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Essays in Finance

邱琦倫

Chyi-Lun Chiou

指導教授：洪茂蔚 博士

Advisor: Mao-Wei Hung, Ph.D.

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中文摘要

長久以來，財務經濟學對於股票報酬率是否存在可預測性一直存在爭議。與此同時，近年來股價異常波動的行為也吸引許多學者的關注。相較於報酬率的可預測性，文獻對於資產報酬的波動性具有較高的共識。依據傳統的資產訂價理論，高風險對應高報酬，由股價波動衡量資產報酬也是一種合理的評價方法。本篇研究主要的目的在於利用不同風險的概念，探討資產報酬的行為特性。除了系統性風險之外，本篇著重於非系統性風險（個別風險）的討論。我們將藉由兩個面相進行分析。首先，我們將以公司的獲利性出發，分析獲利性的變動如何影響資產的報酬。其次，我們將由公司的投資決策思考，分析投資的不確定性如何主導資產的價值與行為。前者的經濟直覺源於公司的價值由其獲利性主導。後者則主張公司的價值是由其擁有的資產決定。研究顯示，獲利性的波動與投資的不確定性在資產報酬行為上提供完全相反的訊息。

首先，在本文的第二章中，我們將利用報酬波動的訊息分析股票的預期報酬。依據 Pástor and Veronesi (2003)所建立的評價模型之中，ROE（股東權益報酬率）的波動值與帳面市值比具有一個負向關係，同時該波動值也會影響資產的平均報酬與變異數。研究顯示，ROE 波動值與未來股票報酬率呈現顯著的負相關。更重要的是，相較於每股盈餘或股利收益率等傳統預測因子，該相關性並不會因加入市值規模與帳面市值比等以價格為基礎的解釋變數而消失。依據 Wei and Zhang (2006)的研究顯示，ROE 波動值可以真實反映資產報酬波動的特性，尤其是個別風險的部分。因此，透過 ROE 波動值的訊息將有助於我們瞭解非系統性風險的評價問題。

接著，在本文的第三章中，我們將分析投資的不確定性如何影響報酬的行為。此篇結合投資與流動性風險的概念探討投資不確定性如何主導資產價值。投資不確定性一方面可以提高等候投資的價值，另一方面卻會因融資的限制而降低

該價值。兩相權衡之下，公司必須選擇一個次佳點進行投資的動作。相較於其他投資與融資的研究，本篇主張在融資限制之下投資不會被迫放棄，而是可以選擇遞延。研究顯示，當投資不確定性愈高時，股票報酬也會愈高。

關鍵字：股票報酬可預測性； 個別風險； 獲利性； 學習效果； 投資不可逆性； 股東權益報酬波動值； 預期收益波動值。

Thesis Abstract

In asset pricing, it is well known that stock return and return volatility vary over time. Literature concerns issues abut whether stock returns are predictable and why stock returns are so volatile. Some literature focuses on the relationship between return and risk to examine how assets are priced. In particular, among these literatures systematic risks and idiosyncratic risks provide different explanations to stock returns. Examining the stock return behavior is critical in that asset allocation and hedge strategy are related to this evolution. The primary objective of this thesis is to investigate the stock return predictability base on firm level analysis. This thesis provides two different schemes in discussing this issue, including profitability base and investment base framework. The former states that the valuation of firm is from it profitability, while that latter asserts that the firm's value is from assts that it holds. We investigate that return-on-equity and investment uncertainty govern the evolution of stock price in an opposite way. Overall, in addition to systematic risks we confirm that it is critical to analyze idiosyncratic risks in valuation.

The first part of this dissertation is to examine the stock return predictability through means of volatile volatility. Based on the work of Pástor and Veronesi (2003), we find that the book-to-market ratio and the price evolution, including average stock return and return volatility, are governed by the firms' profitability. It is straightforward to analyze stock returns by discussing firm's return-on-equity. Evidence shows that in addition to size and value effects, variation in return-on-equity has the predictability in stock returns. We further demonstrate that this connection may contribute to the equity cash flow perspective and the risk argument of book-to-market ratio.

The second part of my dissertation incorporates investment issue in examining stock return behavior. Although recent studies has successfully proved that the value effect results from corporate investment decision, the association between investment uncertainty and stock returns is rarely touched. With irreversibility of investment and learning-by-doing effect, we show that less investment uncertainty follows lower stock returns. If firms face financial constraint in expansion, more investment uncertainty may force them to make suboptimal investment decisions and have more systematic risks.

Keyword: Stock return predictability; Idiosyncratic risks; Profitability; Learning-by-doing; Irreversibility; Variation in return-on-equity; Expected earning volatility.

Contents

Figures

Tables

Chapter 1

Introduction

In asset pricing it is well known that stock returns and return volatility vary over time. Literature concerns issues about whether stock returns are predictable and why stock returns are so volatile. These two issues have generated much attention not only because they relate to gains of investing but also because they have great impacts on hedging demand. Prior literature has applied aggregate macroeconomics point of view and firm level characteristics to examine these issues. The former aims at discussion about systematic risks, while the latter is plausible to investigate idiosyncratic risks. Researchers have noted that firm-level analysis provide more insights. Compared with volatile stock returns, the predictability of stock returns remains doubt.

We attempt to examine the behavior of stock returns based on two distinct schemes in this thesis. On the one hand, we try to rely on information from volatile stock returns to investigate average stock returns. On the other hand, we incorporate investing and financing problem to explore return behavior. These two topics have one thing in common: they both associate with idiosyncratic risks. As a result, both of them face the identical problem why idiosyncratic risks need to be priced. However, these two schemes describe stock returns in opposite ways. In the first part of this thesis, we apply information from profitability to explore the behavior of stock returns, including average returns and return volatility, and the book-to-market ratio. Our intuition relies on the fact that the valuation of a firm is from its profitability so that the valuation ratio and price evolution are governed by firm's performance.

Referring to this connection, prior literature shows that the variation in return-on-equity is good at describing the upward trend of stock return volatility, especially the idiosyncratic stock return volatility (Campbell, Lettau, Malkiel, and Xu, 2001). Applying the variation in return-on-equity as proxy of idiosyncratic return volatility, we find there is a significantly negative association between this variation and average stock returns. Furthermore, we provide two explanations from book-to-market ratio to identify this negative relation, including the equity cash flow perspective and the risk argument. This research not only examines the relation between idiosyncratic risks and stock returns but also confirms the fact that the usefulness of book-to-market ratio is original from the variation in return-on-equity.

In the second part of this thesis, we incorporate investment decision in the firm valuation. Recent studies has successfully applies corporate investment to explain the value effect (Berk, Green, and Naik, 1999). At the same time, the issue about how investment uncertainty affects investment decision has generated much attention in prior literature. The connection between investment uncertainty and stock returns, however, is rarely investigated. The critical point is that the relation between uncertainty and investment is inclusive. In this research we incorporate investment and liquidity issues to examine how investment uncertainty affects the stock returns. If a firm has financial constraint in expansion, today's investment opportunities cannot be exercised even though they are profitable. With the flexibility to postpone, the relationship between investment and liquidity can be altered. Evidence shows that liquidity constraint will force firms to make suboptimal investment decisions because investment uncertainty not only represents variation in future profit but also stands for potential future cash flow shortfall. Higher stock returns induced by more investment uncertainty may result from exposing to more systematic risks or having higher cost of capital.

The organization of this thesis is as follows. We examine how and why the variation in return-on-equity, proxy of idiosyncratic return volatility, predicts average stock returns in Chapter 2. Incorporating investment and liquidity issue, we investigate how and why the expected earning volatility associates with average stock returns in Chapter 3. Some main conclusion remarks are presented in the final chapter.

Chapter 2

The Predictive Ability of Variation in Return-on-equity for Stock Returns

2.1 Abstract

We examine the predictive power of the variation in return-on-equity for stock returns based on the implication of volatility feedback effect. Consistent with the rational valuation framework of Pástor and Veronesi (2003), we shows that portfolios sorted independently by size and book-to-market ratio are conditional on the variation in return-on-equity. We also empirically investigate that the variation in return-on-equity is useful in explaining portfolios stock returns as well as the individual stock returns on the cross section. We further shows that the predictive power of variation in return-on-equity is explained by the risk proxy argument and the equity cash flow perspective of book-to-market ratio. Moreover, the driving force behind these two perspectives about the value and size effect should rely on the connection between the variation in return-on-equity and the behavior of future cash flow. This supports relevance of fundamental accounting information about firm characteristics for explaining stock returns and indicates their application of predicting stock returns. Finally, evidence attributes to examine the relation between return volatility and expected returns in the cross section.

2.2 Introduction

To examine the behavior of asset return, return predictability and excess volatility, is the main issue in the asset pricing literature. Researchers are also interested in documenting the association between risk and returns. It has long been recognized that both the expected stock return and its variation vary over time. Campbell, Lettau, Malkiel, and Xu (2001) find that the level of average stock return volatility has been increasing over time since 1960s. It seems plausible that varying return volatility may have important effects on required stock returns as well as the level of stock prices. The so-called volatility feedback effect suggests that stock price movements are associated with future volatility. Indeed, French, Schwert, and Stambaugh (1987), and Campbell and Hentschel (1992) find that asset returns and innovations from return volatility are negative correlated. If the volatility feedback effect is reliable, it may be useful to examine the return predictability issue through analysis of excess volatility.

The issue about return predictability faces a big challenge in the late of 1990s. There is a historically unprecedented rise in stock prices and other price-based ratio such as price/dividend ratio and price/earning ratio during these years. This rise has reduced the post-war return forecasting regression coefficient in half and weakened the predictive power of these ratios.[1] At the same time, stock returns become more volatile in decades. In particular, Campbell, Lettau, Malkiel, and Xu (2001) show that the idiosyncratic stock return volatility has increased over time, while the volatility of stock market returns remains stable. Pástor and Veronesi (2003) (cross-sectional relations) and Wei and Zhang (2006) (time-series relations) examine that this volatile stock returns result from the increasing volatility of return-on-equity. If the association between variation in return-on-equity and return volatility is reliable (cross-sectional or

[1] Because of the weak forecasting performance of price-dividend ratio, Lettau and Ludvigson (2002) construct a new proxy, log consumption-aggregate wealth ratio to predict stock returns.

time-series), it is straightforward to examine return predictability through the analysis of variability in profitability.

