-mail: d9718001@mail.ntust.edu.tw

THE LONG-TERM WEALTH EFFECT OF SHARE REPURCHASES EVIDENCE FROM TAIWAN

Tai-Yuan Chen, Kainan University
Lie-Jane Kao, Kainan University
Hsing-Yu Lin, Kainan University

ABSTRACT

This paper examines the long-term wealth effect of 948 share repurchase announcements in the Taiwan market. We also investigate what factors determine the wealth effect of share repurchases. Our findings show that share repurchases induce positive buy-and-hold abnormal returns during the 12-month post-announcement period. Undervaluation and unexpected operating profits are the two important factors explaining the wealth effect regardless of firms' investment opportunities. In addition, for firms with poor investment opportunities, estimated repurchase ratio also explains the wealth effect for the two-month period after repurchase announcements but not for the long-term. By contrast, this study does not find the explanatory power of the changes in free cash flow on either the short- or the long-term wealth. The overall evidence supports the undervaluation and the signaling hypotheses, rather than the free cash flow hypothesis.

JEL: G35; G14

KEYWORDS: Share Repurchase; Abnormal Return; Undervaluation; Signaling; Agency Theory

INTRODUCTION

Share repurchases have emerged as a popular payout mechanism in the last decade. For shareholders, share repurchases, which are similar to cash dividends, may convey information about future profitability or represent the firm's commitment to alleviate agency problems (Allen and Michaely, 2003). However, unlike cash dividends, firms are not obligated to accomplish the goals they have set after announcing share repurchases. Thus, the information conveyed by share repurchases is not as reliable as that signaled by dividends.

Share repurchase activity has been allowed in Taiwan since August 2000. Several attempts have been made to determine market reactions to the announcements and determinants which drive the event-period abnormal returns (Chen et al., 2004; Liao et al., 2005; and Lo et al., 2008). However, without a commitment to repurchasing shares, it is possible that the short-term abnormal returns surrounding the announcements are influenced by false information. For instance, the market reacts positively to announcements made by firms that possess potentially serious agency problems. While the market expects the disbursement of excess free cash flow, firms, on the other hand, may simply intend to increase the value of their organization by announcing share repurchases. In this context, examining the short-term abnormal returns may lead to evidence supporting the free cash flow hypothesis, whereas the firms are actually signaling undervaluation. An examination of the long-term abnormal returns can circumvent such concerns. Furthermore, this estimation can also assist in elucidating 1) whether or not share repurchases in Taiwan increase shareholders' wealth in the long-term, and 2) the factors that contribute to long-term wealth.

This paper hence aims to uncover whether share repurchases are capable of increasing shareholders' wealth over the long-term. Based on the evidence presented by Chen et al. (2004), this paper further seeks to discover whether or not the motivation behind repurchasing firms with poor investment opportunities and serious agency problems can be explained by the free cash flow hypothesis over the long-term. In addition, it is also of interest to determine the reasons why firms with a greater number of investment opportunities announce share repurchases, as disbursing excess cash flow is unlikely their purpose.

Our results indicate that share repurchases are made after undervaluation. The evidence is particularly striking for high-Q firms, which is consistent with our prediction and the evidence of Chen et al. (2004). Furthermore, this paper also confirms the existence of a long-term wealth effect during the post-announcement period, which is largely explained by undervaluation and unexpected operating profits. The evidence is solid for both low-Q and high-Q firms. These two factors, along with an estimated repurchase ratio, similarly possess notable explanatory power for the short-term wealth effect. This evidence, however, is more explicit for low-Q firms. On the other hand, this paper, even for firms with poor investment opportunities (low-Q firms), does not find clear evidence to support the free cash flow hypothesis.

The remainder of this paper is organized as follows: the following section discusses hypotheses and reviews the relevant literature; section 3 describes the sample; section 4 discusses the methodology and the formation of the models; section 5 presents the empirical results; and finally, section 6 presents certain conclusions related to our findings.

LITERATURE REVIEW

The undervaluation, signaling, and free cash flow hypotheses make up the three major theories explaining share repurchases. The undervaluation hypothesis predicts the undervaluation of share prices as the motivation for share repurchases; it also predicts that the announcement of share repurchases is preceded by negative abnormal returns and followed by positive abnormal returns. Unlike the undervaluation hypothesis, the signaling hypothesis does not predict whether or not firms are undervalued prior to repurchase announcements. Instead, this hypothesis primarily predicts that managers engage in share repurchasing in order to signal their future profitability and that the value of the firm will increase following the announcements, due to the expected improvement in profitability. In contrast with the two aforementioned hypotheses, the free cash flow hypothesis regards agency costs and investment opportunities as making up the motivation for share repurchases. As defined by Jensen (1986), the hypothesis predicts that firms with poor investment opportunities disburse the excess cash flow through dividends or share repurchases. Since cash payouts alleviate agency problems, firm values are expected to increase following payout announcements.

A number of studies investigate the undervaluation hypothesis by testing the performance of long-term returns. Ikenberry et al. (1995), examining the US market, show that the most undervalued portfolio has 135.91% of four-year buy-and-hold abnormal returns (BHARs) following announcements. Ikenberry et al. (2000) present negative abnormal returns during the twelve-month period preceding repurchase announcements and positive abnormal returns up to three years following announcements in the Canadian market. Evidence for negative BHARs preceding announcements is also presented by Oswald and Young (2004) for the UK market, Hatakeda and Isagawa (2004) for the market in Japan, and Liao et al. (2005) for the Taiwan market. Oswald and Young (2004) also present evidence indicating that the lower the preceding CARs, the more shares firms buy back. Hatakeda and Isagawa (2004) reveal that a drop in previous share prices increases the probability of real buybacks. This finding is consistent with Li and McNally's (2003) findings for Canada.

As for the validity of the signaling hypothesis, Dann et al. (1991) assert that unexpected earnings appear to be positive in each of the five years following the announcement of tender offer repurchases. Moreover, market reactions to tender offer repurchase announcements correlate positively with subsequent unexpected earnings. Hertzel and Jain (1991), who estimate revisions of analysts' earnings forecasts around repurchase announcements, demonstrate that market reactions are positively related to revisions of short-term earnings forecasts. In comparing repurchasing firms with their industry peers, Lie and McConnell (1998) suggest that the operating performance of the repurchase firms is superior, with the outperformance continuing for up to five subsequent years. Lie's (2005) evidence indicates that firms which actually buy back shares experience marked improvement in subsequent operating performance, whereas firms which merely make announcements do not.

Nevertheless, a number of studies advocate the free cash flow hypothesis. Dittmar (2000), who examines a set of theories simultaneously, asserts that undervaluation and excess cash flow are the two crucial factors explaining improvements caused by share repurchases. Her evidence is later supported by the research performed by Michell and Dharmawan (2007) for the Australian market. In their comprehensive study, Grullon and Michaely (2004) show that market reactions surrounding share repurchase announcements correlate well with the free cash flow held by firms that are more likely to overinvest. Similarly, in examining repurchases in Taiwan, Chen et al. (2004) proposes the idea that only firms with poor investment opportunities repurchase in order to forego excess cash flow. In contrast, those with good future prospects repurchase so as to signal undervaluation. Moreover, Lo et al. (2008) propose that preannouncement undervaluation can be attributed to agency problems although the undervaluation and the agency problems apparently possess explanatory power on the abnormal returns surrounding the announcement day.

DATA AND DESCRIPTIVE STATISTICS

The data are collected from two sources. The market observation post system (MOPS) of the Taiwan Stock Exchange provides the details of the share repurchases announced by the firms listed between the years 2000 and 2008. The data consist primarily of the announcement date, estimated repurchase ratio, repurchase ratio, and completion rate. The monthly return data and financial data are collected from the Taiwan Economic Journal (TEJ) database. Observations included in the sample are to meet the following criteria: 1) For each sample firm, only the first announcement in each of the sample years is included. 2) The financial data of the repurchasing firms should be accessible for the period between 1999 and 2008. 3) The firms do not classify as representatives of the finance industry. Overall, the sample contains 948 observations for 374 repurchasing firms.

Table 1: Descriptive Statistics for Share Repurchases between August 2000 and December 2008

Q Ranking	N		Q	ER	RR	CR
1	194	Mean	0.7442	0.0357	0.0207	0.6383
(Low)		Median	0.7613	0.0295	0.0144	0.6936
2	184	Mean	0.9262	0.0296	0.0197	0.7077
		Median	0.9443	0.0258	0.0171	0.8063
3	187	Mean	1.0947	0.0293	0.0186	0.6838
		Median	1.1160	0.0249	0.0151	0.8053
4	200	Mean	1.3791	0.0294	0.0182	0.6868
		Median	1.3848	0.0245	0.0155	0.8000
5	183	Mean	2.2758	0.0272	0.0169	0.6665
(High)		Median	2.0188	0.0239	0.0131	0.7643

This table reports the mean and median estimated repurchase ratio (ER), repurchase ratio (RR), and completion rate (CR) respectively based on Tobin's Q ratio quintile rank. The Q ratio of each observation is compared to all firms listed on the Taiwan Stock Exchange at the end of the year prior to repurchase announcements. The lowest-Q firms are ranked in quintile 1. Q ratio is the sum of the market value of equity and the book value of total debt, divided by the book value of total assets. N denotes the number of the observations in each quintile.

Table 1 shows the distribution of the announcements and the descriptive statistics of the share repurchases, according to Tobin's Q ratio. The Q ratio is computed as the sum of the market value of equity and the book value of total debt divided by the book value of total assets. The quintiles are determined at the end of the year prior to the repurchase announcement, and the ratio is compared to all firms listed on the Taiwan Stock Exchange. The Q ratio of quintile 1 and quintile 2 are, on average, less than one. The mean (median) for the two quintiles is 0.7442 (0.7613) and 0.9262 (0.9443), respectively. In contrast, the Q ratio of the highest-Q firms (quintile 5) is 2.2758 for the mean, and 2.0188 for the median. The average (median) estimated repurchase ratio for the lowest-Q firms is 3.57% (2.95%), percentage much greater than those for the highest-Q firms (2.72% and 2.49% for the mean and median, respectively). Furthermore, on average, the low-Q firms repurchase with a higher percentage of their outstanding shares and have a repurchase ratio of 2.07% for the mean and 1.44% for the median. The completion rate, however, does not differ extensively across the five Q ratio quintiles, and ranges from 63.83% to 70.77%.

METHODOLOGY AND HYPOTHESES DEVELOPMENT

Unlike other payout policies, share repurchases take far more time to implement. This factor makes testing long-term performance important, as the market may not only react to repurchases on the day or in the month when the event takes place but also in subsequent periods. Even if certain repurchase programs are not implemented following the announcements, repurchase announcements remain a signaling mechanism for investors. Furthermore, this paper introduces models used to test directly which hypothesis more effectively predicts the wealth effect of the share repurchases.

Estimation of Long-Term Abnormal Returns

The monthly abnormal returns are estimated for a 25-month period, beginning up to 12 months prior to the repurchase announcement. In keeping with the idea that size and book-to-market ratio are the two most important risk factors which should be taken into account when predicting security returns (Fama and French, 1993), twenty-five reference portfolios have been ranked by size and market-to-book ratio (MB), both of which are determined at the end of the year prior to the announcement. The monthly abnormal returns of the observations (AR_{it}) are computed as the divergence between the monthly raw returns and the average returns of the corresponding reference portfolio. Cross-sectionally averaging the AR_{it} generates the monthly abnormal returns for each sample month (AR_t).

Kothari and Warner (1997) assert that long-term abnormal returns increase with the length of event periods. Following the procedures undertaken by Rau and Vermaelen (2002), this paper examines one thousand pseudo-portfolios to adjust for the skewness of the AR_t. Each pseudo-portfolio is created by randomly drawing a non-repurchasing firm-year from the corresponding reference portfolio for each repurchase announcement in the sample with replacement. Repeating the above drawing procedure a thousand times generates one thousand pseudo-portfolios and one thousand sets of pseudo abnormal returns. The bias-adjusted abnormal returns (AR_{adj}) are computed by subtracting the average pseudo monthly abnormal returns from the AR_t.

The undervaluation hypothesis predicts negative buy-and-hold abnormal returns (BHARs) and ARs prior to the announcements which are expected to precede positive ARs and BHARs.

Estimation of Long-Term Abnormal Returns by Q-Ratio Ranking

Evidence suggests that the free cash flow hypothesis predicts the short-term wealth effect of share repurchases in Taiwan, particularly for firms with poor investment opportunities (Chen*, et al.*, 2004; Lo*, et al.*, 2008). In order to ascertain whether the free cash flow hypothesis predicts the long-term wealth effect as well, this paper examines and compares long-term AR and BHAR performance by Q-ratio ranking. Tobin's Q ratio is utilized as the proxy for investment opportunities (Lang and Litzenberger, 1989). Low-Q firms, which have poor investment opportunities, are expected to repurchase shares in order to disburse any excess cash flow. The market is expected to react positively to their announcements. The free cash flow hypothesis predicts that low-Q firms should be undervalued to a greater extent prior to the announcements, due to their inherent agency problems.

In contrast, high-Q firms have less of an incentive to buy back shares in order to reduce excess cash flow, as they are involved in a greater number of positive-NPV investment projects. However, given that insiders and shareholders are privy to different amounts of information, the market may undervalue the investment projects and their share prices, motivating high-Q firms to buy back shares. The positive-NPV projects may also generate a series of future cash flows, with which insiders are familiar, but that are unknown to general shareholders. According to the signaling hypothesis, high-Q firms may signal this information by announcing share repurchases in order to suggest their superiority over their peers. Overall, both the undervaluation and the signaling hypotheses predict that positive abnormal returns are a typical response to share repurchase announcements. Negative ARs or BHARs are also expected prior to announcements made by undervalued high-Q firms.

Examining the Determinants of the Long-Term Wealth Effect

This paper assumes that investors evaluate short-term and long-term firm values differently and presumes that they will gain greater access to relevant investment information over time. The market is likely to respond to the information announced by firms in the short-term, resulting in short-term ARs. In addition, share buybacks executed by the firms during this period also affect the ARs in month 0 and month 1. Thus, the short-term model is as follows:

$$\mathrm{BHAR}_{(0,1)} = \alpha + \beta_1\left(\mathrm{BHAR}_{(-9,-1)}\right) + \beta_2(\mathrm{ER}) + \beta_3(\mathrm{CR}) + \beta_4(\mathrm{COPFT}) + \beta_5(\mathrm{CFCF}) + \varepsilon \quad (1)$$

where $\mathrm{BHAR}_{(m,n)}$ stands for the adjusted buy-and-hold abnormal returns compounding from month m to month n. ER denotes the estimated repurchase ratio, that is, the number of shares announced to be bought back as the percentage of outstanding shares. CR refers to the completion rate, which is the number of the shares repurchased given as the percentage of the shares announced. Since the managers' real intention remains unknown when repurchases are announced, CR is employed as a proxy for the expected completion rate in model 1.

The change in operating profits, denoted by COPFT, is computed as the operating profit at the end of the announcement year (year 1) minus the operating profit at the end of the previous year (year 0), scaled in terms of the book equity at the end of the previous year (year 0). In line with the implicit assumption that operating profits are a random walk, COPFT is employed as a proxy for unexpected operating profits. The change in free cash flow (CFCF) is the difference between the free cash flow of year 1 and the free cash flow of year 0, scaled in terms of the book equity of year 0. The free cash flow is the sum of tax, capital expenditure, and the increases in the net working capital of year 0 subtracted from the earnings before interest, taxes, depreciation and amortization (EBITDA) of year 0.

With information increasingly available over the long-term, investors are more capable of distinguishing between true and false information. The firms can no longer expect to raise the firm value by announcing and signaling. Hence, the long-term wealth effect not only reflects the information conveyed by the announcements, but also whether or not the signaled information comes to pass. The long-term model is thus as follows:

$$\mathrm{BHAR}_{(0,12)} = \alpha + \beta_1\left(\mathrm{BHAR}_{(-9,-1)}\right) + \beta_2(\mathrm{RR}) + \beta_3(\mathrm{CR}) + \beta_4(\mathrm{COPFT}) + \beta_5(\mathrm{CFCF}) + \mathrm{e} \quad (2)$$

where RR stands for the repurchase ratio, computed as the number of the shares bought as the percentage of shares outstanding. As repurchase announcements in Taiwan are only valid for two months, the long-term model employs a real repurchase ratio (RR) rather than an estimated ratio (ER) to predict $\mathrm{BHAR}_{(0,12)}$.

Prior evidence indicates that share repurchase announcements release favorable information to the market and thus result in a positive wealth effect (Comment and Jarrell, 1991; Liao*, et al.*, 2005; and many others). Ikenberry et al. (1995) further propose that market reactions to the announcements positively correlate with the fraction of share sought. Thus, ER and CR are predicted to positively affect $\mathrm{BHAR}_{(0,1)}$. Similarly, a higher RR and CR represent the firms' solid commitment to actually repurchase shares; these two explanatory variables are expected to positively relate to $\mathrm{BHAR}_{(0,12)}$. In addition, after the announcements, the undervaluation hypothesis expects the market to revise the evaluations for those firms which are undervalued during the pre-announcement period. In this context, the severer undervaluation should result in higher BHARs after the announcements. The coefficient of $BHAR_{(-9,-1)}$ is predicted to be negative in both of the models. Otherwise, if share repurchases are announced as a means of signaling better prospects of future earnings or profitability, COPFT should positively relate to $AR_{(0,1)}$ and $BHAR_{(0,12)}$. The free cash flow hypothesis also suggests that firms with excess cash flow should forego cash in order to mitigate agency problems, thereby indirectly increasing the firm value. The coefficient of CFCF, thus, is predicted to be negative.

The models are also estimated for low-Q and high-Q firms respectively so as to examine directly whether the wealth effect of the two types of firms are determined by different factors. Specifically, this paper expects that share repurchases announced by low-Q firms are explained by the free cash flow hypothesis, as they normally have poor investment opportunities and more free cash flow. Therefore, the CFCF coefficient for low-Q firms is expected to be of greater significance and more negative than for high Q firms. In comparison, high-Q firms with more positive-NPV investment opportunities are expected to have more incentives to suggest undervaluation or better future prospects.

As time and firm effects are inherent to our data, this paper utilizes fixed effect (LSDV) and random effect (GLS) methods to estimate the models. Greene (2003) and Wooldridge (2007) suggest that the two methods are a better choice and that the random effect method is more efficient in estimating coefficients when time and firm effects exist. Furthermore, comprehensive simulation research demonstrated by Petersen (2009) suggests that ordinary least square (OLS) underestimates the true standard errors. The standard errors estimated by the random effect method are unbiased when the firm effect is permanent. Even if the model contains unobservable variables, this bias of GLS standard errors is much smaller than that of OLS standard errors. The above advantages motivate fixed effect and random effect methods to be employed for the purposes of this paper.

EMPIRICAL RESULTS

Long-Term Abnormal Returns of Share Repurchases

Table 2 presents long-term abnormal returns (ARs), which are examined for 25 months, beginning at month -12. Consistent with the prediction of the undervaluation hypothesis, the adjusted abnormal returns (AR_{adj}) appear to be significantly negative in 8 out of 12 months. The announcing firms suffer from approximately 25.11% of undervaluation, in comparison to their reference portfolio, over 12 months prior to announcing share repurchases. The largest drop in BHARs is found in month -1, at -7.85%.

Surprisingly, the AR in the announcement month appears to be -6.24%. This result can be attributed to the fact that the market does not completely and immediately revise its evaluation based on the information conveyed by the announcements. The post-announcement ARs in the months following the announcements supporting this speculation show significant and positive ARs in six out of twelve months. The AR_1 is 1.97%, which is significantly positive.

The positive AR_1 reflects the signaling effect of the announcements. However, it may also be the result of the buyback activities executed by repurchasing firms. Perhaps the most striking result is that the five consecutive positive ARs from month 8 to month 12 cause the $BHAR_{adj}$ to rebound from -29.8% to -13.07%. All of the five abnormal returns are significant at a 1% level. The results imply that shareholders who buy the shares in month 0 and hold them for 12 months would gain about 18% of BHARs. Overall, the evidence is consistent with extant UK and US evidence, supporting the prediction that share repurchases promote a wealth effect in the long-term (Ikenberry*, et al.*, 1995; and Oswald and Young, 2004).

Table 2: Long-Term Abnormal Returns of Share Repurchase Announcements

Month	AR_{adj} (%)	t-stat	$BHAR_{adj}$ (%)	Month	AR_{adj} (%)	t-stat	$BHAR_{adj}$ (%)
				0	-6.24***	-16.61	-31.36
-12	-0.52	-1.32	-0.52	1	1.97***	5.43	-29.39
-11	-2.66***	-6.50	-3.19	2	-2.09***	-5.84	-31.48
-10	0.45	1.20	-2.74	3	-0.38	-1.05	-31.86
-9	-0.46	-1.23	-3.20	4	0.10	0.29	-31.75
-8	-0.96***	-2.58	-4.16	5	0.02	0.05	-31.74
-7	-1.14***	-3.09	-5.30	6	0.60	1.61	-31.14
-6	0.63*	1.69	-4.67	7	-0.62*	-1.77	-31.76
-5	0.01	0.04	-4.66	8	1.96***	5.50	-29.80
-4	-2.45***	-6.76	-7.11	9	1.55***	4.22	-28.24
-3	-4.25***	-11.59	-11.36	10	2.78***	7.69	-25.47
-2	-5.90***	-15.28	-17.27	11	4.80***	12.83	-20.67
-1	-7.85***	-20.89	-25.11	12	7.60***	19.56	-13.07

Table 2 presents the long-term abnormal returns estimated from month -12 to month 12 for the full sample. The abnormal returns (AR) are estimated by comparing the monthly raw returns to the returns of the corresponding reference portfolio. By employing bootstrapping technique, AR_{adj} is the abnormal returns subtracted by the average abnormal returns of the one thousand pseudo portfolios. $BHAR_{adj}$ is the adjusted buy-and-hold abnormal returns compounding from month -12. Statistical test of significance of AR_{adj} (different from 0) is measured by the ***standard error of the average abnormal returns. Significance at 0.01, 0.05 and 0.1 levels are marked with ***, **, and * respectively.***

Long-Term Abnormal Returns of Low- and High-Q Firms

Table 3: Long-Term Wealth Effect of Share Repurchases by Q-ratio Ranking

Rankings	1 (Low)	2	3	4	5 (High)	Q1-Q5
N	194	184	187	200	183	
$BHAR_{(-12,-10)}$	-2.84**	-3.57**	-2.71*	-4.90***	0.38	-3.23
	(-1.98)	(-2.44)	(-1.65)	(-3.27)	(0.26)	(-1.57)
$BHAR_{(-9,-7)}$	-5.17***	-3.68***	-0.32	-1.92	-1.55	-3.62*
	(-3.50)	(-2.52)	(-0.39)	(-1.34)	(-1.09)	(-1.77)
$BHAR_{(-6,-4)}$	5.13***	-0.12	-0.60	-6.30***	-7.11***	12.24***
	(3.94)	(0.02)	(-0.36)	(-4.35)	(-5.27)	(6.53)
$BHAR_{(-3,-1)}$	-9.65***	-19.22***	-18.50***	-20.91***	-21.85***	12.20***
	(-6.96)	(-12.88)	(-11.91)	(-14.63)	(-14.81)	(6.03)
AR_0	0.81	-5.06***	-8.25***	-7.99***	-10.88***	11.69***
	(1.05)	(-6.05)	(-9.12)	(-10.25)	(-13.10)	(10.29)
AR_1	6.00***	3.05***	1.38*	1.96**	-2.86***	8.86***
	(7.68)	(3.59)	(1.64)	(2.31)	(-3.33)	(7.63)
AR_2	-1.45*	-0.82	-0.86	-3.11***	-4.24***	2.78**
	(-1.95)	(-0.94)	(-0.97)	(-3.99)	(-4.99)	(2.46)
AR_3	-0.22	0.92	-0.54	-1.40*	-0.58	0.36
	(-0.29)	(1.08)	(-0.62)	(-1.66)	(-0.71)	(0.32)
$BHAR_{(4,6)}$	6.97***	1.98	-0.83	-0.58	-4.08***	11.04***
	(5.02)	(1.38)	(-0.56)	(-0.39)	(-2.86)	(5.55)
$BHAR_{(7,9)}$	4.50***	6.06***	0.61	1.16	2.17	2.33
	(3.22)	(4.23)	(0.40)	(0.86)	(1.54)	(1.17)
$BHAR_{(10,12)}$	11.46***	20.49***	16.18***	13.88***	13.49***	-2.04
	(7.61)	(13.42)	(10.50)	(9.81)	(9.31)	(-0.97)

*Table 3 presents the long-term abnormal returns estimated from month -12 to month 12 based on Q ratio rankings. The biased-adjusted abnormal returns in month m (AR_m) are computed as the monthly raw returns of the repurchasing firms minus those of the corresponding reference portfolio, adjusted by the average abnormal returns of the one thousand pseudo portfolios. $BHAR_{(m,n)}$ is the adjusted buy-and-hold abnormal returns compounding from month m to month n. Statistical test of significance of AR_m (different from 0) and $BHAR_{(m,n)}$ (different from 0) is measured by the standard error of the ARs or BHARs. Q1-Q5 presents the divergence of AR_m or $BHAR_{(m,n)}$ between quintile 1 and quintile 5. Statistical test of significance of the divergence is carried out by the independent sample t test. Student t statistics are reported in parentheses, and the significance at 0.01, 0.05 and 0.1 levels are marked with ***, **, and * respectively.*

Table 3 demonstrates the long-term wealth effect by Q-ratio ranking. The results emerging from comparing the BHARs and ARs of quintiles 1 and 5 reveal that high-Q firms suffer from serious undervaluation during the pre-announcement period. The $BHAR_{(-3,-1)}$ of high-Q firms is -21.85% (with a t-statistic of -14.81). In comparison, the $BHAR_{(-3,-1)}$ of low-Q firms is -9.65% (with a t-statistic of -6.96), percentage much higher than that of high-Q firms (with a t-statistic of 6.03). A similar situation is also found in the period (-6,-4). The evidence which is consistent with the findings of Chen et al. (2004) implies that high-Q firms tend to repurchase when their shares are undervalued. However, the results are not consistent with the free cash flow hypothesis, as they do not show that low-Q firms are more undervalued than high-Q firms.

With respect to the wealth effect surrounding the announcements, AR_0 and AR_1 are found to monotonously shrink or become more negative as the Q-ratio ranking increases. More specifically, AR_0 and AR_1 for low-Q firms are 0.81% and 6.00%, respectively, and -10.88% and -2.86%, respectively, for high-Q firms. The AR differences between the two quintiles are both significant at a level of 1%, which apparently supports the free cash flow hypothesis. However, later evidence indicates that the higher ARs for low-Q firms can be attributed to other factors.

During the post-announcement period, low-Q firms experience significantly higher ARs or BHARs than high-Q firms. The divergences, respectively significant at levels of 5% and 1%, are 2.78% for AR_2 and 11.04% for $BHAR_{(4,6)}$. Additionally, the only significantly positive BHAR for high-Q firms during the post-announcement period is $BHAR_{(10,12)}$, at 13.49%. Overall, the evidence in this section is generally consistent with the free cash flow hypothesis for low-Q firms, and the undervaluation and signaling hypotheses for high-Q firms, implying that share repurchases signal favorable information to the market. However, the information signaled by the two types of firms may differ.

Short-Term Abnormal Returns, Undervaluation, Profitability, and Free Cash Flow

The main discussions in this section focus on the fixed and random effect models due to the fact that the standard errors produced by OLS models tend to be under-estimated in the presence of time and firm effects (Petersen, 2009). Table 4 presents the regressions of $BHAR_{(0,1)}$ on several variables. Both the fixed and random effect models suggest that the unexpected operating profits (COPFT) positively and significantly relate to $BHAR_{(0,1)}$.

The random effect model shows that a 1% increase in COPFT result in a 0.315% increase in $BHAR_{(0,1)}$. Furthermore, while the random effect model suggests the estimated repurchase ratio (ER) to be the other significant factor explaining $BHAR_{(0,1)}$, the fixed effect model points instead to the pre-announcement buy-and hold abnormal returns ($BHAR_{(-9,-1)}$). The result from estimating the random effect model indicates that a 1% increase in ER provokes a 0.648% increase in $BHAR_{(0,1)}$. On the other hand, in the fixed effect model, in keeping with the predictions of the undervaluation hypothesis, the coefficient of $BHAR_{(-9,-1)}$ is -0.066, and its t statistic is -2.61, significant at a level of 1%.

As mentioned in the literature review, based on their findings for Taiwan repurchases, Chen et al. (2004) suggest that low-Q ($Q < 1$) firms repurchase in order to forego free cash flow while high-Q ($Q > 1$) firms repurchase as a means of signaling undervaluation. However, the evidence presented in Table 4 tells a completely different story. The coefficient on the change of free cash flow (CFCF) is not significant in any model. In particular, the coefficient is positive, albeit insignificant, in the model for low-Q firms, which is contrary to the prediction of the free cash flow hypothesis. In contrast, although partially consistent with Lo et al. (2008), ER and COPFT appear to have a significant effect on $BHAR_{(0,1)}$ in the low-Q model.

The coefficients of the two explanatory variables are 1.200 and 0.486, respectively. Both are significant at a level of 1%. Moreover, $BHAR_{(-9,-1)}$ and CR also explain $BHAR_{(0,1)}$, but the explanatory power is weaker than ER and COPFT. The coefficient of $BHAR_{(-9,-1)}$ is -0.062 and significant at a level of 5%, indicating that the undervaluation hypothesis is capable of explaining low-Q firms. Meanwhile, the explanatory power of the model for high-Q firms is not as explicit as that for low-Q firms.

Table 4: Regressions of Short-Term BHARs on Several Factors

	Predicted Sign	Pooled Model	FE Model	RE Model	RE Q < 1	RE Q > 1
$BHAR_{(-9,-1)}$	-	-0.008	-0.066^{***}	-0.030	-0.062^{**}	-0.045^{*}
		(-0.46)	(-2.61)	(-1.52)	(-1.98)	(-1.84)
ER	+	0.932^{***}	0.092	0.648^{**}	1.200^{***}	-0.094
		(3.25)	(0.18)	(2.06)	(3.11)	(-0.21)
CR	+	0.002	0.007	0.005	0.045^{*}	-0.031
		(0.13)	(0.30)	(0.26)	(1.80)	(-1.32)
COPFT	+	0.298^{***}	0.367^{***}	0.315^{***}	0.486^{***}	0.245^{*}
		(3.79)	(3.05)	(2.91)	(3.28)	(1.90)
CFCF	-	-0.014	0.003	-0.005	0.051	-0.010
		(-0.57)	(0.12)	(-0.24)	(1.36)	(-0.39)
Intercept	+/-	-0.072^{***}	-0.062^{***}	-0.071^{***}	-0.062^{**}	-0.068^{***}
		(-4.17)	(-2.63)	(-3.78)	(-2.50)	(-2.70)
R^2		0.026	0.010	0.023	0.074	0.019
F/X^2		4.91^{***}	2.81^{**}	13.77^{**}	27.72^{***}	7.51
N		943	943	943	386	557

*This table presents the regression model of $BHAR_{(0,1)}$ on several factors. $BHAR_{(m,n)}$ is the adjusted buy-and-hold abnormal returns compounding from month m to month n. FR and RE models denote fixed- and random-effect models respectively. ER and CR respectively denote the estimated repurchase ratio and the completion rate. COPFT and CFCF are respectively the change of operating profits and free cash flow in the year of share repurchases, scaled by the book equity at the end of the previous year. Statistical test of significance of the coefficients is carried out by t or Z test, depending on the regression approach. Estimated standard errors are robust to heteroscedasticity. Student t or Z statistics are reported in the parentheses. The mean VIF of the explanatory variables is 1.04. The significance at 0.01, 0.05 and 0.1 levels are marked with ***, **, and * respectively.*

Table 5: Regressions of Long-Term BHARs on Several Factors

	Predicted Sign	Pooled Model	FE Model	RE Model	RE Q < 1	RE Q > 1
$BHAR_{(-9,-1)}$	-	-0.098^{**}	-0.218^{***}	-0.132^{***}	-0.178^{**}	-0.182^{***}
		(-2.53)	(-3.80)	(-3.05)	(-2.45)	(-3.39)
RR	+	0.746	-1.008	0.522	1.213	-0.870
		(0.82)	(-0.74)	(0.52)	(0.93)	(-0.62)
CR	+	-0.001	0.048	0.004	-0.015	0.028
		(-0.02)	(0.83)	(0.09)	(-0.25)	(0.52)
COPFT	+	1.093^{***}	0.742^{***}	1.073^{***}	1.711^{***}	0.909^{***}
		(6.47)	(2.70)	(3.88)	(4.76)	(2.59)
CFCF	-	-0.028	-0.037	-0.031	0.058	-0.005
		(-0.54)	(-0.58)	(-0.55)	(0.69)	(-0.07)
Intercept	+/-	0.093^{***}	0.063^{*}	0.083^{***}	0.198^{***}	-0.002
		(3.32)	(1.96)	(2.89)	(5.05)	(-0.05)
R^2		0.046	0.027	0.045	0.086	0.048
F / X^2		8.97^{***}	4.90^{***}	23.05^{***}	32.82^{***}	15.68^{***}
N		943	943	943	386	557

*This table presents the regression model of $BHAR_{(0,12)}$ on several factors. $BHAR_{(m,n)}$ is the adjusted buy-and-hold abnormal returns compounding from month m to month n. FR and RE models denote fixed- and random-effect models respectively. RR and CR respectively denote the repurchase ratio and the completion rate. COPFT and CFCF are respectively the change of operating profits and free cash flow in the year of share repurchases, scaled by the book equity at the end of the previous year. Statistical test of significance of the coefficients is carried out by t or Z test, depending on the regression approach. Estimated standard errors are robust to heteroscedasticity. Student t or Z statistics are reported in the parentheses. The mean VIF of the explanatory variables is 1.17. The significance at 0.01, 0.05 and 0.1 levels are marked with ***, **, and * respectively.*

$BHAR_{(-9,-1)}$ and COPFT are the only variables that possess explanatory power in the model for high-Q firms. The coefficients of the two variables are -0.045 and 0.245, respectively, but are only significant at a level of 10%. As opposed to the results for low-Q firms, the repurchase factors, ER and CR, do not have notable effects on the short-term abnormal return of high-Q firms.

Long-Term Abnormal Returns, Undervaluation, Profitability, and Free Cash Flow

Table 5 presents the regressions of the long-term post-announcement BHARs on the explanatory variables. Generally, the long-term model provides evidence consistent with that provided by the short-term model. Moreover, R-squares indicate that the explanatory power of the long-term model outperforms that of the short-term model. Notably, $BHAR_{(-9,-1)}$ and COPFT are the two explanatory variables significantly predicting the $BHAR_{(0,12)}$ for the full sample. The results from examining the random model show that a 1% decline in $BHAR_{(-9,-1)}$ causes a 0.132% increase in $BHAR_{(0,12)}$. Similarly, a 1% increase in COPFT stimulates a 1.073% increase in $BHAR_{(0,12)}$. The fixed effect model provides consistent evidence with that from the random effect model. In contrast, the coefficient for CFCF is -0.031 but insignificant. RR and CR, which are the proxies for the fulfillment of the repurchase programs, also lost their effect on the BHARs over the long-term. The evidence given here supports the predictions of the undervaluation and the signaling hypothesis outright.

The information gleaned from comparing the models for low-Q and high-Q firms further supports the undervaluation and the signaling hypotheses for both types of firms. The coefficients of $BHAR_{(-9,-1)}$ for the low-Q and the high-Q models are -0.178 and -0.182, respectively. Both are significant at a level of 1%. Furthermore, COPFT also demonstrates notable explanatory power for the long-term wealth effect. A 1% increase in COPFT increases the $BHAR_{(0,12)}$ for low-Q firms by approximately 1.711% and by 0.909% for high-Q firms. On the other hand, the free cash flow hypothesis predicts that low-Q firms repurchase shares in order to disburse their excess cash flow, which is favorable information for the market. However, CFCF is not found to have significant explanatory power for $BHAR_{(0,12)}$.

Robust Test

Various alternative variables are employed to insure that the results are not affected by the specification error. In the short-term model, $BHAR_{(0,1)}$ is replaced with AR_0, AR_1, and $BHAR_{(0,2)}$, respectively. In the long-term model, $BHAR_{(0,12)}$ is replaced with $BHAR_{(3,12)}$ in order to exclude the short-term effect potentially induced by the buyback executions during the two-month period following the announcements. In both models, $BHAR_{(-9,-1)}$ is replaced by $BHAR_{(-6,-1)}$. Moreover, the changes in operating profits and the changes in free cash flow are scaled in accordance with total assets. The replacements do not provide new information for this paper.

CONCLUSION

This paper aims to examine the long-term wealth effect of share repurchases and the determinants of the wealth effect for the Taiwan market. Firstly, this paper finds that share repurchase announcements are preceded by negative abnormal returns and followed by positive abnormal returns in the long-term. The evidence is consistent with the findings of Ikenberry et al. (1995), Oswald and Young (2004), Liao et al. (2005) and others. In addition, the findings of this paper indicate that the determinants for the long-term and the short-term wealth effect differ. The factors determining the wealth effect of low-Q and high-Q firms differ as well.

The findings for low-Q firms are somewhat remarkable. The market is found to react more positively to the announcements made by low-Q firms. Apparently, the evidence obtained from examining the abnormal returns supports the predictions of the free cash flow hypothesis. However, when the regression models directly examine the explanatory power of free cash flow, no evidence is found to support the hypothesis. On the contrary, the evidence suggests that the short-term abnormal returns of low-Q firms mainly result from pre-announcement undervaluation and future prospects of profitability, thereby supporting the undervaluation and the signaling hypotheses. Not only are the two hypotheses capable of explaining the short-term abnormal returns, they predict the long-term abnormal returns with even greater success. Furthermore, consistent with Grullon and Michaely's (2004) findings, a higher repurchase ratio and completion rate also promote the short-term, but not the long-term, abnormal returns. The overall findings for low-Q firms imply that, to some extent, share repurchases made by low-Q firms are favorable to investors. However, neither the repurchase ratio nor the completion rate plays an important role in raising the firm value over the long-term. Instead, low-Q firms are expected to increase the shareholders' wealth by improving their operating profits, even though they do not have as many investment opportunities as high-Q firms.

With respect to high-Q firms, the evidence suggests that pre-announcement undervaluation and profitability prospects determine the long-term wealth effect. However, the two factors' explanatory power on the short-term wealth effect is inferior. In addition, the explanatory variables of share repurchases, ER, RR, and CR, do not have a significant effect on either long-term or short-term abnormal returns for high-Q firms, indicating that share repurchases made by high-Q firms do not coincide with investors' main interests. They are thus expected to improve profitability in order to raise the long-term firm value.

In summary, the overall evidence supports the undervaluation and the signaling hypotheses. Although share repurchases appear to be a useful means of increasing the value of a firm, profitability improvement is another key factor determining the wealth effect. A higher repurchase ratio or completion rate may help increase the firm value over the short term, but this effect does not last long. Finally, although firms with poor investment opportunities may repurchase in order to reduce free cash flow, this factor is not the main determinant for shareholders' short-term and long-term wealth.

REFERENCES

Allen, F. & Michaely, R. (2003). "Payout Policy," *Handbook of the Economics of Finance* (vol. 1, part 1, p. 337-429): Elsevier.

Chen, M., Chen, C.-L. & Cheng, W.-H. (2004) "The Announcement Effects of Restricted Open Market Share Repurchases: Experience from Taiwan," *Review of Pacific Basin Financial Markets and Policies,* vol. 7(3), p. 335-354.

Comment, R. & Jarrell, G. A. (1991) "The Relative Signalling Power of Dutch-Auction and Fixed-Price Self-Tender Offers and Open-Market Share Repurchases," *Journal of Finance,* vol. 46(4), p. 1243-1271.

Dann, L. Y., Masulis, R. W. & Mayers, D. (1991) "Repurchase Tender Offers and Earnings Information," *Journal of Accounting and Economics,* vol. 14, p. 217-251.

Dittmar, A. K. (2000) "Why Do Firms Repurchase Stock?," *Journal of Business,* vol. 73(3), p. 331-355. doi: 10.1086/209646

Fama, E. F. & French, K. R. (1993) "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics,* vol. 33, p. 3-56.

Greene, W. H. (2003) *Econometric Analysis* (5th ed.). Upper Saddle River, New Jersey 07458: Pearson Education, Inc.

Grullon, G. & Michaely, R. (2004) "The Information Content of Share Repurchase Programs," *Journal of Finance,* vol. 59(2), p. 651-680. doi: 10.1111/j.1540-6261.2004.00645.x

Hatakeda, T. & Isagawa, N. (2004) "Stock Price Behavior Surrounding Stock Repurchase Announcements: Evidence from Japan," *Pacific-Basin Finance Journal,* vol. 12(3), p. 271-290.

Hertzel, M. & Jain, P. C. (1991) "Earnings and Risk Changes around Stock Repurchase Tender Offers," *Journal of Accounting and Economics,* vol. 14, p. 253-274.

Ikenberry, D., Lakonishok, J. & Vermaelen, T. (1995) "Market Underreaction to Open Market Share Repurchases," *Journal of Financial Economics,* vol. 39(2-3), p. 181-208.