Despite the well-developed of research on the formal model of volatility feedback, we do not rely our analysis on the level of stock return volatility directly. In contrast with previous studies, we investigate the role of profitability on stock returns as this indicator can be directly linked to the excess volatility. In particular, this non-price measure induces firms to refine their performance and improves effectiveness of accounting information. Most importantly, it identifies that the behavior of stock returns can be explained by the changes of fundamental variables. Based on the rational valuation framework, Pástor and Veronesi (2003) show that market-to-book ratio and the dynamics of stock returns are governed by the firms' profitability. They demonstrate that market-to-book ratio and return volatility increase with the total volatility of profitability; however, expected excess returns is only driven by systematic risk of profitability. If stock return volatility is driven by variation in return-on-equity as suggested by Pástor and Veronesi (2003), it seems plausible to analyze the volatile trend of return variance by discussing profitability. Indeed, Wei and Zhang inherit this concept and demonstrate that the downward trend in the level of return-on-equity and the upward trend in the volatility of return-on-equity attribute to the more volatile stock returns found in recent years. In this study, we apply the source of increasing stock return volatility, the variation in return-on-equity, as a reliable measure of idiosyncratic volatility to investigate the issue of return predictability.

There are still other possible measures of risk. French, Schwert, and Stambaugh (1987) examine other three indicators, including the variation in the real interest rate, the covariance between stock market return and consumption, and the variability of decile portfolios formed on the basis of firm size. Perhaps because of the estimation problem, none of these variables provides relevant evidence to support the association between risk and return. In addition, many researchers explore the power of capital asset pricing model beta. Fama and French (1992), however, find that the cross sectional stock returns have no significant relationship with the capital asset pricing model beta. In particular, their finding of the superior explanation power of size and book-to-market for expected stock returns to estimates of CAPM beta then generates much literature concerned with the fundamentals of firm in determining stock prices. Opinions about the size and value effects can be roughly classified into three strands, including risk proxy argument (for example, Fama and French, 1993 and 1995; and Zhang, 2005)[2], market mispricing argument (for example, Lakonishok, Shliefer, and Vishny, 1994), and cash flow perspective (for example, Berk, 1995; Pontiff and Schall, 1998; Biddle and Hunt, 1999; and Clubb and Naffi, 2007). Yet a consistent explanation for the Fama-French results remains a controversial issue.

In this paper, we apply the association between variation in return-on-equity and book-to-market ratio to investigate the predictive power of uncertainty for expected stock returns. We follow the intuition of Pástor and Veronesi (2003) that the book-to-market ratio is governed by the behavior of profitability. Moreover, we relies on the cash flow perspective and the risk argument to examine relevant information behind this indicator. It is straightforward to examine the behavior of stock returns by discussing firm's profitability as suggested by Fama and French (1995). However, we relies on information from the variability of profitability, while the latter focuses on its

[2] Fama and French (1992, 1993) state that the book-to-market ratio is a risk factor because this ratio is related to relative financial distress. Zhang (2005) proposes that book-to-market ratio can represent systematic risks of the firm because it reflects how difficult a firm to adjust its capital stock in business cycle.

mean value. According to their studies, we try to answer two specific questions. The first question is how the variation in return-on-equity is associated with the expected stock returns. The second question is why the variation in return-on-equity has the predictive power for stock returns.

First of all, we document empirical association among volatility of return-on-equity, market values, and book-to-market ratios on firm level. Specifically, we find that sorting stocks to forming portfolios by Fama-French approach seems to be conditional on the variation in return-on-equity. Controlling for size, firms classified as growth stocks significantly experience large variation in return-on-equity prior to the portfolio formation year, while value stocks sustain less variation in return-on-equity. This finding is consistent with the implication from the valuation model of Pástor and Veronesi (2003) that book-to-market ratios and volatility of profitability have a negative association. They assert when the clean surplus relation holds for accounting earnings, the growth rate of book equity is profitability (return-on-equity) minus the dividend yield such that the book-to-market ratio decreases with the variation in return-on-equity.

It is worthy to note that our focus is different to the issue of Pástor and Veronesi (2003) and Wei and Zhang (2006). We attempt to investigate the predictive ability of the variation in return-on-equity on the subsequence stock returns in this study, while they aim at finding the explanatory power of the variation in return-on-equity to the idiosyncratic return volatility.[3] Moreover, our driving force behind the negative association between uncertainty and book-to-market is somewhat different to Pástor and Veronesi (2003). In particular, we analyze the volatility of profitability and propose

[3] Because of the idiosyncratic nature of learning in their model, Pástor and Veronesi (2003) state that the uncertainty about average profitability has no effect on the expected stock returns.

that a large variation in return-on-equity decreases book-to-market because it predicts higher growth rates in book equity, earning, and profitability in the future. On the contrary, Pástor and Veronesi (2003) explore the issue of uncertainty about mean profitability. By introducing learning about average profitability, Pástor and Veronesi (2003) examine that market-to-book ratio increase with uncertainty about average profitability.

Second, we show that average stock returns are significantly related to firm-specific variation in profitability both for portfolios based on sorts and for returns on individual stock in the cross section. We demonstrate that variation in return-on-equity provides additional explanatory power to the cross-sectional monthly stock returns even though other prices related factors are under consideration. Evidence shows that large variation in return-on-equity significantly predicts lower stock returns in the subsequence periods. In particular, our study differs from previous research (Biddle and Hunt,1999; and Clubb and Naffi, 2007) in that we find adding the volatility of return-on-equity, plausible proxy for expected cash flow, does not enhance the value effects in the cross section. On the contrary, the value effect becomes weak within portfolios sorted by profitability volatility.

Finally, we investigate why higher variation in return-on-equity forecasts lower expected stock returns. Mechanically, returns must be governed either by cash flow news or discount rate news. However, in an efficient market, cash flow news is largely idiosyncratic while discount rate changes are common across firm. As a result, stock returns react negatively to volatile profitability only if variation in return-on-equity is associated with lower cash flow. Consistent with the cash flow perspective of Berk (1995), we find large variation in return-on-equity significantly forecasts lower profitability in the near future. In addition, we also investigate the risk argument of book-to-market to discuss the predictive power of uncertainty. Based on the neoclassical framework, Zhang (2005) proposes that because of costly reversibility and countercyclical price of risk value firms have trouble in reducing capital stock in bad times and do not invest even in good times. Thus book-to-market ratio can reflect systematic risks of the firm by discussing difference on investment activity. According to the finding of Anderson and Garcia-Feijóo (2006), growth firms seem to exercise more growth options around the portfolio formation period, while value firms try to contract. Consistent with the risk argument of book-to-market, our evidence shows that more volatile profitability also stimulates firms to involve in more investment activities. We provide another explanation that any difference on investment activity between growth firms and value firms may attribute to the negative association between variation in return-on-equity and book-to-market ratio. Moreover, uncertainty reveals information about future profitability, including mean value and volatility.

Our study makes two main contributions to the literature. First, our finding can complement to the literature of stock returns predictability. We provide an non-price indicator based on profitability to forecast subsequence stock returns. Moreover, this non-price indicator is good at describing the trend in return volatility that makes it more attractive. We indirectly prove that there is a negative association between volatility and expected stock returns in the cross section. A related issue of Ang, Hodrick, Xing, and Zhang (2006) states that stocks with high sensitivities to innovation in aggregate volatility have higher idiosyncratic volatility and lower average stock returns if the market price of volatility risk is negative. Our standpoint is distinct. Based on the framework of Pástor and Veronesi (2003), our finding provides a powerful evidence to support that book-to-market ratio may serve as proxy for systematic risk.[4] Based on their closed-form solution, they show that book-to-market ratio decreases with the instantaneous variance of profitability but increases with the product of market price of risk and volatility of profitability, the critical determinant of expected stock returns, if profitability is well defined.[5] In their framework, profitability involves two kinds of risks, systematic shock and idiosyncratic shock, while excess stock returns only compensates for systematic risk.[6] If market price of risk is positive, stocks with large and positive sensitivity to aggregate shocks should have high average returns. Over our sample periods, growth firms tend to have volatile profitability and earn lower stock returns while value firms seem to experience less volatile profitability and have higher stock returns. Our intuition is that value firms are more sensitive to aggregate shocks but face less idiosyncratic shocks. While the former makes they to earn higher stock returns, the latter makes they to have higher book-to-market ratio. On the contrary, growth firms with lower book-to-market ratio earn lower sock returns because they are less sensitive to aggregate shocks but have large idiosyncratic shocks.[7] Overall, value stocks have higher systematic risks than growth stocks such

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[4] The systematic risk prospective of book-to-market ratio is original from Berk, Green, and Naik (1999). Their point of view relies on the analysis of a firm's investment activities. Gomes, Kogan, and Zhang (2003), Zhang (2005) and Cooper (2006) also apply similar idea to explain the value premium by analyzing a firm's investment decision. In contrast, Pástor and Veronesi (2003) do not investigate the firm's investment policy in analysis book-to-market ratio. Their model is from the traditional asset pricing research that stock valuation is governed by discount rate and cash flow. By setting suitable process for profitability and stochastic discount factor, book-to-market ratio can be associated with systematic risk.

[5] Zhang (2005) proposes that because the market price of risk is countercyclical, the value premium is high in bad times when the price of risk is large.

[6] Pástor and Veronesi (2003) do not investigate the firm's investment decision but simple assume profitability is mean-reverting. This implies the existing capital or asset in place involves two kinds of risks, systematic risk and idiosyncratic risk.

[7] Another explanation is that the market price of volatility risk is negative. Ang, Hodrick, Xing, and Zhang (2006) state that the price of aggregate volatility risk is negative so that stocks more sensitive to volatility risk should have low average returns. Aggregate volatility risk is priced with negative sign because risk-averse agents reduce current consumption to increase precautionary saving when facing more uncertainty about future market returns. In this case, however, we cannot identify that

that they earn higher average returns.

This evidence is also consistent with Cooper (2006) that high book-to-market firms are more sensitive to aggregate shocks and have higher systematic risks if capital investment is largely irreversible. In his model, systematic risks rely on the firm's excess capital capacity, which evolves according to shocks of the firm's profitability. He proposes that because a firm's book-to-market ratio is associated with its excess capital capacity, it may serve as a proxy for its systematic risks. In sum, our empirical evidence is complement to the theoretical work of Pástor and Veronesi (2003) that counts on the analysis of profitability. We show that volatile profitability accompanies with lower book-to-market ratio due to the positive association between variation in return-on-equity and growth rate of book equity. Moreover, higher volatility of return-on-equity accounts for lower expected stock returns in the cross section because it predicts lower profitability in the subsequence periods. Future profitability is positively associated with expected stock returns because it represents a higher expected payoff that must be discounted at a higher expected return for a given current market value.

Second, our finding also amplifies the cash flow perspective and the risk argument on the book-to-market ratio's ability to predict expected stock returns. We find both the volatility of return-on-equity and book-to-market ratios are good at predicting future stock returns. While the former has a negative association with expected returns, the latter provides a positive connection. More specifically, we find the volatility of return-on-equity and the level of book equity provide an opposite explanation to current investment activity, future cash flow, and future growth rate of

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book-to-market ratio is a proxy of systematic risks.

book equity, earnings, and profitability. Consistent with the cash flow perspective of Pontiff and Schall (1998), evidences shows that higher book equity predicts higher average profitability such that firms with higher book-to-market earn higher returns. In contrast, when firms have large variation in profitability, their average future profitability will be low. According to the basic idea of Pástor and Veronesi (2003) that book-to-market ratios decrease with the growth rate of book equity, we find the growth rates of book equity, earnings, and profitability increase with the volatility of return-on-equity but decrease with the level of book equity. All these evidences not only provide some possible explanations for the predictive power of variation in profitability for expected stock returns but also enhance the cash flow perspective on the book-to-market ratio's ability to predict stock returns in which book equity plays an important role. In addition, we find the cash flow perspective and the risk argument of book-to-market have one similarity reflecting on investment activity. According to the theoretical work of Berk, Green, and Naik (1999) and the empirical evidence of Anderson and Garcia-Feijóo (2006), firms with lower book-to-market have lower stock returns because they own and exercise numbers of profitable investment opportunities. Making profitable investments can reduce the average systematic risk of the firm's cash flow in subsequence period, which in turn on average makes stock returns lower. Our evidence also shows that firms with higher variation in profitability or lower book equity can invest more. A possible explanation is that firms with volatile profitability or lower book equity are expected to have lower risk-adjusted discount rates or higher growth rate on profitability, which in turn make investments more attractive.

The paper proceeds as follows. We introduce our motivation with a brief review of the related literature in Section 3. Section 4 describes our measure of variation in return-on-equity and methodology for the analysis of the association between uncertainty, market value, and book-to-market ratio. In Section 5 we investigate some characteristics embodied in the variation in return-on-equity. In Section 6 we investigate whether the variation in return-on-equity affects the subsequence stock returns. In Section 7 we examine why the variation in return-on-equity has the predictive power to stock returns by discussing the risk argument and the equity cash flow perspective of book-to-market ratio. Concluding remarks are shown in Section 8.

2.3 Literature Review

To understand how variation in return-on-equity relates to subsequence stock returns, we relies on the association between profitability and book-to-market ratio. In this section we summarize few explanations of previous research why book-to-market can serve as a predictor of stock returns that is useful to identify the information behind this profitability uncertainty. For the cash flow fundamental perspective, recent literature apply similar framework in discussing the role of book-to-market ratio. They try to perform book-to-market ratio in terms of some fundamental variables they are interested in; then they explain the value effect by discussing properties of these fundamental variables among firms. Considering the dividend process of an all-equity firm that finances its investment entirely with retained earnings, market-to-book ratio has association with profitability and discount rates (Fama and French, 1995). Based on the clean surplus relation, book-to-market ratio is related to future cash flow, interest rates, and excess stock returns (Vuolteenaho, 2000; Clubb and Naffi, 2007). All these methods try to relate book-to-market ratio with other fundamental valuation ratios. On other hand, Pástor and Veronesi (2003) develop a valuation model and obtain a closed-form solution for the firm's market-to-market ratio. They find market-to-book ratio increases with expected profitability and decreases with expected stock returns as shown in Vuolteenaho (2000). Most specifically, they find more volatile profitability can increase market-to-book ratio. They state that uncertainty about a firm's average profitability increases the firm's market-to-book ratio and return volatility. The expected stock returns, however, are not affected by this uncertainty.

Recently, a number of studies have viewed size and book-to-marker as firm-specific properties to relate risk and returns. They suggest that firm valuation and valuation ratios evolve according to optimal investment decisions and that size and book-to-market ratio are critical to explain the cross section of stock returns because they proxy for time-varying systematic risks. Berk, Green, and Naik (1999) develop a real options model that relates average stock returns, systematic risks, and firm characteristics such as size and book-to-market ratio. They suggest as firms exploit profitable investment, their systematic risks will change in a predictable way. Book-to-market is used a state variable to summarize the firm's risks relative to the scale of the asset base, while size proxies for the state variable that describes the relative importance of existing assets and growth options.

Zhang (2005) further develop a neoclassical framework with rational expectation to examine the value premium. He proposes that because of costly reversibility and countercyclical price of risk firms have difficult in cutting assets in place that in turn makes existing assets riskier than growth options especially in bad times when the price of risk is high. Based on the intuition of Berk, Green, and Naik (1999), Anderson and Garcia-Feijóo (2006) further provide an empirical evidence to relate past firm-specific investment activity and valuation ratio. More specifically, they find that size and book-to-market lose part of explanation power to the cross section stock returns once they control for firm-level investment activity.

Based on the equity cash flow perspective of Berk (1995), recent research provides some evidences to support the conjecture that the predictive power of book-to-market seems to result from the relation between book value and future cash flow. Pontiff and Schall (1998) demonstrate that book-to-market will be a better predictor of subsequence returns when book equity is significantly related to future cash flow. When comparing the predictive power of book equity on future cash flow, they find book value from S&P index performs better then that of DJIA index. Thus, S&P book-to-market has a better predictive power on the market returns than the DJIA book-to-market ratio does. Biddle and Hunt (1999) further show that other proxies for expected cash flow in addition to book equity can enhance the cross-sectional relation between market equity and expected stock returns. However, because these cash flow proxies should form ratios with market equity, they reveal similar information with book-to-market.

Clubb and Naffi (2007) develop a log linear model that includes expectations of future boo-to-market and return-on-equity except for current book-to-market to predict future stock returns. Empirical evidence shows that these three variables have significant explanatory power to the UK cross-sectional stock returns even though they include other risk proxy variables to the regression model. More specifically, they find that inclusion expectations of future book-to-market and return-on-equity as additional explanatory variables increase the explanatory power of current book-to-market to expected stock returns.

In brief, in this paper we count on the equity cash flow perspective and the risk argument of book-to-market to investigate the usefulness of variation in return-on-equity on forecasting stock returns and examine information embodied in this indicator. This indicator is non-price but can well describe the upward trend in return volatility that is useful in examining the association between expected returns and return volatility in the cross section.

2.4 Data and Preliminary Analysis

In this section we provide cross-sectional evidences of how the uncertainty about future profitability of a firm relates to its characteristics such as book-to-market ratio (*BE/ME*) and market size (*ME*). Using two specific proxies of variation in return-on-equity, the standard deviation of return-on-equity, *ROEstd*, and the changes of return-on-equity, *DROE*, we find portfolios sorted by size (*ME*) and book-to-market (*BE/ME*) inherit distinct property of variation in return-on-equity, as suggested by previous theoretical work. In the next section, we will investigate some properties of portfolios formed on the uncertainty of profitability to explain the association between variation in profitability and valuation ratio.

Because stock prices moves in response to cash-flow news or discount-rate news, there should be a connection between stock returns and earnings surprises. Previous literature has found that firm valuation is associated with the variance of profitability such that book-to-market may serve as a proxy for variation in return-on-equity. Fama and French (1995) investigate that size and value effects are related to the systematic risks about difference on profitability. Our key question is whether the relation between variation in profitability and returns remains after controlling for other well known forecasting factors such as market equity and book-to-market ratio. To detect these inferences, we count on stock price data from the Center for Research on Securities Prices (CRSP) and financial statement data from COMPUSTAT beginning from 1980 to 2001. In computing proxy of variation in return-on-equity, we require five years of financial data before a company is included in any portfolio. Only nonfinancial firms (SIC other than in the 6000) and firms with ordinary common equity (security type 10 or 11 in CRSP) are discussed in our study. In addition, we also require each firm to have a strictly positive book value prior to portfolio formation year. Overall, the average number of firms per year is 3911 in our sample, compared with an average of about six thousand firms on CRSP and COMPUSTAT databases for the same period. The appendix describes the data in detail. Below we show some properties among portfolios to confirm our inferences and implications behind them.