Ikenberry, D., Lakonishok, J. & Vermaelen, T. (2000) "Stock Repurchases in Canada: Performance and Strategic Trading," *Journal of Finance,* vol. 55(5), p. 2373-2397.

Jensen, M. C. (1986) "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review,* vol. 76(2), p. 323-329.

Kothari, S. P. & Warner, J. B. (1997) "Measuring Long-Horizon Security Price Performance," *Journal of Financial Economics,* vol. 43(3), p. 301-339.

Lang, L. H. P. & Litzenberger, R. H. (1989) "Dividend Announcements: Cash Flow Signalling Vs. Free Cash Flow Hypothesis?," *Journal of Financial Economics,* vol. 24(1), p. 181-191.

Li, K. & McNally, W. (2003) "The Decision to Repurchase, Announcement Returns and Insider Holdings: A Conditional Event Study," *ICFAI Journal of Applied Finance,* vol. 9, p. 55-70.

Liao, T. L., Ke, M.-C. & Yu, H.-T. (2005) "Anomalous Price Behaviour around Stock Repurchases on the Taiwan Stock Exchange," *Applied Economics Letters,* vol. 12(1), p. 29-39.

Lie, E. (2005) "Operating Performance Following Open Market Share Repurchase Announcements," *Journal of Accounting and Economics,* vol. 39(3), p. 411-436.

Lie, E. & McConnell, J. J. (1998) "Earnings Signals in Fixed-Price and Dutch Auction Self-Tender Offers," *Journal of Financial Economics,* vol. 49(2), p. 161-186.

Lo, K.-H., Wang, K. & Yeh, C.-T. (2008) "Stock Repurchase and Agency Problems," *Emerging Markets Finance and Trade,* vol. 44(1), p. 84-94.

Mitchell, J. D. & Dharmawan, G. V. (2007) "Incentives for on-Market Buy-Backs: Evidence from a Transparent Buy-Back Regime," *Journal of Corporate Finance,* vol. 13(1), p. 146-169.

Oswald, D. & Young, S. (2004) "What Role Taxes and Regulation? A Second Look at Open Market Share Buyback Activity in the UK," *Journal of Business, Finance and Accounting,* vol. 31(1-2), p. 257-292.

Petersen, M. (2009) "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches," *Review of Financial Studies,* vol. 22(1), p. 435-480.

Rau, P. R. & Vermaelen, T. (2002) "Regulation, Taxes, and Share Repurchases in the United Kingdom," *Journal of Business,* vol. 75(2), p. 245-282.

Wooldridge, J. M. (2007) *Econometric Analysis of Cross Section and Panel Data*. Cambridge, Massachusetts: The MIT Press.

ACKNOWLEDGEMENT

We would like to thank two reviewers for their helpful suggestions. All errors and omissions remain our responsibility.

BIOGRAPHY

Dr. Tai-Yuan Chen is an assistant professor of finance at Kainan University, Taiwan. He can be contacted at Department of Banking and Finance, Kainan University, No.1 Kainan Road, Luzhu, Taoyuan 33857, Taiwan. Email: tyedward@gmail.com

Dr. Lie-Jane Kao is an associate professor of statistics at Kainan University, Taiwan. She can be contacted at Department of Banking and Finance, Kainan University, No.1 Kainan Road, Luzhu, Taoyuan 33857, Taiwan. Email: ljkao@mail.knu.edu.tw

Ms. Hsing-Yu Lin is a research assistant at Kainan University, Taiwan. She can be contacted at Department of Banking and Finance, Kainan University, No.1 Kainan Road, Luzhu, Taoyuan 33857, Taiwan. Email: m09705002@ms.knu.edu.tw

THE LIQUIDITY EFFECT IN OPTION PRICING: AN EMPIRICAL ANALYSIS

Shih-Ping Feng, National Taiwan University

ABSTRACT

This paper empirically examines whether asset's liquidity can help resolve the known strike-price biases of the Black-Scholes model for different liquidity measures based on trading volume, bid-ask spread and the Amihud's ILLIQ. Our results indicate that, when the underlying asset or its derivative exhibit lower liquidity, the degree of curvature of the strike-price biases will tend to increase, regardless of the liquidity measures used. Furthermore, inspection of R^2 *reveals that the stock's liquidity has an excellent ability in explaining the strike-price biases compared with the option's liquidity in terms of the liquidity measures based on trading volume and the Amihud's ILLIQ.*

JEL: G10; G12; G13

KEYWORDS: Option Pricing; Liquidity; Stock's Liquidity; Option's Liquidity; Strike-Price Biases

INTRODUCTION

The purpose of this paper is to empirically examine whether the underlying asset's liquidity and its derivative's liquidity have potential to help resolve the strike-price biases associated with the Black-Scholes model (Black and Scholes (1973)) as depicted in Figure 1. While most attempts to explain these pricing errors focus on relaxing the Black-Scholes assumption of constant volatility (Heston, 1993 and Heston and Nandi, 2000), later examinations of stochastic volatility indicate that they cannot fully explain the pattern of the pricing errors and conclude that there is a need for a new explanation for this apparent pricing bias (Bakshi *et al*., 1997 and Eraker, 2004).

Liquidity, a new perspective on asset pricing, captures our attention on its potential to resolve the known strike-price biases. Cetin *et al*., (2006) studied the pricing of option in which the stock is not perfectly liquid and concluded that liquidity cost comprises a significant component of an option's price. Liu and Yong (2005) reported that the imperfect stock' liquidity would affect the replication of an option. These results motivated this research. Along the idea of Pena *et al*. (1999), who indicated that explain directly the determinants of the volatility smile is necessary to capture the important reasons behind the apparent failure of Black-Scholes model, we direct our analysis to further investigate the role of the stock's liquidity and its derivative's liquidity in explaining the strike-price biases.

While recent studies point out the choice of liquidity measures may have a significant effect on research outcome (Aitken and Comerton-Forde, 2003), that provides us a strong motivation to employ several different dimensions of liquidity measures to examine whether the liquidity can provide a new explanation for this apparent pricing bias of the Black-Scholes model. Furthermore, this enables us to test whether the effect of liquidity is robust enough for different liquidity measures. This is surely the first contribution of this paper over existing theories.

The second contribution of this paper is that we consider two types of liquidity risk, the underlying asset's liquidity and its derivative's liquidity, into our analysis. It is quite important to notice that these two types of liquidity risk would affect the option price in different way (Liu and Yong, 2005 and Brenner *et al*., 2001). A possible concern is whether these two types of liquidity risk need to be considered into option pricing model simultaneously. However, the existing empirical literature mostly deals with the effect of the stock's liquidity on the option pricing (Cetin *et al*., 2006 and Liu and Yong, 2005). In contrast, such research on the option's liquidity effect is still lacking. This paper fills in this gap. In addition, we provide evidence to show that the option's liquidity is attributed partially to the illiquidity present in its underlying asset.

Figure 1: Absolute Pricing Errors across Strike Prices For General Electric (GE)

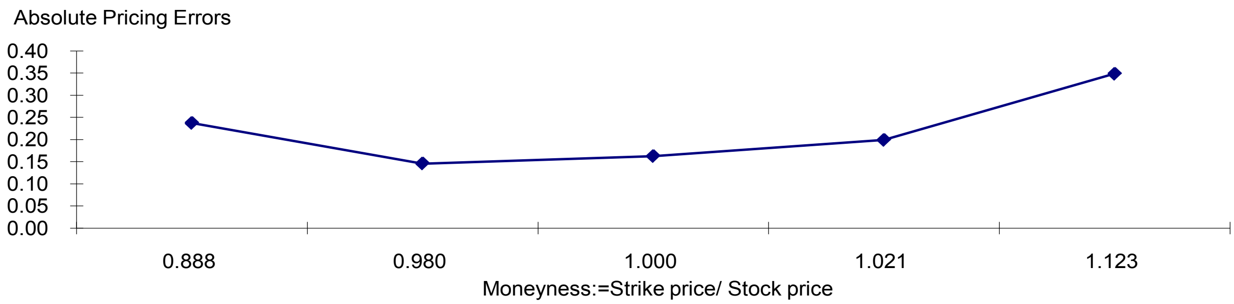


Figure 1 presents the relationship between the absolute pricing errors and the degree of moneyness for GE from 1996/1/1 through 2007/12/31. We employ five intervals for the degree of moneyness. The absolute pricing error is defined as the median of the absolute difference between the market price and the model price for each of the option price data in each moneyness classification.

Empirically, we employ the liquidity measures proposed by Cao and Wei (2010) to investigate the relationship between the degree of curvature in the absolute pricing errors and the asset's liquidity during the period from January 1996 to December 2007. In general, our results support the view that when the underlying asset or its derivative exhibit lower liquidity, the degree of curvature of the strike-price biases will tend to increase, regardless of the liquidity measures used. This means that the underlying asset's liquidity and its derivative's liquidity are both the informative determinants of the pattern of the strike-price biases. On the other hand, inspection of the R^2 reveals that the stock's liquidity has an excellent ability in explaining the strike-price biases compared with the option's liquidity in terms of the trading volume, and the Amihud's ILLIQ, especially after the sample period April 2001. Furthermore, our results indicate that despite the fact that the stochastic volatility can nicely improve the pricing performance of the Black-Scholes model, it is necessary to take both the option's liquidity and the stock's liquidity into account for further development of a more general pricing model. All empirical results regarding the liquidity effect on the curvature of the strike-price biases is the third contribution of this paper.

The rest of the article proceeds as follows. Section II introduces the literature review concerning liquidity proxies. Section III shows the liquidity measures used in this paper. Sections IV describes the data and methodology in the empirical study. Sections V and VI present the empirical results and conclusion.

LITERATURE REVIEW CONCERNING LIQUIDITY PROXIES

There are many liquidity proxies in empirical study. These measures may be divided into two broad categories: trade-base measures and order-base measures. The former is related to trading volume, dollar trading volume and the turnover ratio, while the latter refers to bid-ask spreads. For example, Dater, Naik and Radcliffe (1998) proposed a share turnover ratio as a liquidity proxy. Amihud and Mendelson(1986) used bid-ask spread as liquidity proxy to study the effect of the bid-ask spread on asset pricing. In addition to these two main categories of liquidity measures, Amihud's AILLIQ (2002) which is defined as the ratio of the absolute stock return on volume is also commonly used as liquidity proxy. Acharya and Pedersen (2005) adopt this measure to investigate the relationship between the return and the liquidity risk.

Cao and Wei (2010) compared these three categories of liquidity measures and proposed five liquidity proxies for both the underlying asset and its derivative including the trading volume, the dollar trading volume, the bid-ask spread, the absolute ILLIQ and the percentage ILLIQ to show the evidence of commonality in options present in different liquidity measures.

LIQUIDITY MEASURES

We adopt the liquidity measures used in Cao and Wei (2010) as the proxies of the stock's liquidity and the option's liquidity. We employ the trading volume (VOL) and the dollar trading volume (DVOL) as the transaction-based measure and the bid-ask spread (PBA) as the order-based measure. We also include Amihud's ILLIQ as the price impact measure (AILLIQ, PILLIQ). Table 1 describes the definitions of the liquidity measures.

We briefly discuss the expected relationships among the different liquidity measures. The heavier the trading or dollar trading volume of an asset, the more liquid it is. Since the bid-ask spread represents the cost of a transaction, the lower bid-ask spread denotes higher liquidity. Furthermore, an asset with lower liquidity will have higher values of AILLIQ and PILLIQ. The underlying intuition behind a higher AILLIQ or PILLIQ is that the asset's price moves significantly in response to a small change in volume.

Table 1: Definitions of Liquidity Measures

	Option	Stock
PBA	$\sum_{j=1}^{N} VOL_j \times \frac{ask_j - bid_j}{(ask_j + bid_j)/2} / \sum_{j=1}^{N} VOL_j$	$\frac{ask - bid}{(ask + bid)/2}$
VOL	$\sum_{j=1}^{N} VOL_j$	VOL
DVOL	$\sum_{j=1}^{N} VOL_j \times (ask_j + bid_j)/2$	$VOL \times (ask + bid)/2$
AILLIQ	$\sum_{j=1}^{N} VOL_j \times \frac{\lvert (C_t^j - C_{t-1}^j) - \Delta_{t-1}^j (S_t - S_{t-1}) \rvert}{DVOL_t^j} / \sum_{j=1}^{N} VOL_j$	$\frac{\lvert S_t - S_{t-1} \rvert}{DVOL_t}$
PILLIQ	$\sum_{j=1}^{N} VOL_j \times \frac{\lvert (C_t^j - C_{t-1}^j) - \Delta_{t-1}^j (S_t - S_{t-1}) \rvert / C_{t-1}^j}{DVOL_t^j} / \sum_{j=1}^{N} VOL_j$	$\frac{\lvert S_t - S_{t-1} \rvert / S_{t-1}}{DVOL_t}$

This table is reported for the definitions of the stock liquidity and option liquidity. The Δ *stands for the option's delta,* C_t *is the option price at time t, and the summation is over the distinct options that are traded during the day.*

DATA AND METHODOLOGY

Data

We select five well-known companies with varying liquidity: Federal Express (FDX), General Electric (GE), International Business Machines (IBM), Intel Corporation (INTC), and Texas Instruments (TXN), for our analysis. The data are obtained from Ivy DB Option Metrics and TAQ for the period from January 1, 1996 through December 31, 2007. Specifically, we divided the entire sample period into two sub-periods: January 1, 1996 to March 31, 2001 (an upward trend of the stock price) and April 1, 2001 to December 31, 2007 (a downward trend of the stock price). For each stock, we take the average bid and ask quotes in the last five minutes of trading as the close bid and ask prices. The option prices are defined as the average of the bid and ask option prices. We follow Macbeth and Merville (1979) in adjusting the stock dividends and use the dividend-exclusive stock prices to value the options. Using exclusion filters, we exclude general arbitrage violations, options with a maturity of less than nine days or bid-ask spreads below zero, price quotes lower than 3/8, and zero trading volume options. After processing these filters, there are 43,259 options for FDX, 111,945 options for GE, 217,074 options for IBM, 206,877 options for INTC and 146,766 options for TXN.

METHODOLOGY

The purpose of this paper is to empirically examine whether the liquidity have potential to help resolve the strike-price biases of the Black-Scholes model. Thus, we first verify the quadratic relationship by estimating the coefficient of the degree of curvature in the absolute pricing errors for each day:

$$APE_{ijt} = \alpha_0 + \alpha_1 M_{ijt} + \alpha_2 M_{ijt}^2 + \varepsilon_{ijt}^{APE} \tag{1}$$

where APE_{ijt} is the absolute pricing error of option j on stock i on day t defined as the absolute difference between the market price and the model price, and M_{ijt} is the moneyness of option j on stock i on day t which is defined as the exercise price K_{ij} divided by the stock price S_{it}. In order to calculate the absolute pricing errors, following Macbeth and Merville (1979), we regress the implied volatility σ_{ijt} to the percentage moneyness $m_{ijt} = M_{ijt} - 1$ to obtain the implied volatility for an at-of-money (ATM) option for stock i for each day.

As expected, the estimated α_2 are positive for all companies. These provide evidence to show that there is a quadratic relationship between the absolute pricing errors and the degree of moneyness. To examine whether the asset's liquidity could help resolve the strike-price biases, we employ the idea of Pena *et al.* (1999) to directly examine the relationship between the degree of curvature α_2, the stock's liquidity and the option's liquidity. The degree of curvature in the absolute pricing errors increases at higher levels of α_2.

Geske and Roll (1979) found that there are striking price biases, time-to-expiration biases and variance biases in the pricing errors of the Black-Scholes model. Therefore, we include the individual stock's volatility and the average time-to-expiration for stock i on day t as the explanatory variables for α_2. Since the individual stock's volatility is related to the option's liquidity and the stock's liquidity, we employ the market volatility on day t as a good instrument for the individual stock's volatility and run the following fixed effects panel regression:

$$\alpha_{2,it} = \beta_0 + \beta_1 OL_{it} + \beta_2 V_t + \beta_3 mat_{it} + \beta_4 r_t + \varepsilon_{it}^{\alpha} \tag{2}$$

$$\alpha_{2,it} = \beta_0 + \beta_1 SL_{it} + \beta_2 V_t + \beta_3 mat_{it} + \beta_4 r_t + \varepsilon_{it}^{\alpha} \tag{3}$$

where OL_{it} (SL_{it}) are the option's (stock's) liquidity measures for stock i on day t, V_t is the market volatility on day t, computed as the annualized standard deviation of the $S\&P500$ from the previous three months, mat_{it} is the average time-to-expiration for stock i on day t, and r_t is the average risk-free interest rate on day t. To facilitate the comparison of the two types of liquidity, the unit for the stock's trading volume is 10^9 and for the option's trading volume it is 10^3.

Furthermore, we empirically examine whether the stock's liquidity and the option's liquidity play a simultaneous role in explaining the curvature of the strike-price biases. In practice, the option's liquidity is related to its underlying asset's liquidity. Therefore, before examining whether the stock's liquidity and the option's liquidity need to be considered into option pricing model simultaneously, we must clarify the relationship between the stock's liquidity and the option's liquidity among different liquidity measures. Thus, we run the following panel regression with fixed effects:

$$OL_{it} = \mu_0 + \mu_1 SL_{it} + \varepsilon_{it}^{OL} \tag{4}$$

If there exists for the covariation between the stock's liquidity and the option's liquidity, we would employ the technology using in the Cao and Wei (2010) and use the orthogonalized option's liquidity to control for the potential relationship between the stock's liquidity and the option's liquidity. We run the following panel regression with fixed effects:

$$\alpha_{2,it} = \gamma_0 + \gamma_1 SL_{it} + \gamma_2 \varepsilon_{it}^{OL} + \gamma_3 V_t + \gamma_4 mat_{it} + \gamma_5 r_t + \varepsilon_{it}^{\alpha} \tag{5}$$

where ε_{it}^{OL} is the residual form of the regression that regresses the option's liquidity on the stock's liquidity.

EMPIRICAL RESULTS

Table 2 reports the results of the panel regression for both the option's liquidity and the stock's liquidity as well as for both the entire sample period and two sub-periods. Regardless of sample period, the trading volume measures, VOL and DVOL, the degree of curvature in the absolute pricing errors is negative and significantly related to the option's liquidity and the stock's liquidity in most cases. While for AILLIQ and PILLIQ, the estimated coefficient of the asset's liquidity is positive and significant for both the option's liquidity and the stock's liquidity, except the sub-period prior to the 2001. The price impact measure of liquidity seems to be weakly related to the degree of curvature in the absolute pricing errors for the sub-period during January 1996-March 2001. As for PBA, the estimated coefficient of the stock's liquidity and option's liquidity is positive but the estimated coefficient of the stock's liquidity is negative for the sub-period during January 1996-March 2001.

On average, these results mean that, the lower the liquidity of the option or the lower the liquidity of the stock, the more likely it is that the degree of curvature of the strike-price biases will tend to increase, regardless of the liquidity measure used. It is also the case that the market volatility, the average time-to-expiration and the average risk-free interest rate are also the determinants of the degree of curvature in the absolute pricing errors. This means that despite the fact that the stochastic volatility can provide the improvement of pricing performance associated with the Black-Scholes model, incorporating the asset's liquidity into the option pricing model is necessary. We further compare the relative explanatory power of the option's liquidity and the stock's liquidity. Inspection of the R^2 reveals that the stock's liquidity has an excellent ability in explaining the strike-price biases compared with the option's liquidity in terms of the trading volume, the dollar trading volume, the absolute ILLIQ and the percentage ILLIQ, especially after the sample period April 2001.

We next empirically examine whether the stock's liquidity and the option's liquidity play a simultaneous role in explaining the curvature of the strike-price biases. We first clarify the relationship between the stock's liquidity and the option's liquidity. As expected, the estimated coefficients of the stock's liquidity are both positive and significant in relation to the option's liquidity measure in terms of VOL, DVOL, AILLIQ and PILLIQ. As for PBA, the estimated coefficient of the stock's liquidity is negative and significant. These mean that when an underlying asset has low liquidity, its derivative will have imperfect liquidity in terms of transaction-based measure and the price impact measure. These findings suggest that the liquidity of the derivative is partially attributed to illiquidity present in the underlying asset among the different liquidity measures.

Table 2: Comparison stock's liquidity effect with option's liquidity effect

	Option's Liquidity					Stock's Liquidity				
	OL_{it}	V_t	mat_{it}	r_t	R^2	SL_{it}	V_t	mat_{it}	r_t	R^2
Panel A: Jan 1996 – Dec 2007										
VOL	-0.014**	-11.393**	-5.224**	0.388**	0.259	-27.761**	-11.831**	-4.555**	0.350**	0.262
DVOL	-0.001**	-11.419**	-5.589**	0.407**	0.254	-0.158**	-11.664**	-5.523**	0.403**	0.254
PBA	9.251**	-11.384**	-5.366**	0.395**	0.257	0.278	-11.562**	-5.585**	0.401**	0.254
AILLIQ	0.001**	-11.672**	-5.560**	0.396**	0.254	0.004**	-11.500**	-5.562**	0.394**	0.260
PILLIQ	0.005**	-11.597**	-5.575**	0.396**	0.255	0.660**	-11.577**	-5.607**	0.400**	0.255
Panel B: Jan 1996 – Mar 2001										
VOL	-0.018**	-19.706**	-6.648**	-0.597**	0.266	-59.452**	-17.710**	-6.145**	-0.536**	0.274
DVOL	-0.0003	-20.530**	-7.317**	-0.620**	0.261	-0.068	-20.418**	-7.340**	-0.613**	0.261
PBA	7.373**	-19.563**	-7.209**	-0.457**	0.263	-9.508**	-20.131**	-7.008**	-0.593**	0.262
AILLIQ	-0.002	-20.614**	-7.385**	-0.626**	0.261	0.026*	-20.364**	-7.206**	-0.611**	0.262
PILLIQ	0.008	-20.632**	-7.332**	-0.630**	0.261	-1.091	-20.825**	-7.294**	-0.637**	0.261
Panel C: Apr 2001– Dec 2007										
VOL	-0.004**	-1.203*	-1.685**	0.694**	0.410	-2.412	-1.363*	-1.658**	0.689**	0.410
DVOL	-0.001**	-1.129	-1.700**	0.690**	0.410	0.144**	-1.341*	-1.682**	0.677**	0.411
PBA	1.420	-1.308*	-1.722**	0.691**	0.410	0.725**	-1.053	-1.626**	0.684**	0.412
AILLIQ	0.001*	-1.392**	-1.683**	0.684**	0.410	0.004**	-1.382**	-1.633**	0.669**	0.420
PILLIQ	0.004**	-1.364*	-1.676**	0.680**	0.411	0.822**	-1.433**	-1.671**	0.674**	0.414

*The table is reported for the results of the panel regression model that takes both the stock's liquidity and the option's liquidity into account. * and ** denote rejection at the 10% and 5% significance levels, respectively.*

Table 3 reports the results of the panel regression on investigating whether the stock's liquidity and the option's liquidity need to be considered into option pricing model simultaneously. In terms of the trading volume, VOL and DVOL, the estimated coefficients of the stock's liquidity and the residual of the option's liquidity are negative and significant in most cases, but for the sub-period during January 1996-March 2001, only the stock's liquidity is significant. As for the PBA, the explanatory power of the stock's liquidity and the option's liquidity are not consistent for different sample period. For AILLIQ and PILLIQ, the stock's liquidity is positive and significant. This means that, for AILLIQ and PILLIQ, the stock's liquidity have more explanatory power in terms of explaining the pattern of strike-price biases than the option's liquidity. The market volatility, the average time-to-expiration and the average risk-free interest rate also seem to be determinants associated with the pattern of strike-price biases. It particular,

inspection of the R^2 reveals that taking both these two types of liquidity risk into account could effectively increase the explanatory power in explaining the degree of curvature in the absolute pricing errors compared to using the stock's liquidity and the option's liquidity, respectively. The results also suggest that the option pricing model with stochastic volatility will not be correctly specified as long as we do not consider both these two types of liquidity risk. In summary, all these empirical results provide evidence to conclude that taking the underlying asset's liquidity and its derivative's liquidity into account is a move in the right direction for the further development of a more general pricing model.

Table 3: The Effect of Stock's Liquidity and Option's Liquidity

	Option's Liquidity and Stock' Liquidity					
	SL_{it}	ε_{it}^{OL}	V_t	mat_{it}	r_t	R^2
Panel A: Jan 1996 – Dec 2007						
VOL	-27.297**	-0.007**	-11.647**	-4.605**	0.356**	0.263
DVOL	-0.158**	-0.001*	-11.476**	-5.545**	0.409**	0.255
PBA	0.277	9.462**	-11.192**	-5.378**	0.400**	0.257
AILLIQ	0.004**	-0.0004	-11.499**	-5.568**	0.395**	0.260
PILLIQ	0.660**	0.003**	-11.546**	-5.601**	0.398**	0.256
Panel B: Jan 1996 – Mar 2001						
VOL	-59.453**	-0.0003	-17.715**	-6.141**	-0.536**	0.274
DVOL	-0.067	-0.0003	-20.466**	-7.319**	-0.616**	0.261
PBA	-10.457**	6.748**	-19.206**	-6.928**	-0.440**	0.264
AILLIQ	0.026*	-0.002	-20.334**	-7.248**	-0.608**	0.262
PILLIQ	-1.091	0.008	-20.812**	-7.282**	-0.638**	0.261
Panel C: Apr 2001– Dec 2007						
VOL	-2.310	-0.005**	-1.205*	-1.736**	0.691**	0.411
DVOL	0.146**	-0.001**	-0.993	-1.687**	0.679**	0.411
PBA	0.725**	1.458	-0.967	-1.654**	0.688**	0.412
AILLIQ	0.004**	-0.001**	-1.379**	-1.638**	0.670**	0.421
PILLIQ	0.822**	0.001	-1.425**	-1.668**	0.673**	0.414

*The table is reported for the results of the panel regression for the option's liquidity and the stock's liquidity, respectively. * and ** denote rejection at the 10% and 5% significance levels, respectively.*

CONCLUSION

The purpose of this paper is to examine empirically the effects of the underlying asset's liquidity and its derivative's liquidity on the curvature of the strike-price biases associated with the Black-Scholes model. For this purpose, we employ the liquidity measures used in Cao and Wei (2010) including the trading volume, the dollar trading volume, the bid-ask spread, the absolute ILLIQ and the percentage ILLIQ as the proxy of the option's liquidity and the stock's liquidity.

Empirically, we select five well-known companies with varying liquidity for the period from January 1, 1996 through December 31, 2007 as our empirical data. We employ the idea of Pena *et al*. (1999) to examine directly the relationship between the degree of curvature α_2, the stock's liquidity and the option's liquidity. In general, the results indicate the lower the liquidity of underlying asset or the lower the liquidity of its derivative, the more likely it is that the degree of curvature of the strike-price biases will tend to increase among different liquidity measures. On the other hand, inspection of the R^2 reveals that the stock's liquidity is able to more accurately explain the curvature of the strike-price biases compared with the option's liquidity in terms of the trading volume, the dollar trading volume, the absolute ILLIQ and the percentage ILLIQ, especially for the period after April 2001. The empirical results also show that the stock's liquidity, the option's liquidity and the stock's volatility are all the determinants of the curvature of the strike-price biases. This means that the option pricing model with stochastic volatility will not be correctly specified as long as we do not take the asset's liquidity into account. Furthermore, we provide evidence to show that when pricing derivatives, the liquidity of the underlying asset and its derivative are both important and necessary for further development of a more general pricing model.

This paper offers a direct insight into the effects of the stock's liquidity and its derivative's liquidity on the performance of the Black-Scholes model. We choose five individual stocks for the empirical analysis, and these are more likely to be liquid stocks. Since the number of individual stock option for illiquid stock is less than the liquid stock, and it is not easy to examine the empirical issue addressed in this paper for small firm due to the limitation of empirical data. However, it is important to clarify whether the asset's liquidity is the determinants of the performance of pricing model and the empirical results of this paper document the important of asset's liquidity to option pricing. Furthermore, the future research can examine the effects of underlying asset's liquidity and its derivative's liquidity on pricing performance using data from options on future, and currency options.

REFERENCES

Acharya, V., and L. Pedersen, 2005, Asset Pricing with Liquidity Risk, *The Journal of Financial Economics*, 77, 375-410.

Aitken, M., and C. Comerton-Forde, 2003, How should liquidity be measured? *Pacific-Basin Finance Journal*, 11, 45-59.

Amihud, Y., 2002, Illiquidity and Stock Returns: Cross-Section and Time-Series Effects, *Journal of Financial Markets*, 5, 31–56.

Amihud, Y., and H. Mendelson, 1986, Asset Pricing and the Bid-Ask Spread, *Journal of Financial Economics*, 17, 223-249.

Bakshi, G., C. Cao, and Z. Chen, 1997, Empirical Performance of Alternative Option Pricing Models, *Journal of Finance*, 52, 2003-2049.

Black, F. and M. Scholes, 1973, The Pricing of Options and Corporate Liabilities, *Jounal of Political Economy*, 18, 637-654.

Brenner, M., R. Eldor, and S. Hauser, 2001, The price of options illiquidity, *Journal of Finance*, 56, 789-805.

Cao, M., and J. Wei, 2010, Option Market Liquidity: Commonality and Other Characteristics, *Journal of Financial Markets,* 13, 20-48.

Cetin, U., R. Jarrow, P. Protter, and M. Warachka, 2006, Pricing Options in an Extended Black Scholes Economy with Illiquidity: Theory and Empirical Evidence, *Review of Financial Studies*, 19, 493-529.

Datar, V., N. Naik, and R. Radcliffe, 1998, Liquidity and Stock Returns: An Alternative Test, *Journal of Financial Markets*, 1, 203–219.

Eraker, B., 2004, Do Stock Prices and Volatility Jump? Reconciling Evidence from Spot and Option Prices. *Journal of Finance*, 59, 1367-1403.

Geske, R., and R. Roll, 1979, On Valuing American Call Options with the Black-Scholes European Formula, *The Journal of Finance*, 39, 443-455.

Heston, S., 1993, A Closed-Form Solution for Options with Stochastic Volatility with Applications to Bond and Curry Options, *Review of Financial Studies*, 6, 327-343.

Heston, S. and S. Nandi, 2000, A Closed-form GARCH Option Valuation Model. *Review of Financial*

Studies, 13, 585-625.

Liu, H., and J. Yong, 2005, Option Pricing with an Illiquid Underlying Asset Market, *Journal of Economic Dynamics and Control*, 29, 2125-2156.

Macbeth, J. D., and L. Mervilles, 1979, An Empirical Examination of the Black-Scholes Call Option Pricing Model, *The Journal of Finance*, 34, 1173-1186.

Pena, I., G. Rubio, and G. Derna, 1999, Why do we smile? On the determinants of the implied volatility function, *Journal of Banking and Finance*, 23, 1151-1179.

BIOGRAPHY

Shih-Ping Feng can be contacted at: College of Management, National Taiwan University, No. 1, Section 4, Roosevelt Road, Taipei, Taiwan. Email: d92724016@ntu.edu.tw

A COMPARISON OF NON-PRICE TERMS OF LENDING FOR SMALL BUSINESS AND FARM LOANS

Raymond Posey, Mount Union College
Alan K. Reichert, Cleveland State University

ABSTRACT

This study examines differences in terms of lending for small loans among non-farm commercial banks and farm lenders of different sizes. Large farm lenders more frequently require collateral than large commercial banks, while small farm lenders require collateral less frequently than small commercial banks. In addition, there is evidence that small commercial banks require collateral more frequently than large commercial banks. There is no difference in the frequency of collateral use among farm lenders, regardless of size. The type of the collateral used, real estate vs. non-real estate, is also affected by the term of the loan for farm lenders. The longer the term of the loan, the more frequently real estate is used as collateral.

JEL: G2

KEYWORDS: farm lending, role of collateral, terms of lending

INTRODUCTION

Banks set lending terms in a negotiation with borrowers in an effort to earn a target rate of return and manage the probability of default (PD) and loss given default (LGD). Varying interest rates and non-price terms, such as collateral, can reduce the LGD. However, Stiglitz and Weiss (1981) show that raising interest rates and increasing collateral requirements above a maximum amount can actually reduce the expected return to the bank. This occurs because of adverse selection, in which case only the riskiest borrowers will accept the higher interest rates. Because of this behavior, lenders would have more risk than the higher interest rates compensate for, explaining the lower returns to the lender as interest rates increase. Given this situation, it is rational for banks to ration credit (refuse to lend to certain borrowers), rather than attempt to price it with higher interest rates. This explains why total lending volume may decline in response to tightened lending standards.

Small borrowers tend to be more informationally opaque than large, publicly traded firms. There is a large body of research that examines bank relationship lending by banks. In this case, the banks place some reliance upon the prior relationship with a borrower and the knowledge gained from that relationship, such as cash flows observed in checking accounts. Both loans to the small non-farm (commercial) business sector and loans to the small farm sector represent different forms of small business lending. Given the substantial differences in the risk these firms face and the types of assets such firms possess, it is possible that lenders to these two sectors may view collateral in significantly different ways. This may especially be true since farm businesses are characterized by large fixed assets in the form of land and equipment and are subject to a high degree of output price volatility. The reminder of this paper is organized as follows. Section 2 reviews the prior literature. Section 3 discusses the methodology and the empirical model. Section 4 presents the empirical findings, while Section 5 presents the conclusion.

LITERATURE REVIEW

Many other authors have examined the use of collateral as a non-price means to resolve the asymmetric information between borrower and lender. The borrower knows better than the lender the true risk of the business, and in the case of small businesses, information asymmetry is higher because of the absence of public disclosure of financial data, as is the case with publicly traded companies. Boot and Thakor (1994) examine the use of collateral and conclude that collateral is more likely to be used on a first loan related to a short or non-existent prior banking relationship. The need for collateral can then be reduced or eliminated on subsequent loans to the same borrower following a successful initial loan contract

There are a group of studies that focus on the effects of the lender-borrower relationship on interest rates and the use of collateral. Machauer and Weber (1998) find that German borrowers offer more collateral to their "housebank", the bank with whom they have a primary banking relationship. In this case, it appears the banks may exploit the relationship or are using their private knowledge of the small firm to set the terms of lending. This seems to suggest that a closer banking relationships lead to greater use of collateral, perhaps because the inside knowledge of the lender enable them to identify collateral which might be available to pledge. Contrary to this finding, Elsas and Krahnen (1999) find an inverse relationship between the use of collateral and the strength of the banking relationship. Brick and Palia (2007) examine the use of collateral, loan interest rates, and the length of lending relationships. Here, the length of the banking relationship is used as a measure of the strength of the relationship. They review prior research noting mixed findings on the inter-relationships among interest rate, collateral, and the length of the banking relationship. Berger and Udell (1990) find a positive relationship between the use of collateral and interest rates, whereas in a later study, Berger and Udell (1990) find a no relationship.

Chakraborty and Hu (2006) examine the use of collateral in small business loans. They examine multiple types of loans, including lines of credit and others types, such as fixed term loans. They find a negative relationship between the length of the bank-borrower relationship and the use of collateral for lines of credit. The relationship length is not significant for other types of loans. One key difference between the research of Brick and Palia (2007) versus Chakraborty and Hu (2006) is whether the terms of lending are endogenous or exogenous. Brick and Palia (2007) argue that they are endogenous and use a two-stage procedure in their econometric analysis. This same method is employed in Essay #1 for the same reason. Both Essay #1 and Brick and Palia (2007) find evidence that key loan terms are in fact determined jointly, or simultaneously, and therefore those variables are not predetermined but rather are endogenous. Overall, there is mixed evidence with regard to the relationship between length of the bank lending relationship and the use of collateral. There is also mixed empirical evidence regarding the interplay between the use of collateral and other lending terms.

Walraven and Barry (2004), using data from the Survey of Terms of Bank Lending to Farmers and from call reports, examine the relationship between the effective interest rate charged and various price and non-price terms of lending. They find that secured loans (using collateral) have a higher effective interest rate as do loans secured by farm real estate. In this case, collateral appears to be a complement to interest rates, rather than being a substitute. An important difference in loans to small businesses and loan to farms is that according to Walraven and Barry (2004), over 60% of farm loans are made by small commercial banks. In contrast, approximately 43% of small non-farm commercial loans (<$100,000) are made by small commercial banks based on the November, 2008 Federal Reserve's Terms of Business Lending survey. Thus, not only are the two borrowing sectors, farm and non-farm, unique their primary lenders are quite different as well. Lown and Morgan (2006) examine the effects of changes in loans standards on the quantity of loans made. They argue that the loan standards variable (taken from the Loan Officer Opinion Survey) is an approximate index for a vector of non-price lending terms. They show, using a VAR model, that the volume of C&I loans (commercial and industrial) is negatively effected by an increase in lending standards.

DATA AND METHODOLOGY

Hypotheses

As discussed above, collateral is a common feature of bank loans that can reduce both the probability-of-default (PD) and the loss- given-default (LGD) to the lender and attempt to control asymmetric information between lender and borrower. The empirical evidence regarding the role of collateral is mixed. Given the previous mixed empirical findings, the following broad questions will be addressed in this study: 1) What are the differences in the terms of lending between small business commercial loans and similar (non-real estate) loans to farmers, and how do these differences vary over time?, 2) How are loan risk, collateral, and interest rates related for these two different types of farms and non-farm borrowers?, and 3) How are these lending term relationships affected by the size of the lender?

Farms typically are fixed-asset intensive because both land and equipment is required. As a result, it is anticipated that lenders will seek to use the more readily available and easy to identify collateral for non-real estate loans to farmers. There is evidence from Chakraborty & Hu (2006) that more collateral is required as the size of the borrower (total assets) increases. Furthermore, small banks typically lend to local and regional small borrowers, which may be concentrated by industry type. This would tend to concentrate credit risk in smaller banks where it is more difficult to diversify their loan portfolio. For example, smaller rural banks located in agricultural areas are like to have a loan portfolio heavily concentrated in farm loans to local borrowers. Therefore, the following three hypotheses are tested:

H1: Collateral will be more prevalent in farm lending than in small non-farm commercial loans

H2: Small banks require more collateral than larger lenders due to their more concentrated higher risk loan portfolios.

H3: The importance of collateral will change over time as lenders modify their underwriting (credit) standards to reflect changes in external economic conditions and their internal risk management strategies.

Data

The Federal Reserve Board conducts two quarterly surveys of the terms of lending, one for business (C&I) lending, and one for lending to farmers. More formally, the business lending survey is named E.2 Survey of Terms of Business Lending (STBL), and the other is named E.15 Agricultural Finance Databook (AFD). Both surveys are quarterly and since 1999Q4 have provided the same information with regard to summary loan data. The AFD has more variables and more detailed information than is provided in the STBL, and in some cases has more years of data. It is subdivided into three sections; A) Amount and Characteristics of Farm Loans Made by Commercial Banks; B) Selected Statistics from the Quarterly Reports of Condition of Commercial Banks; and C) Reserve Bank Surveys of Farm Credit Conditions and Farm Land Values.

For this study, the data period is from 2002(Q2) – 2009(Q1). The following six variables common to both surveys will be used: 1) percentage of loans secured by collateral, 2) effective interest rate, 3) degree of credit risk, 4) dollar volume of loans, 5) weighted average maturity, and 6) percentage of loans made under commitment. Both farm and non-farm surveys are subdivided into small and large bank (lenders) categories, so comparisons of the effects of bank size can be made by comparing the results of the same model for the two different size categories. Likewise, comparisons between farm lending and C&I lending can be made using identical models with the different data sets. Loans up to $99,000 are included in this study. One additional variable from the Senior Loan Officer Opinion Survey is used. It is the net percentage of domestic bank respondents that are tightening standards. (That is, the percent of banks that have tightening their credit standards less the percentage of banks that have loosened their lending standards). There are two standards time series, one for small borrowers and one for large. While the size of the typical borrower is not known, since this study examines loans smaller than $100K, it is presumed that the standards series for small borrowers would be most appropriate. Regardless, as shown by Lown and Morgan (2006) the two series are highly correlated. For these time series, the two series have a Pearson correlation coefficient of .968, which is significant at the 1% level. For this study, the small borrower lending standards series will be used.

Although the time series is relatively short (38 quarters), this data does offer the opportunity for examining effects of changes of lending terms on subsequent borrower behavior. All of the time series were tested for the presence of unit roots using the augmented Dickey Fuller procedure. For the variables where the null hypothesis of a unit root cannot be rejected (5% level of significance), they are included in the model in first difference form. When this is the case, either the first or second letter of the variable name is a "D", indicating it is a differenced variable. Furthermore, if the first letter in a variable name is "F", this indicates that the variable applies to a farm lender. If the last letter is an "L", the variable applies to a large lender.

In Table 1, descriptive statistics of the AFD and STBL for the entire time series are provided for the common variables. The data is provided for large farm banks, small farm banks, and for small and large banks. The variables are defined as follows:

1) FOTCOLLAT – non-real estate collateral as a percent of total loans.
2) DSTD – net percentage of lenders increasing lending standards.
3) FDEXRATE – weighted average effective interest rate of loans in excess of the comparable maturity treasury rate.
4) FRISK – weighted average loan risk rating on a scale from 1 to 5, with 5 being the highest risk. The risk ratings are assigned by the lender.
5) FDVOLUME – volume (size) of lenders total loan portfolio ($billions)
6) FMATURE – weighted average maturity of the loan portfolio in months
7) FCOMMIT – percentage of loans made under a prior loan commitment

One difference between the variables in the two surveys is the presence of two collateral variables in the AFD data. The value of the non-real estate collateral ("other" collateral) variable (OTCOLLAT) is the percentage of loans that have non-real estate collateral. Even though the loans examined in this study are non-real estate loans, a portion of the collateral actually used to support non-real estate lending is based on real estate. Given the nature of farms, it is not surprising that collateral of this type may be used for non-real estate loans. A preliminary evaluation of these two forms of collateral reveals that they are negatively correlated. This suggests subsequent analysis must use a single collateral variable due to a high degree of multi-collinearity It also suggests that total collateral variable which is the sum of real estate collateral (RECollat) and non-real estate collateral (OtCollat) may mask differing relationships. The correlation between the two variables is -0.87.