We use two variables to proxy for uncertainty about future profitability: the standard deviation of return-on-equity (Wei and Zhang (2006)) and the changes of return-on-equity ((Kothari, Lewellen, and Warner (2006)). Return-on-equity is defined as earnings divided by lagged book equity in the last year. The variance of return-on-equity used in this study, *ROEstd*, is the sample variance of return-on-equity over the last five years. The changes in return-on-equity used, *DROE*, defines as return-on-equity at the end of fiscal year $t-1$ minus return-on-equity at year $t-3$, where year t is the portfolio formation year. To well capture variation in profitability, the changes in return-on-equity must be modified by absolute value. It is well known that the uncertainty about the future return-on-equity is positively related to the realized variation of past return-on-equity (Wei and Zhang (2006)). And the changes in return-on-equity are useful in describing earning news (Kothari, Lewellen, and Warner (2006)). We focus on the variation in return-on-equity of the 25 portfolios formed by the widely accepted Fama-French method of classifying stocks based on their market size and book-to-market ratio (Fama and French (1993)). We also employ identical conception of Fama and French (1992, 1993) to segment firms by fundamental ratios, adapted when conducting variables for uncertainty across firms. In addition, we use other proxies to represent firm-level variation in return-on-equity, including the changes in return-on-equity between fiscal year $t-1$ and year $t-2$, the earnings changes scaled by lagged book equity, and the modified correlation of coefficient of return-on-equity. However, these results do not cause much change and have been omitted here.

Table 1 characterizes the pattern of profitability uncertainty for portfolios sorted by size and book-to-market over the period 1980 to 2001 for CRSP- and Compustat-listed stocks. Panel A of Table 1 shows the mean and median values of the standard deviation of return-on-equity, *ROEstd*, for 25 portfolios sorted by *ME* and *BE/ME* following Fama and French (1993). We conduct two features from Table 1. First, controlling for *ME*, volatility of profitability consistently decreases with *BE/ME*. For the smallest quintile, *ROEstd* decreases from an average 67.54% for low *BE/ME* firms to 21.25% for high *BE/ME* firms. For the largest quintile, *ROEstd* decreases from an average 13.43% for low *BE/ME* firms to 11.48% for high *BE/ME* firms. In addition, controlling for *BE/ME*, variation in return-on-equity decreases as market equity value becomes large. For the lowest (highest) *BE/ME* quintile, *ROEstd* decrease from 67.54% (21.25%) for the smallest firms to 13.43% (11.48%) for the largest firms. This evidence is consistent with the theoretical work of Pástor and Veronesi (2003) that variation in return-on-equity accounts for the valuation ratio. However, our work differs to Pástor and Veronesi (2003) in that we apply conditional measure of variation in return-on-equity while they use an estimate of unconditional volatility for each firm. As a result, we state that sorting of stocks to portfolios based on firm size and book-to-market seems to be conditional on past variation in profitability. Panel B of Table 1 shows the value of changes in return-on-equity, *DROE,* for identical portfolios, and similar patterns are found in such analysis. Controlling for *ME*, changes in return-on-equity decrease as firms' book-to-market increase. For the smallest quintile, *DROE* decreases from an average 81.96% for low *BE/ME* firms to 26.69% for high *BE/ME* firms. For the largest quintile, the average value of *DROE* is 21.11% for low *BE/ME* quintile and is 9.04% for high *BE/ME* quintile. The size effect is also apparent when controlling for *BE/ME*. Given *BE/ME*, changes in return-on-equity decreases as market equity value becomes large. For the lowest (highest) *BE/ME* quintile, *DROE* decrease from 81.96% (26.69%) for the smallest firms to 21.11% (9.04%) for the largest firms. Similar features are found when we refer to the median values of *ROEstd* or *DROE* .Based on these evidences, we state that portfolios sorted on *ME* and *BE/ME* seem to experience distinct degree

Table 1

Return-On-Equity and Its Sample Variance by Sorts on Size and Book-to-Market Ratio, July 1980 to June 2001

Each year (1980 to 2001), we divide NYSE, AMEX, and NASDAQ stocks into five groups based on their size at the end of June (*ME*, stock price times shares outstanding), and into five groups based on ranked values of book-to-market ratio (*BE/ME*, the ratio of book value of equity at the end of fiscal year $t-1$ divided by market value of equity at the end of December of calendar year $t-1$). Only positive values of *BE/ME* are considered. We use NYSE stocks to determine the size and *BE/ME* breakpoints. We form 25 portfolios by combining the ranked value of size and *BE/ME*. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the prior fiscal year. The standard deviation of return-on-equity (*ROEstd*) used is from the sample variance of yearly return-on-equity over the last five years relative to portfolio formation year. The change in return-on-equity (*DROE*) defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. The standard deviation of return-on-equity and the change of return-on-equity have been winsorized at the 1% and 99% tails of distribution each year. Means (medians) are shown as percentages.

	Low BE/ME	BE/ME-2	BE/ME-3	BE/ME-4	High BE/ME
Panel A: Standard deviation of return-on-equity % (ROEstd) sorted by ME and BE/ME					
Small-ME	67.5(28.3)	32.0(14.0)	26.1(11.4)	21.9(10.1)	21.3(10.2)
ME-2	40.7(13.1)	18.4(7.6)	13.6(6.8)	11.3(6.1)	13.7(7.2)
ME-3	26.2(8.7)	14.6(6.2)	13.0(5.7)	10.4(4.9)	12.2(5.5)
ME-4	23.9(6.9)	12.3(5.7)	11.4(5.9)	10.3(4.6)	9.7(4.6)
Large-ME	13.4(6.1)	8.6(5.4)	9.3(5.2)	6.2(4.1)	11.5(3.7)
Panel B: Change of return-on-equity % (DROE) sorted by ME and BE/ME					
Small-ME	82.0(33.8)	41.6(16.0)	32.1(12.3)	27.5(10.7)	26.7(11.2)
ME-2	52.1(15.2)	24.2(8.5)	17.8(7.1)	14.5(6.5)	18.8(7.6)
ME-3	41.4(10.6)	20.6(6.5)	14.1(5.6)	11.4(5.2)	14.9(5.4)
ME-4	31.8(7.8)	14.7(5.9)	12.8(5.9)	9.2(4.6)	12.8(4.6)
Large-ME	21.1(6.4)	10.7(5.5)	11.5(5.4)	8.0(4.0)	9.0(3.2)

of variation in return-on-equity prior to formation year.

Next, Figure 1 and Figure 2 plot the evolution of *ROEstd* and *DROE* for portfolios based on *ME* and *BE/ME* from 1980 to 2001. These two figures plot the median *ROEstd* and *DROE* that reveal several interesting facts. First, small firms with lower *BE/ME* tend to have higher and volatile volatility of return-on-equity through time. The median increases almost monotonically from 16% in 1980 to over 50% in 2001. On the contrary, over the same periods, other firms seem to exhibit stable profitability, including small and large size firms with higher *BE/ME* and large size firms with lower *BE/ME*. At most of time, the median volatility of return-on-equity is below 15% for these firms. Our evidence is consistent with the finding of Wei and Zhang (2006) that the upward trend in the volatility of return-on-equity is more apparent for newly listed stocks than for existing stocks. Second, controlling for *ME*, firms that classified as high *BE/ME* consistently experience less variation in return-on-equity prior to portfolio formation than firms that classified as low *BE/ME* over the 22 sample year. Third, Controlling for *BE/ME*, firms with small *ME* consistently have larger variation in return-on-equity than firms with large *ME*. Similar patterns are found when we focus on the changes of return-on-equity. Firms with small size and lower *BE/ME* also have an upward trend in the changes of return-on-equity after 1980. In brief, we find firms with distinct market size and valuation ratio exhibit different degree on the variation in return-on-equity.

Evidences from Table 1 and Figure 1 and 2 sustain implication of previous proposed model from Pástor and Veronesi (2003) that *BE/ME* is related to the variation in return-on-equity. Classification of stocks based on firm-specific fundamentals such as *ME* and *BE/ME* seems to rely on information of variation in return-on-equity. More specifically, when portfolios are formed under Fama-French model, low *BE/ME* firms tend to be more volatile in profitability prior to the formation year than high *BE/ME* firms. In addition, small size stocks are also more volatile than firms with big size. Based on the clean surplus relation, the process of book equity is governed by profitability. If *BE/ME* is governed by the uncertainty about book equity growth, it is straightforward to apply variation in return-on-equity to mimic the value effect. Now we realize that there is connection between valuation ratio and variation in return-on-equity, proxy by past variance of return-on-equity or the changes in return-on-equity, theoretically and empirically. It may be useful to conduct the power of book-to-market by investigating the implication behind the variation in return-on-equity. We discuss relevant issues in the next section.

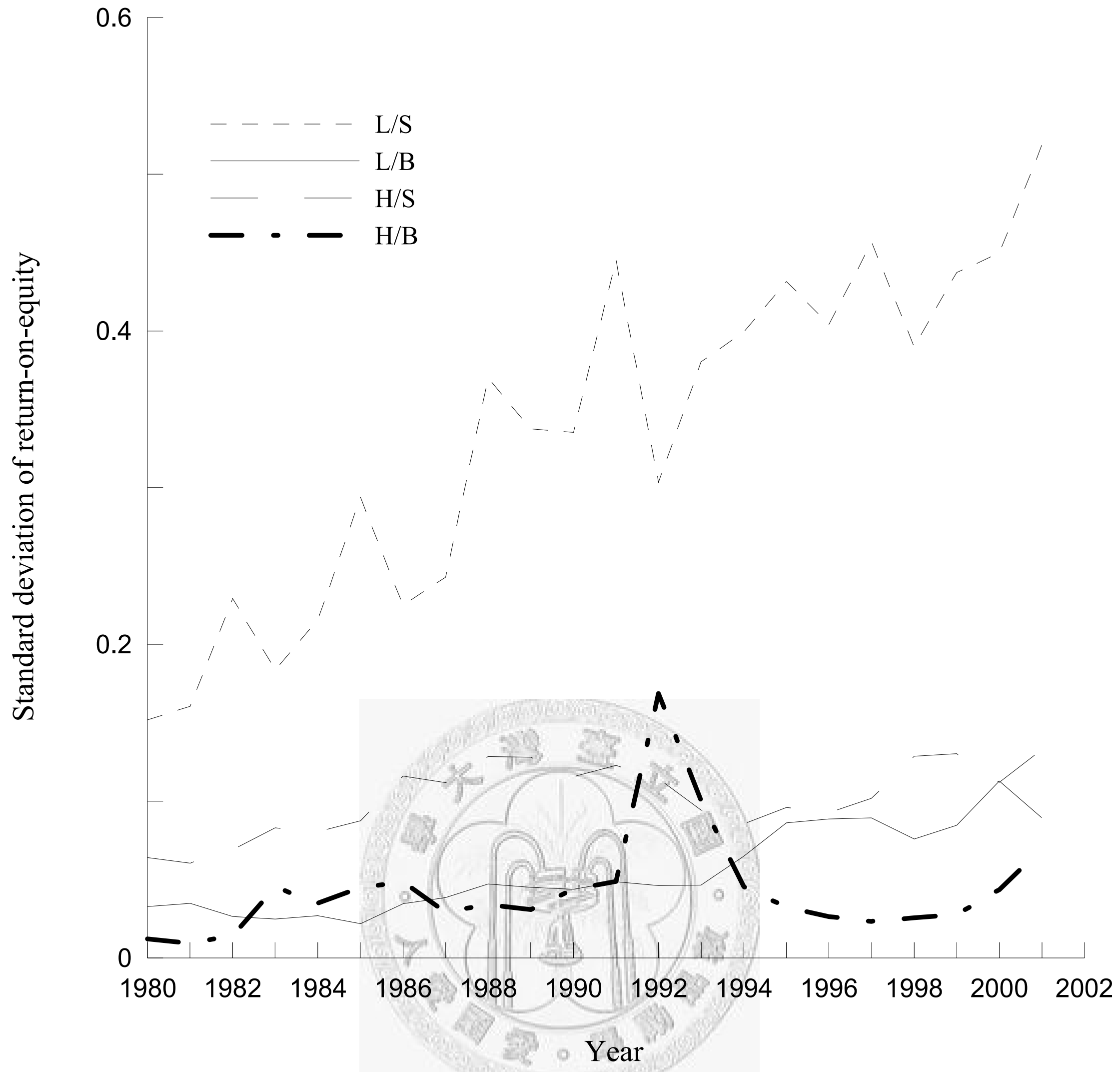

Figure 1: Time-series evolution of the standard deviation of return-on-equity for portfolios sorted by *M*E and *BE/ME,* 1980-2001.

This figure plot the evolution of the standard deviation of return-on-equity for portfolios sorted by market size (*ME*) and book-to-market ratio (*BE/ME*) as described in Table1. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the last fiscal year. The standard deviation of return-on-equity for individual firm used is from the sample variance of yearly ROE over the last five years relative to portfolio formation year. Each year (1980 to 2001) the standard deviation shown is the median standard deviation of return-on-equity for firms in the same portfolio. Only values for stocks in the smallest(S)/largest(B) market size groups and the lowest(L)/highest(H) BE/ME groups are shown.

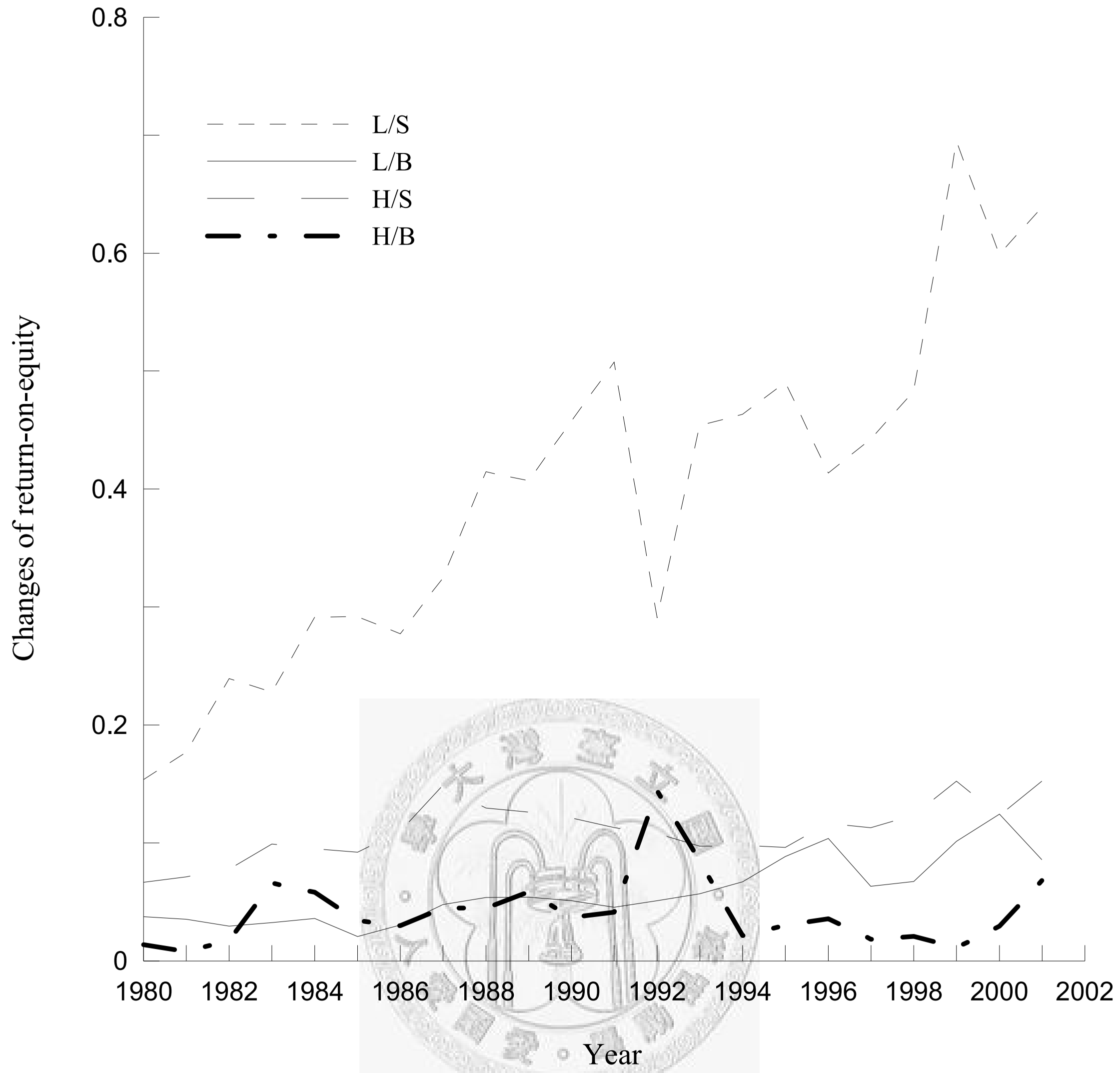

Figure 2: Time-series evolution of the changes of return-0n-equity for portfolios sorted by *M*E and *BE/ME,* 1980-2001.

This figure plot the evolution of the changes of return-on-equity for portfolios sorted by market size (*ME*) and book-to-market ratio (*BE/ME*) as described in Table1. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the last fiscal year. The changes of return-on-equity defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. Each year (1980 to 2001) the changes shown is the median value of changes for firms in the same portfolio. Only values for stocks in the smallest(S)/largest(B) market size groups and the lowest(L)/highest(H) BE/ME groups are shown.

2.5 Properties of Variation in return-on-equity

Fama and French (1992 and 1993) find that size and value effect in the cross section of stock returns and point out factors such as market value and book-to-market ratio that capture the stock returns. To examine what kind of risk factors embodied in the size and book-to-market, Fama and French (1995) relate the behavior of earnings to size and book-to-market factors. Furthermore, they test that stock returns are related to the market size factors in earnings, but not to the book-to-market factors. In this section we first examine what kinds of characteristics embodied in the variation in return-on-equity and then document whether the average stock returns is governed by the variation in return-on-equity in next section. The intuition is that if BE/ME is the reflection of uncertainty and there is a value effect in the cross section of expected stock returns, stock returns can be related to the risks in earnings.[8] We actually find higher variability of profitability is not noise but actually is related to expected return.[9] In order to prevent any possible return anomalies induced by equal-weighted portfolios, we apply the value-weighted portfolio stock returns in the following analysis. Monthly portfolios returns are computed from July of each year t to June of year $t+1$.

First, Panel A of Table 2 shows some characteristics of portfolios sorted by the variation in return-on-equity, proxy by the variation in return-on-equity and the changes in return-on-equity. Each year we form five quintile portfolios based on the volatility of return-on-equity five year before formation. We report the average and median values of valuation ratio, market size, and two leverage variables. The average

[8] The correlation coefficient between book-to-market and volatility of return-on-equity is -0.0328. Moreover, the Spearman's rank correlation coefficient is -0.2275 that means there is a weak negative correlation between book-to-market and volatility of return-on-equity.

[9] Prior research shows that stock prices for individual firms react positively to earnings news but require several quarter to fully reflect the information about earnings, an empirical finding known as "post-earning announcement drift."

and median value of the market size for the five uncertainty portfolios decrease monotonically as we move from the lowest uncertainty group to the highest group. The mean (median) *ME* for the lowest *ROEstd* group is $2320 ($316) millions while it is $384 ($32) millions for the highest *ROEstd* uncertainty group. The average *BE/ME* is 0.90 for the lowest uncertainty group; it then increases in the middle quintiles, peaking at a mean of 0.98, and then decreases to 0.68 for the highest uncertainty group. The median *BE/ME* also performs as the inverse-U shape; it peaks at the second lowest quintiles of 0.79, and down to 0.44 for the highest group. Evidence is consistent with the finding of the previous section that firms with small size and low *BE/ME* experience higher variation in return-on-equity prior to formation year while firms with big and high *BE/ME* face less uncertainty.