Machauer and Weber (1998) discuss the presence of "money illusion", which is the tendency for interest rate risk premiums, measured over some risk free rate, to be lower when nominal interest rates are high and higher when nominal rates are low. To borrowers this procedure appears to stabilize their borrowing rates over the interest rate cycle. There is evidence of this rate smoothing phenomenon over the sample period as the correlation between the fed funds rate and the borrowers risk premium (Exrate) is -0.74.

Table 1 - Descriptive Statistics

Panel A. Large Farm Lenders							
	FDOTCOLL	DSTDS	FDEXRATEL	FMATUREL	FDRISKL	FDVOLUMEL	FCOMMITL
Mean	0.172	1.82	0.014	12.4	-0.002	4299	84.8
Median	0.244	1.90	0.051	11.8	-0.008	0	85.2
Maximum	5.190	21.40	0.554	16.2	0.212	116191	93.0
Minimum	-5.341	-27.30	-0.841	9.1	-0.188	-105635	73.1
Std. Dev.	2.415	10.57	0.326	1.9	0.091	55937	4.0
Observations	37	37	37	37	37	37	37
Panel B. Small Farm Lenders							
	FOTCOLLAT	DSTDS	FDEXRATE	FMATURE	FRISK	FVOLUME	FCOMMIT
Mean	83.8	1.82	0.052	18.3	2.41	201647	49.7
Median	84.2	1.90	0.058	18.0	2.41	193814	50.8
Maximum	90.9	21.40	1.353	25.1	2.54	315965	56.7
Minimum	72.4	-27.30	-1.138	11.6	2.23	117463	33.4
Std. Dev.	3.7	10.57	0.515	3.0	0.08	48278	5.4
Observations	37	37	37	37	37	37	37
Panel C. Large Banks							
	OTCOLLATL	DSTDS	EXRATEL	MATUREL	RISKL	VOLUMEL	DCOMMITL
Mean	83.8	1.82	3.281	47.3	3.49	1507	0.09
Median	84.1	1.90	3.340	46.0	3.50	1486	0.00
Maximum	87.9	21.40	4.480	95.0	3.70	1846	2.10
Minimum	78.7	-27.30	2.340	34.0	3.20	1209	-3.10
Std. Dev.	2.6	10.57	0.523	10.5	0.11	173	1.04
Observations	37	37	37	37	37	37	37
Panel D. Small Banks							
	OTCOLLAT	DSTDS	DEXRATE	MATURE	RISK	VOLUME	DCOMMIT
Mean	86.3	1.82	0.022	294.5	3.14	1275	0.44
Median	86.1	1.90	-0.020	293.0	3.10	1273	0.10
Maximum	90.8	21.40	0.640	409.0	3.30	1682	6.40
Minimum	81.1	-27.30	-0.760	203.0	3.00	915	-5.70
Std. Dev.	2.9	10.57	0.330	47.0	0.07	141	3.38
Observations	37	37	37	37	37	37	37

FOTCOLLAT – non-real estate collateral as percent of loans.
FRISK – self-reported loan risk (1 to 5 scale)
DSTD – percentage of lenders increasing lending standards.
FDVOLUME – loan volume (millions of dollars)
FDEXRATE – interest rate of loans in excess of an appropriate treasury rate.
FMATURE – The maturity of the loans (months)
FCOMMIT – The percentage of loans made under prior commitment

Note: First letter "F" indicates farm lender; last letter "L"is a large lender; "D" indicates the first difference of the series

Alternative Models

The first model to be estimated will be of the following contemporaneous OLS regression:

$$COLLATERAL_t = \alpha + \beta_1 STANDARDS_t + \beta_2 EXRATE_t + \beta_3 MATURE + \beta_4 RISK_t + \beta_5 VOLUME_t + \beta_6 COMMIT + \varepsilon_t \quad (1)$$

This OLS equation will be estimated for four categories of lenders: large and small commercial banks and large and small farm lenders. The presence of possible non-stationarity in the data will be examined and corrected as necessary. Furthermore, Newey-West robust coefficients will be used to address the presence of autocorrelation or heteroscedasticity. Depending upon empirical findings, it may be appropriate to include a lag of the STANDARDS variable rather than its contemporaneous value.

In order to capture dynamic time-varying inter-relationships effects among the variables a vector auto-regressive (VAR) model will be estimated similar to the model used by Lown and Morgan (2004). As discussed previously, certain prior studies consider terms of lending to be exogenous, whereas other research considers the terms of lending to be endogenous or jointly determined. The VAR procedure is quite flexible since it assumes that all the variables in the model are potentially interrelated or endogenous. The VAR model will include the same variables as shown in equation (1) except that the right hand side will include lags of both the dependent variable and selected independent variables. Thus, the VAR model is a series of equations, all of the form specified in equation (2), where the number of equations is equal to the number of variables. To illustrate, the general form of the VAR model will be as follows:

$$COLLATERAL_t = \beta_0 + \Sigma\beta_1 iSTANDARDS_{t-i} + \Sigma\beta_{2i} EXRATE_{t-i} + \Sigma\beta_{3i} MATURE_{t-i} + \Sigma\beta_{4i} RISK_{t-i} + \Sigma\beta_{5i} VOLUME_{t-i} + \Sigma\beta_{6i} COMMIT_{t-i} + \Sigma\beta_{7i} COLLATERAL_{t-i} + \varepsilon_t \quad (2)$$

where, Σ indicates the inclusion of lags of the variables from time t-1 to time n. The number of lags (n) to be used is an empirical matter and will be based on the lowest values for the AIC and SIC summary statistics. The number of lags of the variables will be limited because of the relatively short length of the time series. Given the limited number of degrees of freedom, the VAR model will be estimated using only those independent variables found to be statistically significant in equation (1). The credit standards variable may or may not be exogeneous. Loan and Morgan (2006) suggest that it represents a proxy for all non-price terms of lending. In their research, they find a negative relationship between credit standards and aggregate loan volume and assume credit standards to be exogenous. However, it may be that lenders, in order to properly manage their loan portfolio, may adjust underwriting standards for internal purposes, and not simply in response to external economic factors or monetary policy changes.

Finally given the expectation that tightening of lending standards will influence both priced and non-price terms of lending, Granger causality tests will be conducted to determine which variable(s) appear to precede or "cause" the others variables to change. While the appropriate number of lags is an empirical matter, prior research suggests that no more than 4 lags should be necessary.

EMPIRICAL RESULTS

OLS Results

Equation (1) was first estimated using OLS for the four categories of lenders. These results are provided in Table 2, Panels A-D. Six variables are used in each model. The credit standards variable used in each model is specified in first difference form (DSTD), hence a positive value for the variable would indicate that credit standards are being tightened at an increasing rate. Several other independent variables, loan commitment (COMMMITL), interest rate risk premium (DEXRATEL), and loan volume (VOLUME) are also specified in first difference form as needed to correct for non-stationarity.

The dependent variable in this section is specified in levels, not in first difference form. The model for Large Farm Lenders (Panel A) showed strong first-order auto-correlation, while the Durbin-Watson statistic for the other models was marginal at the 5% level. Thus, all four models include a first-order autoregressive term, AR(1), which proved to be highly significant in all models. In addition, all models were tested for the presence of heteroscedasticity, using both the White and Bruesch-Pagan-Godfrey tests. In Panel A, the results for Large Farm Lenders are provided. FMATURITY is significant at the 10% level and carries a negative sign. This result is consistent with the previously mentioned correlation where maturity is negatively correlated with use of non-real estate collateral. FCOMMITL is positive and significant at the 5% level. The credit standards variable is not significant.

The equation estimated in Panel B for small farm loans is significant at the 1% level, but once again the standards variable is not significant. As with large lenders, loan maturity (FMATURE) is negative and statistically significant. Risk is not significant. Maturity is negative and significant, as is the case for large farm lenders. Loan volume is positive and significant, while the coefficient on loan commitment (FCOMMIT) is negative and significant at the 5% level. The interest rate variables, FRISK and FEXRATE, are not statistically significant.

The OLS results for large commercial banks are provided Panel C. The overall regression is significant at the 1% level and loan risk (RISKL) is the only significant variable in the model and carries a negative coefficient. This sign may appear inconsistent with expectations as it would be expected that banks would require collateral on riskier loans to mitigate the risk. An alternate explanation for the negative sign is that the loan portfolio is riskier because fewer loans require collateral. This could occur when the competitive environment forces banks to reduce their collateral demands in order to secure the loan.

In Panel D., the results for small commercial banks are provided. Loan volume is significant and negatively related to collateral usage. This negative relationship between loan volume contrasts to the positive but small coefficient reported in Panel B. This may be due to abundant levels of both real estate and non-real estate collateral available from farms borrowers. Loan commitment (DCOMMIT) is also significant at the 10% and negatively related to collateral usage.

To summarize the OLS results, in the regression for large farm lenders, maturity and commitment are significant at conventional levels. Maturity is also negative and significant for small farm lenders. Commitment is significant, but negatively related to collateral, contrary to the findings for large farm lenders. For small farm lenders, the first difference of volume is used in the analysis so the proportion of collateral used increases as volume increases. Risk is the only significant variable for large banks. For small banks, higher volume is associated with a lower proportion of collateral in loans, suggesting looser terms of lending in periods of higher volume. For both types of small lenders, the proportion of loans made under commitment is negatively associated with the proportion of collateral required, suggesting borrowers may benefit from the prior commitment regarding collateral requirements when compared to current lending standards. For small farm lenders, loan maturity is negative and significant, consistent with the finding that non-real estate collateral is negatively related to loan term. The most consistent finding is that commitment is significant in three of the four lender type estimations. In general, each lender category appears to have unique, contemporaneous explanatory variables for the proportion of loans requiring collateral.

Table 2 - OLS Regression Results

Panel A. Large Farm Lenders				**Panel B. Small Farm Lenders**			
Dependent Variable: FOTCOLLAT				Dependent Variable: FOTCOLLAT			
Variable	Coefficient	t - statistic	Significance	Variable	Coefficient	t - statistic	Significance
C	68.52	6.52	***	C	116.49	6.36	***
DSTDS	-0.01	-0.48		DSTDS	0	-0.01	
FDEXRATEL	0.93	0.96		FDEXRATE	0.67	0.73	
FMATUREL	-0.28	-1.85	*	FRISK	-2.089	-0.31	
FDRISK	-0.08	-0.24		FDVOLUME	0	1.95	*
FDVOLUME	0.00000501	1.09		FMATURE	-0.846	-4.89	***
FDCOMMITL	0.27	2.47	**	FCOMMIT	-0.247	-2.44	**
AR(1)	0.90	12.03	***	AR(1)	0.353	1.89	*
F statistic	14.69		***	F statistic	3.99		***
Adj R-squared	0.73			Adj R-squared	0.37		

Panel C. Large Banks				**Panel D. Small Banks**			
Dependent Variable: OTCOLLATL				Dependent Variable: OTCOLLAT			
Variable	Coefficient	t - statistic	Significance	Variable	Coefficient	t - statistic	Significance
C	113.350	7.64	***	C	87.95	4.37	***
DSTDS	-0.007	-0.23		DSTDS	0.03	0.77	
DEXRATEL	0.114	0.12		DEXRATE	-0.45	-0.46	
RISKL	-9.346	-2.45	**	RISK	1.55	0.24	
MATUREL	0.023	0.74		VOLUME	-0.01	-2.18	**
VOLUMEL	0.001	0.49		MATURE	0.01	0.59	
DCOMMITL	0.385	1.39		DCOMMIT	-0.17	-1.87	*
AR(1)	0.555	3.69	***	AR(1)	0.62	4.05	***
F statistic	4.77		***	F statistic	4.83		***
Adj R-squared	0.43			Adj R-squared	0.43		

This table presents the OLS results for each of the four lender types. The equation estimated is of the form: $COLLATERALt = \alpha + \beta_1 STANDARDSt + \beta_2 EXRATEt + \beta_3 MATURE + \beta_4 RISKt + \beta_5 VOLUMEt + \beta_6 COMMIT + \varepsilon t$ *The data is from the period 2002Q2 - 2009Q1. ***, **, * denotes significance at the 1%, 5%, and 10% level, respectively.*

VAR Results

VAR models of the form described in equation (2) were estimated for each of the four lender categories and the results are provided in Table 3, Panels A-D. Because of the limited number of observations, all the VAR models include the collateral and standards variables, and at least two more variables having the lowest p value in their respective OLS regression. Furthermore, all variables with significance levels below 0.10 are included in the respective VAR model.

The VAR results for large farm lenders are provided in Panel A. In equation (1) DSTD are explained by one lag of FDOTCOLL and one and two lags of FDRISKL. Thus, as collateral is increased lending standards are subsequently loosened, and as loan risk increases credit standards are subsequently tightened. In equation (2) none of lagged variables appear to impact FDOTCOLL in a significant way. The strongest explanatory variable identified in equation (3) for FMATUREL is its own value lagged two quarters. One lag of DSTD is also significant, suggesting that maturities increase in response to tightening standards. In equation (4) the variable FMATUREL lagged one quarter has a positive impact on changes in loan risk (FDRISKL). This suggests that as maturity increases, loan risk subsequently increases.

The results for small farm loans reported in Panel B in equation (1) for DSTD indicate that none of the explanatory variables are significant. In equation (2), FOTCOLLAT is explained by one lag of DSTD (negative sign) and two lags of FCOMMIT, which is positive and statistically significant. In equation (3) FDVOLUME is explained by a one quarter lag in its own value which carries a negative coefficient. Thus, an increase in loan volume is followed by a subsequent decrease in volume. In equation (4), FMATURE is explained by one lag of DSTD and one lag of FOTCOLLAT, both with positive coefficients. This suggests that as standards tighten and collateral is required more, loan maturities increase. In equation (5), FCOMMIT is explained by both one and two lags of FDVOLUME, where the signs of both coefficients are both positive. This indicates that as volume increases, the proportion of loans made under commitment increases in subsequent quarters.

The results for large commercial banks are provided in Panel C. None of the lags of the variables are significant in explaining the DSTD in equation (1). One lag of VOLUMEL is positive and significant in explaining OTCOLLAT in equation (2). As previously noted, VOLUMEL was not significant at conventional levels in the contemporaneously OLS model, but one lag is significant here, suggesting that loan volume increases lead to increased use of collateral in the following quarter. In equation (3) loan RISK is positively related to its own value lagged one period and the same is true for loan volume in equation (4).

The VAR results for small commercial banks are provided in Panel D. In equation (1) the value of the risk premium lagged two quarters is weakly related to changes in loan standards two quarters later. In equation (2) the one quarter lagged value of OTCOLLAT is positively related to OTCOLLAT. In equation (3) one lag of OTCOLLAT is negative and significant in explaining VOLUME. This result is similar to the findings for small farm lenders where one lag of FOTCOLLAT is positive and significant in the FDVOLUME equation. None of the lagged variables are significant in explaining risk premiums (DEXRATE) as indicated in equation (4), indicating once again that contemporaneous relationships may be more important. However, one lag of DSTD is significant in the DCOMMIT model, equation (5), suggesting that as lending standards tighten more loans are made under commitment. Perhaps this occurs because borrowers take advantage of the pre-existing loan commitment to obtain new loans after standards are tightened. Finally, as seen in equation (5) the percent of loan commitments is negatively related to its lagged value.

Granger Causality

Given the complex lag relationships between the variables as evidenced by the VAR analysis, Granger causality is explored. Table 4 - Panels A-D provides the Granger results for each of the four loan samples. Lags of 5 or more quarters were not found to be significance. In many cases, two lags were sufficient to demonstrate a relationship. For all analyses in this section, 4 quarterly lags are used. While analyses were conducted among all pairs of variables in the model, only the results indicating Granger causality at the 10% level or better are reported in Table 4.

Table 3 - VAR Results

Panel A. Large Farm Lenders

	-1		-2		-3		-4	
	DSTDS	STD ERR	FDOTCOLL	STD ERR	FMATUREL	STD ERR	FDRISKL	STD ERR
DSTDS(-1)	-0.004	0.19	-0.031	0.04	0.056	0.03*	0.001	0
DSTDS(-2)	0.136	0.17	-0.031	0.04	0.012	0.03	-0.001	0
FDOTCOLL(-1)	-2.212	0.81**	-0.101	0.19	0.208	0.14	0.006	0.01
FDOTCOLL(-2)	-1.007	0.83	-0.267	0.19	0.147	0.15	0.004	0.01
FMATUREL(-1)	-0.005	1.02	0.115	0.24	0.137	0.18	0.023	0.01**
FMATUREL(-2)	0.246	1.12	0.401	0.26	-0.384	0.2*	0	0.01
FDRISKL(-1)	45.962	23.71	0.072	5.51	-4.765	4.12	-0.37	0.21*
FDRISKL(-2)	47.283	23.53*	-1.999	5.47	-6.54	4.09	-0.194	0.21
C	-0.949	16.42	-5.953	3.81	15.259	2.85***	-0.289	0.14*
Adj. R-squared	0.142		0.083		0.24		0.147	
F-statistic	1.705		1.385		2.345		1.732	

Panel B. Small Farm Lenders

	-1		-2		-3		-4		-5	
	DSTDS	STD ERR	FOTCOLLAT	STD ERR	FDVOLUME	STD ERR	FMATURE	STD ERR	FCOMMIT	STD ERR
DSTDS(-1)	0.024	0.2	-0.12	0.06*	750.638	631	0.104	0.05**	0.081	0.08
DSTDS(-2)	0.099	0.2	-0.056	0.06	388.348	653	0.064	0.05	-0.09	0.09
FOTCOLLAT(-1)	-0.8	0.72	-0.008	0.22	3158	2,298	0.423	0.19**	0.132	0.3
FOTCOLLAT(-2)	0.745	0.77	0.04	0.24	-260.501	2,449	-0.042	0.2	-0.037	0.32
FDVOLUME(-1)	0	-	0	-	-0.468	0.17**	0	-	0	
FDVOLUME(-2)	0	-	0	-	-0.048	0.16	0	-	0	
FMATURE(-1)	-0.436	1.01	0.006	0.31	-1658	3,215	0.17	0.26	0.362	0.42
FMATURE(-2)	1.537	0.95	0.332	0.29	-5110	3,031	-0.161	0.24	-0.295	0.4
FCOMMIT(-1)	-0.314	0.45	-0.199	0.14	-1465	1,432	0.154	0.12	0.279	0.19
FCOMMIT(-2)	0.349	0.46	0.28	0.14*	1732	1,470	-0.075	0.12	-0.05	0.19
C	-16.486	94.18	70.99	29.08**	-137,665	300,958	-17.888	24.2	29.547	39.4
Adj. R-squared	-0.11		0.162		0.416		0.125		0.182	
F-statistic	0.662		1.658		3.425		1.486		1.755	

Panel C. Large Banks

	-1		-2		-3		-4	
	DSTDS	STD ERR	OTCOLLATL	STD ERR	RISKL	STD ERR	VOLUMEL	STD ERR
DSTDS(-1)	-0.067	0.2	0.041	0.04	-0.002	0	-0.165	2.83
DSTDS(-2)	-0.088	0.2	-0.03	0.04	-0.002	0	-0.801	2.92
OTCOLLATL(-1)	-0.275	1.19	0.303	0.21	0.011	0.01	3.031	17.21
OTCOLLATL(-2)	0.925	1.09	0.003	0.19	-0.002	0.01	2.281	15.71
RISKL(-1)	-26.144	25.79	-5.68	4.59	0.453	0.21 **	69.988	373
RISKL(-2)	-0.669	26.17	0.466	4.66	0.213	0.21	108.04	379
VOLUMEL(-1)	0.008	0.01	0.004	0 *	0	-	0.405	0.2 **
VOLUMEL(-2)	0.002	0.01	0.001	0	0	-	0.213	0.19
C	26.224	156	68.47	27.87 **	0.514	1.28	-492	2,265
Adj. R-squared	-0.105		0.377		0.372		0.1	
F-statistic	0.595		3.577		3.518		1.474	

Table 3 - VAR Results Continued

Panel C. Small Banks										
	-1		-2		-3		-4		-5	
	DSTDS	STD ERR	OTCOLLAT	STD ERR	VOLUME	STD ERR	DEXRATE	STD ERR	DCOMMIT	STD ERR
DSTDS(-1)	0.142	0.2	-0.008	0.05	0.635	2.09	-0.002	0.01	0.086	0.05*
DSTDS(-2)	-0.09	0.2	-0.069	0.05	-2.822	2.15	0.001	0.01	0.037	0.05
OTCOLLAT(-1)	0.563	0.98	0.637	0.23**	-24.23	10.43**	-0.019	0.03	-0.335	0.25
OTCOLLAT(-2)	-0.578	1.03	0.062	0.24	14.42	10.88	-0.036	0.03	0.352	0.26
VOLUME(-1)	0.008	0.02	0.002	0	0.082	0.2	0	0	-0.006	0.01
VOLUME(-2)	0.017	0.02	-0.001	0	-0.111	0.2	0	0	-0.001	0.01
DEXRATE(-1)	-1.591	6.35	0.221	1.46	-40.34	67.43	-0.161	0.2	-1.169	1.58
DEXRATE(-2)	11.022	6.53*	-0.344	1.5	34.283	69.31	-0.321	0.2	1.166	1.63
DCOMMIT(-1)	1.134	0.81	0.306	0.19*	-9.706	8.54	-0.003	0.03	-0.591	0.2***
DCOMMIT(-2)	0.124	0.73	0.002	0.17	-4.569	7.78	-0.016	0.02	0.066	0.18
C	-30.65	103.56	24.225	23.81	2154	1099*	4.419	3.22	8.546	25.8
Adj. R-squared	-0.093		0.258		0.036		-0.101		0.268	
F-statistic	0.711		2.18		1.126		0.687		2.245	

This table presents the Vector Autor Regression (VAR) results for the two sizes of banks. The equation esimated is of the form: $COLLATERAL_t = \beta_0 + \Sigma\beta_{1i}STANDARDS_{t-i} + \Sigma\beta_{2i}EXRATE_{t-i} + \Sigma\beta_{3i}MATURE_{t-i} + \Sigma\beta_{4i}RISK_{t-i} + \Sigma\beta_{5i}VOLUME_{t-i} + \Sigma\beta_{6i}COMMIT_{t-i} + \Sigma\beta_{7i}COLLATERAL_{t-i} + \varepsilon_t$ *Two lags are included for each variable. The dependent variable is listed at the top of the column. The data sample is from 2000Q3 through 2009Q1. The standard error is denoted by STD ERR. ***, **, * denotes significance at the 1%, 5%, and 10% level, respectively*

Panel A provides the results for large farm lenders. A number of significant relationships are shown. The use of collateral is Granger caused by maturity, loan commitments, and standards. Loan maturity is Granger caused by both risk and volume. Loan risk is Granger caused by the interest rate risk premium. Credit standards is Granger caused by loan commitments. Panel B provides the results for small farm lenders. The use of collateral is Granger caused by standards and loan commitments and is somewhat similar to the case for large farm lenders, except that maturity is not significant. Maturity is Granger caused by the interest rate premium, loan commitments, and volume. The interest rate premium is Granger caused by standards and loan commitments. Risk and Volume are Granger caused by maturity. Loan commitments are Granger caused by loan volume.

Granger causality appears to be weaker and less prevalent among commercial banks compared to farm lenders. For example for large commercial banks (Panel C), there are a much smaller number of significant relationships. Lending standards Granger causes maturity, while loan commitments Granger cause changes in the interest rate premium, and loan volume Granger causes changes in loan commitments. Finally, Panel D provides the results for small commercial banks. Loan commitments are Granger caused by collateral and credit standards. Collateral Granger causes interest rate premiums and risk Granger causes Standards. For small commercial banks, most of the relationships found are only weakly significant at only the 10% level. Unlike farm lenders, the picture of Granger causality is quite different for banks. For each pair of variables where Granger causality is significant, the pairs differ between large and small banks. The only common causal factor is standards where for large banks it Granger causes maturity and for small banks it Granger causes commitment. Each bank type appears to have its own unique relationship with regard to Granger causality.

Given their close interrelationship, the following briefly summarizes both the VAR and Granger causality results. Loan commitments have a generally consistent effect on the use of collateral among farm lenders. For small farm lenders, loan commitments explains the use of collateral in the OLS regression and in the VAR results, two lags of loan commitment are also significant in explaining collateral usage. Loan commitment is shown to Granger-cause the use of non-real estate collateral for both larger and small farm lenders. These findings support the view that changes in the proportion of loans made under commitments affects the use of collateral. One possible explanation is that as standards tighten, borrowers may be more inclined to exercise a prior loan commitment rather than requesting a new loan with their current bank or seeking a loan with a new lender. It may also be that under these circumstances, current collateral requirements have become tougher, so it is preferable to the borrower to exercise the prior commitment. Note that in the small farm lender OLS analysis, the coefficient for commitment is negative and significant, which is consistent with this explanation. The use of non-real estate collateral in small lenders, regardless of type, is influenced by contemporaneous changes in lending volume and commitment. The sign on commitment is always negative, indicating that as the proportion of loans made under commit increase, the proportion of loans requiring collateral decreases. However, the sign on volume is positive for small farm lenders but negative for small commercial banks, indicating a lender-specific difference in behavior. Changes in loan credit standards over time play a role in many of the relationships observed.

Table 4: Granger Causality Results

Panel A. Large Farm Lenders			
Null Hypothesis:	Obs.	F-statistic	Probability
DSTDS does not Granger Cause FDOTCOLL	33	2.212	0.098*
FMATUREL does not Granger Cause FDOTCOLL	33	4.016	0.012**
FCOMMITL does not Granger Cause FDOTCOLL	33	3.414	0.024**
FCOMMITL does not Granger Cause DSTDS	33	2.975	0.040**
FMATUREL does not Granger Cause FDEXRATEL	33	2.833	0.047**
FDEXRATEL does not Granger Cause FDRISKL	33	3.571	0.020**
FDRISKL does not Granger Cause FMATUREL	33	2.900	0.043**
FDVOLUMEL does not Granger Cause FMATUREL	33	2.472	0.072*
Panel B. Small Farm Lenders	**Obs.**	**F-statistic**	**Probability**
DSTDS does not Granger Cause FOTCOLLAT	33	4.0612	0.0118**
FCOMMIT does not Granger Cause FOTCOLLAT	34	3.2831	0.0271**
DSTDS does not Granger Cause FDEXRATE	33	2.6632	0.0571*
FDEXRATE does not Granger Cause FMATURE	33	3.1480	0.0325**
FCOMMIT does not Granger Cause FDEXRATE	33	2.7288	0.0529*
FMATURE does not Granger Cause FRISK	34	2.3214	0.0846*
FMATURE does not Granger Cause FDVOLUME	33	2.8407	0.0464**
FDVOLUME does not Granger Cause FMATURE	33	2.2428	0.0944*
FDVOLUME does not Granger Cause FCOMMIT	33	3.0765	0.0353**
FCOMMIT does not Granger Cause FMATURE	34	2.9013	0.0422**
Panel C. Large Banks	**Obs.**	**F-statistic**	**Probability**
DSTDS does not Granger Cause MATUREL	33	2.941	0.041**
DCOMMITL does not Granger Cause DEXRATEL	33	2.784	0.050**
VOLUMEL does not Granger Cause DCOMMITL	33	2.865	0.045**
Panel D. Small Banks	**Obs.**	**F-statistic**	**Probability**
OTCOLLAT does not Granger Cause DEXRATE	33	2.403	0.078*
OTCOLLAT does not Granger Cause DCOMMIT	33	2.360	0.082*
RISK does not Granger Cause DSTDS	33	3.069	0.036**
DSTDS does not Granger Cause DCOMMIT	33	2.419	0.076*

***, **, * denotes significance at the 1%, 5%, and 10% level, respectively.
For a discussion of Granger causality see Granger (1969)
FOTCOLLAT – non-real estate collateral as percent of loans.
DSTD – percentage of lenders increasing loan standards.
FDEXRATE – interest rate of loans in excess of the treasury rate.
FCOMMIT – the percentage of loans under prior commitment.
FRISK – self-reported loan risk
FDVOLUME – loan volume
FMATURE – The maturity of the

Note: First letter "F" indicates farm lender; last letter "L" is a large lender; "D" indicates the first difference of the

On a contemporaneous basis, changes in credit standards were not found to be significant in any of the OLS panel regressions. In the VAR analysis, a one-quarter lag of credit standards is significant in explaining: 1) maturity in the case of large farm lenders, 2) collateral and maturity for small farm lenders, and 3) loans commitments for small commercial banks. Furthermore, changes in lending standards Granger- cause collateral in both size of farm lenders, but does not affect the use of collateral among commercial banks. Changes in lending standards Granger-cause maturity in large banks and loan commitments in small banks. In total, changes in lending standards Granger-cause five terms of lending variables.

Prior research suggests that the lending standards variable, as defined by the Federal Reserve, represents a composite of non-priced terms of lending and is related to economic or monetary policy factors. As such, it is often viewed as an exogenous variable that constitutes an external "shock" to the banking system. The results of this study tends to this view since it is a significant explanatory variable in four VAR models, but is itself influenced by only one other variable. The Granger causality results also show that in only one case are credit standards Granger-caused by another variable, whereas the credit standards variable Granger-causes five other variables and appears at least once in each lender category.

Despite the evidence that standards may be exogenous, the cases where other variables explain credit standards (contemporaneously or with a time lag) cannot be ignored. Loan risk is negative and significant in explaining collateral for large banks, but is not significant in any other of the OLS equations. One and two lags of loan risk are positive and significant in the credit standards VAR equation for large farm lenders. Risk also Granger-causes changes in lending standards for small commercial banks. All of these results suggest that changes in lending standards are made in response to changes in the risk of the loan portfolio, as would be expected of lenders. In these situations, credit standards appear to be endogenous. The fact that credit standards is not significant in any of the OLS results, but is often significant in the VAR analysis and Granger causality tests, suggests that there are time lags in the lender's response to changes in credit standards.

CONCLUSION

This study examines the use of non-real estate collateral for small loans by four types of lenders: large and small farm lenders and large and small banks. The purpose of the research is to determine how terms of lending differ as a function of lender type and lender size. Four different types of analyses were performed: 1) Bi-variate t-tests for differences in mean values (not reported), 2) panel regressions using OLS, 3) vector auto-regressions (VAR), and 4) Granger causality tests.

The results indicates that collateral is used more frequently among farm loans than commercial loans, and may simply reflect the fact that collateral is typically more plentiful for farms than other small businesses. Based on simple uni-variate t-tests (not reported), large farm lenders do use more collateral than large commercial banks, but small commercial banks use collateral more frequently than small farm lenders. Hence, the relationship varies by type of lender. Furthermore, small commercial banks use collateral more frequently than large commercial banks, while farm lenders regardless of size appear to use similar levels of collateral. For non-real estate loans, lenders can require either real estate or other assets to be pledged as collateral. For all sizes of farm lenders, loan maturity is negative and significant in explaining the use of non-real estate collateral. Thus, the shorter the term of the loan the more likely the use of non-real estate collateral.

Loan commitments have a somewhat consistent effect on the use of collateral among farm lenders. For small farm lenders, loan commitments explains the use of collateral in the OLS regression and in the VAR results; while two lags of commitment are also significant in explaining collateral usage. Commitment is shown to Granger-cause the use of non-real estate collateral for both larger and small farm lenders. These findings support the view that changes in the proportion of loans made under commitments affects the use of collateral. Furthermore, the use of non-real estate collateral in small lenders, regardless of type, is influenced by contemporaneous changes in lending volume and commitment. The sign on commitment is always negative, indicating that as the proportion of loans made under commit increases, the proportion of loans requiring collateral decreases.

Furthermore, using VAR analysis to study changes in credit standards over time, the results indicate that one-quarter lags in the variable are significant in explaining: 1) maturity in the case of large farm lenders, 2) collateral and maturity for small farm lenders, and 3) loans commitments for small commercial banks. Furthermore, changes in lending standards Granger-cause collateral in farm lenders, but does not affect the use of collateral among commercial banks. Furthermore, changes in lending standards Granger-cause maturity in large banks and loan commitment in small banks. While the empirical evidence is generally consistent with the view that changes in credit standards are exogenous, in certain cases changes in lending standards are made in response to changes in the risk of the loan portfolio.

Outstanding loan commitments may also play an important role since the loan terms are negotiated before the loan is made. One lag of credit standards is significant in the VAR model in the loan commitment equation for small commercial banks. Maturity has contemporaneous explanatory power in the use of collateral in both sizes of farm lenders, and in either case, as maturity increases less non-real estate collateral is more frequently used. On the other hand, for small banks, longer loan maturities are associated with greater use of collateral.

Prior research reveals inconsistent findings regarding the use of collateral. This research helps explain some of these inconsistencies as the use of collateral varies by both the type and size of the lender. Furthermore, various types of collateral appear to be used differently, with real estate collateral being used more frequently as loan maturities lengthen. In summary, while this research does not entirely explain the use of collateral in the lending process, is supports the notion that the role of collateral is complex and strongly supports an endogenous modeling approach. Future research is needed to further clarify the role of collateral in the lending process.

REFERENCES

Berger, A., and Udell, G. (1995). Relationship Lending and Lines of Credit in Small Firm Finance. *Journal of Business*, 68, 351-381.

Boot, A. and Thakor, A. (1994). Moral Hazard and Secured Lending in an Infinitely Repeated Credit Market Game. *International Economic Review*, 35, 899 - 920.

Brick, I. and Palia, D. (2007). Evidence of Jointness in the Terms of Relationship Lending. *J. Financial Intermediation*. 16, 452-476.

Chakraborty, A. and Hu, C. (2006). Lending relationships in line-of-credit and non-line-of-credit loans; Evidence from collateral use in small business. *Journal of Financial Intermediation*, 15, 86 – 107.

Elsas, R. and Krahnen, J. (1999). Collateral, Default Risk, and Relationship Lending: An Empirical Study on Financial Contracting. Mimeo 1999/13. Center for Financial Studies. House of Finance, Grneburgplatz 1, HPF H5, D-60323 Frankfurt am Main.

Granger C. (1969). Investigating Causal Relationships by Econometric Models and Cross-Spectral Methods, *Econometrica*, 424-438.

Lown, C. and Morgan, D. (2006). The Credit Cycle and the Business Cycle: New Findings Using the Loan Officer Opinion Survey. *Journal of Money, Credit, and Banking*, 38, 1575 – 1597.

Machauer, A. and Weber, M. (1998). Bank Behavior Based on Internal Credit Ratings of Borrowers. Journal of Banking and Finance, 22, 1355-1383.

Stiglitz, J. and Weiss,A. (1981). Credit Rationing in Markets with Imperfect Information. *American Economic Review*, 71 Issue, 393 – 411.

Walraven, N. and Barry, P. (2004). Bank Risk Ratings and the Pricing of Agricultural Loans. *Agricultural Finance Review*, 107 – 118.

BIOGRAPHY

Dr. Ray Posey is Department Chair and Professor of Business Administration, Mount Union College. He can be contacted at Department of Business Administration , Mount Union, Ohio, Alliance, Ohio 44601. Email: Poseyra@muc.edu.

Dr. Alan K. Reichert is a Professor of Finance at Cleveland State University. He can be contacted at Department of Finance, College of Business, Cleveland State University, 2121 Euclid Avenue, Cleveland, Ohio 44115. Email: a.reichert@csuohio.edu.

LONG-RUN OPERATING PERFORMANCE OF PREFERRED STOCK ISSUERS

Devrim Yaman, Western Michigan University

ABSTRACT

In this paper, we study the long-run operating performance of preferred stock issuers. We use three different measures of operating performance; pre-tax cash flows, profit margin and return on assets. We study the performance of industrial firms, financial firms, and utilities separately, as well as the performance of the whole sample. Our results indicate that the operating performance of preferred stock issuers as a whole declines in the three-years before the issue. We find that profitability continues to decline after the issue. This finding is consistent with earlier findings on bond and common stock issuers. We also find that the decline in profitability is more pronounced for financial firms, although the cash flows of financial firms increase after the offering. The results show that the operating performance after the issue is worse for firms that raise large amounts of capital through the issue. There is also some evidence that preferred stock issuers with information asymmetry have lower operating performance following the issue.

JEL: G30, G32

KEYWORDS: Preferred stock; long-run performance; operating performance

INTRODUCTION

Preferred stock is an essential and popular method of raising capital by firms. During the period 1985-1999, firms raised $324.63 billion in U.S. markets by engaging in 2,636 preferred stock offerings. Over the same period, firms made 7,017 seasoned equity offerings raising $606.03 billion (Bajaj, Mazumdar, and Sarin, 2002). Since 1990 the size of the public market for preferred stock quadrupled, reaching $193 billion in 2005 (Dash, 2009). Despite the importance of preferred stock, there are only a handful of studies on this security. Prior studies such as Wansley et al. (1990), Houston and Houston (1990), Stickel (1991), Rao and Moyer (1992), Lee and Figlewicz (1999), and Callahan, et al. (2001) focus on the announcement returns, characteristics and the motivations of issuing firms. Recently, Howe and Lee (2006) and Abhyankar and Ho (2006) study the long-run stock performance of preferred stock issuers.

In this paper, we study the long-run operating performance of preferred stock issuers. The only other study that examines this issue is Lee and Johnson (2009). We extend previous research by studying the change in operating performance of our sample firms from the period right before the offering, besides raw operating performance. We also contribute to the literature by analyzing the factors that may affect the operating performance of preferred stock issuers. We use recent data and our sample period is long, covering a period of 13 years.

Our sample consists of 1,334 publicly issued non-convertible preferred stock issues offered in US markets between 1992 and 2004. We measure operating performance using three proxies; the cash flows of the firm, the profit margin and the return on assets. We study the performance of industrial firms, financial firms and utilities separately, as well as the performance of the whole sample. We find that the operating performance of firms in all industry types deteriorate gradually until the issuance. Profitability is also lower after the issue compared to the year before the issue. This decrease in performance is more pronounced for financial firms, although there is an increase in the cash flows of these firms. We find that the performance of firms that issue large amounts of preferred stock is better than the performance of firms that issue small amounts. There is also some evidence that firms with low book-to-market ratios and large firms have better post-issue performance.

The rest of this paper is organized as follows: In section 2, we summarize the findings of previous studies on the long-run stock and operating performance of bonds and stocks. In section 3, we develop our hypotheses and in section 4, we present the results of the tests of these hypotheses. In section 5, we conclude the paper.

PRIOR RESEARCH

Long-run Performance of Straight Bonds and Common Stock

Studies have mixed results for the long-run performance of straight bond issuers. Hansen and Crutchley (1990) and McLaughlin et al. (1998a) show that the long-run operating performance of straight bond issuers are negative while Bae et al. (2002) show that the performance is insignificant. Dichev and Piotroski (1999) find that the long-run stock returns of straight bond issuers are insignificant while Spiess and Affleck-Graves (1999) and Eckbo et al. (2000) show that these issuers underperform. Dichev and Piotroski also find that public debt issuers underperform the market while private debt issuers outperform the market.

Studies show that both the operating performance and stock performance are negative for equity issuers in the long-run (Hansen and Crutchley (1990), McLaughlin et al. (1998a), Cheng (1998), and Kang et al. (1999)). Jung et al. (1996) find that the long-run stock performance of equity issuers is lower than that for straight bond issuers, although there is no statistically significant difference. Cheng (1998) shows that the underperformance is less severe for equity issuers that use the proceeds for capital investments. Eckbo et al. (2000) find that when equity issuers lower their leverage as a result of the issue, they also decrease their exposure to unexpected inflation and default risk. This, in turn, decreases their expected returns relative to matched firm.

Studies also analyze different sub-samples of equity issues. For example for the case of private equity issues, Hertzel et al. (2002) show that these issues have positive announcement effects and negative long-run stock returns since investors are overoptimistic about the future prospects of equity issuers. Kang et al. shows the performance of firms placing the privately is similar to the performance of firms that place the issue publicly. Alderson and Betker (2000) study withdrawn equity issues and show that the long-run operating and stock performance of firms that withdraw the offering is lower than control firms. The overvaluation before the announcement of the issue is concentrated among smaller firms and the underperformance is higher among firms that announced the offering during periods of high equity issue volume. For equity issues in which the seller is an insider, Clarke et al. (2004) find that the long-run stock returns are negative and operating performance declines after the issue. Their findings are consistent with the hypothesis that managers issue overvalued shares at secondary equity offerings.

Long-run Performance of Preferred Stock

Howe and Lee (2006) and Abhyankar and Ho (2006) study the long-run stock performance of preferred stock issuers. Howe and Lee find that preferred stock issuers underperform only in the year after the issuance. Two and three years after the issue, the issuers do not consistently underperform. Howe and Lee argue that the one-year underperformance is driven by the small firms in their sample. They find that financial firms do not underperform while industrial firms and utilities underperform for a short period of time. Abhyankar and Ho study convertible preferred stock. They show that preferred stock issuers obtain positive stock returns before the issue. As in Howe and Lee, they find that preferred stock issuers underperform after the issue. They argue that the stock price reaction is related to the “debt-like” and “equity-like” characteristics of the convertible security. They also find that the long-run underperformance is more severe when they allow for time-varying risk in their model.

Lee and Johnson (2009) study the operating performance of preferred stock issuers. They find that the profitability of preferred stock issuers declines until the year of the issue and gradually recovers after that. Lee and Johnson also show that preferred stock issuers have higher capital expenditure plus R&D expenses to assets ratios compared to other firms before the issue and until two years after the issue. The market-to-book ratio of preferred stock issuers is also higher before the offering and until one year after the offering. They show that financial firms do not show any abnormal operating performance patterns before or after the issue whereas the industrial firms show patterns similar to the whole sample.

HYPOTHESES ON THE LONG-RUN OPERATING PERFORMANCE OF PREFERRED STOCKS

Preferred stock is a hybrid security that has both debt-like and equity-like characteristics. Just like debt, preferred stockholders get a stated amount of dividend. In case of liquidation, they also receive a stated value. However, just like common stock dividends, when determining the taxable income of a corporation, preferred dividends cannot be deducted as interest expense. Also, as with common stockholders, preferred stockholders cannot force the firm into bankruptcy if the firm cannot pay the dividends (Ross et al. 2008). The hybrid nature of this security implies that the long-run operating performance will be similar to the performance of bonds and stocks.

Spiess and Affleck-Graves (1995, 1999) show that the long-term stock performance of both bonds and common stock are negative. This finding is consistent with the argument that firms take advantage of “windows of opportunity” and issue securities when they are overvalued. Similarly, Hansen and Crutchley (1990), McLaughlin et al. (1998a), and Cheng (1998) show that the long-run operating performance of bond and common stock issuers is also negative. Since preferred stock has both debt and equity characteristics, we expect preferred stock issuers to have negative long-run operating performance.

McLaughlin et al. (1998a) indicate that two years before the issue there is a decrease in the operating performance of common stock issuers compared to the previous year, although the performance increases a year before the issue. In the case of bond issuers, the operating performance declines gradually beginning three years before the issue. The hybrid characteristic of preferred stocks suggests that the operating performance of preferred stock should also decrease in the years leading to the issue year. However, the window of opportunity hypothesis suggests the opposite effect of an increase in operating performance in the years before the issue. In this hypothesis, firms issue securities when the firm is in good financial position and therefore there should be an improvement in operating performance prior to the issue.

In Myers and Majluf (1984), overvaluation of securities is higher for firms with high information asymmetry. Therefore, Myers and Majluf predict a more negative operating performance following preferred stock issues when firms have high information asymmetry. Miller and Rock (1985) argue that unanticipated financing implies that managers expect a shortfall in future cash flows. Hence, Miller and Rock predict a negative relation between the size of the issue and the operating performance after the offering. Consistent with these arguments, McLaughlin et al. (1998a) show that bond and common stock issuing firms with the largest information asymmetry (measured with the size and market value of the firm) have the largest declines in operating performance following the issue while McLaughlin et al. (1998b) show companies that make relatively larger offers have larger declines in operating performance following the issue. Similarly, Loughran and Ritter (1995) and Spiess and Affleck-Graves (1995) show that the poor long-run stock performance following common stock issues is more severe for smaller firms while Spiess and Affleck-Graves (1999) show that for bond issuers the long-run stock performance is worse for smaller firms, and firms with large issues. In this study, we test whether similar relations exist for preferred stock issuers and measure whether smaller firms, firms with high market-to-book ratios, and firms that issue large offerings obtain lower long-run operating performance following preferred stock issuance.

METHODOLOGY AND RESULTS

Data and Sample Characteristics

Our sample consists of non-convertible preferred stock issues offered in US public markets between 1992 and 2004. All issues are completed and traditionally registered. We obtain issue-related data from Thomson Financial's Securities Data Corporation (SDC) Database and firm-related data from Compustat. As in D'Mello et al. (2003), we classify firms with two-digit SIC codes of 49 as utilities, firms with one-digit SIC codes of 6 as financial institutions and all other firms with valid SIC codes as industrial firms. Our final sample consists of 1,334 preferred stock issues offered by 876 firms. 96 of these issues were made by industrial firms, 989 issues were made by financial firms, and 249 issues were made by utilities.

Table 1: Frequency Distribution of Offerings and Firms

Year	All Firms		Industrial Firms		Financial Firms		Utilities	
	# of issues	# of firms	# of issues	# of firms	# of issues	# of firms	# of issues	# of firms
1992	229	143	15	11	141	85	73	47
1993	288	198	18	15	182	131	88	53
1994	69	57	8	7	42	35	19	16
1995	38	32	1	1	35	29	2	2
1996	85	80	17	17	54	49	14	14
1997	109	106	11	11	79	77	19	18
1998	66	64	7	7	54	52	5	5
1999	64	59	11	10	46	42	7	7
2000	15	12	0	0	13	10	2	2
2001	37	35	0	0	32	30	5	5
2002	17	17	0	0	15	15	2	2
2003	195	130	3	3	187	122	5	5
2004	122	87	5	5	109	76	8	8
Total	1,334	876	96	80	989	655	249	147

This table presents the frequency distribution of publicly placed preferred stock offerings in US markets during the period 1992-2004 and the firms that made these offerings. Preferred stock offering data is obtained from Thomson Financial's Securities Data Corporation Database.

Table 1 presents the frequency distribution of preferred stock offerings and firms that make the offerings over the sample period. The number of issues varies throughout the sample period and most of the offerings were made during the first half of the sample period for the whole sample and the three sub-samples. In the first six years, there were a total of 818 issues made compared to 516 issues made in the last seven years. The number of offerings for the first six years is 70 for industrial firms, 533 for financial firms and 215 for utilities. For the whole sample, the lowest number of offerings was in the year 2000 while the highest number of offerings was in 1993. There were 15 preferred stock issues made by 12 firms in 2000 and 288 offerings made by 198 firms in 1993. The highest number of issues was also in 1993 for industrial firms and utilities with 18 and 88 offerings in each group respectively. There were no preferred stock offerings in years 2000, 2001, and 2002 for industrial firms while utilities had only two offerings in years 1995, 2000, and 2002. For financial firms, the lowest number of offerings was in 2000 (13 offerings) and the highest number of offerings was in 2003 (187 offerings).

Table 2: Firm and Issue Characteristic

Variable		All Firms	Industrial Firms	Financial Firms	Utilities
Total Assets		40,690.22 (2,923.79)	25,550.08 (3,549.36)	44,499.07 (2,952.98)	3,813.64 (1,672.76)
Market Value of Equity		4,065.08 (1,109.00)	6,824.88 (3,290.00)	3,969.15 (1,056.00)	1,762.00 (649.00)
Issue Size		135.26 (72.05)	222.19 (150.00)	140.41 (70.00)	81.29 (50.00)
Standardized Issue Size		0.051 (0.03)	0.12 (0.04)	0.04 (0.03)	0.03 (0.03)
Market-to-book Ratio		0.28 (0.16)	0.37 (0.28)	0.28 (0.12)	0.31 (0.16)
Exchange (%)	NYSE/AMEX	89.62	63.64	91.94	89.31
	NASDAQ	5.25	10.91	5.53	1.53
	Other	5.13	25.45	2.53	9.16

This table presents the firm and issue characteristics of the sample. Total Assets is the book value of total assets. Market Value of Equity is the price multiplied by *the number of common shares outstanding. Issue Size is the total proceeds from the issue. Standardized Issue Size is the total proceeds divided by the book value of total assets. Market-to-Book Ratio is the price* multiplied by *the number of common shares outstanding,* divided by *common equity. Exchange (%) shows the percentage of firms in the sample listed in NYSE/AMEX, NASDAQ and other exchanges. In each row (except for the exchange), the first figure is the mean value while the figure in parentheses is the median value.*

In Table 2, we present the characteristics of the firms and issues in our sample. The average book value of assets in our sample is $ 40,690 million while the median is $ 2,924 million. Financial firms have the highest average asset size with $ 44,499 million. The average asset size is $ 25,550 million for industrial firms and $ 3,814 million for utilities. We define market value of equity as the price of common stock multiplied by the number of common shares outstanding. The average market value of equity in the sample is $ 4,065 million while the median is $ 1,109 million. Industrial firms have the largest market value of equity with a mean of $ 6,825 million and a median of $ 3,290 million. The average market value of equity is $ 3,969 million for financial firms and $ 1,762 million for utilities.

We use two measures for the size of the issue; raw issue size and standardized issue size. Raw issue size is the total proceeds raised from the issue and standardized issue size is the total proceeds adjusted by the book value of the assets of the firm. The average raw issue size is $ 135 million for the whole sample while the median is $ 72 million. On average, the issues were about 5.06% of the total assets of the sample firms. Industrial firms issued the largest offerings with an average size of $ 222 million, representing 12.14% of their assets. The average issue size was $ 140 million and $ 81 million for financial firms and utilities, representing 4.41% and 3.18% of their assets, respectively.

In this paper, we measure the growth opportunities of the firm with the market-to-book ratio. Market-to-book ratio is the stock price of the firm multiplied by the number of outstanding common shares of the company, divided by common equity. The average market-to-book ratio is 0.28 for the sample firms while the median of this ratio is 0.16. Industrial firms have the highest market-to-book ratio with a mean of 0.37 and a median of 0.28. The average market-to-book ratio is 0.28 for financial firms and 0.31 for utilities. 89.62% of the sample firms were listed on the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX) while 5.25% of were listed on NASDAQ. 63.64 % of industrial firms were listed on NYSE or AMEX while 10.91 % were listed on NASDAQ. 91.94% of financial firms and 89.31% of utilities were listed on NYSE or AMEX.

Measures of Operating Performance

Following Lee and Loughran (1998), Lewis et al. (2001), and Hertzel et al. (2002), we use the profit margin and the return on total assets as our measures of operating performance. We measure profit margin as income before extraordinary items divided by net sales and return on total assets as income before extraordinary items divided by total assets. As in McLaughlin et al. (1996, 1998a, 1998b), Alderson and Berker (2000), and Lewis et al. (2001) we also use the pre-tax cash flows as an additional measure. A benefit of the pre-tax cash flow measure is that it is not impacted by the changes in interest expense, the level of assets in place, and the level of taxes that may affect the other measures. Hence, pre-tax cash flows will not be affected by the capital structure policies, investment levels, and the tax status of the sample firms. We measure pre-tax cash flows with the operating income before depreciation and amortization (Compustat item 13). We standardize pre-tax cash flows with the book value of assets (Compustat item 6) because the cash flows depend on the value of the firm's assets and with standardized cash flows we can compare the performance of firms with each other and across time.

As in McLaughlin et al. (1998b), we analyze the long-run operating performance of preferred stock issuers over a seven-year period, beginning three years before the issue and ending three years after the issue. We also study the change in operating performance of the sample firms after the offering compared to their performance before the offering. Change in operating performance is the difference in the operating performance measures in one, two, and three years after the offering from the performance in the year before the offering.

Long-run Operating Performance

In Table 3, we present the mean and median operating performance results for the years -3 to +3 relative to the issue year. Panel A shows the results for the whole sample. The average pre-tax cash flows decrease from 7.35% of total assets in year -3 to 6.07% in year -1. There is some increase in the pre-tax cash flows in years +1 and +3, and a decrease in year +2. The average profit margin decreases from 18.24% in year -2 to 17.65% in year -1. The profit margin increases to 18.66% in year +1 but decreases to 13.52% in year 3. The average return on assets is 2.37% in year -3 and decreases to 1.61% in year 0. The return on assets increases to 2.2 % in year +1 but decreases again in year +3. The median values follow the same pattern for most periods.

Panel B of Table 3 presents the annual operating results for industrial firms. There is a dramatic decrease in operating performance before the offering until the issue year using all three measures. The average pre-tax cash flows drop from 14.74% in year -3 to 7.29% in year 0. The profit margin drops from 5.32% to -4.58% and the return on assets drops from 2.27% to -4.09% during the same period. After the issue, pre-tax cash flows increase to 15.02% in year +1 but decreases to 12.10% the next year. The profit margin and return on assets follow the same pattern. The profit margin increases to 6.17% in year +1 and decreases back to 4.02% in year 2 while the return on assets increases to 3.37% and decreases to 1.75% during the same period.

Table 3: Annual Operating Performance

Variable	Year -3	Year -2	Year -1	Year 0	Year +1	Year +2	Year +3
Panel A: All Firms							
Cash Flows	7.35 (6.55)	6.58 (5.66)	6.07 (4.76)	5.17 (4.35)	6.58 (4.73)	5.99 (5.05)	6.95 (5.17)
Profit Margin	18.13 (12.72)	18.24 (14.74)	17.65 (14.07)	18.30 (13.72)	18.66 (14.01)	16.36 (13.19)	13.53 (12.30)
Return on Assets	2.37 (2.42)	2.14 (1.95)	2.00 (1.93)	1.61 (1.68)	2.21 (1.64)	1.73 (1.33)	1.65 (1.41)
Panel B: Industrial Firms							
Cash Flows	14.74 (12.78)	13.75 (13.31)	12.31 (11.05)	7.29 (11.47)	15.02 (12.51)	12.10 (11.03)	13.72 (12.57)
Profit Margin	5.32 (3.38)	3.02 (4.53)	-2.14 (3.07)	-4.58 (6.10)	6.17 (4.84)	4.02 (4.21)	5.17 (6.88)
Return on Assets	2.27 (2.42)	1.13 (1.53)	0.78 (1.58)	-4.09 (1.74)	3.37 (2.87)	1.75 (2.69)	2.80 (3.71)
Panel C: Financial Firms							
Cash Flows	4.96 (4.25)	4.11 (3.37)	3.79 (2.72)	3.92 (2.84)	4.03 (3.34)	3.86 (2.91)	4.11 (3.13)
Profit Margin	19.94 (15.72)	20.18 (17.25)	20.13 (15.86)	21.33 (16.08)	20.46 (16.07)	17.95 (14.36)	14.61 (14.06)
Return on Assets	2.28 (2.03)	2.16 (1.86)	2.06 (1.79)	2.16 (1.36)	2.03 (1.35)	1.64 (1.23)	1.41 (1.17)
Panel D: Utilities							
Cash Flows	11.62 (12.55)	11.46 (12.65)	10.38 (10.32)	10.12 (9.64)	10.58 (11.04)	11.21 (11.91)	11.50 (12.04)
Profit Margin	11.21 (11.77)	11.31 (11.25)	10.21 (9.46)	8.86 (6.34)	10.82 (10.50)	10.53 (9.90)	11.16 (10.68)
Return on Assets	3.79 (4.19)	3.56 (3.66)	3.02 (2.98)	2.61 (2.33)	3.18 (3.21)	3.39 (3.62)	3.55 (3.41)

This table presents the mean and median annual operating performance of the sample firms. Cash flows is the operating income before depreciation and amortization standardized with the book value of assets. Profit Margin is the income before extraordinary items divided by net sales and Return on Assets is the income before extraordinary items divided by total assets. In each row, the first figure is the mean value while the figure in parentheses is the median value.

The operating performance results for financial firms are presented in Panel C of Table 3. We observe a pattern of a decrease in operating performance before the issue in financial firms as well. The average pre-tax cash flows decrease from 4.96% to 3.79% and return on assets decreases from 2.28% to 2.06% from year -3 to year -1. The average profit margin increases from 19.94% in year -3 to 20.18% in year -2 but decreases back to 20.13% in year -1. After the offering, the average pre-tax cash flow decreases from 4.03% in year +1 to 3.86% in year +2, although it increases to 4.11% in year 3. The average profit margin and return on assets decrease gradually to 14.61% and 1.41% respectively in year +3.

In Panel D of Table 3, we present the operating performance results for utilities. There is a gradual decrease in the operating performance of utilities before the offering. The average pre-tax cash flow decreases from 11.62% to 10.12% from year -3 to year 0, while the profit margin and return assets decrease from 11.21% to 8.86% and 3.79% to 2.61% respectively. The average profit margin decreases from year +1 to year +2 while the pre-tax cash flow and the return on assets increase gradually after the offering.

Overall, the results in Table 3 show that there is a decrease in the operating performance of preferred stock issuers before the offering. This result is consistent with the findings of McLaughlin et al. (1998a) for the case of stock and bond issues. We find that the decrease in performance exists in all industry types. Our results also indicate that the decrease in performance continues after the offering, except for utilities.

Table 4: Changes in Operating Performance

Variable	Year +1	Year +2	Year +3
Panel A: All Firms			
Cash Flows	0.74	0.38	0.77
	(0.12)	(0.27)	(0.19)
Profit Margin	0.93	-1.16	-4.64***
	(0.52)	(-0.18)	(-1.6)*
Return on Assets	0.19	-0.28	-0.40
	(-0.16)**	(-0.21)***	(-0.34)***
Panel B: Industrial Firms			
Cash Flows	3.10	0.37	1.83
	(1.04)	(-0.01)	(0.94)
Profit Margin	7.81*	5.85	7.90*
	(1.77)	(0.98)	(1.73)
Return on Assets	2.69	0.91	2.21
	(0.88)	(0.10)	(1.59)
Panel C: Financial Firms			
Cash Flows	0.21*	0.36**	0.42**
	(0.12)	(0.27)	(0.13)
Profit Margin	0.26	-1.94*	-6.32***
	(0.33)	(-0.29)	(-2.72)***
Return on Assets	-0.063	-0.42***	-0.72***
	(-0.16)**	(-0.32)***	(-0.48)***
Panel D: Utilities			
Cash Flows	0.19	0.49	0.77
	(-0.46)	(0.01)	(0.62)
Profit Margin	0.61	0.42	1.04
	(-0.02)	(1.24)	(2.19)
Return on Assets	0.16	0.30	0.46
	(-0.29)	(-0.01)	(0.06)

*This table presents mean and median changes in operating performance of sample firms after the offering. Change in operating performance is defined as the operating performance in years +1, +2, and +3 minus the operating performance in year -1, where year 0 is the issue year. In each row, the first figure is the mean value while the figure in parentheses is the median value. We use t-tests to test the significance of the means the sign test to test the significance of the medians. ***, **, and * denote significance at 1, 5 and 10 percent levels respectively.*

Table 4 shows the change in operating performance of preferred stock issuers following the issue compared to their performance before the issue. The change in operating performance is defined as the difference in operating performance of the firm in years +1, +2, and +3 minus their performance in year -1. Panel A presents the change in performance of all firms in our sample. There was no significant change in the pre-tax cash flows in the three years after the issue. The profit margin, however, decreased significantly three years after the issue. The average decrease in profit margin is 4.64% while the median decrease is 1.6%. The median decrease in return on assets was also significant in all three years following the offering. For example three years after the offering the operating performance decreased by 0.34%.

In Panel B of Table 4, we present the change in performance for industrial firms while in panels C and D we present the change in performance for financial firms and utilities, respectively. For industrial firms although there is no significant change in the pre-tax cash flows and return on assets in the three years after the offering, there is a marginal increase (significant only at 10% level) in the average profit margin of industrial firms in years +1 and +3. The average pre-tax cash flow increases for financial firms after the offering while the profit margin and return on assets decrease. For example, in year +3 the average pre-tax cash flows increase by 0.42% while the median cash flow does not change significantly. During the same period, the average decrease in profit margin is 6.32% while the median decrease is 2.72%. The return on assets decreases significantly in all three years. The average decrease in return on assets is 0.42% in year 2 and 0.72% in year 3. There is no significant change in the operating performance of utilities in our sample.

Overall, the results in Table 4 show that profitability, measured with the profit margin and return on assets, decreases after the offering. This result is consistent with Howe and Lee (2006) and Abhyankar and Ho (2006) who find negative stock performance for preferred stock issuers following the issue. The results is also consistent with Hansen and Crutchley (1990), McLaughlin et al. (1998a), and Cheng (1998) who find negative operating performance after the issuers of common stocks and bonds and with Spiess and Affleck-Graves (1995, 1999) who find negative long-run stock returns for common stock and bond issuers. Our results indicate that the decrease in profitability is most pronounced for financial firms. There is some increase in the pre-tax cash flows of financial firms although there is no significant change for the whole sample.

Factors that Affect Long-run Operating Performance

Table 5: Determinants of Operating Performance

Variable	All Firms	Industrial Firms	Financial Firms	Utilities
Panel A: Market-to-Book Subsamples				
Cash Flows	1.34	7.44	-1.29	1.60
	(-0.20)	(5.10)	(-0.79)**	(1.98)
Profit Margin	2.91	7.87	3.65	-0.21
	(-4.46)**	(1.55)	(-5.37)**	(1.22)
Return on Assets	0.05	3.00	-0.16	0.18
	(-0.25)	(2.72)	(-0.43)	(0.53)
Panel B: Asset Size Subsamples				
Cash Flows	-1.21	3.65	0.15	-1.98
	(-0.03)	(3.054)	(0.39)	(-2.94)
Profit Margin	-1.80	1.47	3.22	4.73
	(0.99)	(4.19)	(-0.08)	(2.04)*
Return on Assets	0.58	1.15	0.42	-0.06
	(0.41)**	(4.36)	(0.44)	(-0.02)
Panel C: Standardized Issue Size Subsamples				
Cash Flows	3.19*	8.08	1.19	1.65
	(1.63)**	(6.07)	(1.41)**	(2.94)
Profit Margin	5.97*	4.60	5.37	1.58
	(3.63)**	(-1.61)	(4.76)*	(-0.24)
Return on Assets	0.22	1.14	-0.14	1.10*
	(-0.15)	(1.58)	(-0.20)	(1.44)

This table presents the differences in mean and median changes in operating performance of sample firms after the offering. In each row, the first figure is the mean value while the figure in parentheses is the median value. We use t-tests to test the significance of the means the sign test to test the significance of the medians ***, **, *and* * *denote significance at 1, 5 and 10 percent levels respectively.*

We study the factors that affect the operating performance of preferred stock issuers in Table 5. We specifically test whether information asymmetry and amount of financing affect the long-run operating performance of preferred stock issuers. We measure information asymmetry with the growth opportunities and the size of the firm. Smith and Watts (1992) argue that managers of firms with better growth opportunities will have better knowledge of the firm's future prospects compared to outsiders. Hence, there is higher information asymmetry between managers and outside investors for firms with better growth opportunities. Similarly, information asymmetry will be higher for smaller firms since fewer analysts follow them (McLaughlin et al., 1998a). The amount of financing is measured with the total proceeds from the issue standardized with the book value of assets. In this table, we test the differences in the changes in operating performance after the offering for different subsamples. We define the change in operating performance as the operating performance in year +3 minus the operating performance in year -1, where year 0 is the issue year.

In Panel A, we test the influence of the growth opportunities. We measure growth opportunities with the market-to-book ratio of the firm. In this panel, we define the difference in the change in operating performance with the change in operating performance for firms with market-to-book ratios above sample median minus the change in operating performance for firms with market-to-book ratios below sample median. We find that the median difference in the change in profit margin is significantly negative for the whole sample. This result indicates that the profit margin is lower for firms that have high market-to-book ratios. We also find that the median cash flows and profit margin are lower for financial firms with high market-to-book ratios, although growth opportunities do not affect the long-run performance of industrial firms and utilities. In Panel B, we measure information asymmetry with the size of the firm proxied by the total assets. Total assets is the total book value of assets. In Panel B, the difference in the change in operating performance is defined as the change in operating performance for firms with total assets above sample median minus the change in operating performance for firms with total assets below sample median. We find that for the whole sample the median return on assets is higher for large firms while for utilities the profit margin is higher. The size of the firm does not have an influence on the performance of industrial and financial firms.

We measure the influence of the size of the issue in Panel C. In this panel, the difference in the change in operating performance is defined as the change in operating performance for firms with standardized issue size above sample median minus the change in operating performance for firms with standardized issue size below sample median. For the whole sample, we find that both the mean and median differences in the change in cash flows and profit margin are significantly positive. This results shows that cash flows and profit margin are higher for firms that make larger offerings. We also find that the median cash flow and profit margin are higher for financial firms that issue larger offerings while the average return on assets is higher for utilities that issue large offerings.

The findings in Table 5 indicate that overall the long-run operating performance is better for firms that make larger offerings. There is also some evidence that preferred stock issuers with low information asymmetry have better operating performance. The latter result is consistent with McLaughlin et al. (1998a, 1998b) who find similar results for the cases of bond and common stock offerings.

CONCLUSIONS

In this paper, we study the long-run operating performance of the issuers of preferred stock. We hypothesize that the operating performance of preferred stock issuers will decrease before the issue and this decrease will continue after the issue. We also expect the decrease in operating performance to be more pronounced for firms with high information asymmetry and larger offerings.

Our sample consists of non-convertible completed preferred stock issues offered in US public markets. There are 1,334 issues in our sample offered by 876 firms during the 1992-2004 period. Consistent with our hypothesis, we find that there is a decrease in operating performance of preferred stock issuers before the offering. The decrease is evident in industrial firms, financial firms and utilities. After the offering, overall there is a decrease in the profitability of preferred stock issuers. The decrease in profitability is more pronounced for financial firms, although these firms have higher cash flows after the offering. We also find that issuers of large offerings have better long-run operating performance after the offering. There is also some evidence that preferred stock issuers with low information asymmetry have better operating performance.

Our study shows that preferred stock issuers in different types of industries can have different long-run operating performances. Future studies should analyze whether these differences in operating performance persists for stock and bond offerings. Future research should also study the industry effect in long-run stock performance.

REFERENCES

Abhyankar, A. and Ho K. (2006), Long-run abnormal performance following convertible preference share and convertible bond issues: New evidence from the United Kingdom. *International Review of Economics and Finance*, 15, 97-119.

Alderson, M. J. and Berker, B. L. (2000), The long-run performance of companied that withdraw seasoned equity offerings. *Journal of Financial Research*, 23, 157-178.

Bae, G. S., Jeong, J., Sun, H. and Tang, A. P. (2002), Stock return and operating performance of securities issuers. *Journal of Financial Research*, 25, 337-352.

Bajaj, M., Mazumdar, S.C., and Sarin, A. (2002), The cost of issuing preferred stock. *Journal of Financial Research*, 25, 577-592.

Callahan, C.M., Shaw, W.H., and Terando, W.D. (2001), Tax and regulatory motivations for issuing non-voting, non-convertible preferred stock. *Journal of Accounting Research*, 39, 463-480.

Cheng, L. (1998), Equity issue underperformance and the timing of security issues. Working Paper, National Economic Research Associates Inc.

Clarke, J., Dunbar C., and Kahle, K. (2004), The long-run performance of secondary equity issues: A test of the windows of opportunity hypothesis. *Journal of Business*, 77, 575-603.

Dash, S. (2009), *Standard and Poor's Preferred Stock Primer*, McGraw Hill Irwin.

Dichev, I.D. and Piotroski, J.D. (1999), The performance of long-run stock returns following issues of public and private debt. Journal of Business Finance and Accounting, 26, 1103-1132.

D'Mello, R., Tawatnuntachai, O., and Yaman, D. (2003), Does the sequence of seasoned equity offerings matter? *Financial Management*, 32, 59-86.

Eckbo, B.E., Masulis, R.W., and Norli, Oyvind. (2000), Seasoned public offerings: Resolution of the 'New Issues Puzzle'. *Journal of Financial Economics*, 56, 251-291.

Hansen R. S. and Crutchley, C. (1990), Corporate earnings and financings: An empirical analysis. *Journal of Business*, 63, 347-371.

Hertzel, M., Lemmon, M. Linck J. S., and Rees L. (2002), Long-run performance following private placements of equity. *Journal of Finance*, 57, 2595-2617.

Houston, A.L.Jr. and Houston, C.O. (1990), Financing with preferred stock. *Financial Management*, 19, 42-54.

Howe, J. and Lee H. (2006), The long-run stock performance of preferred stock issuers. *Review of Financial Economics*, 15, 237-250.

Jung, K., Kim, Y., and Stulz, R.M. (1996), Timing, investment opportunities, managerial discretion, and the security issue decision. Journal of Financial Economics, 42, 159-185.

Kang, J., Kim, Y., and Stulz, R.M. (1999), The underreaction hypothesis and the new issue puzzle: Evidence from Japan. *Review of Financial Studies*, 12, 519-534.

Lee, H.W. and Figlewicz, R.E. (1999), Characteristics of firms that issue convertible debt versus convertible preferred stock. *Quarterly Review of Economics and Finance*, 39, 547-563.

Lee, H. and Johnson, D.T. (2009), The operating performance of preferred stock issuers. *Applied Financial Economics*, 19, 397-407.

Lee, I. and Loughran T. (1998), Performance following convertible bond issuance. *Journal of Corporate Finance*, 4, 185-207.

Lewis, C. M., Rogalski R. J., and Seward, J. K. (2001), The long-run performance of firms that issue convertible debt: an empirical analysis of operating characteristics and analyst forecasts. *Journal of Corporate Finance*, 7, 447-474.

Loughran, T. and Ritter, J.R. (1995), The new issues puzzle. Journal of Finance, 50, 23-51.

McLaughlin, R., Safieddine, A., and Vasudevan, G.K. (1996), The operating performance of seasoned equity issuers: Free cash flow and post-issue performance. *Financial Management*, 25, 41-53.

McLaughlin, R., Safieddine, A., and Vasudevan, G.K. (1998a), The information content of corporate offerings of seasoned securities: An empirical analysis. *Financial Management*, 27, 31-45.

McLaughlin, R., Safieddine, A., and Vasudevan, G.K. (1998b), The long-run performance of convertible bond issuers. *Journal of Financial Research*, 21, 373-388.

Miller M. H. and Rock K. (1985), Dividend policy under asymmetric information. *Journal of Finance*, 40, 1031-1051.

Myers, S., and Majluf, N. S. (1984), Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, 13, 187–221.

Rao, R. and Moyer, R.C. (1992), The effect of non-convertible preferred stock retirement on shareholder wealth. *Journal of Economics and Finance,* 16, 11-25

Ross, S.A., Westerfield, R.W. and Jaffe, J. (2008), *Corporate Finance*, McGraw-Hill Irwin.

Smith, C., and Watts, R. L. (1992), The investment opportunity set and corporate financing, dividend, and compensation policies. *Journal of Financial Economics*, 32, 263–292.

Spiess, D.K. and Affleck-Graves, J. (1995), Underperformance in long-run stock returns following seasoned equity offerings. *Journal of Financial Economics*, 38, 243-267.

Spiess, D.K. and Affleck-Graves, J. (1999), The long-run performance of stock returns following debt offerings. *Journal of Financial Economics*, 54, 45-73.

Stickel, S.E. (1991), The ex-dividend behavior of nonconvertible preferred stock returns and trading volume. *Journal of Financial and Quantitative Analysis*, 26, 45-61.

Wansley, J.W., Elayan F.A., and Maris, B.A. (1990), Preferred stock returns, creditwatch, and preferred stock rating changes. *Financial Review*, 25, 265-285.

ACKNOWLEDGEMENT

The author thanks the editor and the two reviewers for their excellent comments.

BIOGRAPHY

Devrim Yaman is an Associate Professor of Finance at Western Michigan University. She can be contacted at Department of Finance & Commercial Law, Haworth College of Business, Western Michigan University, Kalamazoo, MI 49008, USA. Email: devrim.yaman@wmich.edu.

THE CAPITAL ASSET PRICING MODEL'S RISK-FREE RATE

Sandip Mukherji, Howard University

ABSTRACT

The risk-free rate is an important input in one of the most widely used finance models: the Capital Asset Pricing Model. Academics and practitioners tend to use either short-term Treasury bills or long-term Treasury bonds as the risk-free security without empirical justification. This study investigates the market and inflation risks of Treasury securities with different maturities over different investment horizons. The results show that mean real returns, volatility, and market and inflation risks, of Treasury securities increase with the maturity period. Only Treasury bills do not have any market risk for 1- and 5-year periods, and they have the lowest market risk over 10 years. Although Treasury securities of all maturities have significant inflation risk, Treasury bills have the lowest inflation risk over all three horizons. Further, the inflation beta and explanatory power of inflation for real Treasury bill returns decline with the investment horizon. Over 10 years, inflation and market risks explain only 13% of variations in real Treasury bill returns, compared to 20% of intermediate government bond returns, and 23% of long government bond returns. These findings indicate that Treasury bills are better proxies for the risk-free rate than longer-term Treasury securities regardless of the investment horizon.

JEL: G11; G12

KEYWORDS: Risk-free rate, Capital Asset Pricing Model, investment horizon

INTRODUCTION

The Capital Asset Pricing Model (CAPM), developed by Sharpe (1964) and Lintner (1965), is one of the most widely used models in finance. According to this model, a firm's cost of equity (Ke) is a linear function of its market risk: $Ke = Rf + (Rm - Rf)\,\beta e$, where Rf is the risk-free rate, Rm is the expected market return, (Rm – Rf) is the market risk premium, and βe is the equity beta, denoting market risk.

The importance of identifying appropriate inputs for practical applications of this model has produced a voluminous body of empirical studies, aimed primarily at estimating the market risk premium and beta. The third component of the model — the risk-free rate — has received scant attention. The risk-free rate is an important model input since it not only determines the intercept, but also affects the slope of the linear equation. A higher risk-free rate implies a higher intercept and flatter slope compared to a lower rate. Academics and practitioners tend to use either short-term Treasury bills or long-term Treasury bonds as the risk-free security without empirical justification.

The CAPM is a single-period model, but the period is not specified. In theory, it could be applied to periods of any length, for example, 1, 5, or 10 years. Although a 10-year period does contain 1- and 5-year periods, a 1-year period also contains months and weeks. The length of the period does not matter as long as all the parameters are measured over the same period. Treasury bills, intermediate-term government bonds, and long-term government bonds match the time horizons of short-, medium-, and long-term investments, respectively. Matching the maturity period of the risk-free security with the investment horizon minimizes interest rate risk, although it does not eliminate inflation risk, and its effect on market risk is an empirical issue.

For a risk-free security, the return actually realized should be equal to the expected return. No security is truly risk-free, but Treasury securities are normally used as the closest proxy for a risk-free security because they have practically no default risk. Although the nominal returns on Treasury securities are risk-free, their real returns are not; they are exposed to inflation risk. Unanticipated inflation inversely affects real returns on securities with fixed cash flows, and it has a stronger influence on longer-term securities, whose cash flows are fixed for longer periods.

Since the relevant risk measure in the CAPM is market risk, indicating the sensitivity of an investment's returns to movements in market returns, the market beta of a risk-free security must be zero. The CAPM is a one-factor model, which assumes that market risk is the only risk that is priced by investors. However, as Fama and French (2002) noted, the goal of investment in portfolio theory is consumption, which is related to real rather than nominal returns. Therefore, the realized real return on a risk-free security should be equal to its expected real return. An appropriate proxy for the risk-free rate for each horizon should have no significant market or inflation risk. This study empirically investigates the market and inflation risks of Treasury securities with different maturities over different investment horizons.

The remainder of the paper is organized as follows. Section 2 reviews the literature. The data and methodology are described in Section 3. Section 4 presents the empirical results and Section 5 concludes the paper.

LITERATURE REVIEW

Empirical tests of the CAPM have provided mixed results. Black, Jensen, and Scholes (1972) regressed average monthly excess returns over T. Bills against betas of portfolios during 1931-65 and reported that the slope and intercept were significantly different from the values predicted by the CAPM. Fama and Macbeth (1973) found a positive linear relationship between average return and beta during 1926-68. Fama and French (1992) showed that book-to-market equity and firm size have significant explanatory power for stock returns, but beta is not significantly related to stock returns, during 1963-90. Kothari, Shanken, and Sloan (1995) drew attention to survivor bias in the Compustat data used in the Fama and French (1992) study and took issue with the interpretation of their results.

In a survey by Graham and Harvey (2001), responses from chief financial officers at a cross-section of 392 U.S. firms indicated that 73.5% of respondents always, or almost always, use the CAPM to estimate the cost of equity. Another survey of highly regarded corporations, leading financial advisors, and best-selling textbooks and trade books by Bruner et al. (1998) revealed that 85% of sample firms use the CAPM or a modified CAPM. These studies indicate the widespread use of the CAPM and the importance of identifying appropriate inputs for the model.

Empirical studies of the CAPM parameters have focused primarily on the input that is hardest to estimate: the market risk premium. Since a stock market index is a common proxy for the market portfolio, the equity premium is generally considered the market risk premium. Blanchard (1993) estimated that the equity premium over 20-year government bonds increased from 3% to 5% in the early 1930s to more than 10% in the late 1940s, but declined to 2% to 3% by the early 1990s due to a fall in expected real returns on stocks and an increase in expected real risk-free rates. Siegel (1998) reported that the equity premium was 4.0% over T. Bills, and 3.3% over long-term government bonds, over a longer period, from 1802 through 2004. Dimson, Marsh and Staunton (2002) showed that, while the geometric mean U.S. equity premium has been above average, at 5.6% over T. Bills and 4.8% over long-term government bonds, five of sixteen countries studied offered higher premiums than the U.S. over a 102-year period. Claus and Thomas (2001) estimated the equity premium over 10-year government bonds at about 3% or less in the

U.S. and five other large stock markets. These studies indicate that researchers have measured the equity premium relative to both T. Bills and long-term government bonds, with varying results.

Some studies have indicated that the return interval used in the regression has a significant impact on the beta estimate. Reilly and Wright (1988) showed that there were large differences in the betas estimated by Value Line Investment Survey and Merrill Lynch Investment Service, which calculate beta over five years, using weekly and monthly returns, respectively. Gunthorpe and Levy (1994) found that stocks with betas below one based on daily returns had betas above one based on annual returns, and vice versa. Levy, Gunthorpe, and Wachowicz (1994) indicated that the return interval used for the beta estimate should be consistent with the investor's expected holding period.

No previous study has attempted to identify the appropriate risk-free rate for the CAPM. Academics and practitioners arbitrarily use short-term or long-term government securities as proxies for the risk-free security. Bruner et al. (1998) found wide variation in the choice of risk-free rates for the CAPM. Practitioners strongly prefer long-term bonds; 70% of corporations and financial advisors use Treasury bonds with maturities of ten years or greater, while 10% or less use Treasury bills. By contrast, 43% of books recommend using Treasury bills and only 29% recommend long-term Treasury bonds. Observing that the risk-free rate should match the period of the cash flows, the authors conclude: "for most capital projects and corporate acquisitions, the yield on the US government Treasury bond of ten or more years in maturity would be appropriate." (p. 26)

The yields on risk-free securities are related to their maturity periods. As Wilson and Shailer (2004) noted, long-term bonds with no default risk normally offer higher yields than similar short-term securities due to an interest rate risk premium. Yields for different long-term maturities, however, tend to be fairly similar. Bruner et al. (1998) observed that the specific maturity of the long-term bond used is not important because yield curves are generally flat beyond 10 years. There is evidence that Treasury bonds are exposed to both market and inflation risks. Cornell (1999) found that 5- and 20-year Treasury bonds have significantly positive market betas, measured over 48-month periods. Fama and Schwert (1977) reported that government bond returns were strongly negatively related to unanticipated changes in expected inflation, and the negative relationship was stronger for longer-term bonds.

Treasury inflation-protected securities (TIPS), introduced in 1997, are indexed to inflation. However, these securities are offered only in maturities of 5 and 10 years, and they pay semiannual coupons, which are exposed to inflation risk. Moreover, TIPS are likely to have negative market betas because real stock returns have negative inflation betas. Fama and Schwert (1977) found that monthly, quarterly and semiannual stock returns were negatively related to expected and unexpected inflation as well as to changes in unexpected inflation. The results of Boudoukh and Richardson (1993) also indicated that 5-year real stock returns were negatively related to inflation. These findings suggest that TIPS, which are indexed to inflation, will have negative market betas.

DATA AND METHODOLOGY

Monthly returns during 1926-2007 are obtained from Ibbotson Associates (2008) and deflated by the inflation rate, measured by changes in the Consumer Price Index, to compute real returns on the following securities: Treasury bills – the bill with the shortest maturity not less than one month; intermediate-term government bonds – a bond with a maturity near five years; long-term government bonds – a bond with a maturity near twenty years; and large company stocks – the Standard and Poor's 500 stock composite index, which is the commonly used proxy for the market.

The data available for 82 years contain only sixteen 5-year and eight 10-year non-overlapping returns. Bootstrapping reduces estimation risk when the parameters of a distribution are not known. Bootstraps resample data using the observed distribution, instead of an assumed distribution, to approximate the distribution of an estimator. Block bootstraps preserve both serial and cross-sectional correlations within the blocks. The returns for different horizons are estimated by drawing 1,000 random blocks with replacement from the real monthly returns for 1926-2007. For the annual returns, a month is randomly sampled with replacement a thousand times, the continuously compounded real monthly returns on stocks, Treasury securities, and inflation are aggregated for each 12-month period starting with the sampled month, and the 12-month real returns are calculated by subtracting inflation from the security returns. For the annualized 5-year returns, the continuously compounded real monthly returns on stocks, Treasury securities, and inflation are summed for each 60-month period starting with the sampled month, and the annualized real returns are estimated as the differences between the mean 12-month returns on the securities and inflation. The annualized 10-year real returns are estimated in a similar manner as the annualized 5-year real returns, except that the mean 12-month real returns are calculated for 10-year periods.