Panel A of Table 2 also show the leverage property embodied in the uncertainty quintiles. We apply two leverage variables used by Fama and French (1992), including the ratio of book assets to market equity, *A/ME*, and the ratio of book assets to book equity, *A/BE*. *A/ME* is interpreted as a measure of market leverage while *A/BE* is a measure of book leverage. Evidence shows that the mean value of *A/ME* and *A/BE* both increase monotonically from the lowest uncertainty group to the highest uncertainty group. For example, the mean *A/ME* (*A/BE*) for the lowest uncertainty group is 1.95 (2.06) while it is 2.64 (8.51) for the highest uncertainty group. However, we find the book leverage has a dramatic increasing from the lowest uncertainty groups to the highest uncertainty groups (from 2.06 for lowest *ROEstd* to 8.51 for highest *ROEstd*). The difference between market and book leverage is book-to-market equity, $\ln(BE/ME) = \ln(A/ME) - \ln(A/BE)$, as noted by Fama and French (1992). Thus, if a firm's book leverage is high relative to its market leverage, it may sustain a lower valuation ratio. In other word, firms with lower valuation ratios may have a lower book equity or larger book equity growth as investigated by Pástor and Veronesi (2003). We will provide some evidences to complete this argument latter in this work.

Similar evidences are found when we conduct portfolios formed by the changes in return-on-equity. Both the valuation ratio, *BE/ME*, and market size, *ME*, decrease with this uncertainty proxy, while both market and book leverage increase with the same proxy. In particular, the average of book leverage increases dramatically from 2.14 for the lowest *DROE* group to 7.19 for the highest *DROE* group, while market leverage only increases from 2.00 to 2.43 for the identical portfolios. In Panel A of Table 2 we also find that the standard deviation of subsequence monthly returns also monotonically increases with the variation in return-on-equity as proposed by previous literature (Pástor and Veronesi (2003) and Wei and Zhang (2006)). The volatility of stock return is 4.0% in the lowest uncertainty group and 6.88% in the highest uncertainty group when we conduct variation in return-on-equity as our proxy. In addition, when we refer to changes in return-on-equity as primary proxy, the volatility of stock return is 4.07% in the lowest uncertainty group and 7.00% in the highest uncertainty group.

Panel B shows that for the year after portfolio formation, average monthly returns are 1.33% for the lowest *ROEstd* portfolio versus 0.60% for the highest *ROEstd* portfolio. In addition, the average monthly return difference between low and high *ROEstd* portfolios is 0.73%. Using the *t* tests on the equality of means, the two groups are significantly different at 1%. When we refer to *DROE*, similar trend on average monthly returns is revealed. The average monthly returns are 1.34% for the lowest *DROE* portfolio versus 0.85% for the highest *DROE* portfolio with difference up to

0.50%. And the *t* tests on the equality of means for the lowest and highest groups is significantly different at 10%. We interpret these results as consistent with Pástor and Veronesi (2003) that book-to-market ratio is associated with the variation in return-on-equity such that there is a connection between variation in return-on-equity and subsequence stock returns. Specifically, we inherit their implication that the variation in return-on-equity involves two kinds of risks, systematic and idiosyncratic shocks. However, the discount rates or expected returns are only driven by systematic shocks. Holding expected returns constant, the return difference between low and high profitability uncertainty portfolios will eliminate. That is what we find in Panel B of Table 2, where we present evidence on the association between variation in return-on-equity and subsequence stock returns, controlling for market value of equity. Stocks are first classified into three groups base on *ME*, and then into five quintile portfolios based on proxy of variation in return-on-equity.

Although we find the leverage variable increases with the proxy of uncertainty, it is not clear if the variation in return-on-equity can be related the distress event when market size is controlled. It is well-known that firms with small size and high book-to-market could be viewed as firms with higher distress risks. As a result, the variation in return-on-equity should have a larger effect on the risk and return relation for small rather than large firms. However, evidence reveals different signal when we conduct different proxies. We find that there is a large significant return difference between lowest and highest uncertainty groups for large market equity firms when using variance of return-on-equity as proxy variable. On the contrary, the largest significant return difference between lowest and highest uncertainty groups reveals on the small market equity firms when referring to change in return-on-equity as proxy variable. Overall, we suggest that the variation in return-on-equity contains both systematic and idiosyncratic risks so that there is connection between this uncertainty and subsequence stock returns. In addition, additional risks revealed by the difference on variation in return-on-equity are compensated for smallest and largest market size firms when market equity is controlled. However, we cannot identify the distress risks by examining the uncertainty.

Table 2

Summary Statistics of Portfolios Formed on Standard Deviation of Return-on-Equity and Difference of Return-on-Equity

At the end of June of each year t, $t = 1980$ to 2001, five portfolios are formed on the basis of ranked values of the standard deviation of return-on-equity. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the prior fiscal year. The standard deviation of return-on-equity (*ROEstd*) used is from the sample variance of yearly return-on-equity over the last five years relative to portfolio formation year. The change in return-on-equity (DROE) defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. Quintile portfolios are ranked in ascending order. BE is the book value of equity at the end of fiscal year $t-1$. A is total book assets from the latest fiscal year ending in calendar year $t-1$. The accounting ratios are measured using market value of equity *ME* at the end of December of calendar year $t-1$. Firm size (*ME*, market value of equity) is measured in June of year t, with *ME* dominated in millions of U.S. dollars. Returns are computed over the 12 months following portfolio formation (total of 264 months). The monthly value-weighted returns are based on monthly rebalancing. The variable *sigma* is the standard deviation of monthly value-weighted returns. The last column of Panel B presents the average monthly return difference between low and high quintile portfolios. Superscripts a, b, c refer to 1%, 5%, and 10% significance levels, respectively, for *t*-statistics testing the equality of monthly returns between low and high uncertainty groups. In Panel C and D the reported median of average return-on-equity and its volatility is from the subsequence five years after portfolio formation. The last column of Panel C and D reports the *p*-value for Wilcoxon rank-sum Z-statistics testing the equality of distributions between the two groups, high and low quintile stocks.

Panel A: Characteristics of Portfolios Based on *ROEstd* and *DROE*

	Low *ROEstd*	2	3	4	High *ROEstd*	Low *DROE*	2	3	4	High *DROE*
BE/ME	0.90	0.97	0.98	0.95	0.68	0.91	0.92	0.93	0.91	0.67
(median)	(0.76)	(0.79)	(0.77)	(0.71)	(0.44)	(0.75)	(0.73)	(0.73)	(0.67)	(0.42)
ME	2320	1759	1257	779	384	1727	1750	1131	739	400
(median)	(316)	(145)	(83)	(44)	(32)	(185)	(126)	(79)	(50)	(33)
A/ME	1.95	2.07	2.30	2.59	2.64	2.00	2.05	2.20	2.40	2.43
(median)	(1.42)	(1.49)	(1.52)	(1.58)	(1.21)	(1.41)	(1.40)	(1.43)	(1.44)	(1.11)
A/BE	2.06	2.10	2.31	2.76	8.51	2.14	2.29	2.49	2.78	7.19
(median)	(1.85)	(1.84)	(1.92)	(2.10)	(2.41)	(1.85)	(1.86)	(1.87)	(2.01)	(2.33)
Sigma	4.00	4.59	4.91	5.57	6.88	4.07	4.48	4.97	5.43	7.00

Panel B: Average value-weighted monthly percent returns by *ROEstd* and *DROE*（%）

	Low *ROEstd*	2	3	4	High *ROEstd*	Low-High	Low *DROE*	2	3	4	High *DROE*	Low-High
All	1.33	1.23	1.02	1.18	0.60	0.73 [a]	1.34	1.15	1.11	1.06	0.85	0.50 [c]
Small	1.54	1.66	1.77	1.70	1.26	0.28	1.78	1.53	1.49	1.65	1.16	0.62 [b]
Medium	1.42	1.51	1.50	1.42	1.04	0.37	1.48	1.39	1.43	1.34	1.00	0.48 [c]
Large	1.41	1.10	1.37	0.98	0.93	0.48 [b]	1.33	1.24	1.15	1.09	0.91	0.43 [c]

Panel C: Return-on-equity after formation by *ROEstd* and *DROE*（%）

	Low *ROEstd*	2	3	4	High *ROEstd*	*p*-value	Low *DROE*	2	3	4	High *DROE*	*p*-value
All	11.31	10.51	8.72	6.77	4.73	0	10.50	10.29	9.03	6.73	4.41	0
Small	7.01	6.56	5.97	4.80	3.54	0	5.15	5.54	5.10	4.66	2.94	0
Medium	9.94	10.33	10.16	7.99	5.44	0	9.20	9.88	8.93	7.41	4.46	0
Large	12.76	13.11	12.72	11.58	10.31	0	12.32	12.57	12.64	11.76	10.17	0

Panel D: Standard deviation of return-on-equity after formation by *ROEstd* and *DROE*（%）												
	Low *ROEstd*	2	3	4	High *ROEstd*	*p*-value	Low *DROE*	2	3	4	High *DROE*	*p*-value
All	7.09	11.41	16.18	25.26	59.11	0	9.11	11.59	16.08	24.31	52.71	0
Small	7.71	12.00	13.95	19.94	43.46	0	14.59	15.21	18.01	22.55	44.66	0
Medium	6.35	8.87	12.09	16.16	35.51	0	10.06	10.60	13.67	17.86	35.07	0
Large	6.15	8.07	11.53	15.32	30.20	0	7.48	8.46	10.90	14.63	27.45	0

Next, we provide some evidences to examine what kind of idiosyncratic risks may contain in the variation in return-on-equity. In order to investigate the relevant cash flow information embodied in the proxy of variation in return-on-equity, in Panel C and D of Table 2 we report the association between variation in return-on-equity prior to portfolio formation and the behavior of return-on-equity in the following five years after formation, controlling for market value of equity. Because large and small firms have distinct scale on the ongoing projects, their operation risks are different. If effects of variation in return-on-equity can be fully captured by market size, then the variation in return-on-equity would not reveal any additional information on the behavior of cash flow when market equity is under control. However, our evidence shows that, even controlling for market value of equity, the behavior of return-on-equity after formation year is different among groups sorted by variation in return-on-equity. In Panel C we find that the median return-on-equity monotonically decreases with the variation in return-on-equity with and without controlling market equity size. For example, median return-on-equity for small market equity firms is 7.01% in the lowest *ROEstd* group, 5.97% in the middle *ROEstd* group, and 3.54% in the highest *ROEstd* group. Using the Wilcoxon rank-sum test, the highest and lowest uncertainty groups are significantly different at the 1% level. Panel D indicates that the realized variance of return-on-equity is positively related to the variation in return-on-equity after portfolio formation for small, median, and large size groups. Median variance of return-on-equity after portfolio formation for large market equity firms is 6.15% in the lowest *ROEstd* group, 11.53% in the middle *ROEstd* group, and 30.20% in the highest *ROEstd* group, respectively. Z-statistics for the Wilcoxon test also reveal that the two extreme uncertainty groups are also significantly different at the 1% level.