The market and inflation risks of each of the three Treasury securities are investigated through the following univariate and multiple regression models, separately for 1-, 5-, and 10-year periods:

$$\mathrm{Rt} = \alpha + \beta\mathrm{i}\ \mathrm{Inflation} + \varepsilon\mathrm{t} \tag{1}$$

$$\mathrm{Rt} = \alpha + \beta\mathrm{m}\ \mathrm{Market\ Return} + \varepsilon\mathrm{t} \tag{2}$$

$$\mathrm{Rt} = \alpha + \beta\mathrm{i}\ \mathrm{Inflation} + \beta\mathrm{m}\ \mathrm{Market\ Return} + \varepsilon\mathrm{t} \tag{3}$$

where Rt is the real return on Treasury security t, α is the regression intercept, βi is the inflation beta, βm is the market beta, relative to S&P 500 index returns, and εt is the error term.

EMPIRICAL RESULTS

The descriptive statistics in panel A of Table 1indicate that the mean annual inflation rate during the study period was 2.85% and the mean real risk-free returns increased with maturity, from 0.84% for Treasury bills (TB) to 2.26% for intermediate-term government bonds (IGB) and 2.38% for long-term government bonds (LGB). Stocks provided mean real returns of 6.32%. The means were above the medians for inflation, IGB, and LGB, but below the medians for TB and stocks, indicating positive skewness in the former and negative skewness in the latter continuously compounded returns. The standard deviations of real returns increased with maturity and risk, being lowest for TB and highest for stocks. However, the risk-return tradeoff, measured by the coefficient of variation (CV), was best for IGB, followed by stocks, LGB, and TB.

All the three Treasury securities will yield the same cost of equity for investments with a market beta of one. However, for defensive investments, the cost of equity will be lowest if TB is the risk-free security and highest if LGB is the risk-free security. By contrast, for aggressive investments, the cost of equity will be highest if TB is the risk-free security and lowest if LGB is the risk-free security. For example, based on the mean returns in panel A, for an investment with a beta of 0.5, using TB, IGB, and LGB as the risk-free securities produce CAPM-estimated real costs of equity of 3.58%, 4.29%, and 4.35%, respectively. For an investment with a beta of 1.5, using TB, IGB, and LGB as the risk-free securities yield real costs of equity of 9.06%, 8.35%, and 8.29%, respectively. These examples illustrate that whether TB or Treasury bonds are used as the risk-free security has a greater impact on the cost of equity than the maturity period of the Treasury bond used.

Table 1: Descriptive Statistics of Inflation and Real Risk-free and Stock Returns

	Inflation	Treasury Bills	Intermediate Govt. Bonds	Long Govt. Bonds	Stocks
Panel A. 1-Year Returns					
Maximum (%)	17.78	12.60	23.40	35.90	63.80
Mean (%)	2.85	0.84	2.26	2.38	6.32
Median (%)	2.73	1.06	1.81	2.00	7.98
Minimum (%)	-11.39	-17.42	-17.32	-32.45	-102.14
Standard Devn. (%)	4.23	4.03	6.45	9.25	20.72
Coeff. of Variation	1.48	4.82	2.86	3.89	3.28
Panel B. Annualized 5-Year Returns					
Maximum (%)	8.43	7.86	11.80	15.83	29.33
Mean (%)	2.43	0.53	2.00	2.15	5.48
Median (%)	2.37	0.69	1.69	1.58	5.98
Minimum (%)	- 6.13	- 6.27	- 6.14	-10.80	-20.83
Standard Devn. (%)	2.63	2.67	3.62	4.60	7.73
Coeff. of Variation	1.08	4.99	1.81	2.14	1.41
Panel C. Annualized 10-Year Returns					
Maximum (%)	8.46	4.54	8.89	10.77	17.38
Mean (%)	3.39	0.41	1.88	1.82	7.11
Median (%)	3.21	1.02	1.36	0.46	8.35
Minimum (%)	- 2.64	- 5.44	- 4.54	-6.28	-4.37
Standard Devn. (%)	2.39	2.22	3.10	4.09	5.17
Coeff. of Variation	0.71	5.42	1.65	2.24	0.73

Descriptive statistics of returns and volatility of inflation,, real risk-free returns, and real stock returns for periods of 1, 5, and 10 years.

The mean annualized 5-year inflation rate of 2.43% in panel B was lower than the annual rate. The mean annualized 5-year real returns of 0.53% for TB, 2.00% for IGB, 2.15% for LGB, and 5.48% for stocks were also below their annual means. This pattern of mean returns, and the relationships between mean and median returns, were similar to those for annual returns. However, the differences between the annualized 5-year mean and median returns were smaller than those for annual returns for all securities except LGB. The standard deviations were lower for all securities, and the pattern across securities was similar to that for annual returns. The CV was also lower for all securities except TB, and stocks had the lowest CV, followed by IGB, LGB, and TB.

The mean annualized 10-year inflation rate of 3.39% in panel C was the highest, while the mean real returns of 0.41% for TB, 1.88% for IGB, and 1.82% for LGB were the lowest, of all the three horizons. Mean real stock returns of 7.11% were the highest of the three horizons. Unlike the previous patterns, LGB had lower mean returns than IGB over 10 years. All the three Treasury securities had the widest difference between mean and median returns over the 10-year period, but this difference was wider for stocks in the 1-year period. Annualized 10-year returns had the lowest standard deviations for all securities, and the lowest CV for all securities except TB, which had the highest CV over 10 years. The pattern of CV across securities over 10 years was similar to that for 5 years.

The descriptive statistics in Table 1 indicate that TB had the lowest standard deviation of returns, but highest CV, because of its very low real returns, in all the three horizons. The best proxy for a risk-free security should have the lowest risk; its low return is irrelevant. TB returns have the lowest volatility, and their volatility declines with the investment horizon. However, the appropriate risk measure in the CAPM is not overall volatility, but market beta, which can be formulated as the product of the volatility of the security's returns relative to the volatility of market returns and the correlation of the security's returns with market returns. The market betas of Treasury securities over different horizons are evaluated through regressions.

Table 2: Regressions of Annual Real Risk-free Returns

	Treasury Bills	Intermediate Govt. Bonds	Long Govt. Bonds
Panel A. Regressions against Real Market Returns			
Intercept	0.01**	0.02**	0.02**
(T-statistic)	(6.69)	(10.19)	(6.78)
Market Beta	-0.01	0.01	0.05**
(T-statistic)	(-1.43)	(1.36)	(3.51)
Adjusted R-square	0.00	0.00	0.01
Panel B. Regressions against Inflation			
Intercept	0.03**	0.05**	0.06**
(T-statistic)	(28.31)	(25.96)	(19.40)
Inflation Beta	-0.72**	-0.96**	-1.19**
(T-statistic)	(-35.93)	(-25.40)	(-20.38)
Adjusted R-square	0.56	0.39	0.29
Panel C. Regressions against Real Market Returns and Inflation			
Intercept	0.03**	0.05**	0.05**
(T-statistic)	(27.76)	(24.75)	(17.99)
Market Beta	-0.00	0.02**	0.06**
(T-statistic)	(-0.83)	(2.70)	(4.97)
Inflation Beta	-0.72**	-0.96**	-1.20**
(T-statistic)	(-35.87)	(-25.56)	(-20.79
(F-statistic)	645.63	328.22	225.00
Adjusted R-square	0.56	0.40	0.31

Univariate and multiple regressions of annual real risk-free returns against real market returns and inflation.
**, ** indicate significance at the 1 and 5 percent levels, respectively.*

The regressions of annual real risk-free returns in Table 2 show that the market betas of TB and IGB are not significantly different from zero. LGB have a significant market beta of 0.05 but market returns explain only 1% of LGB returns. All the three Treasury securities have significantly negative inflation betas, which increase in magnitude with the maturity period. This indicates that inflation hurts longer-term securities, whose cash flows are fixed for longer periods, more than shorter-term securities. Inflation explains 56% of variations in TB returns, but only 29% of variations in LGB returns, suggesting that inflation is the primary determinant of the real returns of short-term Treasury securities, but other factors have a greater influence on the real returns of long-term Treasuries. In the multiple regressions, the only material change is that IGB have a significant stock beta of 0.02. These results show that, in the short-term, only TB do not have any market risk and, although Treasury securities of all maturities are exposed to significant inflation risk, TB have the lowest inflation risk.

The regressions of annualized 5-year real risk-free returns in Table 3 indicate that only LGB have a significant market beta (0.08) and market returns explain only 2% of LGB returns. Inflation betas are significantly negative for all the three Treasury securities and increase in magnitude with maturity. The explanatory power of inflation is lowest for LGB returns and highest for TB returns, but inflation explains only 38% of variations in 5-year TB returns compared to 56% of variations in 1-year TB returns. Multiple regressions slightly increase the market and inflation betas of IGB and LGB compared to the univariate regressions, and the market beta of IGB becomes significantly positive. These findings are similar to the short-term results. In the medium-term also, TB are the only Treasury security with no market risk, and they have the lowest inflation risk. Further, the inflation beta and explanatory power of inflation for TB returns are lower in the medium-term than in the short-term.

Table 4 shows that market betas are significantly positive for annualized 10-year real returns on Treasury securities of all maturities, but TB have the lowest market beta of 0.09 while LGB have the highest market beta of 0.26. All the three Treasury securities have significantly negative inflation betas, which increase in magnitude with maturity. Inflation explains only 12% of variations in TB returns, compared to 20% of variations in IGB and LGB returns. The inflation beta and explanatory power of inflation for TB returns are lowest in the long term. Multiple regressions reduce both the market and inflation betas of all the three securities, compared to the univariate regressions, and produce adjusted R-squares that are very similar to those for the inflation regressions. This suggests that the significantly positive market betas primarily reflect common variations in the real returns on stocks and Treasury securities due to inflation. The market beta of TB in the multiple regression is significant, but very low, at 0.04. These findings indicate that, in the long-term, TB have the lowest market and inflation risks, and these two factors explain only 13% of variations in TB returns, compared to 20% of IGB returns and 23% of LGB returns.

Table 3: Regressions of Annualized 5-Year Real Risk-free Returns

	Treasury Bills	**Intermediate Govt. Bonds**	**Long Govt. Bonds**
Panel A. Regressions against Real Market Returns			
Intercept	0.01**	0.02**	0.02**
(T-statistic)	(5.69)	(13.75)	(9.71)
Market Beta	-0.01	0.01	0.08**
(T-statistic)	(-0.90)	(0.90)	(4.17)
Adjusted R-square	0.00	0.00	0.02
Panel B. Regressions against Inflation			
Intercept	0.02**	0.04**	0.04**
(T-statistic)	(22.59)	(31.71)	(26.15)
Inflation Beta	-0.62**	-0.81**	-0.93**
(T-statistic)	(-24.61)	(-23.23)	(-19.73)
Adjusted R-square	0.38	0.35	0.28
Panel C. Regressions against Real Market Returns and Inflation			
Intercept	0.02**	0.04**	0.04**
(T-statistic)	(20.17)	(27.55)	(21.33)
Market Beta	0.00	0.03**	0.10**
(T-statistic)	(0.48)	(2.66)	(6.31)
Inflation Beta	-0.62**	-0.82**	-0.95**
(T-statistic)	(-24.58)	(-23.42)	(-20.48)
(F-statistic)	302.67	274.90	222.05
Adjusted R-square	0.38	0.35	0.31

*Univariate and multiple regressions of annualized 5-yeal real risk-free returns against real market returns and inflation. *, ** indicate significance at the 1 and 5 percent levels, respectively.*

Table 4: Regressions of Annualized 10-Year Real Risk-free Returns

	Treasury Bills	**Intermediate Govt. Bonds**	**Long Govt. Bonds**
Panel A. Regressions against Real Market Returns			
Intercept	-0.00	0.01**	-0.00
(T-statistic)	(-1.91)	(5.57)	(-0.27)
Market Beta	0.09**	0.14**	0.26**
(T-statistic)	(6.69)	(7.38)	(11.20)
Adjusted R-square	0.04	0.05	0.11
Panel B. Regressions against Inflation			
Intercept	0.02**	0.04**	0.04**
(T-statistic)	(13.16)	(25.21)	(21.96)
Inflation Beta	-0.32**	-0.58**	-0.76**
(T-statistic)	(-11.72)	(-15.77)	(-15.76)
Adjusted R-square	0.12	0.20	0.20
Panel C. Regressions against Real Market Returns and Inflation			
Intercept	0.01**	0.03**	0.03**
(T-statistic)	(6.33)	(14.54)	(9.54)
Market Beta	0.04**	0.05**	0.16**
(T-statistic)	(3.09)	(2.70)	(6.87)
Inflation Beta	-0.29**	-0.54**	-0.64**
(T-statistic)	(-9.95)	(-13.88)	(-12.70
(F-statistic)	74.01	128.81	153.44
Adjusted R-square	0.13	0.20	0.23

*Univariate and multiple regressions of annualized 10-yeal real risk-free returns against real market returns and inflation. *, ** indicate significance at the 1 and 5 percent levels, respectively.*

The descriptive statistics in Table 1 showed that the mean real returns and volatility of Treasury securities increase with the maturity period regardless of the investment horizon. The regression results in Tables 2 through 4 show that the market and inflation risks of Treasury securities are also directly related to the maturity period for all horizons. For each Treasury security, market risk increases moderately and inflation risk declines considerably over longer periods. TB are the best proxy for the risk-free rate, with little or no market risk and the lowest inflation risk over all periods.

CONCLUSION

The risk-free rate is an important input in one of the most widely used finance models: the Capital Asset Pricing Model. Academics and practitioners tend to use either short-term Treasury bills or long-term Treasury bonds as the risk-free security without empirical justification. The goal of this paper was to identify the appropriate proxy for the risk-free rate, which has the lowest market and inflation risks over different horizons. The returns on risk-free securities and stocks as well as inflation rates for different horizons were estimated by drawing 1,000 random blocks from the real monthly returns for 1926-2007. The market and inflation risks of Treasury securities with different maturities over different investment horizons were investigated through univariate and multiple regressions. The results showed that mean real returns, volatility, and market and inflation risks, of Treasury securities increase with the maturity period. Only Treasury bills do not have any market risk for 1- and 5-year periods, and they have the lowest market risk over 10 years. Although Treasury securities of all maturities have significant inflation risk, Treasury bills have the lowest inflation risk over all three horizons. Further, the inflation beta and explanatory power of inflation for real Treasury bill returns decline with the investment horizon. Over 10 years, inflation and market risks explain only 13% of variations in real Treasury bill returns, compared to 20% of intermediate government bond returns, and 23% of long government bond returns. These findings indicate that Treasury bills are better proxies for the risk-free rate than longer-term Treasury securities regardless of the investment horizon. Since this study uses U.S. data, the results apply only to the U.S. market. Researchers may conduct similar studies with data from other markets to identify appropriate risk-free rates for those markets.

REFERENCES

Black, Fischer, Jensen, Michael C. and Scholes, Myron (1972), "The Capital Asset Pricing Model: Some Empirical Tests," in *Studies in the Theory of Capital Markets*, ed. Michael Jensen, 79-121. New York: Praeger.

Blanchard, Oliver J. (1993), "Movements in the Equity Premium," *Brookings Papers on Economic Activity*, 2, 75-138.

Boudoukh, J. and Richardson, M. (1993), "Stock Returns and Inflation: A Long-horizon Perspective," *The American Economic Review*, 83, 1346-55.

Bruner, R. F., Eades, K. M., Harris, R. S., and Higgins, C. (1998), "Best Practices in Estimating the Cost of Capital: Survey and synthesis," *Financial Practice and Education*, 8, 13-28.

Claus, James and Thomas, Jacob (2001), "Equity Premia as Low as Three Percent? Evidence from Analysts' Earnings Forecasts for Domestic and International Stock Markets," *The Journal of Finance*, 56, 1629-66.

Cornell, B. (1999), "Risk, Duration, and Capital Budgeting: New Evidence on Some Old Questions," *Journal of Business*, 72, 183-200.

Dimson, Elroy, Marsh, Paul and Staunton, Mike (2002), *Triumph of the Optimists: 101 Years of Global Investing Returns*, Princeton University Press, Princeton, NJ.

Fama, Eugene F. and French, Kenneth R. (1992), "The Cross-section of Expected Stock Returns," *Journal of Finance*, 47, 427-65.

Fama, Eugene, F. and MacBeth, James D. (1973), "Risk, Return, and Equilibrium: Empirical Tests," *Journal of Political Economy*, 81, 607-36.

Fama, Eugene F. and Schwert, G. W. (1977), "Asset Returns and Inflation," *Journal of Financial Economics*, 5, 115-46.

Graham, J. R. and Harvey, C. R. (2001), "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics*, 60, 187-243.

Gunthorpe, D. and Levy, H. (1994), "Portfolio Composition and the Investment Horizon," *Financial Analysts Journal*, 50, 51-56.

Ibbotson Associates (2008), *Stocks, Bonds, Bills, and Inflation Yearbook*, Chicago, IL.

Kothari, S. P., Shanken, Jay and Sloan, Richard G. (1995), "Another Look at the Cross-section of Expected Stock Returns," *Journal of Finance*, 50, 185-224.

Levy, H., Gunthorpe, D. and Wachowicz, Jr., J., (1994), "Beta and An Investor's Holding Period," *Review of Business*, 15, 32-35.

Lintner, John (1965), "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets," *Review of Economics and Statistics*, 47, 13-37.

Reilly, F. and Wright, D. J., (1988), "A Comparison of Published Betas," *Journal of Portfolio Management*, 14, 64-69.

Sharpe, W. F. (1964), "Capital Asset Prices – A Theory of Market Equilibrium under Conditions of Risk," *Journal of Finance*, 19, 425-42.

Siegel, Jeremy J. (1998), *Stocks for the Long Run: The Definitive Guide to Financial Market Returns and Long-term Investment Strategies*, 2nd ed., McGraw-Hill, New York, NY.

Wilson, M. and Shailer, G. (2004), "The Term Structure of Discount Rates and Capital Budgeting Practice," *Journal of Applied Management Accounting Research*, 2, 29-40.

BIOGRAPHY

Dr. Sandip Mukherji, CFA, is a Professor of Finance and Director of the Center for Financial Services at Howard University. He has published 30 research papers in refereed journals, worked on faculty internship and consulting projects at Goldman Sachs, and held a Research Fellowship from the Morgan Stanley Foundation. He can be contacted at the Dept. of Finance, Intl. Business, and Insurance, School of Business, 2600 6th Street, NW, Washington, DC 20059. Email: smukherji@howard.edu.

The International Journal of Business and Finance Research ♦ Volume 5 ♦ Number 2 ♦ 2011

EQUITY MARKET TIMING AND SUBSEQUENT DELISTING LIKELIHOOD

Frank D'Souza, Loyola University Maryland
Harold Fletcher, Loyola University Maryland
Octavian Ionici, American University

ABSTRACT

Timing the market for equity is an accepted practice by managers who in theory have the best interests of current shareholders in mind. It is clear that by using their superior information, managers can indeed successfully issue overvalued equity to the new shareholders. Recent research has determined that some firms do well after a market timed issue, while others underperform. The post-issue performance is linked to the investment opportunity set of the issuing firms as well as their choice of investments. In general, firms without good investment options will perform poorly. We extend this line of research by studying the post-issue delisting pattern of market timing firms and the two subsets. Specifically, we research whether firms that mistakenly time the market for equity are more likely to compromise their future and get delisted (through acquisitions, bankruptcies etc.) in the immediate future than those firms that have a use for the funds. Using logistic regression models, we show that firms that are market timing firms and that lack good investment opportunities are indeed more likely to get delisted; strengthening the growing argument that equity market timing does not always result in shareholder benefit.

JEL: G14, G32

KEYWORDS: equity market timing, delisting likelihood

INTRODUCTION

Seasoned equity offerings (SEOs) have been events of considerable interest in terms of financial research. The announcement period impacts of SEO as well as the long-run impact on the issuing firm's stock price have been studied. In general most researchers have observed a significantly negative announcement effect as well as significant long run underperformance for issuing firms.

Baker and Wurgler (2002) summarize the research conclusions documenting post-issue underperformance and offer the under-performance as evidence that managers are able to time the market for equity. The reasoning being, that by timing the market, these managers are presumed to be taking advantage of the new, entering shareholders and adding benefit to the current shareholders at the new shareholders' expense.

In the more recent past, however, there has been new research that challenges the statement made by Baker and Wurgler (2002) and these research papers make one crucial change to the way we view SEO research. In previous studies SEO issuing firms were typically studied as one sample. Hertzel and Li (2009), and D'Souza and Rao (2009) move away from that model and divide SEO firms into two subsets based on their ability to productively use the funds raised. Both papers make the startling find that not all SEO issuing firms underperform, just the ones that are not in the best position to use additional funds.

We further this new research by providing additional evidence on the SEO issuing firms. Most studies with regard to SEOs have spanned 3-5 years and have focused on performance. We felt that it was important to research the long term impact that equity market timing has on the survival of these firms. We thus use the methodology of D'Souza and Rao (2009) to create the two subsets of issuing firms. Using a time horizon of eight years, we provide evidence that besides simply underperforming, managers of firms that issue additional stock (without having a viable use for it) compromise the very existence of their firms. We find that firms in the "overvalued" subset are significantly more likely to get delisted within eight years than their "growth" counterparts. Our results provide additional support for the argument that simply issuing additional equity does not result in benefit for the current shareholders.

LITERATURE

Equity market timing is also an area that has been studied extensively and there is strong support for the premise that managers are able to use their superior information to take advantage of new shareholders by issuing overvalued stock. The window of time that managers find themselves faced with this decision to issue relatively higher priced stock is called a window of opportunity. This phrase *window of opportunity* is used by Bayless and Chaplinsky (1996) to indicate a period where the information costs are reduced for all firms – typically during hot markets (high volume of equity issues).

SEOs have typically been accompanied by an announcement period drop in the stock price. Asquith and Mullins (1986), Mikkelson and Partch (1986), Bhagat and Hess(1986) and Eckbo and Masulis (1992) find a significant, average two-day announcement period return of between -3.0% and -3.6%. Long run studies by Ritter (1991) Loughran and Ritter (1995), Spiess and Affleck-Graves (1995), Brav and Gompers (1997) find evidence of post issue long-run (3-5 years) underperformance; the post-issue underperformance is generally viewed as a success for managers of market timing firms and as a benefit for the old shareholders. Fama (1998), the one of the few researchers who challenged the findings in this area, did so by questioning the validity of the research methodology. Fama (1998) offered that seasoned equity offerings (SEOs) may appear to perform poorly only because they are not evaluated against the correct benchmark. However, Jegadeesh (2000) addresses Fama's criticism by considering various benchmarks. Jegadeesh's findings indicate that the SEO firms underperform all of them. Thus, he concludes that the observed underperformance is indeed related to market over-optimism about their future prospects.

Eckbo, Masulis and Norli (2000) proposed a risk-based explanation. They offer an explanation that issuing equity would result in a lower default risk and lower liquidity risk. A lower post-issue return would thus be expected. They claimed that the underperformance observed in matched-firm studies results from a failure of the methodology of the matched-firm technique to provide a proper control for risk. They showed that once appropriate control is applied, post-SEO underperformance is insignificant. However, Jegadeesh (2000) refuted their claim by showing that Eckbo, Masulis and Norli (2000) include IPOs in their benchmark, causing the level of underperformance to be significantly understated. In the recent past, this body of research is once again being reexamined in order to understand why post- issue underperformance occurs. Carlson, Fisher and Gimmarino (2006) offer a real-investment explanation of post-issue underperformance. They theorize that when firms with growth opportunities (options), finance and exercise those options (by investing in the opportunities), it causes a decline in returns. The reason for this being that the new assets (assets in place) are less risky than the growth options that they replace. This view is supported by Li, Livdan, and Zhang (2008).

The most recent papers however, take a different approach to studying the long run underperformance by SEO issuing firms. Unlike earlier research that examines all issuers as one set, these studies create subsets based on investment opportunities. Hertzel and Li (2009) use the method of Rhodes-Kropf, Robinson, and Vishwanathan (2005) to decompose the market-to-book value ratio (MB) into growth and misvaluation components. They use this to create their subsets. They find that firms with better growth opportunities invest more in capital expenditures and R&D than firms with greater mispricing. However, the firms that invest more heavily do not underperform, while the firms that invest less do significantly underperform. D'Souza and Rao (2009) also find that all issuing firms do not underperform. They use a behavioral methodology to segregate firms into *window of opportunity* and *window of temptation* subsets. They go on to show that the *windows of temptation firms (ones without good investment opportunities) are* the ones that underperform and cause the overall sample of issuers to significantly underperform. The *window of opportunity firms* do not underperform.

In this paper, we extend the current body of research. The current literature focuses on the post-issue performance by either studying the return or the earnings of issuing firms. We ask a related, but different question - Does the act of equity market timing compromise the future of firms that mistakenly issue equity (without having a use for the funds)? We follow the methodology of D'Souza and Rao (2009) to obtain our sample set and the subsets of Growth firms (firms with investment options to use the new capital) and Overvalued firms (firms that issue equity without having a use for the funds). The rest of the paper is organized as follows: the hypothesis development is discussed in the next section, followed by the data and methodology section. The next section comprises of the empirical results and our conclusions are presented in the last section.

Hypotheses

There is increasing evidence showing that all firms do not underperform post-SEO and as such it casts serious doubt on the assertion that post-issue underperformance is good for the issuing firms. If a firm's managers put the firm's future in jeopardy by unnecessarily taking on additional equity capital, then we would expect that to manifest itself at the most basic level; the continued survival of the firm.

Palepu (1985) uses a logit model to test the likelihood of a firm being a takeover target. He tested six hypotheses that are frequently suggested in the academic and/or popular finance literature regarding firms that are likely to become acquisition targets. The two hypotheses that he found supported were: 1) The inefficient management hypothesis and 2) The growth-resource mismatch hypothesis.

Both the above are linked when it comes to equity market timing. If the firm's managers are inefficient in evaluating the need for additional capital and take on additional capital without having a use for those funds, it would lead to a growth-resource mismatch. The firm would have no avenues to use the new funds and would end up hoarding the funds. This would in turn make the firm an attractive takeover target since it is now cash (resource) rich. If on the other hand, the firm's managers decide to use the funds anyway, they would end up wasting the funds and leave the firm in a weakened state, making it increasingly likely that the firm might face bankruptcy or other financial problems that would cause it to be delisted.

We hypothesize that from the set of equity market timing firms, the firms without viable investment opportunities (Overvalued firms) are more likely to get delisted in the near future (we study the firms for eight years post-issue) than firms that had a viable use for the funds (Growth firms).

DATA AND METHODOLOGY

The data for the market-to-book value ratio (MB) is obtained from the Compustat database. Market equity is defined as common shares outstanding (item 25) times price (item 199). Book equity is defined as total assets less total liabilities (item 181) less preferred stock (item 10) plus deferred taxes (item 35) plus convertible debt (item 79). When preferred stock is missing, it is replaced with the redemption value of preferred stock (item 56). MB is computed as the end of quarter MB_{t-1} where t = the quarter of the equity issue announcement. To select the sample of firms for this study, we use the method of D'Souza and Rao (2009), as detailed below.

We start with all firms that undertake a seasoned equity issue between the years 1981 and 2000. From these, financial firms and regulated utilities are dropped from the sample. If a firm has more than one

SEO within a five year span, the second issue is not included. To ensure that these firms are truly equity market timing firms, only those with a debt-to-equity ratio below their industry median, as well as a market-to-book ratio above their industry median are retained. We now have the overall sample of firms and they are further broken down into the two subsets (growth & overvalued) using information on the direction of insider trades. For the firms where insiders were net buyers (or had a low level of net sales), the firm is considered a growth firm (with viable investment opportunities). For the firms where insiders had a higher level of net sales, the firm is considered an overvalued firm (with no viable investment opportunities). The firms are studied for a period of eight years post-SEO.

The delisting data for this study is obtained from the CRSP database. We use three classifications for delisting. The first of these is "Acquisitions / Mergers" (CRSP delisting codes 200 – 300). The second classification is "Liquidations" (delisting codes 400 – 490) and the last classification is "Dropped from Exchange" (delisting codes 500 – 591). The reasons for dropped from exchange include, but are not limited to: insufficient number of shareholders, bankruptcy, declared insolvent, delinquent in filing, price fell to below acceptable level, etc.

To test the hypothesis, the following logit model is used (a probit model is also used for robustness). We use it to ascertain if there is a significant difference in the likelihood of one of the two subsets of firms (Growth firms vs. Overvalued firms) getting delisted by either being acquired, going out of business, or being dropped from an exchange due to subsequent problems.

$$\begin{aligned} Delisting = \; & \beta_0 + \beta_1(Firm\ Type_{t-1}) + \beta_2(Debt_{t-1}) + \beta_3(Proceeds_{t-1}) \\ & + \beta_4(M/B_{t-1}) + \beta 5(Size_{t-1}) + \beta_6(ROA_{t-1}) + \beta_7(Cash_{t-1}) + \beta_8(Z\ Score_{t-1}) \end{aligned} \tag{1}$$

In the above equation, *Delisting* is a binary variable that takes on the value 1 if the firm is delisted within eight years of the market timed SEO, 0 if the firm is still a going concern. *Firm type* is also a binary variable that takes on the value 1, if the firm is a Growth firm and 0 if the firm is an Overvalued firm. *Debt* constitutes the long term debt of the firm and it is scaled by the value of the firms' total assets. The *Proceeds* variable represents the dollar value of capital raised through the market-timed SEO. This variable is also scaled by total assets. *M/B* is the firms market-to-book ratio prior to the market timed SEO. Higher levels of MB would indicate either overvaluation or strong growth opportunities. *Size* (of the firm) is given by the natural log of the market capitalization of the firm prior to the market timed SEO. *ROA* is the return on assets ratio prior to the market timed SEO and is included to control for the prior performance of the sample firms. *Cash* is represented by the cash & marketable securities holding of the firm prior to the SEO. The last control variable is the *Z- Score*. This variable is computed based on the methodology of Altman, 1968 and is used to control for the bankruptcy risk of the sample firms. A Z-Score value of less than 1.81indicates a high probability of bankruptcy while a value greater than 2.99 indicates a low probability of bankruptcy.

EMPIRICAL RESULTS

We begin by reviewing the full sample of market timing firms and the two subsets. From Table 1, we observe that although on average the firms are small cap firms, the overvalued firm's subset is comprised of slightly smaller firms than the growth firm's subset. The MB ratio is also, on average, higher for the overvalued firms than the growth firms. The two other observations that we highlight are the Z score and the ratio of Proceeds/Total Assets. The overvalued firms, pre-issue, have a higher Z score than the growth firms, which would indicate a lower default/bankruptcy risk. The overvalued firms also issue a greater proportion of new equity in relation to their current level of total assets than the growth firms. At first glance, this supports our hypothesis, since these firms mistakenly believe that issuing overvalued equity without a use for the funds is good for the shareholders. Thus, we would expect these firms to issue as much equity as they can.

Table 1 and 2 present the univariate statistics and the covariance matrix for the full sample of 448 market timing firms, and the two subsets. We observe that on average, these firms are micro-cap firms with an average market capitalization of 155.4 (ln 5.046) million. The growth firms are on average slightly larger than the overvalued firms. The overvalued subset has a slightly higher market-to-book ratio, on average. It is also interesting to note that the overvalued firms raised more capital as a percentage of total assets than the growth firms did. This could indicate that the managers of these firms were simply looking to issue as much new stock as they could. From the covariance matrix we see that for the two subsets, there is a strong positive correlation between the cash on hand, the creditworthiness of a firm (Z score) and the amount of new capital raised. We also see a strong positive correlation between the market-to-book ratio for overvalued firms and the amount of new capital raised, indicating that that these firms capitalized on the *window of opportunity* to raise new funds.

Table 1: Univariate Statistics of the Full Sample and Subsets

Panel A: Full Sample of Equity Market Timing Firms						
Variable	**N**	**Mean**	**Std. Dev**	**Sum**	**Minimum**	**Maximum**
Debt/TA	448	0.004	0.008	1.586	0.000	0.061
Proceeds/TA	448	0.767	0.908	343.798	0.004	10.268
MB ratio	448	10.639	15.007	4809.000	0.670	76.450
Ln Size	448	5.046	1.589	2281.000	1.151	11.216
ROA	448	0.095	0.228	42.270	-1.162	0.554
Cash/TA	448	0.007	0.014	3.085	0.000	0.119
Z-Score	448	5.855	6.458	2647.000	0.070	25.280
Panel B: Growth Firms Subset						
Variable	**N**	**Mean**	**Std. Dev**	**Sum**	**Minimum**	**Maximum**
Debt/TA	225	0.004	0.007	0.785	0.000	0.053
Proceeds/TA	225	0.670	0.824	150.759	0.004	4.963
MB ratio	225	9.365	13.631	2145.000	0.670	72.310
Ln Size	225	5.251	1.791	1202.000	1.151	11.216
ROA	225	0.096	0.239	21.577	-1.162	0.554
Cash/TA	225	0.006	0.014	1.257	0.000	0.119
Z-Score	225	5.150	5.934	1179.000	0.070	24.380
Panel C: Overvalued Firms Subset						
Variable	**N**	**Mean**	**Std. Dev**	**Sum**	**Minimum**	**Maximum**
Debt/TA	223	0.004	0.008	0.802	0.000	0.061
Proceeds/TA	223	0.866	0.978	193.039	0.005	10.268
MB Ratio	223	11.948	16.226	2664.000	0.770	76.450
Ln Size	223	4.836	1.323	1079.000	1.577	9.269
ROA	223	0.093	0.217	20.693	-0.875	0.432
Cash/TA	223	0.008	0.013	1.828	0.000	0.094
Z-Score	223	6.579	6.893	1467.000	0.074	25.280

This table shows the univariate statistics of the full sample and subsets.

To evaluate the post-issue performance, we first look at the data in Figures 1 and 2. Figure 1 graphs the number of delistings by year. Our sample consists of 448 firms with 223 firms in the Overvalued subset and 225 in the Growth subset. From Figure 1, we note that the over the eight years, post-issue, more Overvalued firms are delisted than Growth firms. The two subsets display very little difference over the first three years, but from year 4 onwards more of the Overvalued firms face problems than Growth firms.

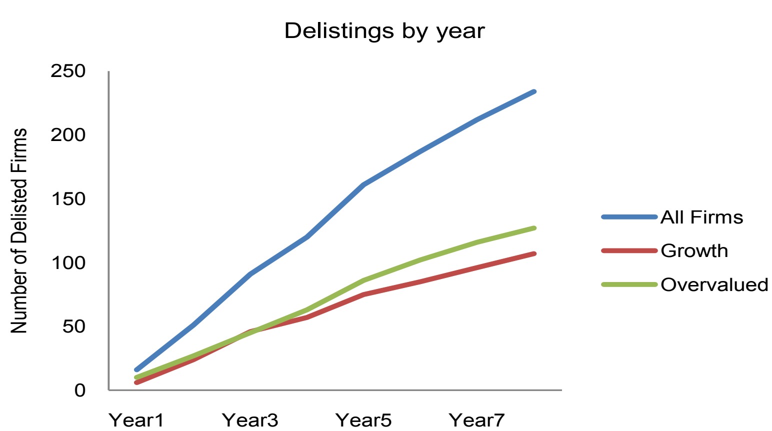
Table 2: Covariance Matrix for the Full Sample and the 2 Subsets

Panel A:	Full Sample = 448 Firms						
	Debt	**Size**	**Proceeds**	**MB**	**ROA**	**Cash**	**Z Score**
Debt	1						
Size	-0.1365	1					
Proceeds	-0.1973	-0.0204	1				
MB	-0.0487	0.1971	0.5161	1			
ROA	0.037	0.0377	-0.4167	-0.0091	1		
Cash	-0.1465	-0.2751	0.3744	0.032	-0.5493	1	
Z Score	-0.154	0.2478	0.5977	0.8005	-0.1245	0.0435	1
Panel B:	**Overvalued Firms Subset = 223 Firms**						
	Debt	**Size**	**Proceeds**	**MB**	**ROA**	**Cash**	**Z Score**
Debt	1						
Size	-0.2057	1					
Proceeds	-0.1207	0.1243	1				
MB	-0.0628	0.2694	0.6973	1			
ROA	0	-0.0586	-0.386	-0.0735	1		
Cash	-0.1093	-0.2667	0.3257	0.0468	-0.5467	1	
Z Score	-0.1492	0.3432	0.6878	0.9298	-0.0965	0.0317	1
Panel C:	**Growth Firms Subset = 225 Firms**						
	Debt	**Size**	**Proceeds**	**MB**	**ROA**	**Cash**	**Z Score**
Debt	1						
Size	-0.1166	1					
Proceeds	-0.2653	-0.1236	1				
MB	-0.0436	0.1373	0.1981	1			
ROA	0.0695	0.1026	-0.4615	0.0888	1		
Cash	-0.1627	-0.2709	0.4201	0.0216	-0.5561	1	
Z Score	-0.2383	0.2795	0.5066	0.2532	-0.3034	0.0808	1

This table shows the covariance matrix for the full sample and the 2 subsets

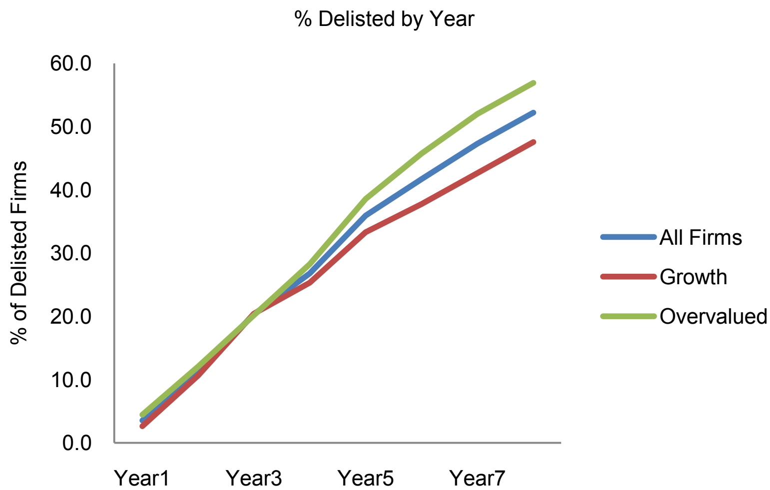
The graph on Figure 2 takes into account the percentage of firms that end up getting delisted and we again see the clean break from the fourth year onwards. It seems that from these graphs that it take about 3 years for the mistake (of raising additional capital without having a use for it) to catch up with the overvalued firms.

Figure 1: Number of Firm Delisting by Year



This table shows the number of firm delisted by year.

Figure 2: The Percentage of Firms Delisted by Year



This figure shows the percentage of firms delisted by year.

Table 3 presents the comparisons of delistings by number and percentage and these are graphed in Figures 1 and 2. We formally test our hypothesis by using a logistic regression as detailed previously. The results of the logistic regression are presented in Table 4. We check to see if there is a significantly higher likelihood of the Overvalued firms failing (post-SEO) than the Growth firms. The probability modeled is that delisting = 1. From the results in Table 4, we see that sign on the coefficient for Growth firms is negative and significant (at the 5% level) indicating that Growth firms are significantly less likely to get delisted post-SEO than the Overvalued firms which are significantly more likely to get delisted; thereby confirming our hypothesis. Another interesting observation is the fact that the variable for the size of the new equity offering (Proceeds/TA) is also significantly positive. This indicates that managers of firms which take on more capital than they possibly need also put their firms' future at risk.

Table 3: Comparisons of Delistings by Number and Percentage

Panel A: Comparison of Delistings by Year - Number of Firms Delisted

Delisted in	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8
All Firms	16	51	91	120	161	187	212	234
Growth	6	24	46	57	75	85	96	107
Overvalued	10	27	45	63	86	102	116	127

Panel B: Comparison of Delistings by Year - % of Firms Delisted

Delisted in	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8
All Firms	3.6	11.4	20.3	26.8	35.9	41.7	47.3	52.2
Growth	2.7	10.7	20.4	25.3	33.3	37.8	42.7	47.6
Overvalued	4.5	12.1	20.2	28.3	38.6	45.7	52.0	57.0

This table shows the comparisons of delistings by number and percentage of firms.