When referring to the changes in return-on-equity as primary proxy of variation in return-on-equity, similar evidence about the behavior of return-on-equity is found. After portfolio formation, median return-on-equity decreases with *DROE*, while median variance of return-on-equity increases with *DROE*, with and without controlling market size. For example, median return-on-equity for small market equity firms is 5.15% in the lowest *DROE* group, 5.10% in the middle *DROE* group, and 2.94% in the highest *DROE* group. Median variance of return-on-equity after portfolio formation for large market equity firms is 7.48% in the lowest *DROE* group, 10.90% in the middle *DROE* group, and 27.45% in the highest *DROE* group, respectively. In addition, the Wilcoxon rank-sum tests show that the two extreme groups are also significantly different at the 1% level when conducting the level and the volatility of return-on-equity. In sum, we find our proxy of variation in return-on-equity really reveals relevant information about the behavior of future cash flow, including the level and the volatility of return-on-equity, even though we control the market equity value.

2.6 Fluctuation of Profitability and Cross Section of Stock Returns

In this section, we document associations between firm-specific variation in return-on-equity, book-to-market, size, and average stock returns using regression analysis of monthly returns. The key question is how the variation in return-on-equity associates with the expected stock returns. Moreover, we examine whether this relation remains after controlling for the known determinants of cross section stock returns. We apply the Fama-MacBeth (1973) regression analysis to investigate individual stock monthly returns. Table 3 presents the results of Fama-MacBeth regression, where parameters estimates are the time-series average of the cross sectional slopes. For each explanatory variable, the reported *t*-statistics in the parentheses are adjusted for autocorrelation and conditional heteroskedasticity. To exclude possible errors from extreme observations, we follow the similar method used by Fama and French (1992) to adjust observations. For each independent variable, the top and bottom 1% observations are set equal to the 1% and 99% percentiles.

As suggested by Fama and French (1992), our evidence shows that *BE/ME* is powerful in explaining the cross section of average stock returns over the period of 1980 to 2001. When returns of individual firm are regressed on ln(*BE/ME*), the estimated parameter is 0.57% with a *t*-statistics of 5.34. Consistent with Fama and French (1992), the size effect is significant. The average slope from the monthly regressions of returns on ln(*ME*) alone is -0.14%, with a *t*-statistics of -2.18. However, over our sample period, book-to-market somewhat replaces size in explaining average returns. When both ln(*BE/ME*) and ln(*ME*) are included on the regression, only ln(*BE/ME*) is significant with a *t*-statistics of 3.74 and slope of 0.50%. In addition, we also apply two variables, market leverage (*A/ME*) and book leverage (*A/BE*), to study the leverage effect. Similar to Fama and French (1992), the leverage effect measured by ln(*A/ME*) and ln(*A/BE*) is also significant in our study. Our evidence shows that ln(*A/ME*) has a positive association with stock returns while there is a negative connection between ln(*A/BE*) and average stock returns. By simple decomposition, $\ln(BE/ME) = \ln(A/ME) - \ln(A/BE)$, the relationship among *BE/ME*, leverage, and stock returns are apparent. The estimated parameters (*t*-statistics) for leverage effect alone, ln(*A/ME*) and ln(*A/BE*), are 0.55% (4.88) and -0.67% (-7.18), respectively. If ln(*ME*) is also included in the regression, the corresponding parameters (*t*-statistics) for ln(*A/ME*) and ln(*A/BE*) are 0.47% (3.38) and -0.60% (-6.53), respectively. However, the size effect is irrelevant in this regression. Consistent with Fama and French (1992), our evidence suggests that the involuntary leverage effect, captured by the difference between *A/ME* and *A/BE*, is relevant in our sample periods.

Next, we investigate whether the variation in return-on-equity relates to the average stock returns even if the size and book-to-market effects is included in the regression analysis. The more surprising fact is that the estimated parameter of proxy of uncertainty is significant and governed with negative sign. We find that the inclusion of variation in return-on-equity absorbs the apparent roles of book-to-market and leverage in average stock returns. The regression of stock returns on *ROEstd* alone produces an estimate of -0.24%, with a *t*-statistics of -2.36. That is firms with higher variation in return-on-equity generate lower subsequent stock returns. The intuition is that if there is a positive association between book-to-market and stock returns and this valuation ratio also decreases with variation in return-on-equity, expected stock returns may negatively correlate with variation in profitability. Most important of all, this significant negative relation can still be hold even though other price scaled variables are included. Parameter estimates (*t*-statistics) for ln(*ME*), ln(*BE/ME*), and *ROEstd* are, respectively, -0.12% (-1.72), 0.32% (2.77), and -0.17% (-2.70). We find when the regression includes both book-to-market and variance of return-on-equity as independent variables, the estimates of the slope coefficients of book-to-market are somewhat reduced, but remains significant. Moreover, when the leverage effect variables, ln(*A/ME*) and ln(*A/BE*), substitute for book-to-market in the regression, both proxies are significant with parameters (*t*-statistics) of 0.31% (2.58) and -0.42% (-4.36), respectively. If the leverage effects are present, parameter estimates (*t*-statistics) for ln(*ME*) and *ROEstd* are -0.12% (-1.74) and -0.14% (-2.17), respectively. In brief, the coefficient of variation in return-on-equity, *ROEstd*, is significantly negative for all specification. In particular, book-to-market ratio loses some part of their explanatory power to the subsequence stock returns when proxy of variation in return-on-equity is included in the regression analysis.

Furthermore, we also apply the changes in return-on-equity (*DROE*) as another proxy of variation in return-on-equity to monthly returns regression analysis. In return regression, the coefficient of ln(1+*DROE*) alone is significant and governed by negative sign with parameter estimate (*t*-statistics) of -0.64% (-2.43). Consistent with results found in *ROEstd*, the estimated of *DROE* remain significantly negative even though other price scaled variables are included. Parameter estimates (*t*-statistics) for ln(*ME*), ln(*BE/ME*), and ln(1+*DROE*) are, respectively, -0.13% (-1.75), 0.39% (3.38), and -0.42% (-2.49). When we replace the valuation ratio with the involuntary leverage effect variables, ln(*A/ME*) and ln(*A/BE*), in the return regression, evidence shows that both the involuntary leverage effect variables and ln(1+*DROE*) are significant, yet the size effect remains also weak. The estimated parameters (*t*-statistics) for ln(*A/ME*) and ln(*A/BE*) are 0.37% (3.09) and -0.49% (-5.84), respectively. The slope coefficient for ln(1+*DROE*) is -0.38% with *t*-statistics of -2.18. And parameter estimated for ln(*ME*) is -0.13% with insignificant *t*-statistics of -1.76. This evidence implies the changes in return-on-equity remain highly statistically significant even though the involuntary leverage effect is controlled.

Researchers have reported that the predictive power of book-to-market to stock returns referring to the cash flow perspective. Consequently, we also examine the implication of equity cash flow perspective that adding other plausible proxy for expected equity cash flow enhances the cross-sectional relation between market equity

Table 3

Average Parameter Values from Cross-Sectional Regressions of Monthly Stock Returns on Firm Size, Book-to-Market Ratio, Leverage, Standard Deviation of Return-on-Equity, and Difference of Return-on-Equity

Monthly returns are regressed on *ME*, *BE/ME*, proxy of leverage (*A/ME* and *A/BE*), standard deviation of return-on-equity, and difference of return-on-equity. *BE* is the book value of equity at the end of fiscal year $t-1$. *A* is total book assets from the latest fiscal year ending in calendar year $t-1$. The accounting ratios are measured using market value of equity *ME* at the end of December of calendar year $t-1$. Firm size (*ME*) is measured as the market value of equity (price times share outstanding) at the end of June of each year t, $t = 1980 \text{ to } 2001$. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the prior fiscal year. The standard deviation of return-on-equity (*ROEstd*) used is from the sample variance of yearly return-on-equity over the last five years relative to portfolio formation year. The change in return-on-equity (*DROE*) defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. The variance of raw returns, denoted as *VR*, is defined as the sample variance of monthly raw returns within the fiscal year $t-1$. Year t is the formation year. The reported slope coefficients and their standard errors are computed from the time-series of the estimated cross-sectional slope coefficients. The *t*-statistics, adjusted for heteroskedasticity and one-year lag autocorrelation, are in the parentheses. ln denotes natural logarithm. To avoid spurious inferences from extreme values, the smallest and largest 1% of the observations for each explanatory variable are replaced by the 1% and 99% values.