Table 4: Logistic Regression Results

Parameter	Estimate		Std. Error	Wald	P-Value
Growth Firms	-0.409	**	0.198	4.261	0.039
Debt/TA	19.868		16.507	1.449	0.229
Proceeds/TA	0.319	*	0.174	3.341	0.068
MB	0.008		0.020	0.164	0.686
LnSize	-0.002		0.076	0.001	0.980
ROA	-1.256	**	0.579	4.701	0.030
Cash/TA	-10.810		9.601	1.268	0.260
Z-Score	-0.019		0.034	0.325	0.568
Intercept	0.250		0.463	0.290	0.590
N	445				
Pseudo R-Square	0.0609				
Likelihood Ratio	20.7892	***			

*This table presents the results of the logistic regression. The binary dependent variable is the delisting event. It takes on the value of 1 if delisted and 0 otherwise. The probability modeled is Delisting = 1. The exogenous variables are listed below. The "Growth Firms" variable is a binary variable which takes on value of 1 if the firm is a growth firm and 0 if it is a no growth / overvalued firm.*** Indicates statistical significance at the 0.01 level, ** Indicates statistical significance at the 0.05 level.*

Table 5: Comparison of Firm Delistings by Size Quartiles

Quartile 1	Firms	Year 1 Num (%)	Year 2 Num (%)	Year 3 Num (%)	Year 4 Num (%)	Year 5 Num (%)	Year 6 Num (%)	Year 7 Num (%)	Year 8 Num (%)
Overall	112	3 (2.7%)	10 (8.9%)	25 (22.3%)	31 (27.7%)	40 (35.7%)	50 (44.6%)	53 (47.3%)	55 (49.1%)
Growth	72	2 (2.8%)	7 (9.7%)	16 (22.2%)	19 (26.4%)	24 (33.3%)	30 (41.7%)	31 (43.1%)	33 (45.8%)
Overvalued	40	1 (2.5%)	3 (7.5%)	9 (22.5%)	12 (30.0%)	16 (40.0%)	20 (50.0%)	22 (55.0%)	22 (55.0%)
Quartile 2									
Overall	112	4 (3.6%)	13 (11.6%)	23 (20.5%)	31 (27.7%)	40 (35.7%)	47 (42.0%)	52 (46.4%)	59 (52.7%)
Growth	54	1 (1.9%)	6 (11.1%)	12 (22.2%)	16 (29.6%)	20 (37.0%)	21 (38.9%)	23 (42.6%)	27 (50.0%)
Overvalued	58	3 (5.2%)	7 (12.1%)	11 (19.0%)	15 (25.9%)	20 (34.5%)	26 (44.8%)	29 (50.0%)	32 (55.2%)
Quartile 3									
Overall	112	4 (3.6%)	16 (14.3%)	24 (21.4%)	31 (27.7%)	42 (37.5%)	48 (42.9%)	56 (50.0%)	61 (54.5%)
Growth	39	1 (2.6%)	6 (15.4%)	10 (25.6%)	12 (30.8%)	13 (33.3%)	14 (35.9%)	16 (41.0%)	17 (43.6%)
Overvalued	73	3 (4.1%)	10 (13.7%)	14 (19.2%)	19 (26.0%)	29 (39.7%)	34 (46.6%)	40 (54.8%)	44 (60.3%)
Quartile 4									
Overall	112	5 (4.5%)	12 (10.7%)	19 (17.0%)	27 (24.1%)	39 (34.8%)	42 (37.5%)	51 (45.5%)	59 (52.7%)
Growth	60	2 (3.3%)	5 (8.3%)	8 (13.3%)	10 (16.7%)	18 (30.0%)	20 (33.3%)	26 (43.3%)	30 (50.0%)
Overvalued	52	3 (5.8%)	7 (13.5%)	11 (21.2%)	17 (32.7%)	21 (40.4%)	22 (42.3%)	25 (48.1%)	29 (55.8%)

Table 5 is a robustness check to ensure that the results observed using the logistic regression is not a size effect. Small firms are considered more susceptible to financial problems than larger firms and as such larger firms in general are more stable. In the table below, we first separate the overall sample into four size quartiles and then study these as the overall sample and the two (growth / overvalued subsets). We focus on the percentage of firms delisted for each category/subcategory. What we observe is that for equity market timing firms, the size of the firm is not really much of a factor. No discernable pattern can be drawn from the (overall) delisting percentages for the four size quartiles. In terms of the growth and overvalued firm subsets, our results are robust – no matter what the size quartile, the overvalued subset has a higher percentage of delisted firms than the growth subset.

CONCLUSION

In prior research on equity market timing, managers have received credit for the observed underperformance post-SEO. More recently, however, researchers have created subsets of the overall sample of equity market timing firms and found that not all firms underperform. The goal of our paper is to extend this line of research to explore the impact of equity market timing on the long term survival of these firms. If equity market timing is not always good, we should be able to observe that in the post-issue survival of the firm. We use the methodology of D'Souza and Rao to populate our sample of equity market timers and our growth / overvalued subsets. We study the delisting pattern of the sample and subsets over eight years and use a logistic regression methodology to determine if one subset is more likely to get delisted over this period than the other.

Our results show that the overvalued firms are more likely to get delisted post-SEO than the growth firms, the ones with viable investment opportunities. Firms that take on a higher proportion of capital (in relation to total assets) are also more likely to get delisted. This further confirms that not all equity market timing is good for the current shareholders. This research adds on to the new body of literature which shows that post-issue underperformance is not a phenomenon that affects all firms that issue stock through a market-timed SEO, just the ones that do not have a viable use for the funds. Our results further those results and show that not only do the Overvalued firms underperform post-SEO, but that the managers of the Overvalued firms also jeopardize the future of their firms by making them more susceptible to a takeover and/or financial problems. The findings in this paper can be used to further the literature on mergers and acquisitions in general and on takeover targets in particular.

REFERENCES

Altman, E., (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, Journal of Finance, 23(4), 589-609.

Asquith, P., and Mullins, D. (1986). Equity issue and offering dilution, Journal of Financial Economics, 15(1-2), 61-89.

Baker, M., and Wurgler, J. (2002). Market timing and capital structure, Journal of Finance, 57(1), 1-32.

Bhagat, S and A. Hess, 1986, Size effects of seasoned stock issues: Empirical evidence, Journal of Business 59, 567-584.

Brav, A., and Gompers, P. (1997). Myth or reality? The long-run underperformance of initial public offerings: Evidence from venture capital and nonventure capital-backed companies, Journal of Finance, 52(4), 1791-1822.

Bayless, M. and Chaplinsky, S. (1996). Is there a window of opportunity for seasoned equity issuance? Journal of Finance 51(1), 253-278.

Carlson, Murray, Adlai Fisher, and Ron Giammarino, 2006, Corporate investment and asset price dynamics: Implications for SEO event studies and long-run performance, Journal of Finance 61 (2), 1009–1034.

D'Souza, F., and Rao, R. (2009, October). Equity Market Timing, Investment Opportunity and Shareholder Benefit. Paper presented at the FMA Conference. http://69.175.2.130/~finman/Reno/Papers/EquityMarketTiming_IOnSB-FMA.pdf

Eckbo, B., and R. Masulis, 1992, Adverse selection and the rights offer paradox, Journal of Financial Economics 293-332.

Eckbo, B., Masulis, R., and Norli, O. (2000). Seasoned public offerings: Resolution of the 'new issues puzzle', Journal of Financial Economics, 56(2), 251-291.

Fama, E. (1998). Market efficiency, long-term returns, and behavioral finance, Journal of Financial Economics, 49(3), 283-306.

Hertzel, M. G., Li, Z., 2010. Behavioral and rational explanations of stock price performance around SEOs: evidence from a decomposition of market-to-book ratios. Journal of Financial and Quantitative Analysis, forthcoming.

Jegadeesh, N. (2000). Long-run performance of seasoned equity offerings: Benchmark errors and biases in expectations, Financial Management Journal, 9(3), 5-30.

Li, E., Livdan, D., and Zhang, L. (2009). Anomalies, Review of Financial Studies, 22(11), 4301-4334.

Loughran, T., and Ritter, J. (1995). The new issues puzzle, Journal of Finance, 50(1), 23-51.

Mikkelson, W., and M. Partch, 1986, Valuation effects of security offerings and the issuance process, Journal of Financial Economics 15, 31-60.

Palepu, Krishna G. (1985). Predicting Takeover Targets: A Methodological and Empirical Analysis. Journal of Accounting and Economics, 8, pp. 3-35.

Rhodes-Kropf, M., D.T. Robinson, and S. Viswanathan, 2005, Valuation waves and merger activity: The empirical evidence, Journal of Financial Economics 77, 561-603.

Ritter, J. (1991). The long-run performance of initial public offerings, Journal of Finance, 46(1), 3-27.

Spiess, K., and Affleck-Graves, J. (1995). Underperformance in long-run stock returns following seasoned equity offerings, Journal of Financial Economics, 38(3), 243-267.

BIOGRAPHY

Dr. Frank D'Souza is Assistant Professor of Finance at Loyola University Maryland. He can be contacted at: Department of Finance, Sellinger School of Business and Management, Loyola University Maryland, 4501North Charles Street, Baltimore, MD 21210, US. Email: fpdsouza@loyola.edu

Dr. Harold Fletcher is Professor of Finance at Loyola University Maryland. He can be contacted at: Department of Finance, Sellinger School of Business and Management, Loyola University Maryland, 4501North Charles Street, Baltimore, MD 21210, US. Email:tau@loyola.edu

Dr. Octavian Ionici is Executive in Residence at American University. He can be contacted at: Department of Finance / Real Estate, Kogod School of Business, American University, 4400 Massachusetts Avenue, NW, Washington, DC 20016, US. Email:oionici@american.edu

THE VALUATION OF RESET OPTIONS WHEN UNDERLYING ASSETS ARE AUTOCORRELATED

Yu-Hong Liu, National Cheng Kung University
I-Ming Jiang, Yuan Ze University
Shih-Cheng Lee, Yuan Ze University
Yu-Ting Chen, National Cheng Kung University

ABSTRACT

This paper introduces the autocorrelation effect of assets' returns into the valuation model of reset options. The MA(q) process, which is an extension of MA(1) process noted by Liao and Chen (2006), is applied to the valuation of reset options in this paper. Due to the impact of autocorrelation on the volatility of assets' returns, the probability of reset and the value of reset option are affected. Positive autocorrelation increases the value of a reset option by increasing the probability of reset. On the contrary, negative autocorrelation decreases the probability of a reset and reset premium. Moreover, the reset timing is affected by the autocorrelation characteristics. In the case of positive autocorrelation, the investors tend to reset earlier to prevent a possible loss. Positive autocorrelation is also significant for the hedging of reset options. This paper demonstrates that positive autocorrelation characteristics lessens the delta jump and gamma jump problem.

JEL: G12, G13

KEYWORDS: Reset Option, Autocorrelation; MA(*q*) process, Delta Jump; Gamma Jump

INTRODUCTION

To give investors more protection, increasing numbers of derivatives with embedded reset clauses have become available. These reset clauses can be exercised at any time during the life of the contract or only limited to some predetermined dates. The reset clauses commonly contain the date of maturity or the strike price. Options with reset rights on the maturity date commonly exist in crude oil offshore exploration and production contracts. This reset clause allows the holder to reset the maturity of the investment option and to look for better investment conditions. Crude oil price is the critical factor affecting the value of this kind of option. If crude oil price movements can be forecast by certain models, the value of the reset clause might be affected.

The model derived from Liao and Chen (2006) is an important contribution pricing of a vanilla option whose underlying asset has autocorrelation characteristics. However no existing studies consider the impact of this autocorrelation characteristic on the value of a reset option. Due to the path dependence of reset options, it is reasonable to expect that the impact of autocorrelation on the prices of reset options might be augmented. Many studies have demonstrated different valuation models for reset options with different reset conditions. The main objective of this paper is to apply a MA(*q*) process, which is an extension of MA(1) process mentioned by Liao and Chen (2006), to capture the effect of autocorrelation. We also discuss the impact of autocorrelation on a valuation model of a reset option.

The remainder of this paper is organized as follows. In Section 2, we introduce the autocorrelation effect and formulate modified valuation models for four kinds of options with reset rights embedded. The autocorrelation impact and the types of reset options are based on the previous studies of Gray and Whaley (1997, 1999), Cheng and Zhang (2000), Liao and Wang (2002), Liao and Chen (2006). In Section 3, we demonstrate the numerical analysis to compare the difference properties between the traditional reset option model and the proposed model. Finally, Section 4 provides some concluding comments.

LITERATURE REVIEW

Besides the phenomenon of mean reversion and extreme jump, many scholars argue that crude oil prices are highly autocorrelated [Deaton and Laroque (1992), Deaton and Laroque (1996), and Chambers and Bailey (1996)]. Just like for other commodities, such high autocorrelation is basically due to time dependencies in supply and demand shocks and performances of speculators. On the other hand, consider the options with reset rights on the strike price, which is the major consideration of this paper. Commonly, the underlying assets of this kind of reset option are financial assets. There is a growing consensus that many financial asset returns can be efficiently predicted. Many scholars argue that the lagged price autocorrelation of financial asset is one source of this predictability [Lo and MacKinlay (1988); Poterba and Summers (1988); Conrad and Kaul (1988); Mech (1993); Patro and Wu (2004); Bianco and Reno (2006)]. Especially in emerging markets, many studies attribute the pervasive phenomenon of autocorrelation to irrational trading strategies, such as the feedback trading strategy [McKenzie and Faff (2003); Faff, Hiller and McKenzie (2005)]. Whether the reset clauses are on the date of maturity or the strike price, they are designed to protect the holders from the uncertainty of underlying assets. However, once the predictability of the underlying assets is significant, it can be expected that decreasing uncertainty of underlying assets would affect the value of the reset right.

Existing reset option valuation models fail to consider autocorrelation characteristic of underlying assets. Like the Black-Scholes model, reset option valuation models are based on the assumption that the stock prices follows a geometric Brownian motion process, implying that stock returns are independent. Lo and Wang (1995) argue that predictability of asset returns makes the price of options based on the predictable underlying assets to be different from fair value under the assumption of independent stock returns. They introduce the predictability concept into the Black-Scholes model and argue that the effect on option prices critically depends on how predictability is specified in the drift. They find that if drift only depends on exogenous time-varying economic factors, an increase in predictability reduces the asset's prediction error variance and decreases option prices. If drift also depends on lagged prices, an increase in predictability can increase or decrease option values. Their conclusions are based on the assumptions that the conditional mean of asset returns doesn't depend on past prices or returns, conditional expectation of the prediction error is zero, and the unconditional variance of asset return is fixed.

Because of the convertible relationship between AR(∞) process and MA(1) process, Liao and Chen (2006) further use a first-order moving average process [MA(1) process] to extract the autocorrelation from the asset returns' first moment which introduces the predictability characteristics into the diffusion term of dynamic process of stock returns and improves the limitation of only capturing predictability in the drift term. Liao and Chen (2006) derive the valuation model of European options when underlying asset returns are autocorrelated, which is also a more flexible model than the Black-Scholes model. The major difference between Liao's model and the Black-Scholes model is volatility input. The total volatility input in Liao's model is the conditional standard deviation of continuous-compounded returns over the option's remaining life. The total volatility input in Black-Scholes model is indeed the diffusion coefficient of a geometric Brownian motion times the square root of an option's time to maturity. Liao and Chen find that the impact of autocorrelation introduced by the MA(1)-type process is significant to option values even when the autocorrelation between asset returns is weak.

The main objective of this paper is to apply a MA(q) process, which is an extension of MA(1) process mentioned by Liao and Chen (2006), to capture the effects of autocorrelation. We also discuss the impact of autocorrelation on a valuation model of a reset option. According to Liao and Chen (2006), if the asset's return is positively (negatively) correlated, the volatility input is greater (smaller) than that in traditional geometric Brownian motion. If the volatility is affected by the autocorrelation, the probability of triggering reset conditions which impact the value of reset options would also be affected.

After adjusting the valuation model of the reset option to account for autocorrelation effects, we find that when the underlying asset return is positively (negatively) autocorrelated, the value of the reset option derived from our model is higher (lower) than the value derived from other general reset valuation models. Furthermore, according to the study of Dai, Kwok, and Wu (2003), they state that the optimal reset policy of a reset option, which allows holders to discretionarily choose any timing to reset the strike price, depends on the time dependent behaviors of the expected discounted value of the at-the-money option received upon reset timing. In this paper, we further find that the autocorrelation characteristic of underlying asset returns also affects the optimal reset policy. When the autocorrelation is positive (negative), the holders of reset options tend to reset earlier (later). This paper also shows that if we consider the positive autocorrelation effect on the reset option, we can lessen the problem of hedging for the reset option, such as delta jump.

MODEL DEVELOPMENT

Dynamic Process of Autocorrelated Asset Return

Without loss of generality, this paper uses a stock as the underlying asset and assumes there is no dividend during the holding period. Assume that the current time is t_0, the maturity time is T, and the time to maturity is τ, where $\tau = T - t_0$ and $\tau > 0$. Instead of assuming that stock returns follow the geometric Brownian motion process, we not only follow the continuous MA(1)-type (first-order moving average process) dynamic process introduced by Liao and Chen (2006), but further extend the MA(1)-type dynamic process to the MA(q)-type dynamic process. We assume the dynamics process of the stock returns for all $t_0 \le t \le T$ as follows:

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t + \sigma \sum_{\varphi=1}^{q} \beta_\varphi dW_{t-\varphi h} \tag{1}$$

where S_t is the stock price in the time t, dS_t / S_t is the instantaneous stock return, μ is the expected instantaneous rate of return, $\sigma > 0$ is the instantaneous standard deviation of return, $dt > 0$ is a small time interval, and $h > 0$ is a fixed, but arbitrary, small constant. q is the order of MA(q)-type dynamic process. W_t is a one-dimensional standard Brownian motion and $dW_{t-i}, i = 0,\ h,\ 2h, \ldots,\ qh$ are the increments of the standard Brownian motion at time $t-i$. For $\varphi = 1,\ 2,\ \ldots,\ q$, the coefficient β_φ represents the impact of the past shocks, which is assumed to satisfy $|\beta_\varphi| \le 1$.

Liao and Chen (2006) proved there exists a probability measure Q for the MA(1) process defined in Eq. (1). Following their study, the MA(q) process under the martingale probability measure Q can be represented as follows.

$$\frac{dS_t^Q}{S_t^Q} = rdt + \sigma dW_t^Q + \sigma \sum_{\varphi=1}^{q} I_A \cdot \beta_\varphi dW_{t-\varphi h}^Q \tag{2}$$

where $I_A = 1_{\{t_0 + qh \le t \le T\}}$. Note that when $t_0 \le T \le t_0 + qh$, the dynamic process reduces to a geometric Brownian motion. Accordingly, the Black-Scholes formula is a special case of the MA(q)-type option model with maturity shorter than h. On the other hand, if $T \ge t_0 + qh$, the dynamic process of the stock return is not identical to a geometric Brownian motion. However, we can view the dynamic process of the stock return to be driven by $(q+1)$ one-dimensional Brownian motions $W_{1,t-t_0}^Q$, $W_{2,t-t_0}^Q, \ldots,$ $W_{q+1,t-t_0}^Q$, where we make the assumption that $\{W^Q_{1,t-t_0},\ W^Q_{2,t-t_0},\ldots,\ W^Q_{q+1,t-t_0}\} \equiv \{W^Q_{t-t_0},\ I_A \cdot W^Q_{(t-h)-t_0},\ I_A \cdot W^Q_{(t-2h)-t_0}$ $,\ldots,\ I_A \cdot W^Q_{(t-qh)-t_0}\}$, given the following properties:

(i) For $t \in [t_0 + qh,\ T]$, $W^Q_{1,(t-h)-t_0} \equiv W^Q_{2,t-t_0}$, $W^Q_{2,(t-h)-t_0} \equiv W^Q_{3,t-t_0},\ldots,\ W^Q_{q,(t-h)-t_0} \equiv W^Q_{q+1,t-t_0}$, and $dW^Q_{1,t-h} = W^Q_{(t-h)-t_0+dt} - W^Q_{(t-h)-t_0} = dW^Q_{2,t}$, $dW^Q_{2,t-h} = dW^Q_{3,t},\ldots,\ dW^Q_{q,t-h} = dW^Q_{q+1,t}$.

(ii) $dW^Q_{1,t}$, $dW^Q_{2,t},\ldots,\ dW^Q_{q+1,t}$ and are independent, which also means the covariance $E(dW^Q_{1,t} \cdot dW^Q_{2,t} \cdot \ldots \cdot dW^Q_{q+1,t}) = 0$.

Based on the definition of $W^Q_{1,t-t_0}$, $W^Q_{2,t-t_0},\ldots,\ W^Q_{q+1,t-t_0}$, the dynamic process of the stock return in Eq. (2) can be further represented as:

$$\frac{dS^Q_t}{S^Q_t} = rdt + \sigma d\left(W^Q_1 + \sum_{\varphi=1}^{q} \beta_\varphi W^Q_{1+\varphi}\right)_t \tag{3}$$

Following the MA(q)-type dynamic process in Eq. (3), the Itô integral equation of stock price is:

$$S^Q_t = S^Q_{t_0} \exp\{r(t-t_0) - \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta^2_\varphi)(t-\varphi h - t_0) + (t-t_0)] + \sigma \sum_{\varphi=1}^{q}(1+\beta_\varphi)W^Q_{(t-\varphi h)-t_0} + \sigma W^Q_{t-(t-qh)}\} \tag{4}$$

where $S^Q_{t_0}$ is the stock price in the time t_0 under the martingale probability measure Q, the quadratic variation of $\left(W^Q_1 + \sum_{\varphi=1}^{q} \beta_\varphi W^Q_{1+\varphi}\right)_t$ equals $\int_{t_0}^{t}(1 + \sum_{\varphi=1}^{q} I_{B(u)} \cdot \beta_\varphi)^2 du$, and $I_{B(u)} = 1_{\{t_0 \le u \le t-qh\}}$ is an indication variable. Furthermore, according to Girsanov's theorem, we can transform the martingale probability measure Q into probability measure R. The dynamic process of a one-dimension R-Brownian motion W^R_z can be defined as:

$$dW^R_z = \begin{cases} dW^Q_z - \sigma(1 + \sum_{\varphi=1}^{q} \beta_\varphi)dz, & \forall z \in [t_0,\ T-qh] \\ dW^Q_z - \sigma dz, & \forall z \in [T-qh,\ T] \end{cases}$$

where $z = t,\ t-\varphi h$, for $\varphi = 1,\ 2,\ \ldots,\ q$. And, the solution of the stock price at time t under probability measure R can be represented by using Itô lemma as:

$$S^R_t = S^R_{t_0} \exp\{r(t-t_0) + \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta^2_\varphi)(t-\varphi h - t_0) + (t-t_0)] + \sigma \sum_{\varphi=1}^{q}(1+\beta_\varphi)W^R_{(t-\varphi h)-t_0} + \sigma W^R_{t-(t-qh)}\}. \tag{5}$$

The Valuation of Standard Reset Option with Single Reset Right under the Ma(Q) Process

The reset option we mention in this subsection is a standard European-type reset option with single reset right. This type of reset option gives its holder a right to reset their strike price on only one pre-specified reset date. In the remainder of this subsection we take a standard European-type reset put with single reset right as the example of valuation. The holder of the standard European-type reset put with single reset has the right to reset the strike price to the prevailing stock price when the stock price exceeds the original strike price on the pre-specified reset date. The terminal payoff of the reset put is:

$$\begin{cases} S_t - S_T & \text{if } S_t > K,\ S_T \le S_t \quad \text{(reset on time } t\text{)} \\ K - S_T & \text{if } S_t \le K,\ S_T \le K \quad \text{(not reset on time } t\text{)} \\ 0 & \text{if } (S_t > K,\ S_T \ge S_t)\ or\ (S_t \le K,\ S_T \ge K) \end{cases}$$

where time t is the pre-specified reset date, S_t is the prevailing stock price on time t, K is the original strike price, and S_T is the stock price at the maturity. Therefore, the expected terminal value of the reset put is the sum of the expected conditional terminal payoffs, weighted by their probability of occurring, and the value of the standard European-type reset put under the martingale probability measure Q is represented as follows.

$$\begin{aligned} RP_{t_0} &= e^{-r(T-t_0)} E^Q(S_t - S_T \mid S_t > K, S_T < S_t) \cdot P_r^Q(S_t > K, S_T < S_t) \\ &\quad + e^{-r(T-t_0)} E^Q(K - S_T \mid S_t \le K, S_T < K) \cdot P_r^Q(S_t \le K, S_T < K) \end{aligned} . \tag{6}$$

And we define

$$\begin{aligned} P_1 &= e^{-r(T-t_0)} E^Q(S_t - S_T \mid S_t > K, S_T < S_t) \cdot P_r^Q(S_t > K, S_T < S_t) \\ P_2 &= e^{-r(T-t_0)} E^Q(K - S_T \mid S_t \le K, S_T < K) \cdot P_r^Q(S_t \le K, S_T < K) \end{aligned} \tag{7}$$

where RP_{t_0} is the value of MA(q)-type standard European-type reset put at time t_0. Assume the underlying asset returns follow the MA(q)-type dynamic process described as Eq. (3), then the value of reset part of standard European-type reset put, P_1, can be represented as:

$$P_1 = S_{t_0} \cdot e^{-r(T-t)} \cdot N(d'_{1+}) \cdot N(-b'_{1-}) - S_{t_0} \cdot N(d'_{1+}) \cdot N\left(-b'_{1+}\right). \tag{8}$$

And, in the similar way, the value of non-reset part of standard European-type reset put, P_2, can be represented as:

$$P_2 = e^{-r(T-t_0)} \cdot K \cdot N_2\left(-d'_{1-}, -d'_{2+}, \rho\right) - S_{t_0} \cdot N_2\left(-d'_{1+}, -d'_{2-}, \rho\right). \tag{9}$$

Therefore, the value of MA(q)-type standard European-type reset put can be represented as:

$$\begin{aligned} RP_{t_0} &= P_1 + P_2 \\ &= S_{t_0} \cdot e^{-r(T-t)} \cdot N(d'_{1+}) \cdot N(-b'_{1-}) - S_{t_0} \cdot N(d'_{1+}) \cdot N\left(-b'_{1+}\right) \\ &\quad + e^{-r(T-t_0)} \cdot K \cdot N_2\left(-d'_{1-}, -d'_{2+}, \rho\right) - S_{t_0} \cdot N_2\left(-d'_{1+}, -d'_{2-}, \rho\right) \end{aligned} \tag{10}$$

where t is the reset date of the reset put, r is the risk-less interest rate, $N(a)$ is a cumulative univariate normal distribution function with upper integral limit a. $N_2(c, d, \rho)$ is a cumulative bivariate normal distribution function of c and d with covariance ρ and, the other parameters as follows.

The valuation model of standard European-type reset put mentioned in the study of Gray and Whaley (1997, 1999) can be viewed as the special case of our valuation model when $\beta_\varphi = 0$ and $h = 0$, which means the underlying asset return is independent.

<u>The Valuation of a Standard Reset Option with Multiple Reset Rights Under the Ma(Q) Process</u>

In this subsection, we extend the valuation model of standard European-type reset options to a more generalized formula, which has multiple reset times, only one of which the holders can choose. According to the valuation model for this type of reset mentioned by Cheng and Zhang (2000), we assume a standard European-type reset put with n reset times $0 < t_1 < t_2 < \ldots < t_n < T$, and we define $t_0 = 0$, $T = t_{n+1}$. The holder of this reset put has the right to reset the strike price to the prevailing stock price when the stock price exceeds the original strike price on the pre-specified reset dates. The terminal payoff of the reset put is:

$$\begin{cases} S_{t_i} - S_T & \text{if } S_{t_i} = Max[K, S_{t_1}, S_{t_2}, \ldots, S_{t_n}],\ S_T \le S_{t_i} \qquad \text{(reset on time } t_i\text{)} \\ K - S_T & \text{if } K = Max[K, S_{t_1}, S_{t_2}, \ldots, S_{t_n}],\ S_T \le K \qquad \text{(not reset on time } t_i\text{)} \\ 0 & \text{if } (S_{t_i} = Max[K, S_{t_1}, S_{t_2}, \ldots, S_{t_n}] > K,\ S_T \ge S_{t_i}) \text{ or } (K = Max[K, S_{t_1}, S_{t_2}, \ldots, S_{t_n}],\ S_T \ge K) \end{cases}$$

And, the value of the MA(q)-type standard European-type reset put with n reset times at the time t_0 is represented as follows.

$$NRP_{t_0} = e^{-r(T-t_0)} E\{Max[K, S(t_1), S(t_2), \ldots, S(t_n), S(T)]\}^+ = NP_1 + NP_2 \tag{11}$$

where $NP_1 = e^{-r(T-t_0)} \sum_{i=1}^{n} \{E[S(t_i) - S(T)] \cdot I_{\{S(t_i) = Max[K, S(t_1), S(t_2), \ldots, S(t_n), S(t_{n+1})]\}}\}$ is the value of reset part of reset put if the holder reset on any of the pre-specified reset time t_i, and $NP_2 = e^{-rT} \{E[K - S(T)] \cdot I_{\{K = Max[S(t_1), S(t_2), \ldots, S(t_n), S(t_{n+1})]\}}\}$ is the value of non-reset part of reset put. $S(t_1), \ldots, S(t_n)$ are stock prices at the reset times $t_1,\ t_2,\ \ldots,\ t_n$.

$$d'_{1\pm} = \frac{\ln(\frac{S_{t_0}}{K}) + r(t-t_0) \pm \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t-\varphi h - t_0) + (t-t_0)]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t-\varphi h - t_0) + (t-t_0)}},$$

$$b'_{1\pm} = \frac{r(T-t) \pm \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(T-\varphi h - t) + (T-t)]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(1+\beta_\varphi)^2(T-\varphi h - t) + q(T-t)}},$$

$$d'_{2\pm} = \frac{\ln(\frac{S_{t_0}}{K}) + r(T-t_0) \mp \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(T-\varphi h - t_0) + (T-t_0)]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(T-\varphi h - t_0) + (T-t_0)}},$$

$$\rho = \frac{t - qh - t_0}{\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t-\varphi h - t_0) + (T-t_0)} \cdot \sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(T-\varphi h - t_0) + (T-t_0)}}.$$

Again, assume the underlying asset returns follow the MA(q)-type dynamic process described as Eq. (3), then

$$\begin{aligned} NRP_{t_0} = \sum_{i=1}^{n}\{ & S_{t_0}e^{r(t_i - t_0)} \cdot N(C_0, C_1, C_2, \ldots, C_{i-1}; \Sigma_i) \cdot [e^{-r(T-(t_i - t_0))}N(\hat{\hat{\hat{C}}}_{i+1}, C_{i+2}, \ldots, C_{n+1}; \hat{\Sigma}_i) \\ & - e^{-rt_i} \cdot \overline{N}(C_{i+1}, C_{i+1}, \ldots, C_{n-1}; \overline{\Sigma}_i)]\} + Ke^{-rT} \cdot N(D_{1+}, D_{2+}, \ldots, D_{(n+1)+}; \tilde{\Sigma}_i) \\ & - S_{t_0} \cdot e^{-rt_0} \cdot N(D_{1-}, D_{2-}, \ldots, D_{(n+1)-}; \dot{\Sigma}_i) \end{aligned} \tag{12}$$

where $N(C_0, \ldots, C_{i-1}, \Sigma_i)$, $N(\hat{\hat{C}}_{i+1}, \ldots, C_{n+1}, \hat{\Sigma}_i)$, $\overline{N}(C_{i+1}, \ldots, C_{n+1}, \overline{\Sigma}_i)$, $N(D_{1+}, \ldots, D_{(n+1)+}, \tilde{\Sigma}_i)$, and $N(D_{1-}, \ldots, D_{(n+1)-}; \dot{\Sigma}_i)$ are the cumulative multivariate normal distribution functions with covariance Σ_i, $\overline{\Sigma}_i$, $\hat{\Sigma}_i$, $\tilde{\Sigma}_i$, $\dot{\Sigma}_i$ respectively. And, the other parameters as follows.

$$C_0 = \frac{\ln(\frac{S_{t_0}}{K}) + r(t_i - t_0) + \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t_i-\varphi h - t_0) + (t_i-t_0)]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t_i-\varphi h - t_0) + (t_i-t_0)}},$$

$$C_k = \frac{\{r + \frac{1}{2}\sigma^2 \cdot [1 + \sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)]\} \cdot (t_i - t_k)}{\sigma\sqrt{[1 + \sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)] \cdot (t_i - t_k)}}, \quad \forall k = 1, 2, \ldots, i-1,$$

$$\hat{C}_k = \frac{\{r - \frac{1}{2}\sigma^2 \cdot [1 + \sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)]\} \cdot (t_i - t_k)}{\sigma\sqrt{[1 + \sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)] \cdot (t_k - t_i)}}, \qquad \forall k = i+1, i+2, \ldots, (n+1),$$

$$D_{i\pm} = \frac{-\ln(\frac{S_{t_0}}{K}) - r(t_i - t_0) \pm \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t_i - \varphi h - t_0) + (t - t_0)]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(t_i - \varphi h - t_0) + (t - t_0)}}, \qquad \forall i = 1, 2, \ldots, (n+1).$$

Also, the valuation model in this subsection provides more flexibility than the model derived by Cheng and Zhang (2000). The model of Cheng and Zhang (2000) is the special case of the model developed here when $\beta_\varphi = 0$ and $h = 0$, which means the underlying asset return is independent.

<u>The Valuation of Reset Option with *M* Reset Level and Continuous Time Under the Ma(Q) Process</u>

In practice, a European-type reset option with *m* reset level is a more common instrument than a European-type standard reset option we mentioned before. In this subsection we apply the MA(*q*) process to the valuation of a European-type reset option with *m* reset levels which has been derived by Liao and Wang (2002). For example, a European-type reset call with *m* reset levels $D_1, D_2, \ldots, D_m$ has a set of reset strike prices $K_1, K_2, \ldots K_m$ and the original strike price $K = K_0$. The trigger condition of reset is that, if the minimum stock price during the period of $[0,\ T_0]$ or what we call the monitoring window falls in the pre-specified reset intervals, the strike price can be reset to corresponding strike price. The terminal payoff of this type of reset call can be represented as:

$$\begin{cases} S_T - K^*, \text{ where } K^* = K_i & \text{if } D_i \geq \underset{t \leq s \leq T_0}{Min}\ S(s) > D_{i+1},\ S_T \geq K_i,\ for\ i = 0, \ldots, m \\ 0 & \text{if } D_i \geq \underset{t \leq s \leq T_0}{Min}\ S(s) > D_{i+1},\ S_T \leq K_i,\ for\ i = 0, \ldots, m \end{cases}$$

Based on the concept of partial barrier options and the martingale method, Liao and Wang (2002) mentions that the European-type reset call with *m* reset levels can be viewed as the combination strategy of vanilla call and down-and-out call, which can be inferred as:

$$\begin{aligned} C_t^{\mathrm{Re}set} &= e^{-r(T-t)} Max\left[S(T) - K^*\right]^+ \\ &= e^{-r(T-t)} \sum_{i=0}^{m} [S(T) - K_i]^+ \{I[\underset{t \leq s \leq T_0}{Min}\ S(s) \geq D_{i+1}] - I[\underset{t \leq s \leq T_0}{Min}\ S(s) \geq D_i]\} \\ &= S(t)N[d_+(K_m, \tau)] - K_m e^{-r\tau} N[d_-(K_m, \tau)] + \sum_{i=1}^{m}(DOC_t^{i-1,i} - DOC_t^{i,i}) \end{aligned} \tag{13}$$

where $C_t^{\mathrm{Re}set}$ is the value of MA(*q*)-type reset call with *m* reset levels at the time t, $S(t)$ is the stock price at the time t. $DOC_t^{j,i}$ refers to the down-and-out call with strike price K_j and barrier level D_i, and $\tau = (T-t)$ is time to maturity. $N(a)$ is a cumulative univariate normal distribution function with upper integral limit *a*. Therefore, it is straightforward to see that the European-type reset call with *m* reset levels and continuous reset date with reset period $\lambda = (T_0 - t)$ less than time to maturity τ can be replicated with the following trading strategies: (1) Purchase one unit of European call option with strike price K_m; (2) Purchase one unit of European down-and-out call option with strike price , K_{i-1}, barrier D_i, $i = 0,...,m$, for each *i*; (3) Short sell one unit of European down-and-out call option with strike price K_i, barrier D_i, $i = 0,...,m$, for each *i*. The valuation model of a European call option with strike price K_m under MA(1) process has been derived by Liao and Chen (2006). If we extend to the MA(*q*) process, the call price can be represented as:

$$C_t = S(t)N[d_+(K_m,\tau)] - K_m e^{-r\tau} N[d_-(K_m,\tau)]$$

where

$$d_\pm(K_m,\tau) = \frac{\ln(\frac{S_{t_0}}{K_m}) + r\tau \pm \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(\tau - \varphi h) + \tau]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(\tau - \varphi h) + \tau}}.$$

Also, based on the MA(*q*) process and the martingale method, the valuation model of a MA(*q*)-type European down-and-out call option with strike price K_j and barrier D_i, where $j = i-1 \; or \; i$ and $i = 0,...,m$, can be represented as follows.

$$\begin{aligned} DOC_t^{j,i} &= S(t)N_2[d_+(K_j,\tau), d_+(D_i,\lambda), \rho'] - K_j e^{-r\tau} N_2[d_-(K_j,\tau), d_-(D_i,\lambda), \rho'] \\ &-\{S(t)(\frac{D_i}{S(t)})^{1+\frac{2r}{\sigma^2}} N_2[g_+(D_i,K_j), h_+(D_i), \rho'] - K_j e^{-r\tau}(\frac{D_i}{S(t)})^{-1+\frac{2r}{\sigma^2}} N_2[g_-(D_i,K_j), h_-(D_i), \rho']\} \end{aligned} \quad (14)$$

where $N_2(c,d,\rho')$ is a cumulative bivariate normal distribution function of *c* and *d* with covariance ρ'. And, the other parameters as follows.

$$d_\pm(D,\lambda) = \frac{\ln(\frac{S(t)}{D}) + r\lambda \pm \frac{1}{2}\sigma^2\left[\sum_{\varphi=1}^{q}\left(2\beta_\varphi + \beta_\varphi^2\right)\left(\lambda - \varphi h\right) + \lambda\right]}{\sigma\sqrt{\sum_{\varphi=1}^{q}\left(2\beta_\varphi + \beta_\varphi^2\right)\left(\lambda - \varphi h\right) + \lambda}},$$

$$g_\pm(D,K) = \frac{\ln(\frac{D^2}{K \cdot S(t)}) + r\tau \pm \frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(\tau - \varphi h) + \tau]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi + \beta_\varphi^2)(\tau - \varphi h) + \tau}},$$

$$h_{\pm}(D)=\frac{\ln(\frac{S(t)}{D})+r\lambda\pm\frac{1}{2}\sigma^2[\sum_{\varphi=1}^{q}(2\beta_\varphi+\beta_\varphi^2)(\lambda-\varphi h)+\lambda]}{\sigma\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi+\beta_\varphi^2)(\lambda-\varphi h)+\lambda}},$$

$$\rho'=\frac{\lambda-qh}{\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi+\beta_\varphi^2)(\tau-\varphi h)+\tau}\cdot\sqrt{\sum_{\varphi=1}^{q}(2\beta_\varphi+\beta_\varphi^2)(\lambda-\varphi h)+\lambda}}.$$

Straightforwardly, when $\beta_\varphi=0$ and $h=0$, which means the underlying asset return is independent, the valuation model in this subsection can be reduced to the valuation model of a European-type reset call with *m* reset levels and continuous reset date derived by Liao and Chen (2006).

NUMERICAL ANALYSES OF MA(1)-TYPE RESET OPTIONS

Effects on the Value of Reset Options

To capture the effect of autocorrelated underlying asset returns on the value of reset options, we make some numerical analysis to compare the difference between a MA(*q*)-type reset option and a non-autocorrelated reset option. For the simplification, we consider the MA(*q*)-type reset option with order $q=1$. First, assume there are four MA(1)-type standard reset puts, and each reset put has a single reset date on $t=0.5$ year from the initiation of contract. Assume these four MA(1)-type standard reset puts have the same original strike price $K_0=\$40$, risk-free rate $r=5\%$, volatility of the underlying asset $\sigma=40\%$, time to maturity $T-t_0=1$ year, and autocorrelation persistence period $h=1/12$ year. But these four MA(1)-type standard reset puts have different autocorrelation coefficients $\beta=0.75,\ 0.5,\ -0.1,\ -0.2$. Fig.1 demonstrates the value comparison between the non-autocorrelate $(\beta=0)$ standard reset put and four MA(1)-type standard reset puts. Different from a vanilla put, Fig. 1 shows that the reset characteristics makes the non-autocorrelated standard reset put and the MA(1)-type standard reset puts have the U-shaped behavior. From the Eq. (10), the MA(1)-type standard reset put with single reset right, we know that the value of the put (non-reset part) with the initial strike price, P_2, decreases when the stock price rises. But, the increasing stock price also increases the probability of reset and makes value of reset part, P_1, increases. This reset premium makes the reset put have the U-shaped behavior. To discuss the impact of autocorrelation of underlying asset returns on the reset put, the Eq. (10) can be further represented as follows.

$$\begin{aligned}RP_{t_0}&=P_1+P_2\\&=S_{t_0}\cdot e^{-r(T-t)}\cdot\{N(d_{2+})+[N(d'_{1+})-N(d_{2+})]\}\cdot\{N(-b_{2-})+[N(-b'_{1-})-N(-b_{2-})]\}\\&\quad-S_{t_0}\cdot\{N(d_{2+})+[N(d'_{1+})-N(d_{2+})]\}\cdot\{N(-b_{2+})+[N(-b'_{1+})-N(-b_{2+})]\}\\&\quad+e^{-r(T-t_0)}\cdot K\cdot\{N_2(-d_{2-},-d_{3+},\rho^*)+[N_2(-d'_{1-},-d'_{2+},\rho)-N_2(-d_{2-},-d_{3+},\rho^*)]\}\\&\quad-S_{t_0}\cdot\{N_2(-d_{2+},-d_{3-},\rho^*)+[N_2(-d'_{1+},-d'_{2-},\rho)-N_2(-d_{2+},-d_{3-},\rho^*)]\}\end{aligned}\tag{17}$$

where

$$d_{2\pm} = \frac{\ln(\frac{S_{t_0}}{K}) \pm (r + \frac{1}{2}\sigma^2)(t - t_0)}{\sigma\sqrt{t - t_0}} \quad , \quad b_{2\pm} = \frac{\left(r \pm \frac{1}{2}\sigma^2\right)\tau}{\sigma\sqrt{\tau}}, \quad d_{3\pm} = \frac{\ln(\frac{S_{t_0}}{K}) + \left(r \mp \frac{1}{2}\sigma^2\right)\lambda}{\sigma\sqrt{\lambda}},$$

$$\rho^* = \sqrt{\frac{t - t_0}{T - t_0}}.$$

From the Eq. (17), we know that when the underlying asset return is not autocorrelated, $N(d_{2+})$, $N(-b_{2-})$ and $N(-b_{2+})$ represent the probability that the reset put is reset and in the money at the maturity. $N_2(-d_{2-}, -d_{3+}, \rho^*)$ and $N_2(-d_{2+}, -d_{3-}, \rho^*)$ represent the probability that the reset put is not reset and become a vanilla in-the-money put at the maturity. After introducing the autocorrelation effect into the reset put, the probability of reset is affected. Even if the reset put is not reset, the autocorrelation effect still affects the probability that the reset put is in the money at the maturity.

Compared to the non-autocorrelated standard reset put, Figure 1 demonstrates that when the autocorrelation of underlying asset returns is positive (negative) which means $\beta > 0$ ($\beta < 0$), the values of the MA(1)-type standard reset puts have higher (lower) values than that of the non-autocorrelated standard reset put. Because the positive (negative) shock introduced by MA(1)-type process increases (decreases) the volatility of underlying asset returns, which also increases (decreases) the probability of reset. Due to the increasing (decreasing) probability of reset, a MA(1)-type standard reset put has more (less) reset premium than the non-autocorrelated standard reset put. As the degree of positive (negative) autocorrelation increases, the increasing (decreasing) probability of reset makes the difference between the MA(1)-type standard reset put and the non-autocorrelated standard reset put further increase.

Figure 1: Value Comparison between Non-autocorrelated Standard Reset Put and MA(1)-type Standard Reset Puts when Time to Maturity is One Year

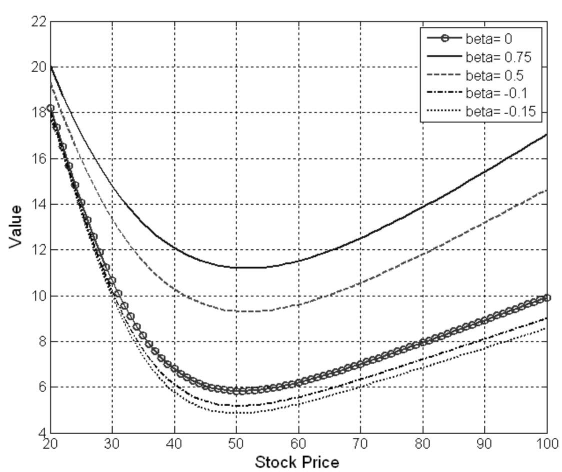


Figure 1 shows the value of different standard reset puts with $\beta = 0.75,\ 0.5,\ 0, -0.1, -0.15$ *under different stock price. Assume reset date is* $t = 0.5$ *year from buying the option, original strike price is* $K_0 = \$40$*, risk-free rate is* $r = 5\%$*, volatility of the underlying asset is* $\sigma = 40\%$*, time to maturity is* $T - t_0 = 1$ *year, and autocorrelation persistence period is* $h = 1/12$ *year. We find that the reset option with positive autocorrelation has a higher (lower) value than the non-autocorrelated reset option.*

Compared to the MA(1) process, if the past shocks are in the same direction (all $\beta_\varphi > 0$ or all $\beta_\varphi < 0$, where $\varphi = 1,\ 2,\ \ldots,\ q$), the impact of the positive or negative autocorrelation captured by the MA(q) process on the reset put is augmented. However, if the past shocks are in different directions (some $\beta_\varphi > 0$, and some $\beta_\varphi < 0$), the impact of autocorrelation would be uncertain. Fig. 2 demonstrates this phenomenon between the MA(1)-type reset put and the MA(2)-type reset put. When the β_1 and β_2 are all positive (negative), the probability of reset would be much higher (lower), and the value of reset put would increase (decrease) more. However, if the signs of β_1 and β_2 are different, the interaction of β_1 and β_2 would have a uncertain impact on the reset put, which means the value of reset put might be increase or decrease.

Figure 1: Value Comparison among Non-autocorrelated Standard Reset Put, MA(1)-type Standard Reset Puts, and MA(2)-type Standard Reset Puts when Time to Maturity is One Year

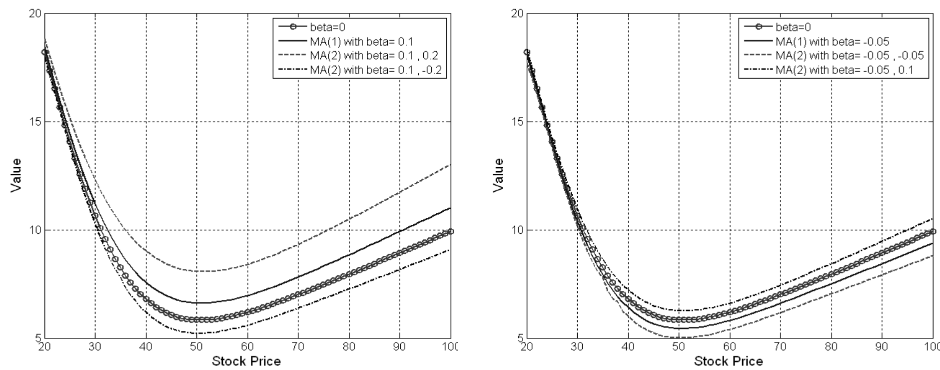


Figure 2 shows the values of non-autocorrelated reset put ($\beta = 0$), MA(1)-type reset puts ($\beta_1 = 0.1,\ -0.05$), and MA(2)-reset puts ($(\beta_1,\ \beta_2) = (0.1,\ 0.2),\ (0.1,\ -0.2),\ (-0.05,\ -0.05), (-0.05,\ 0.1)$) under different stock price. Assume reset date is $t = 0.5$ year from buying the option, original strike price is $K_0 = \$40$, risk-free rate is $r = 5\%$, volatility of the underlying asset is $\sigma = 40\%$, time to maturity is $T - t_0 = 1$ years, and autocorrelation persistence period is $h = 1/365$ year. Compared to the MA(1)-type reset put, the value of the MA(2)-type reset put becomes much larger (smaller) when both β_1 and β_1 are positive (negative). However, if the signs of β_1 and β_1 are different, the impact of autocorrelation would be uncertain.

Moreover, we find that the effect of autocorrelation characteristics on other type of reset options, such as a reset option with *m* reset levels, is consistent with the effect on standard reset options. Consider five reset calls with three reset levels which are the common practical cases. Assume the original strike price is $K_0 = \$100$, risk-free rate is $r = 5\%$, three reset levels are $(D_1, D_2, D_3) = (80, 70, 60)$, time to maturity is $T - t_0 = 1$ year, autocorrelation persistence period is $h = 1/365$ year, and the autocorrelation is $\beta = -0.2,\ -0.1,\ 0,\ 0.25,\ 0.4$ respectively. Table 1 and Table 2 demonstrate the value comparison of these five reset calls when the reset period is $T_0 - t_0 = 1/12$ year and $T_0 - t_0 = 3/12$ year respectively, given different stock prices $S(t_0) = \$80,\ \$100,\ \$115$, volatility $\sigma = 30\%,\ 50\%$, and corresponding reset strike prices (K_1, K_2, K_3).

From Table 1 and Table 2, we first find that if the autocorrelation of underlying asset return is positive, the value of the MA(1)-type reset call with three reset levels is higher than that of the non-autocorrelated reset call with the same reset levels. If the autocorrelation of underlying asset return is negative, the value of the MA(1)-type reset call with three reset levels is lower than that of the standard reset call with the same reset levels. The difference in value increases (decreases) as the autocorrelation becomes more positive (negative). Second, under the same reset levels $(D_1, D_2, D_3) = (80, 70, 60)$, the reset call has a higher value with lower reset strike prices (K_1, K_2, K_3). Third, in cases of higher stock price than reset levels and the lower volatility of stock returns, the value of a non-autocorrelated reset call reduces to the vanilla call, and the value of a MA(1)-type reset call reduces to the MA(1)-type vanilla call. Also, we find that when the duration of the reset period increase (from one month to three month), both the value of the MA(1)-type reset call and the non-autocorrelated reset call increase.

Table 1: Comparison between Non-autocorrelated Reset Calls and MA(1)-type Reset Calls, with Three Reset Levels and One Month Reset Period

σ	$S(t_0)$	(K_1, K_2, K_3)	Degree of Autocorrelation				
			$\beta = -0.2$	$\beta = -0.1$	$\beta = 0$	$\beta = 0.25$	$\beta = 0.4$
30%	85	(80,70,60)	7.0372	8.4260	9.7863	13.0876	15.0047
		(85,75,65)	6.1443	7.4288	8.6996	11.8306	13.6751
		(90,80,70)	5.4349	6.6145	7.7947	10.7486	12.5146
	100	(80,70,60)	11.9738	13.1254	14.2978	17.3279	19.2051
		(85,75,65)	11.9705	13.1157	14.2761	17.2473	19.0726
		(90,80,70)	11.9680	13.1079	14.2579	17.1783	18.9577
	115	(80,70,60)	22.9370	23.8748	24.8644	27.4917	29.1423
		(85,75,65)	22.9370	23.8748	24.8643	27.4902	29.1370
		(90,80,70)	22.9370	23.8748	24.8643	27.4888	29.1324
50%	85	(80,70,60)	14.3718	16.4713	18.5189	23.4302	26.2379
		(85,75,65)	13.0191	15.0578	17.0588	21.9058	24.7027
		(90,80,70)	11.8451	13.8130	15.7592	20.5241	23.3008
	100	(80,70,60)	18.4484	20.5733	22.7227	28.1105	31.2999
		(85,75,65)	18.3210	20.3795	22.4563	27.6632	30.7569
		(90,80,70)	18.2114	20.2093	22.2196	27.2584	30.2617
	115	(80,70,60)	28.4268	30.2935	32.2105	37.1745	40.2297
		(85,75,65)	28.4223	30.2811	32.1838	37.0819	40.0820
		(90,80,70)	28.4185	30.2703	32.1601	36.9982	39.9474

Table 1 shows the value of different reset calls with different stock price $S(t_0) = \$85,\ \$100,\ \$115$*, different reset strike price* $(K_1, K_2, K_3) = (80,70,60),\ (85,75,65),\ (90,80,70)$*, and different volatility* $\sigma = 30\%,\ 50\%$*, given* $\beta = -0.2,\ -0.1,\ 0, 0.25,\ 0.4$*. Assume original strike price is* $K_0 = \$40$*, risk-free rate is* $r = 5\%$*, time to maturity is* $T - t_0 = 1$ *year, reset period is* $T_0 - t_0 = 1/12$ *year, and autocorrelation persistence period is* $h = 1/365$ *year.*

Table 2: Comparison between Non-autocorrelated Reset Calls and MA(1)-type Reset Calls, with Three Reset Levels and Three Months Reset Period

σ	$S(t_0)$	(K_1, K_2, K_3)	Degree of Autocorrelation				
			$\beta = -0.2$	$\beta = -0.1$	$\beta = 0$	$\beta = 0.25$	$\beta = 0.4$
30%	85	(80,70,60)	8.8218	10.3992	11.8476	15.3117	17.2997
		(85,75,65)	7.2630	8.7791	10.1582	13.4891	15.4285
		(90,80,70)	6.0653	7.4622	8.7552	11.9249	13.8003
	100	(80,70,60)	12.3346	13.7600	15.1891	18.8338	21.0373
		(85,75,65)	12.1819	13.5321	14.8773	18.3020	20.3826
		(90,80,70)	12.0757	13.3509	14.6216	17.8512	19.8191
	115	(80,70,60)	22.9514	23.9209	24.9671	27.8582	29.7426
		(85,75,65)	22.9452	23.9046	24.9330	27.7425	29.5578
		(90,80,70)	22.9409	23.8918	24.9051	27.6452	29.4000
50%	85	(80,70,60)	16.7147	18.9395	21.0248	25.9087	28.6384
		(85,75,65)	14.7320	16.9865	19.0633	23.9577	26.7194
		(90,80,70)	13.0382	15.2718	17.3220	22.1952	24.9729
	100	(80,70,60)	20.2613	22.8048	25.2422	31.1031	34.4358
		(85,75,65)	19.5642	22.0078	24.3382	29.9863	33.2357
		(90,80,70)	18.9879	21.3129	23.5391	28.9809	32.1469
	115	(80,70,60)	28.9805	31.1902	33.4455	39.2145	42.6657
		(85,75,65)	28.7919	30.9217	33.0859	38.6256	41.9590
		(90,80,70)	28.6400	30.6888	32.7688	38.0968	41.3193

Table 2 shows the value of different reset calls with different stock price $S(t_0) = \$85,\ \$100,\ \$115$*, different reset strike price* $(K_1, K_2, K_3) = (80,70,60),\ (85,75,65),\ (90,80,70)$*, and different volatility* $\sigma = 30\%,\ 50\%$*, given* $\beta = -0.2,\ -0.1,\ 0, 0.25,\ 0.4$*. Assume original strike price is* $K_0 = \$40$*, risk-free rate is* $r = 5\%$*, time to maturity is* $T - t_0 = 1$ *year, reset period is* $T_0 - t_0 = 3/12$ *year, and autocorrelation persistence period is* $h = 1/365$ *year.*

Effects on the Reset Timing of Reset Options

Recall that a reset option may allow a holder to choose reset time discretionarily, and whether the option value is maximized depends on the timing that the holder elects to exercise their reset right. Figure 3 demonstrates the optimal reset timing for a non-aotocorrelated reset put $(\beta = 0)$ and four MA(1)-type reset puts $(\beta = 0.75,\ 0.5,\ -0.04)$. Assume the initial stock price is $S_0 = \$40$, original strike price is $K_0 = \$40$, risk-free rate is $r = 5\%$, volatility of the underlying asset is $\sigma = 40\%$, time to maturity is $T - t_0 = 2$ years, and autocorrelation persistence period is $h = 1/12$ year.

Figure 2: Optimal Reset Timing Comparison between the Non-autocorrelated Standard Reset Put and MA(1)-type Standard Reset Puts

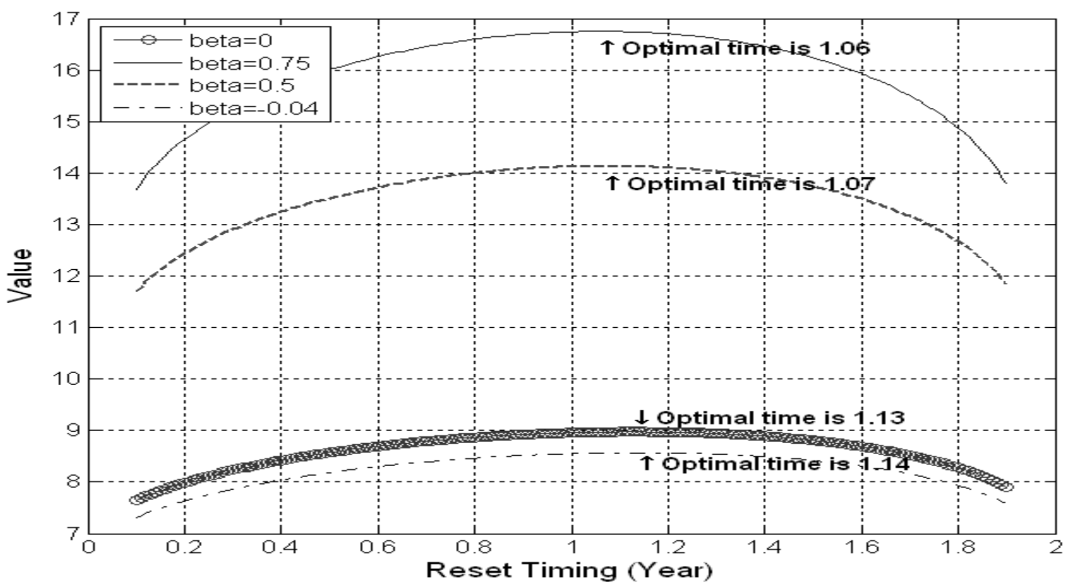


Figure 3 shows the optimal reset timing of different shout puts with $\beta = 0.75,\ 0.5,\ 0,\ -0.04$ *under different stock price. Assume initial stock price is* $S_0 = \$40$, *original strike price is* $K_0 = \$40$, *risk-free rate is* $r = 5\%$, *volatility of the underlying asset is* $\sigma = 40\%$, *and autocorrelation persistence period is* $h = 1/12$ *year. We find that the positive (negative) autocorrelation makes the optimal reset timing earlier (later).*

Figure 3 shows that, for a non-aotocorrelated reset put, the optimal reset timing is 1.13 years from the initial time of the put. However, if the underlying asset return has positive autocorrelation, the optimal reset timing for a MA(1)-type reset put is advanced. The optimal reset timings of MA(1)-type reset puts with $\beta = 0.75$ and $\beta = 0.5$ are 1.06 years and 1.07 years respectively. If the autocorrelation is positive, this positive shock makes the volatility of underlying asset returns increase. Holders of the positive MA(1)-type reset puts have more uncertainty of the underlying assets price movement. Therefore, rational holders of the MA(1)-type reset puts tend to reset earlier to protect themselves from possible loss. On the other hand, if the underlying asset return has negative autocorrelation, we find that the optimal reset timing for a MA(1)-type reset put is postponed. The optimal reset timings of MA(1)-type reset puts with $\beta = -0.04$ is 1.14 years. Because the negative autocorrelation decreases the volatility of underlying asset returns, holders of the MA(1)-type reset puts have more certainty that the underlying asset price would not change too much. Therefore, to wait for more profit, holders tend to delay their reset timing.

Figure 3: Delta Jumps of Three Reset Calls with Different Degrees of Positive Autocorrelation under Volatility 30%

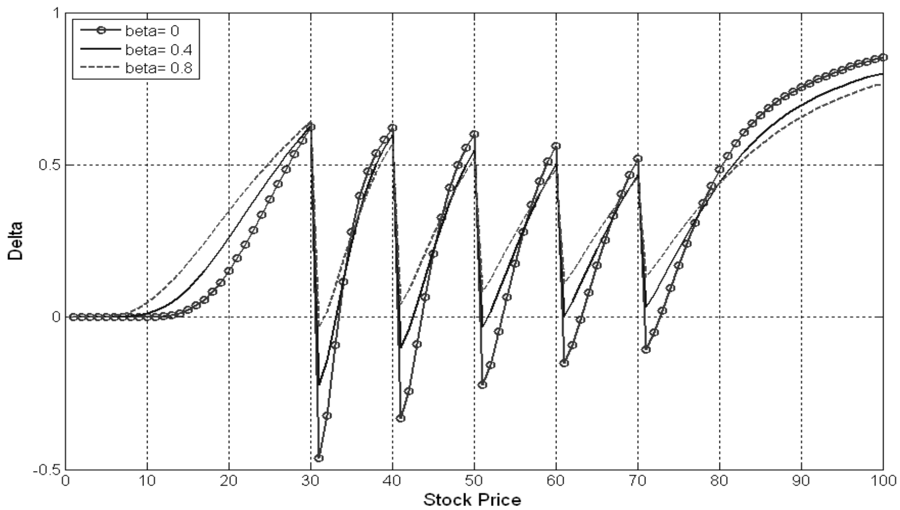


Figure 4 shows the delta jumps of three reset calls with different degree of positive autocorrelation $\beta = 0,\ 0.4,\ 0.8$*, same five reset levels* $(D_1, D_2, D_3, D_4, D_5) = (70, 60, 50, 40, 30)$*. Assume the original strike price is* $K_0 = \$80$*, risk-free rate is* $r = 5\%$*, volatility is* $\sigma = 30\%$*, time to maturity is* $T - t_0 = 1$ *year, reset period is* $T_0 - t_0 = 1/12$ *year, autocorrelation persistence period is* $h = 1/365$ *year, and reset strike prices are* $(K_1, K_2, K_3, K_4, K_5) = (70, 60, 50, 40, 30)$*. We find that the positive autocorrelation decrease the delta jumps problems.*

Effects on the Delta Jump and the Gamma Jump of Reset Options

Following the study of Liao and Chen (2006) and introducing MA(1)-process, the delta of the reset call with *m* reset levels can be represented as:

$$\frac{\partial C_t^{\mathrm{Reset}}}{\partial S(t)} = N[d_+(K_m, \tau)] + \sum_{i=1}^{m} \left(\frac{\partial DOC_t^{i-1,i}}{\partial S(t)} - \frac{\partial DOC_t^{i,i}}{\partial S(t)}\right). \tag{20}$$

It is well known that the *delta jump* problem makes hedging difficult for reset options. When the holders of the reset option reset their strike prices, the reset option changes from an out-of-money option into an in-of-money option, which causes a significant change of delta (delta jump). We can also explain the phenomenon of delta jump from Eq. (20). Because the strike prices of $DOC_t^{i-1,i}$ and $DOC_t^{i,i}$ are different, $(\frac{\partial DOC_t^{i-1,i}}{\partial S(t)} - \frac{\partial DOC_t^{i,i}}{\partial S(t)})$ would not equal zero. Therefore, if the stock price touches any of the reset barriers, the delta jump happens. For example, consider three reset calls with the same contract terms, except for the different degrees of autocorrelation $\beta = 0,\ 0.4,\ 0.8$. Assume these three reset calls have the same initial original strike price $K_0 = \$80$, five reset levels $(D_1, D_2, D_3, D_4, D_5) = (70, 60, 50, 40, 30)$, risk-free rate $r = 5\%$, five corresponding reset strike prices $(K_1, K_2, K_3, K_4, K_5) = (70, 60, 50, 40, 30)$, time to maturity $T - t_0 = 1$ year, and reset period $T_0 - t_0 = 1/12$ year. Figure 4 and Table 3 demonstrate the comparisons of delta jump between the non-autocorrelated reset call and two positive autocorrelation reset calls under volatility $\sigma = 30\%$. Figure 5 and Table 4 demonstrate the comparisons of delta jump between the non-autocorrelated reset call and two negative autocorrelation reset calls under a higher volatility $\sigma = 30\%$.

Table 3: Delta Gap Comparison of Three Reset Calls with Different Degree of Positive Autocorrelation under Volatility 30%

	Stock Price				
	30	40	50	60	70
$\beta = 0$	1.0869	0.9522	0.8237	0.7144	0.6277
$\beta = 0.4$	0.8498	0.6980	0.5818	0.4981	0.4361
$\beta = 0.8$	0.6737	0.5297	0.4383	0.3745	0.3268

Table 3 shows that, under the lower volatility $\sigma = 30\%$, as the degree of autocorrelation increases, delta gaps of MA(1)-type reset calls with positive autocorrelation become more lower than that of the non-autocorrelated reset call.

Figure 4: Delta Jumps of Three Reset Calls with Different Degrees of Negative Autocorrelation under Volatility 30%

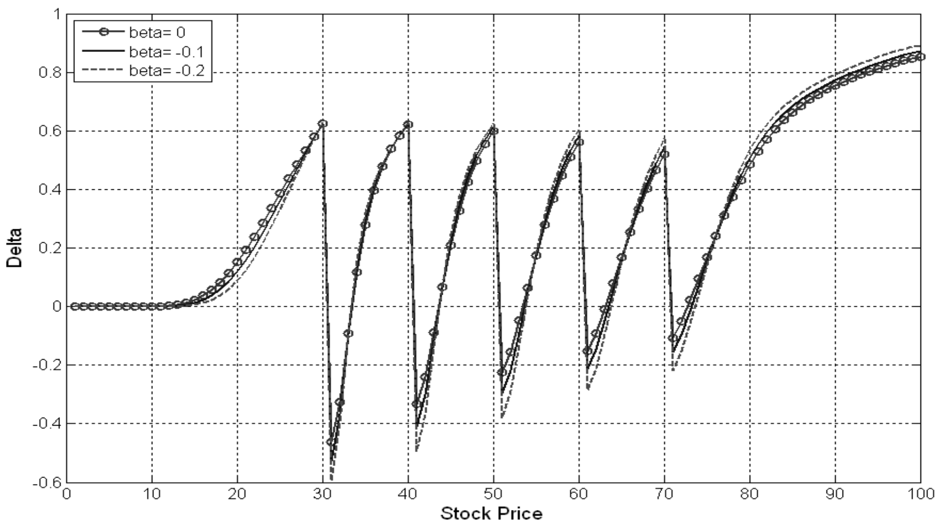


Figure 5 shows the delta jump of three reset calls with different degree of negative autocorrelation $\beta = 0,\ -0.1,\ -0.2$, same five reset levels $(D_1, D_2, D_3, D_4, D_5) = (70, 60, 50, 40, 30)$. Assume the original strike price is $K_0 = \$80$, risk-free rate is $r = 5\%$, volatility is $\sigma = 30\%$, time to maturity is $T - t_0 = 1$ year, reset period is $T_0 - t_0 = 1/12$ year, autocorrelation persistence period is $h = 1/365$ year, and reset strike prices are $(K_1, K_2, K_3, K_4, K_5) = (70, 60, 50, 40, 30)$. We find that the negative autocorrelation makes the delta jumps more serious than the non-autocorrelated reset option.

From Figure 4, we find that, whether for the non-autocorrelated reset call or MA(1)-type reset calls, the delta jumps happen whenever the stock price touches the reset barriers. However, the degree of delta jumps of MA(1)-type reset calls with positive autocorrelation is lower than that of the non-autocorrelated reset call. We measure this degree of delta jump by *delta gap* which is the difference of delta before reset timing and after reset timing. Table 3 shows that, under the lower volatility $\sigma = 30\%$, as the degree of autocorrelation increases, delta gaps of MA(1)-type reset calls with positive autocorrelation become more lower than that of the non-autocorrelated reset call. For example, when the reset barrier is \$30, the higher degree of positive autocorrelation makes the delta gap decrease from 1.0869 to 0.6737. When the stock price decreases becomming closer to the reset barrier, due to the fact that the strike price can be adjusted to a new higher level if the stock the stock price actually touches the barrier, the reset call is more valuatable. Moreover, because the MA(1)-type reset call with positive autocorrelation causes a higher probability of reset than the non-autocorrelated reset call, the value of MA(1)-type reset call is even higher than that of the non-autocorrelated reset call near the reset barrier. And, the associated delta of MA(1)-type reset call with positive autocorrelation is highr than that of the non-autocorrelated reset call near the reset barrier.

Table 4: Delta Gap Comparison of Three Reset Calls with Different Degrees of Negative Autocorrelation under Volatility 30%

	Stock Price				
	30	40	50	60	70
$\beta = 0$	1.0869	0.9522	0.8237	0.7144	0.6277
$\beta = -0.1$	1.1542	1.0328	0.9074	0.7945	0.7007
$\beta = -0.2$	1.2219	1.1221	1.0033	0.8898	0.7900

Table 4 shows the comparisons of delta jumps between the non-autocorrelated reset call and two MA(1)-type reset calls with negative autocorrelation, i.e. $\beta = -0.1$ *and* $\beta = -0.2$*. For the MA(1)-type reset calls with negative autocorrelation, because the negative autocorrelation of asset return makes the probability of reset near the barriers decrease, the value and the delta of the MA(1)-type reset calls with negative autocorrelation are less than that of the non-autocorrelated reset call. Therefore, the negative autocorrelation causes the delta gap to be larger.*

Besides the hedging difficulty of delta jump, gamma jump is another problem for hedgeing. Recall that gamma measures the rate of change in delta as the underlying stock price changes. In other words, gamma can be viewd as a measure of how poorly a dynamic delta hedge would perform when it is not rebalanced in response to a change in the asset price. Figure 6 demonstrates that gamma jumps happen whenever the stock price touches reset barriers. When the stock price decreases becomming closeser to the reset barrier, gamma tends to increase because the foreseen delta jump would make the delta change dramatically. This means that the performance of a dynamic hedge is quite poor near every reset barrier. However, the positive (negative) autocorrelation actually decreases (increases) the problem of gamma jump. The advantage of positive autocorrelation effect on the hedging of reset options is the most significant contribution of this paper.

Figure 5: Gamma Jumps of Three Reset Calls with Different Degrees of Autocorrelation under Volatility 30%

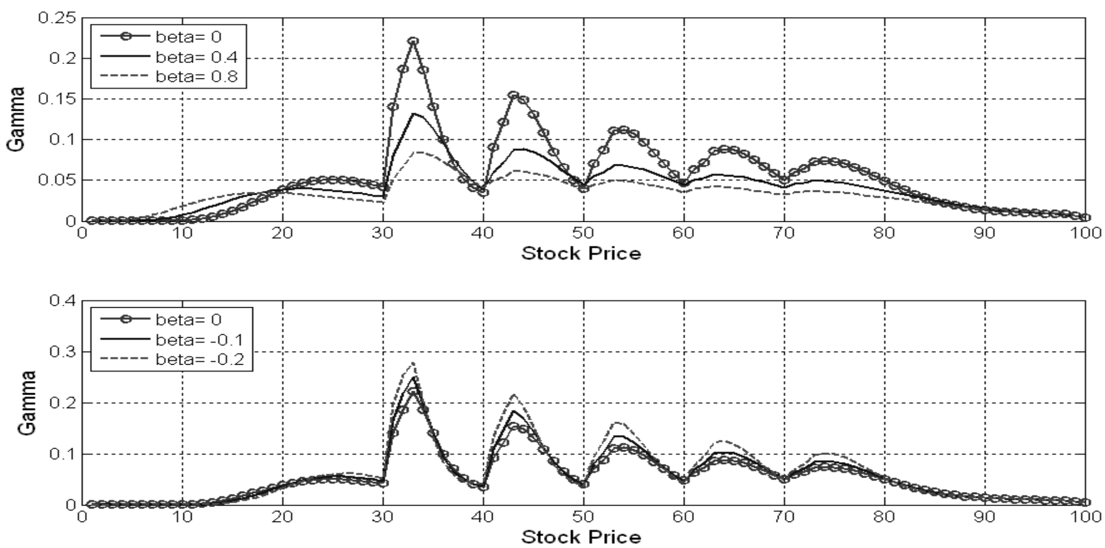


Figure 6 shows the gamma jumps of reset calls with different degrees of positive autocorrelation $\beta = 0,\ 0.4,\ 0.8$ *and negative autocorrelation* $\beta = 0,\ -0.1,\ -0.2$*, same five reset levels* (D_1, D_2, D_3, D_4, D_5)=(70,60,50,40,30). *Assume the original strike price is* $K_0 = \$80$*, risk-free rate is* $r = 5\%$*, volatility is* $\sigma = 30\%$*, time to maturity is* $T - t_0 = 1$ *year, reset period is* $T_0 - t_0 = 1/12$ *year, autocorrelation persistence period is* $h = 1/365$ *year, and reset strike prices are* (K_1, K_2, K_3, K_4, K_5)=(70,60,50,40,30). *We find that the positive autocorrelation decreases the gamma jumps and the negative autocorrelation increases the gamma jumps*

CONCLUSIONS

The main contribution of this paper is to demonstrate the impact of underlying assets' autocorrelation on reset options. The autocorrelation of asset returns is a pervasive phenomenon in the financial field. This autocorrelation characteristic affects not only the dynamic process of asset prices, but some characteristics of the reset option. We apply the MA(q) process. This process is an extension of the MA(1) process mentioned by Liao and Chen (2006) who extracted the autocorrelation of financial asset returns from the asset returns' first moment through the form of a first-order moving average process.

We develop modified models for different types of reset options with reset clause on the strike prices. For a MA(1)-type reset option, we find that the positive (negative) autocorrelation of underlying asset returns makes the volatility of underlying assets, reset probability, and the value of reset option increase (decrease). Furthermore, we find that the positive autocorrelation of underlying asset returns makes the holder of the reset option tend to reset earlier, which prevents a possible loss. To the contrary, the negative autocorrelation of underlying assets makes the holder of the reset option tend to reset later because the small volatility of the underlying asset weakens the advantage of reset. On the other hand, the effect of underlying assets' autocorrelation on hedging of the reset option is also an important contribution in this paper. When the holder of the reset option resets their strike price, the reset option changes from an out-of-money option into an in-of-money option, which causes significant changes of delta (delta jump) and gamma (gamma jump). Although the problem of delta jump and gamma jump still exist in the reset option, we find that the positive autocorrelation of underlying assets actually lessen the degree of delta jump and gamma jump.

This paper has some limitations. First, the paper only considers autocorrelation characteristics of asset returns from the asset returns' first moment through the form of a first-order moving average process. Further research, might consider other different dynamic pricing processes to capture the autocorrelation, such as ARCH or GARCH models. Instead of autocorrelation, one can also capture the predictability of underlying asset returns from other exogenous variables. One can discuss the effect of different types of asset predictability on the reset option. Second, besides considering the single stock price as the reset trigger, further research can consider the reset option using average prices as a reset trigger. This type of reset option is very common in practice. If average price is used as the reset trigger, the impact of predictability of underlying asset return might be augmented. One can discuss the effect of the predictability of asset returns on this type of reset option. Third, this paper only focuses on the reset option with reset clause on the strike price. Further research might consider other reset options with different reset clauses, such as the reset clause on the maturity date. This type of reset option gives the holder a right to postpone the maturity date of the reset option. One can discuss the effect of predictability of asset returns on this type of reset option. Last, the reset conditions in this paper are based on the underlying asset. Further research might consider other reset options whose reset conditions are related to the other particular events, such as the credit quality of a firm. For example, a reset option may be designed to allow the holders to reset the strike price if the credit rating of firm decreases to certain level. One can discuss the impact on this type of reset option if the underlying asset returns or credit quality are predictable.

REFERENCE

Bianco, S. and Reno, R. (2006), Dynamics of intraday serial correlation in the Italian futures market. *Journal of Futures Markets*, 26, 61-84.

Chambers, M. and Bailey, R. (1996), A theory of commodity price fluctuations. *Journal of Political Economics*, 104, 924-957.

Cheng, W.Y. and Zhang, S. (2000), The analytics of reset options. *Journal of Derivatives*, 8, 59-71.

Conrad, J. and Kaul, G. (1988), Time-variation in expected returns. *The Journal of Business*, 61, 409-425.

Dai, M., Kwok, Y. and Wu, L. (2003), Options with multiple reset rights. *International Journal of Theoretical and Applied Finance*, 6, 637-653.

Deaton, A. and Laroque, G. (1992), On the behavior of commodity prices. *Review of Economic Studies*, 59, 1-23.

Deaton, A. and Laroque, G. (1996), Competitive storage and commodity price dynamics. *Journal of Political Economics*, 104, 896-923.

Faff, R.W. and Hiller D. and McKenzie, M. (2005), An investigation of conditional autocorrelation and cross-autocorrelation in emerging markets. *Review of Pacific Basin Financial Markets and Policies*, 8, 467-499.

Gray, S.F. and Whaley, R. (1997), Valuing bear market reset warrants with a periodic reset. *Journal of Derivatives*, 5, 99-106.

Gray, S.F. and Whaley, R. (1999), Reset put options: valuation, risk characteristics, and an application. *Australian Journal of Management*, 24, 1-20.

Hamao, Y., Masulis, R. and Ng, V. (1990), Correlation in price changes and volatility across international stock markets. *the Society for Financial Studies*, 3:2, 281-307.

Liao, S.L. and Chen, C.C. (2006), The valuation of European options when asset returns are autocorrelated. *Journal of Futures Markets*, 26, 85-102.

Liao, S.L. and Wang, C.W. (2002), Pricing arithmetic average reset options with control variates. *Journal of Derivatives*, 10, 59-74.

Lo, A. and MacKinlay, A. (1988), Stock market prices do not follow random walks: evidence from a simple specification test. *Review of Financial Studies*, 1, 41-66.

Lo, A., and Wang, J. (1995), Implementing option pricing models when asset returns are predictable. *Journal of Finance*, 50, 87–129.

McKenzie, M.D. and Faff, R. (2003), The determinants of conditional autocorrelation in stock returns. *Journal of Financial Research*, 26, 259-274.

Mech, T.S. (1993), Portfolio return autocorrelation. *Journal of Financial Economics*, 34, 307-334.

Patro, D.K. and Wu, Y. (2004), Predictability of short-horizon returns in international equity markets. *Journal of Empirical Finance*, 11, 553-583.

Poterba, J.M. and Summers, L. (1988), Mean reversion in stock prices: evidence and implications. *Journal of Financial Economics*, 22, 27-59.

ACKNOWLEDGEMENT

The authors wish to thank the anonymous reviewers for their excellent comments, resulting in a significant improvement in the quality of this paper.

BIOGRAPHY

Yu-hong Liu is an assistant professor of Finance and Banking at National Cheng Kung University. He can be contacted at: Graduate Institute of Finance and Banking, National Cheng Kung University, Tainan City 70101, Taiwan, R.O.C.; Email: yuhong@mail.ncku.edu.tw; Tel: +886-6-2757575-53429; Fax: +886-6-2757575-53400.

I-ming Jiang is an assistant professor of Department of Finance at Yuan Ze University. He can be contacted at: Department of Finance at Yuan Ze University, No. 135, Far-East Rd., Chung-Li, Taoyuan, Taiwan, R.O.C.; Email: jiangfinance@saturn.yzu.edu.tw; Tel: +886-3-4638800-3662; Fax: +886-3-4354624.

Shih-Cheng Lee is an associate professor of Department of Finance at Yuan Ze University. He can be contacted at: Department of Finance at Yuan Ze University, No. 135, Far-East Rd., Chung-Li, Taoyuan, 32003, Taiwan, R.O.C.; Email: sclee@saturn.yzu.edu.tw; Tel: +886-3-4638800-2191; Fax: +886-3-4354624.

Yu-Ting Chen is a master student from of Finance and Banking at National Cheng Kung University. He can be contacted at: 3F., No.102, Xialin Rd., South Dist., Tainan City 702, Taiwan, R.O.C.; Email: chenyt@livemail.tw; Tel:+886-937349332.

The International Journal of Business and Finance Research ♦ Volume 5 ♦ Number 2 ♦ 2011

IMPLIED INDEX AND OPTION PRICING ERRORS: EVIDENCE FROM THE TAIWAN OPTION MARKET

Ching-Ping Wang, National Kaohsiung University of Applied Sciences
Hung-Hsi Huang, National Pingtung University of Science and Technology
Chien-Chia Hung, National Pingtung University of Science and Technology

ABSTRACT

This study examines both restricted and unrestricted Black-Sholes models, according to Longstaff (1995). Using the Taiwan index options for each day from January 2005 to December 2008, the unrestricted model simultaneously solves the implied index value and implied volatility whereas the restricted model only solves the implied volatility. Next, this study compares the pricing performance of restricted and unrestricted Black-Scholes models. The empirical results show he implied index value is almost higher than the actual index value. Moneyness has a significant negative impact on the index pricing error for calls but negative impact for puts. Open interest has a significantly negative impact on the index pricing error for calls. Volatility for calls has no significant effect on the index pricing error. The path-dependent effect on index pricing error increases with index returns. The unrestricted model has significantly less option pricing bias for calls than the restricted model. The option pricing error for calls in the restricted model has much larger negative bias near the middle maturity. The R-square in the restricted model is always much larger than the unrestricted model for both calls and puts. Finally, the option pricing errors are significantly affected by moneyness and time to expiration for all cases; this fact is consistent with Longstaff (1995). Additionally, based on the criterion of adjusted R-square, this study investigated the optimal explanatory variables of index pricing error.

JEL: G12; G13; G14

KEYWORDS: Index pricing error, option pricing error, Black-Scholes, implied volatility, implied index

INTRODUCTION

Under the assumptions that agents are risk neutral and rational, Samuelson (1965) proved that futures prices must be martingales with respect to the information set. According to the theory about the Martingale property and no arbitrage opportunity, Black and Scholes (1973) and Merton (1973) developed the option pricing framework. Option pricing theory can be viewed as a main pillar of modern finance theory. Harrison and Kreps (1979) showed that violations of a martingale restriction on the expected future stock price under a risk-neutral density represent arbitrage opportunities in frictionless security markets. Similarly, under the no-arbitrage condition, the value of a European option is given by its expected future payoff under a risk-neutral probability measure discounted at the riskless interest rate. Restated, in the no-arbitrage framework, the underlying asset price implied by the option pricing model must be equal to its actual market price. This means that the cost of a synthetic position via the option market is equal to the price of the underlying asset. However, because of market frictions and the unrealistic assumption in option pricing models (e.g. Black-Scholes (simply B-S)), the implied price need not equal its actual market price.

Longstaff (1995) showed that the implied index value is nearly higher than the actual index value. In this paper, we attempt to verify the results of Longstaff (1995). Additionally, following Longstaff (1995), this study examines both the restricted and unrestricted B-S models. Using the Taiwan Index Options (TXO) data for each day, the unrestricted model simultaneously solves the implied index value and implied volatility whereas the restricted model only solves the implied volatility. Naturally, the implied index need not be equal to the actual index. Having an extra parameter, however, the unrestricted model should fit the actual option prices better. There are the following reasons why TXO is examined to verify the results of Longstaff. First, American options are used as sample in Longstaff (1995) , while the B-S model is based on European options. TXO with European-style contracts therefore is more in line with the B-S assumption. Additionally, when dividends are announced, the American call option prices are usually higher than European options. On the other hand, regardless of whether there are dividends, American put option prices are always higher than European options. Hence, Longstaff only examined call options. Due to TXO with European-style contracts, we can examine both the call and put options. Moreover, unlike many index markets, there is a price limit for Taiwan market, accordingly, the result in this study may not necessarily be the same as that of previous research.

This study is organized as follows. The next section briefly discusses the relevant literature. The third section introduces implied volatility and implied index. The fourth section presents the definition and impact factors of pricing errors, including the index pricing error and option pricing error. The fifth section analyzes the empirical results, including the difference between the implied index and actual index; the pricing performance comparison of restricted and unrestricted Black-Scholes models; and the regression of option pricing errors on the moneyness and time to expiration. Finally, the sixth section concludes.

LITERATURE REVIEW

Previous studies have examined the option pricing biases in the B-S model. For example, Black and Scholes (1973) found call options are over-valued/under-valued if the stock return volatility is high/low. MacBeth and Mervile (1980) used the stock options traded on CBOE, and found that the CEV (constant elasticity of variance) model fits market prices of call options significantly better than the Black-Scholes model. Using all reported trades and quotes on the 30 most active CBOE option classes from August 23, 1976 through August 31, Rubinstein (1985) performed the nonparametric tests of alternative option pricing models. The result showed that short-maturity out-of-the-money calls are priced significantly higher relative to other calls than the Black-Scholes model, and striking price biases relative to the Black-Scholes model are also statistically significant but have reversed themselves after long periods of time.

Although implied volatility is widely believed to be informationally superior to historical volatility since it is the “market's” forecast of future volatility, Canina and Figlewski (1993) examined the S&P 100 index options traded in 1983 and found implied volatility is a poor forecast of subsequent realized volatility. They verified that implied volatility has virtually no correlation with future volatility, and it does not incorporate the information contained in recent observed volatility. Using S&P 100 index options data, Longstaff (1995) verified that the implied cost of the index is significantly higher in the options market than in the stock market, and is directly related to measures of transaction costs and liquidity. Also, the Black-Scholes model has strong bid-ask spread, trading volume, and open interest biases. The result indicates that option pricing models that relax the martingale restriction perform significantly better. Strong and Xu (1999) investigated the Longstaff's martingale restriction on S&P 500 index options over the period 1990 through 1994. Assuming the S&P index follows a lognormal distribution, the result reveals that the implied index value from options consistently overestimates the market value. However, when adopting a generalized distribution allowing for nonnormal third and fourth moments, the martingale restriction is economically insignificantly rejected.

Turvey and Komar (2006) extracted the implied market price of risk for options on live cattle futures as a test of the Martingale restriction. The results generally reject the Martingale restriction and the risk neutral hypothesis. Corrado (2007) focused on a method to impose a martingale restriction in an option pricing model developed from a Gram–Charlier and Edgeworth density expansion, and found that a martingale restriction “invisible” in the option price. By adopting the weekly observations of both put and call $/£ currency options on corresponding futures contracts for the period December 1989 to November 2000 in the empirical analysis, Busch (2008) employed the normal inverse Gaussian distribution for estimating the option implied risk neutral density, and found that the martingale restriction is in most cases satisfied. Ville-Goyets et al. (2008) empirically investigated the martingale hypothesis for agricultural futures prices, by using a nonparametric approach where the expected return depends nonparametrically on a linear index. The empirical result indicated that the Samuelson’s (1965) hypothesis is statistically rejected. Restated, the results indicate that the estimated index contains statistically significant information regarding the expected futures returns.

METHODOLOGY: IMPLIED VOLATILITY AND IMPLIED INDEX

Black and Scholes (1973) assumed that stock prices follow a lognormal distribution. If the stock price is substituted by the futures price, Black-Scholes formulas for call and put options are as follows.

$$\begin{cases} Call = e^{-rT}[F_0\, N(d_1) - K\, N(d_2)] \\ Put = e^{-rT}\left[K\, N(-d_2) - F_0\, N(-d_1)\right] \\ d_1 = \dfrac{\ln(F_0/K) + \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}},\ \ d_2 = d_1 - \sigma\sqrt{T} \end{cases} \tag{1}$$

where F_0 is the futures price at time 0, r is the risk-free interest rate, σ is the volatility of the futures return, K is the strike price, T is the expiration date, and $N(\cdot)$ is the cumulative distribution function of a standard normal variable. The theoretical option price $P = P(F_0, r, \sigma, K, T)$ based on Equation (1) implies that excluding the futures index, risk-free interest rate, strike price and expiration date, the option price is related to the magnitude of the volatility. Accordingly, by inverting the Black-Scholes formula, we can obtain the implied volatility corresponding to the restricted model. Additionally, following Longstaff (1995), we invert the B-S model to estimate both the implied index value and the implied volatility corresponding to the unrestricted model. Mathematically,

$$\text{Restricted Model: } \min_{\sigma} \sum\nolimits_{i=1}^{n} (\hat{P}_i - P_i)^2 \tag{2}$$

$$\text{Unrestricted Model: } \min_{\sigma,\, F} \sum\nolimits_{i=1}^{n} (\hat{P}_i - P_i)^2 \tag{3}$$

where n represents the number of option observations, P_i and $\hat{P}_i$ represent the actual option price and fitted option price of the i-th option. In Equation (2), $\hat{P}_i$ is obtained by using actual index as the value for F_0 in the B-S formula; but in Equation (3), $\hat{P}_i$ is obtained by using implied index as the value for F_0.

Pricing Errors

Referring to Longstaff (1995), we regress the index pricing error on moneyness, time to expiration, market liquidity, and volatility.

$$(\hat{F} - F)/F = \alpha_0 + \beta_1 M + \beta_2 T + \beta_3 AR + \beta_4 AR_{-1} + \beta_5 AR_{-2} \tag{4}$$

$$+ \beta_6 OI + \beta_7 Vol + \beta_8 N + \beta_9 R + \beta_{10} R_{-1} + \beta_{11} R_{-2} + \varepsilon$$

where $(\hat{F}-F)/F$ is index pricing error defined as the percentage difference between the implied index $\hat{F}$ and actual index *F*; *M* represents moneyness which equals *F/K* for call and *K/F* for put; *T* represents time to expiration, and ε is disturbance; AR, AR_{-1} and AR_{-2} are used as the volatility proxies, respectively denoting the current and first two lagged absolute daily returns on the index; *OI*, *Vol* and *N* are used as the liquidity proxies, respectively representing the open interest, total trading volume and number of options used to compute the implied index value for that day; R, R_{-1} and R_{-2} are employed to capture the path-dependent effects on option pricing, respectively denoting the current and first two lagged daily returns on the index. Additionally, this study will regress the option pricing errors from the restricted and unrestricted models on the moneyness and time to expiration as follows.

$$\text{Option Pricing Error} = \alpha_0 + \beta_1\mathrm{M} + \beta_2\mathrm{T} + \varepsilon \qquad (5)$$

where the option pricing errors include the four indicators: $\hat{P}-P$, $|\hat{P}-P|$, $(\hat{P}-P)/P$ and $|(\hat{P}-P)/P|$.

Data

The daily call and put option prices are obtained from Taiwan Economic Journal (TEJ) with the sample period from January 2005 to December 2008. The risk-free interest rate is one-year time savings deposit interest rate by the First Bank of Taiwan. Options with expiration dates in the nearby months are actively traded and are able to reflect the most information. However, the implied volatility will change abnormally in the week before expiration. Accordingly, nearby-month options whose expiration dates are longer than 8 days are selected.

The trading hours of TXO is from 8:45 am to 1:45 pm while the trading hours in the spot market is from 9:00 am to 1:30 pm. To avoid the non-synchronous trading problem, this study estimates the daily implied volatility and implied index by using the five-minute window, 13:25 to 13:30 pm, in which options are the most actively traded. For each day, the number of contracts with no more than three is excluded. Options that violate the upper or lower boundary conditions are also eliminated, where the conditions are $(F-K)e^{-rT} \le Call \le F$ and $(K-F)e^{-rT} \le Put \le Ke^{-rT}$. The resulting data includes 239,044 call and 193,301 put options.

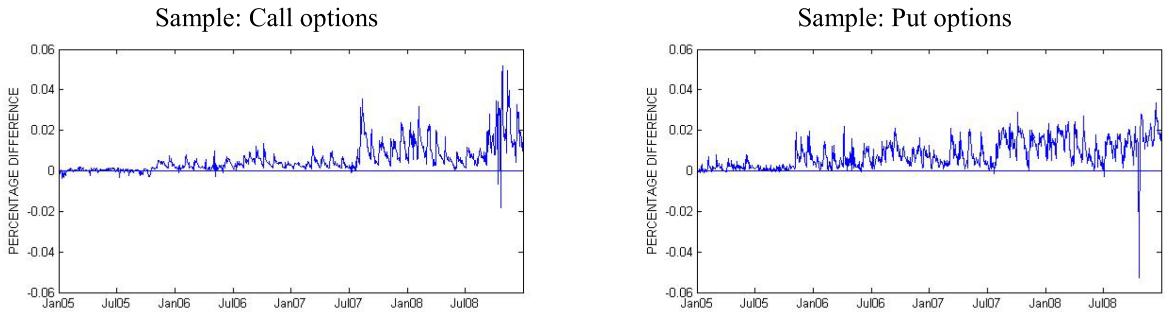
EMPIRICAL RESULTS

Index Pricing Error

Empirically, the Matlab grid search method is carried out to estimate the parameters. Figure 1 plots the time series of index pricing error for call and put options. As shown, like Longstaff (1995), on average, the index pricing error is positive. That is, the implied index value is almost higher than the actual index value. We can view an option as a levered position in the underlying asset, so, the cost of purchasing stock via the options market is more expensive than in the stock market.

For the total sample period from 2005 to 2008, the regression result of Equation (4) are shown in Table 1. Additionally, for examining the robustness of time horizon, this study divides the total sample period into two subsamples in which the regression results of index pricing error are listed in Tables 2 and 3, respectively. The sample period for Table 2 is 2005 to 2006 and the sample period for Table 3 is 2007 to 2008. It is worth mentioning the “financial tsunami” during 2008. Accordingly, we suspect a structural change during that period of time.

Figure 1: Percentage Difference between the Implied Index and the Actual Index



This figure plots the time series of index pricing error for call and put options. The call and put option prices are obtained from Taiwan Economic Journal (TEJ).

We observe that the main results are robust for the total sample period and two subsamples, as follows. Moneyness has a significant negative impact on the index pricing error for calls; this fact is consistent with Longstaff (1995). However, moneyness has a significant positive impact on the index pricing error for puts. Next, the coefficient for the open interest is significantly negative for calls, which agrees with the result from Longstaff (1995). In terms of volatility for calls, different from Longstaff (1995), the current and first two lagged absolute daily returns on the index have no significant effect on the index pricing error. Moreover, contrary to Longstaff (1995), the path-dependent effect on index pricing error increases with index returns.

Finally, the best fitting regression model provided in Tables 1 through 3 have the largest adjusted R-square among these explanatory variables in Equation (4). The optimal explanatory variables of index pricing error exclude the volatility proxies for calls during the total sample period as well as the period of 2005 to 2006. Besides, the optimal explanatory variables additionally exclude T and R_{-2} during the period of 2007 to 2008.

For puts, however, the optimal explanatory variables of index pricing errors somewhat differ from the total sample period and the two subsamples. For instance, the optimal explanatory variables for the total sample period include M, T, AR_{-2}, OI and N. The optimal explanatory variables for the sample period of 2005 to 2006 include M, OI, Vol, N, R, R_{-1} and R_{-2}. The optimal explanatory variables for the sample period of 2007 to 2008 include M, T, AR_{-2}, OI, Vol and N.

Option Pricing Errors

Figure 2 shows that option pricing error from restricted model decreases with the moneyness for calls; this fact is opposite to Longstaff (1995). Like Longstaff (1995), the unrestricted model has significantly less option pricing bias for calls than the restricted model. Figure 3 displays the option pricing error for calls in the restricted model has much larger negative bias near the middle maturity. Tables 4 and 5 display the regression results of option pricing errors on the moneyness and the time to expiration.

Table 1: Regression Results of Index Pricing Error from 2005 to 2008

	Call options				Put options			
Model	**Equation (4)**		**Best fitting**		**Equation (4)**		**Best fitting**	
$\text{Int}\times 10^{-2}$	27.97	(13.03)	28.42	(15.64)	-21.32	(-12.53)	-21.39	(-12.67)
$\text{M}\times 10^{-2}$	-27.59	(-13.02)	-28.04	(-15.64)	21.15	(12.44)	21.26	(12.85)
$\text{T}\times 10^{-5}$	-6.57	(-2.16)	-6.88	(-2.50)	8.85	(3.43)	8.77	(3.40)
$\text{AR}\times 10^{-5}$	8.31	(0.38)			26.18	(1.04)		
$\text{AR}_{-1}\times 10^{-5}$	9.62	(0.42)			21.32	(0.91)		
$\text{AR}_{-2}\times 10^{-5}$	14.68	(0.80)			40.25	(2.76)	43.51	(2.59)
$\text{OI}\times 10^{-9}$	-7.00	(-6.07)	-6.92	(-6.15)	-2.81	(-1.60)	-3.88	(-2.08)
$\text{Vol}\times 10^{-9}$	-3.41	(-1.41)	-3.08	(-1.46)	-1.63	(-0.49)		
$\text{N}\times 10^{-5}$	-12.03	(-1.45)	-10.03	(-1.11)	10.52	(1.42)	11.48	(1.66)
$\text{R}\times 10^{-5}$	117.32	(5.55)	119.32	(5.99)	-0.60	(-0.05)		
$\text{R}_{-1}\times 10^{-5}$	52.92	(4.39)	53.46	(4.34)	1.99	(0.21)		
$\text{R}_{-2}\times 10^{-5}$	23.61	(1.84)	22.90	(1.77)	-0.95	(-0.10)		
R^2	0.7286		0.7282		0.6775		0.6756	
Adj R^2	0.7256		0.7260		0.6739		0.6740	

This table shows the regression result of Equation (4). Newey-West heteroscedasticity and autocorrelation robust t-statistics are shown in parentheses. Int is the regression intercept.

Table 2: Regression Results of Index Pricing Error from 2005 to 2006

	Call options		Put options	
Model	**Equation (4)**	**Best fitting**	**Equation (4)**	**Best fitting**
$\text{Int}\times 10^{-2}$	12.80 (6.79)	12.72 (7.26)	-23.13 (-9.41)	-23.77 (-11.76)
$\text{M}\times 10^{-2}$	-12.24 (-6.58)	-12.17 (-7.04)	23.09 (9.29)	23.77 (11.86)
$\text{T}\times 10^{-5}$	-3.78 (-2.24)	-3.74 (-2.29)	1.85 (0.76)	
$\text{AR}\times 10^{-5}$	-4.20 (-0.24)		7.61 (0.28)	
$\text{AR}_{-1}\times 10^{-5}$	-9.80 (-0.77)		-14.36 (-0.63)	
$\text{AR}_{-2}\times 10^{-5}$	4.20 (0.32)		10.12 (0.51)	
$\text{OI}\times 10^{-9}$	-7.60 (-8.74)	-7.61 (-8.75)	-2.53 (-1.51)	-2.64 (-1.62)
$\text{Vol}\times 10^{-9}$	2.84 (1.75)	2.70 (1.96)	8.33 (2.78)	8.70 (3.13)
$\text{N}\times 10^{-5}$	-23.70 (-2.93)	-24.36 (-3.05)	-18.52 (-1.36)	-21.67 (-1.75)
$\text{R}\times 10^{-5}$	80.43 (7.15)	80.01 (7.38)	38.78 (2.16)	35.24 (2.03)
$\text{R}_{-1}\times 10^{-5}$	47.92 (5.91)	48.58 (6.15)	54.94 (4.08)	52.87 (3.91)
$\text{R}_{-2}\times 10^{-5}$	39.89 (3.86)	40.47 (3.87)	37.89 (2.26)	36.65 (2.26)
R^2	0.4949	0.4941	0.6125	0.6108
Adj R^2	0.4833	0.4858	0.6037	0.6052

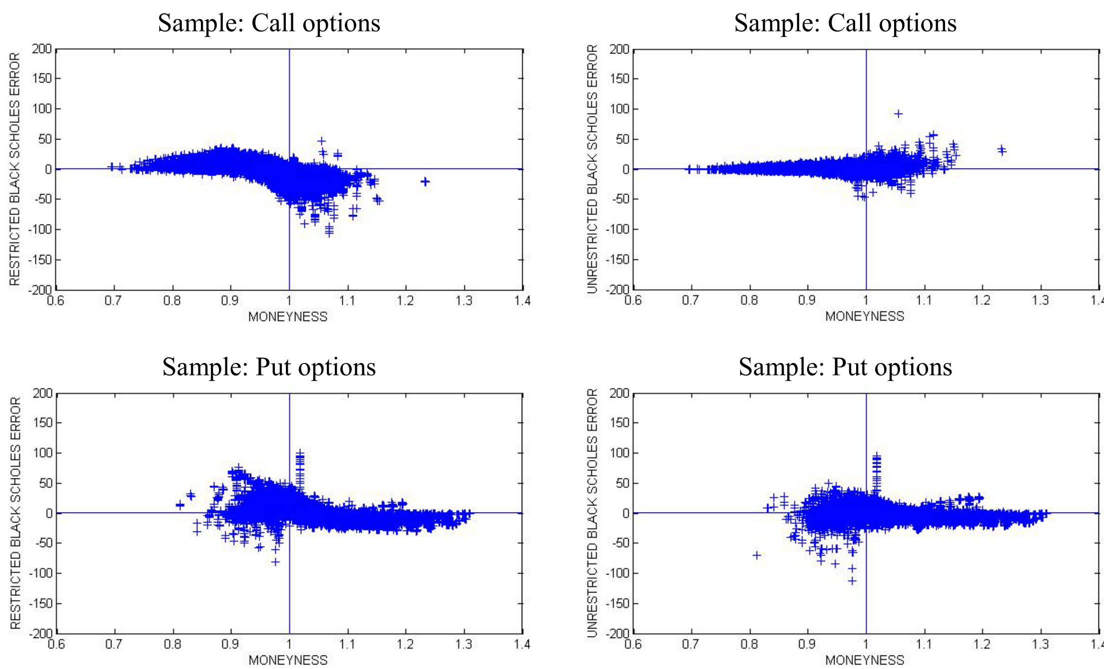
This table shows the regression result of Equation (4). Newey-West heteroscedasticity and autocorrelation robust t-statistics are shown in parentheses. Int is the regression intercept.

Table 3: Regression Results of Index Pricing Error from 2007 to 2008

	Call options				Put options			
Model	Equation (4)		Best fitting		Equation (4)		Best fitting	
$\text{Int}\times 10^{-2}$	27.39	(10.41)	28.48	(17.22)	-18.25	(-7.74)	-18.13	(-7.11)
$\text{M}\times 10^{-2}$	-27.12	(-10.50)	-28.14	(-16.64)	18.30	(7.89)	18.22	(7.48)
$\text{T}\times 10^{-5}$	2.94	(0.57)			16.88	(4.18)	16.91	(4.15)
$\text{AR}\times 10^{-5}$	16.45	(0.60)			11.64	(0.38)		
$\text{AR}_{-1}\times 10^{-5}$	13.40	(0.49)			8.65	(0.33)		
$\text{AR}_{-2}\times 10^{-5}$	18.20	(0.80)			25.92	(1.59)	27.78	(1.71)
$\text{OI}\times 10^{-9}$	-4.50	(-1.71)	-5.08	(-2.00)	-2.61	(-0.77)	-3.63	(-1.08)
$\text{Vol}\times 10^{-9}$	-11.72	(-2.26)	-10.32	(-2.39)	-10.26	(-1.72)	-9.09	(-2.46)
$\text{N}\times 10^{-5}$	-11.14	(-1.15)	-10.86	(-1.21)	9.02	(1.17)	8.81	(1.15)
$\text{R}\times 10^{-5}$	107.59	(4.04)	111.48	(4.74)	3.25	(0.21)		
$\text{R}_{-1}\times 10^{-5}$	43.39	(2.96)	44.10	(2.99)	-4.88	(-0.51)		
$\text{R}_{-2}\times 10^{-5}$	9.29	(0.60)			-5.94	(-0.59)		
R^2	0.7024		0.7005		0.6319		0.6311	
Adj R^2	0.6956		0.6968		0.6236		0.6266	

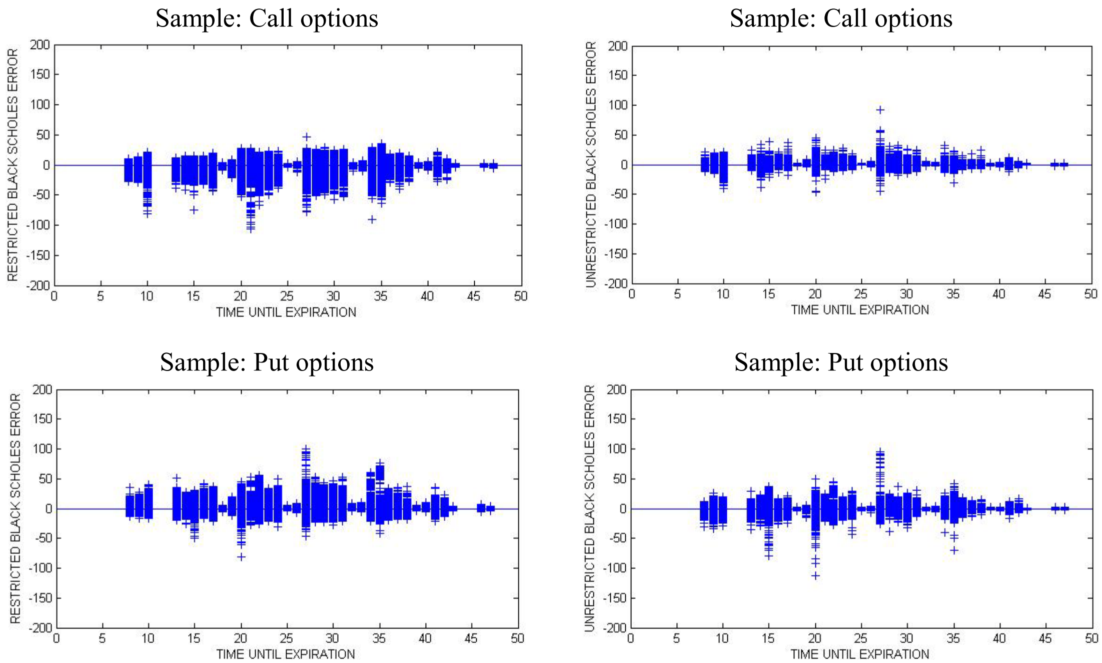
This table shows the regression result of Equation (4). Newey-West heteroscedasticity and autocorrelation robust t-statistics are shown in parentheses. Int is the regression intercept.

Figure 2: Option Pricing Error against the Moneyness of Options



The unrestricted model simultaneously solves the implied index value and implied volatility whereas the restricted model only solves the implied volatility. Option pricing error represents $\hat{P}-P$. *M is moneyness which equals F/K for call and K/F for put.*

Figure 3: Option Pricing Error against the Time to Expiration of Options



The unrestricted model simultaneously solves the implied index value and implied volatility whereas the restricted model only solves the implied volatility. Option pricing error represents $\hat{P} - P$.

Table 4: Regression of Option Pricing Errors on Moneyness (*F/K*) and Time to Expiration

Pricing Error	Est. Model	Int	M	T	R^2
Panel A: Call options					
$\hat{P} - P$	Restricted	100.81 (346.1)	-102.01 (-348.2)	-0.0702 (-50.03)	0.3373
	Unrestricted	5.84 (46.43)	-5.81 (-45.94)	-0.0041 (-6.72)	0.0088
$\vert \hat{P} - P \vert$	Restricted	11.18 (40.97)	-8.88 (-32.34)	0.0883 (67.11)	0.0273
	Unrestricted	-2.96 (-30.43)	4.34 (44.44)	0.0142 (30.32)	0.0101
$(\hat{P} - P)/P$	Restricted	2.49 (261.9)	-2.46 (-257.9)	-0.0018 (-39.58)	0.2182
	Unrestricted	0.0388 (7.56)	-0.0442 (-8.58)	0.0004 (16.02)	0.0017
$\vert (\hat{P} - P)/P \vert$	Restricted	2.76 (328.9)	-2.70 (-319.7)	-0.0024 (-59.14)	0.2996
	Unrestricted	0.9548 (219.7)	-0.91 (-209.0)	-0.0015 (-73.26)	0.1574
Panel B: Put options					
$\hat{P} - P$	Restricted	112.42 (391.1)	-111.26 (-398.1)	0.0685 (45.92)	0.4505
	Unrestricted	44.51 (218.9)	-44.48 (-225.0)	0.0363 (34.44)	0.2078
$\vert \hat{P} - P \vert$	Restricted	-27.43 (-100.8)	30.68 (116.0)	0.0424 (30.01)	0.0736
	Unrestricted	-15.17 (-84.72)	17.39 (99.9)	-0.0072 (-7.78)	0.0492
$(\hat{P} - P)/P$	Restricted	3.02 (444.3)	-3.10 (-469.9)	0.0047 (134.3)	0.5405
	Unrestricted	1.87 (316.7)	-1.93 (-336.1)	0.0036 (118.4)	0.3819
$\vert (\hat{P} - P)/P \vert$	Restricted	-2.64 (-394.5)	2.752 (423.1)	-0.0045 (-129.4)	0.4899
	Unrestricted	-1.73 (-305.5)	1.81 (328.4)	-0.0036 (-122.7)	0.3734

M is moneyness which equals F/K for call and K/F for put. The regression result is based on the ordinary least squares method. The t-statistics are shown in parentheses.

In Table 4, the moneyness is equal to *F/K* for calls and *K/F* for puts. In Table 5, the moneyness is equal to *F-K* for calls and *K-F* for puts. Whatever the explained variables are $\hat{P}-P$, $(\hat{P}-P)/P$, $|\hat{P}-P|$ and $|(\hat{P}-P)/P|$, Tables 4 and 5 show that the R-square in the restricted model is always much larger than the unrestricted model for both calls and puts. This fact infers that the option pricing errors for the unrestricted model are less affected by moneyness and time to expiration. It is worth mention that the option pricing errors are significantly affected by moneyness and time to expiration for all cases.

Table 5: Regression of Option Pricing Errors on Moneyness (F-K) and Time to Expiration

Pricing Error	Est. Model	Int	M	T	R^2
Panel A: Call options					
$\hat{P}-P$	Restricted	-1.27 (-42.20)	-0.0142 (-363.50)	-0.0749 (-54.13)	0.3568
	Unrestricted	0.02 (1.16)	-0.0009 (-53.21)	-0.0051 (-6.72)	0.0117
$\|\hat{P}-P\|$	Restricted	2.28 (79.75)	-0.0014 (-38.72)	0.0864 (65.69)	0.0292
	Unrestricted	-1.37 (-134.47)	0.0004 (31.96)	0.0131 (27.83)	0.0062
$(\hat{P}-P)/P$	Restricted	0.02 (261.9)	-0.0003 (-258.81)	-0.0019 (-40.67)	0.2193
	Unrestricted	-0.01 (9.62)	-0.0000 (-3.65)	0.0004 (17.00)	0.0014
$\|(\hat{P}-P)/P\|$	Restricted	0.06 (69.00)	-0.0004 (-319.32)	-0.0024 (-60.19)	0.2991
	Unrestricted	0.04 (89.05)	-0.0001 (-225.27)	-0.0016 (-77.73)	0.1780
Panel B: Put options					
$\hat{P}-P$	Restricted	1.14 (34.58)	0.0172 (405.76)	0.0769 (51.93)	0.4600
	Unrestricted	-0.10 (-4.08)	0.006 (192.74)	0.0358 (32.93)	0.1615
$\|\hat{P}-P\|$	Restricted	3.32 (104.95)	-0.0043 (-104.76)	0.0422 (29.65)	0.0623
	Unrestricted	2.34 (111.87)	-0.0019 (-68.77)	-0.0048 (-5.14)	0.0239
$(\hat{P}-P)/P$	Restricted	-0.09 (-109.17)	0.0005 (455.74)	0.0049 (136.99)	0.5255
	Unrestricted	-0.06 (88.72)	0.0003 (304.68)	0.0037 (115.87)	0.3384
$\|(\hat{P}-P)/P\|$	Restricted	0.12 (146.44)	-0.0004 (407.09)	-0.0046 (-131.10)	0.4710
	Unrestricted	0.08 (120.11)	-0.0003 (-297.99)	-0.003 (-120.06)	0.3310

M is moneyness which equals F-K for call and K-F for put. The regression result is based on the ordinary least squares method. The t-statistics are shown in parentheses.

CONCLUSIONS

This study tests the pricing error between the implied index and the actual index in Taiwan index options market. The paper analyzes the performance of the restricted and unrestricted Black-Sholes model in describing option prices. Using the Taiwan index options for each day from January 2005 to December 2008, the unrestricted model simultaneously solves the implied index value and implied volatility whereas the restricted model only solves the implied volatility. Next, this study compares the pricing performance of restricted and unrestricted Black-Scholes models. Finally, the regression of the option pricing error from the restricted and unrestricted models on moneyness and time to expiration is performed. The main results are summarized as follows.

First, the implied index value is almost higher than the actual index value; this implies that the cost of purchasing stock via the options market is more expensive than in the stock market. Second, moneyness has a significant negative impact on the index pricing error for calls but negative impact for puts. Third, the open interest is significantly negative impact on the index pricing error for calls. Fourth, in terms of volatility for calls, the current and first two lagged absolute daily returns on the index have no significant effect on the index pricing error. Fifth, the path-dependent effect on index pricing error increases with index returns. Six, based on the criterion of adjusted R-square, the optimal explanatory variables of index pricing error exclude the volatility proxies for calls. The optimal explanatory variables for the total sample period include *M*, *T*, AR_{-2}, *OI* and *N* for puts. Seventh, the option pricing error from restricted model decreases with the moneyness for calls. The unrestricted model has significantly less option pricing bias for calls than the restricted model. The option pricing error for calls in restricted model has much larger negative bias near the middle maturity. Eighth, the R-square in the restricted model is always much larger than the unrestricted model for both calls and puts. Finally, the option pricing errors are significantly affected by moneyness and time to expiration for all cases; this fact is consistent with Longstaff (1995).

REFERENCES

Black, F. and Scholes, M. (1973), The pricing of options and corporate liabilities. *Journal of Political Economy*, 8, 1637–1659.

Busch, T, (2008), Testing the martingale restriction for option implied densities. *Review of Derivatives Research*, 11, 61–81.

Canina, L. and Figlewski, S. (1993), The informational content of implied volatility. *Review of Financial Studies*, 6, 659–681.

Corrado, C. (2007), The hidden martingale restriction in Gram-Charlier Option Prices. *Journal of Futures Markets*, 27, 517–534.

Harrison, J.M. and Kreps, D.M. (1979), Martingales and arbitrage in multiperiod securities markets. *Journal of Economic Theory*, 20, 381–408.

Longstaff, F.A. (1995), Option pricing and the martingale restriction. *Review of Financial Studies,* 8, 1091–1124.

Macbeth, J.D. and Merville, L.J. (1980), Tests of the Black-Scholes and Cox call option valuation models. *Journal of Finance*, 35, 285–300.

Merton, R. C. (1973), Theory of rational option pricing. *Bell Journal of Economics and Management Science*, 4, 141–183.

Rubinstein, M. (1985), Nonparametric tests of alternative option pricing models using all reported trades and quotes on the 30 most active CBOE option classes from August 23, 1976 through August 31, 1978. *Journal of Finance*, 40, 455–480.

Samuelson, P.A. (1965), Proof that properly anticipated prices fluctuate randomly. *Industrial Management Review*, 6, 41–49.

Strong, N. and Xu, X. (1999), Do S&P 500 index options violate the martingale restriction. *Journal of Futures Markets*, 19, 499–521.

Turvey, C.G. and Komar, S. (2006), Martingale restrictions and the implied market price of risk. *Canadian Journal of Agricultural Economics*, 54, 379–399.

Ville-Goyets, C., Dhaene, G. and Sercu, P. (2008), Testing the martingale hypothesis for futures prices: implications for hedgers. *Journal of Futures Markets*, 28, 1040–1065.

ACKNOWLEDGEMENT

The authors wish to thank the editor and the anonymous reviewers for their excellent comments, resulting in a significant improvement in the quality of this paper.

BIOGRAPHY

Ching-Ping Wang, Correspondence Author, Associate Professor in Graduate Institute of Commerce, National Kaohsiung University of Applied Sciences; No. 415, Jiangong Rd., Sanmin District, Kaohsiung City 80778, Taiwan; E-mail: cpwang@cc.kuas.edu.tw; Fax: +886-7-3814526.

Hung-Hsi Huang, Professor in Graduate Institute of Finance, National Pingtung University of Science and Technology; No. 1, Hseuhfu Rd., Neipu, Pingtung 91201, Taiwan; E-mail: d86723002@ntu.edu.tw; Fax: +886-8-7740236; Tel: +886-8-7740236.

Chien-Chia Hung, MBA student in Graduate Institute of Finance, National Pingtung University of Science and Technology; No. 1, Hseuhfu Rd., Neipu, Pingtung 91201, Taiwan; E-mail: senka0921@yahoo.com.tw.

REVIEWERS

The IBFR would like to thank the following members of the academic community and industry for the much appreciated contribution as reviewers.

Vera Adamchik
University of Houston-Victoria
Yousuf Al-Busaidi
Sultan Qaboos University
Glyn Atwal
Groupe Ecole Supérieure de Commerce de Rennes
Susan C. Baxter
Bethune-Cookman College
Karel Bruna
University of Economics-Prague
Wan-Ju Chen
Diwan College of Management
Leonel Di Camillo
Universidad Austral
Steven Dunn
University of Wisconsin Oshkosh
William Francisco
Austin Peay State University
Lucia Gibilaro
University of Bergamo
Danyelle Guyatt
University of Bath
Zulkifli Hasan
Islamic University College of Malaysia
Tejendra N. Kalia
Worcester State College
Ann Galligan Kelley
Providence College
Halil Kiymaz
Rollins College
Bohumil Král
University of Economics-Prague
Christopher B. Kummer
Webster University-Vienna
Mary Layfield Ledbetter
Nova Southeastern University
Xin (Robert) Luo
Virginia State University
Andy Lynch
Southern New Hampshire University
Cheryl G. Max
IBM
Avi Messica
Holon Institute of Technology
Cameron Montgomery
Delta State University
Bilge Kagan Ozdemir
Anadolu University
Dawn H. Pearcy
Eastern Michigan University
Rahim Quazi
Prairie View A&M University
Anitha Ramachander
New Horizon College of Engineering
Kathleen Reddick
College of St. Elizabeth
Matthew T. Royle
Valdosta State University
Tatsiana N. Rybak
Belarusian State Economic University
Rafiu Oyesola Salawu
Obafemi Awolowo University
Paul Allen Salisbury
York College, City University of New York
Sunando Sengupta
Bowie State University
Smita Mayuresh Sovani
Pune University
Jiří Strouhal
University of Economics-Prague
Ramona Toma
Lucian Blaga University of Sibiu-Romania
Jorge Torres-Zorrilla
Pontificia Universidad Católica del Perú
K.W. VanVuren
The University of Tennessee – Martin
Veronda Willis
The University of Texas at San Antonio
Eduardo Sandoval
Universidad de Concepción
M. Shahadat Hossain
SUNY Potsdam

ARBITROS

El IBFR agradece a los siguientes miembros de nuestro cuerpo de *Ad-Hoc Reviewers* por su contribución académica.

María Antonieta Andrade Vallejo
Instituto Politécnico Nacional
Olga Lucía Anzola Morales
Universidad Externado de Colombia
Antonio Arbelo Alvarez
Universidad de la Laguna
Hector Luis Avila Baray
Instituto Tecnologico De Cd. Cuauhtemoc
Graciela Ayala Jiménez
Universidad Autónoma de Querétaro
Sheila Nora Carrillo Incháustegui
Univ. Peruana Cayetano Heredia
María Antonia Cervilla de Olivieri
Universidad Simón Bolívar
Semei Leopoldo Coronado Ramírez
Universidad de Guadalajara
Tomás J. Cuevas-Contreras
Universidad Autónoma de Ciudad Juárez
Javier de León Ledesma
Univ. de Las Palmas de Gran Canaria -Tafira
Carlos Fong Reynoso
Universidad de Guadalajara
Arturo Hernández
Universidad Tecnológica Centroamericana
Lourdes Jordán Sales
Universidad de Las Palmas de Gran Canaria
Santiago León Ch.,
Universidad Marítima del Caribe
Graciela López Méndez
Universidad de Guadalajara-Jalisco
Virginia Guadalupe López Torres
Univ. Autónoma de Baja California
Angel Machorro Rodríguez
Instituto Tecnológico de Orizaba
Omaira Cecilia Martínez Moreno
Univ. Autónoma de Baja California
Alaitz Mendizabal Zubeldia
Univ. del País Vasco/ Euskal Herriko U.
Juan Nicolás Montoya Monsalve
Univ Nacional de Colombia-Manizales
Alberto Elías Muñoz Santiago
Fundación Universidad del Norte
Juan Carlos Robledo Fernández
Universidad EAFIT-Medellin
Universidad Tecnologica de Bolivar
José Gabriel Ruiz Andrade
Univ. Autónoma de Baja California
Juan Manuel San Martín Reyna
Univ. Autónoma de Tamaulipas
Francisco Sanches Tomé
Instituto Politécnico da Guarda
Deycy Janeth Sánchez Preciado
Universidad del Cauca
María Cristina Sánchez Romero
Instituto Tecnológico de Orizaba
Pol Santandreu i Gràcia,
Universitat de Barcelona
Santandreu Consultors
Victor Gustavo Sarasqueta
Universidad Argentina de la Empresa UADE
Jaime Andrés Sarmiento Espinel
Universidad Militar de Nueva Granada
Lorena Vélez García
Universidad Autónoma de Baja California
Alejandro Villafañez Zamudio
Instituto Tecnologico de Matamoros
Hector Rosendo Villanueva Zamora
Universidad Mesoamericana
Alfonso Rodríguez Ramírez
Universidad Libre Seccional Cali
Neyda Cardozo Sánchez
Universidad Nacional Experimental de Táchira
Benjamin Castillo Osorio
Universidad del Sinú-Sede Monteria
Luz Stella Pemberthy Gallo
Universidad del Cauca
Adolfo León Plazas Tenorio
Universidad del Cauca
Luis Eduardo Sandoval Garrido
Universidad Militar de Nueva Granada
Oskar Villarreal Larrinaga
Univ. del País Vasco/Euskal Herriko Univ.
Adriana del Carmen Rodríguez Guardado
Universidad de Guadalajara

HOW TO PUBLISH

Submission Instructions

The Journal welcomes submissions for publication consideration. Authors wishing to submit papers for publication consideration should e-mail their manuscripts to editor@theIBFR.com. Complete directions for manuscript submission are available at the Journal website www.theIBFR.com. Papers may be submitted for initial review in any format. However, authors should take special care to address spelling and grammar issues prior to submission. Authors of accepted papers are required to precisely format their document according to the guidelines of the journal.

There is no charge for paper reviews. The normal review time for submissions is 90-120 days. However, authors desiring a quicker review may elect to pay an expedited review fee. Authors who pay the expedited review fee are guaranteed an initial review within two weeks of submission and receipt of the fee. Authors of accepted papers are required to pay a publication fee based on the length of the manuscript. Please see our website for current publication and expedited review rates.

Authors submitting a manuscript for publication consideration must guarantee that the document contains the original work of the authors, has not been published elsewhere, and is not under publication consideration elsewhere. In addition, submission of a manuscript implies that the author is prepared to pay the publication fee should the manuscript be accepted.

Subscriptions

Individual and library subscriptions to the Journal are available. Please contact us by mail or by email to: admin@theibfr.com for updated information.

Contact Information

Mercedes Jalbert, Managing Editor
The IBFR
P.O. Box 4908
Hilo, HI 96720
editor@theIBFR.com

Website

www.theIBFR.org or www.theIBFR.com

PUBLICATION OPPORTUNITIES

Review of Business & Finance Case Studies

Review of Business and Finance Case Studies publishes high-quality case studies in all areas of business, finance and related fields. Cases based on real world and hypothetical situations are welcome.

All papers submitted to the Journal are double-blind reviewed. The RBFCS is listed Cabell, Ulrich's Periodicals Directory. The Journal is distributed through SSRN and EBSCO*Host* publishing, with presence in over 70 countries.

The journal accept rate is between 15 and 25 percent

Business Education and Acreditation (BEA)

Business Education & Accreditation publishes high-quality articles in all areas of business education, curriculum, educational methods, educational administration, advances in educational technology and accreditation. Theoretical, empirical and applied manuscripts are welcome for publication consideration.

All papers submitted to the Journal are double-blind reviewed. BEA is is listed Cabell, Ulrich's Periodicals Directory. The Journal is distributed through SSRN and EBSCO*Host* publishing, with presence in over 70 countries.

The journal acceptance rate is between 15 and 25 percent.

Accounting and Taxation (AT)

Accounting and Taxation (AT) publishes high-quality articles in all areas of accounting, auditing, taxation and related areas. Theoretical, empirical and applied manuscripts are welcome for publication consideration.

All papers submitted to the Journal are double-blind reviewed. BEA is listed Cabell, Ulrich's Periodicals Directory. The Journal is distributed through SSRN and EBSCO*Host* publishing, with presence in over 70 countries.

The journal acceptance rate is between 5 and 15 percent.