Panel A: Full samples					
ln(*ME*)	ln (*BE/ME*)	ln(*A/ME*)	ln(*A/BE*)	*ROEstd*	ln*(1+ DROE)*
-0.14					
(-2.18)					
	0.57				
	(5.34)				
-0.10	0.50				
(-1.29)	(3.74)				
		0.55	-0.67		
		(4.88)	(-7.18)		
-0.10		0.47	-0.60		
(-1.33)		(3.38)	(-6.53)		
				-0.24	
				(-2.36)	
-0.12	0.32			-0.17	
(-1.72)	(2.77)			(-2.70)	
-0.16				-0.30	
(-2.67)				(-3.40)	
	0.43			-0.09	
	(4.60)			(-1.00)	
-0.12		0.31	-0.42	-0.14	
(-1.74)		(2.58)	(-4.36)	(-2.17)	
					-0.64
					(-2.43)
-0.12	0.39				-0.42
(-1.75)	(3.38)				(-2.49)
-0.17					-0.81
(-2.76)					(-3.47)
	0.50				-0.21
	(5.35)				(-0.88)
-0.13		0.37	-0.49		-0.38
(-1.76)		(3.09)	(-5.84)		(-2.18)

Panel B: Full samples				
ln(*ME*)	ln(*BE/ME*)	*VR*	*ROEstd*	ln*(1+DROE)*
-0.11	0.31	0.91	-0.17	
(-1.89)	(3.12)	(0.38)	(-2.60)	
-0.13	0.32	0.19		-0.49
(-2.02)	(3.28)	(0.08)		(-3.27)

Panel C: NBER expansions				
-0.05	0.36	-1.36	-0.21	
(-0.80)	(3.53)	(-0.52)	(-3.15)	
-0.07	0.36	-1.87		-0.64
(-0.94)	(3.63)	(-0.74)		(-4.03)

Panel D: NBER recessions				
-0.43	0.07	12.94	0.06	
(-3.53)	(0.21)	(2.35)	(0.31)	
-0.45	0.10	11.11		0.30
(-3.70)	(0.32)	(2.20)		(0.71)

and subsequence stock returns. Indeed, we find inclusion of *DROE* can enhance the cross section relation between market equity and subsequence returns. When ln(*BE/ME*) is excluded from the regression analysis, parameter estimates (*t*-statistics) for ln(*ME*) and ln(1+*DROE*) are -0.17% (-2.76) and -0.81% (-3.47), respectively. In addition, the exclusion of ln(*BE/ME*) also enhances the size effect when conducting ln(*ME*) and *ROEstd* in the regression analysis. Parameter estimates (*t*-statistics) for ln(*ME*) and *ROEstd* are -0.16% (-2.67) and -0.30% (-3.40), respectively. This implies that the variation in return-on-equity may help to control the cross section variation for expected equity cash flow in market equity that is irrelevant to expected subsequence returns. In particular, we find the cross section association between average stock returns and variation in return-on-equity is strengthened when includes market equity in the regression. One possible explanation is that market size helps to control distress effect so that the relation between uncertainty and returns becomes more apparent. On the contrary, when we only conduct ln(*BE/ME*) and ln(1+*DROE*) in the regression analysis, uncertainty effect disappears. Parameter estimates (*t*-statistics) for ln(*BE/ME*)and ln(1+*DROE*) are 0.50% (5.35) and -0.21% (-0.88), respectively. Consistent with the result for *DROE*, the coefficient of *ROEstd* is not significant when only *BE/ME* is controlled. Overall, we suggest that the uncertainty really contain relevant information about expected cash flow as embodied in book-to-market ratio.

Another possibility for the significance of uncertainty is that variability of profitability reveals information about return variance, especially reflecting idiosyncratic volatility. To detect this possibility, we include the lagged value of stock return volatility in the regression analysis. Moreover, we check our analysis cross business cycles because the return distributions is asymmetric. Panel B of Table 3 shows the full samples regression results when return variance is included. We find uncertainty remains negatively significant even though the return variance is controlled. Parameter estimates for *ROEstd* is -0.17% with *t*-statistics of -2.60. The size and value effect are also apparent. The corresponding parameters (*t*-statistics) for ln(*ME*) and ln(*BE/ME*) are -0.11% (-1.89) and 0.31% (3.12), respectively. In particular, the return variance is not significant in this case. Similar results are found when we investigate *DROE* as our proxy. Except for the return variance, other variables are significant in an expectation way. Panel C of Table 3 shows the regression analysis for NBER expansions. In this case, only ln(*BE/ME*) and uncertainty remain very significant. Return variance does not show any significant relation with average stock returns. However, when we focus on NBER recession periods, return variance becomes significant with positive sign. In particular, the role of ln(*ME*) is somewhat enhanced, while the value effect and uncertainty become irrelevant. Overall, variation in return-on-equity somewhat reduces the role of lagged return variance, especially in the expansions. During recessions, book-to-market and uncertainty become useless. A possible explanation is that at bad times systematic volatility risk is more critical.

From the cross sectional monthly return regression analysis shown in Table 3, we investigate that there is a significantly negative association between profitability uncertainty and subsequence stock returns even inclusion other price scaled variables. In particular, we explore that the association between book-to-market and stock returns can eliminate after controlling the variation in return-on-equity and market size. To examine the consistence of this negative association, we further document the relation between variation in return-on-equity and stock returns through the analysis of portfolio returns. Table 4 presents the average monthly stock returns for portfolios constructed by the fundamentals of firms including *ME*, *BE/ME*, and proxy of variation in return-on-equity. In the first step, we form five portfolios based on the variation in return-on-equity, proxy by standard deviation of return-on-equity (*ROEstd*) and changes in return-on-equity (*DROE*). Next, within each variation group, stocks are classified into two groups based on their market size (S-small or B-big), and independently, classified into three groups based on their book-to-market ratios (H-high, M-medium, and L-low).

In Panel A of table 4 we present the value-weighted average monthly stock returns as well as *p*-values for comparisons between portfolios classified by differences in *ROEstd*, *ME*, and *BE/ME*. First we find portfolio returns decrease with the variation in return-on-equity. The average monthly return for the highest uncertainty group is 1.33% while it is 0.60% for the lowest group. Within each portfolio for stocks also sorted by *ME* and *BE/ME*, the lowest returns are found among firms with the highest variation in return-on-equity. For example, for firms classified as small and low *BE/ME* (L/S), the average return is 1.36% for the lowest uncertainty group and only 0.55% for the highest uncertainty group. Two additional evidences can be drawn from the comparisons of value-weighted portfolio returns in Panel A of Table 4. Controlling for size, there is evidence of book-to-market effect only among small *ME* firms. Average value-weighted returns for L/S and H/S stocks are 1.28% and 1.70%, respectively, and are significantly different from each other at the 5% level (the *p*-value is 0.0237). In contrast, average value-weighted returns for L/B and H/B stocks are 1.18% and 1.27%, respectively, but the comparison of return difference for L/B and H/B stocks is not significant with the *p*-value of 0.6928. Next, controlling for *BE/ME*, there is size effect independent to value effect only found among high *BE/ME* firms.

Average value-weighted returns of 1.70% for H/S firms are significantly different from returns of 1.27% for H/B firms at the 5% level (the *p*-value is 0.0486).

In addition, average valued-weighted returns are significantly different when firms differ in terms of both *ME* and *BE/ME*. Average stock returns for L/B and H/S stocks are 1.18% and 1.70%, respectively, and are significantly different from each other at 5% level (the *p*-value is 0.0257). Most interesting, we find there are few significant difference between *ME* and *BE/ME* sorted portfolios as the variation in return-on-equity is under control. Significant differences can be found only between the returns of L/S versus H/S for the highest and the second highest uncertainty groups. The *p*-values are 0.0243 for the second highest uncertainty group and 0.0051 for the highest. The return comparisons for H/S versus H/B firms are only significant in the highest uncertainty group with *p*-value of 0.0435. However, *p*-value for comparisons of average returns for L/B versus H/S stocks is only insignificant in the lowest uncertainty group with *p*-value of 0.3216.

Panel B of Table 4 describes the identical analysis for comparisons of value-weighted returns for portfolios sorted by *DROE*. Results are very similar to those shown for *ROEstd*. For example, returns also decrease monotonically with *DROE* from 1.34% in the lowest uncertainty group to 0.85% in the highest group. Differences between value-weighted returns for portfolios sorted by *ME* and *BE/ME* become insignificantly with most uncertainty group. The *p*-values for comparisons of average returns for L/B versus H/S stocks are 0.1453 for the lowest uncertainty group, 0.0712 for the second group, and 0.1132 for the lowest uncertainty group. In sum, we find that the variation in profitability in the past and the change in profitability, proxy of variation in return-on-equity, are useful in explaining the cross sectional stock returns even though size and valuation ratio are included. Most interestingly, differences in returns attribute to market equity and book-to-market become weak when uncertainty is measured properly.

Table 4

Average Monthly Percent Returns for Portfolios Sorted on Book-to-Market, Size, Standard Deviation of Return-on-Equity, and Difference of Return-on-Equity

At the end of June of each year t, $t = 1980$ to 2001, stocks are allocated to five quintiles based on standard deviation of return-on-equity (*ROEstd*) or the changes of return-on-equity (*DROE*). *ROEstd* used is from the sample variance of yearly return-on-equity over the last five years relative to portfolio formation year. *DROE* defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. Within each uncertainty group, stock are allocated to two groups based on their market value at the end of June (S, B), and, independently of the size sort, to three groups based on book-to-market equity of prior fiscal year (H, M, L). Firms with negative book values are excluded when calculating the breakpoints or when forming the size and BE/ME portfolios. Value-weighted raw returns are computed from July of year t to June of year $t+1$. The monthly value-weighted returns are based on monthly rebalancing.

	Mean Percent Returns					p -Value for Comparisons					
	All stocks	L/S	L/B	H/S	H/B	L/S vs. H/S	L/B vs. H/B	H/S vs. H/B	L/S vs. L/B	L/B vs. H/S	L/S vs. H/B
Panel A: Mean of Value-Weighted Portfolio Returns for Stocks Sorted on Standard Deviation of Return-on-equity (*ROEstd*)											
Low *ROEstd*	1.33	1.36	1.38	1.61	1.30	0.1957	0.7660	0.1593	0.9192	0.3216	0.8568
2	1.23	1.60	1.19	1.80	1.25	0.4082	0.8266	0.0542	0.1462	0.0236	0.3214
3	1.02	1.22	0.97	1.75	1.49	0.0940	0.0856	0.3980	0.4819	0.0101	0.5590
4	1.18	1.20	1.07	1.98	1.71	0.0243	0.0570	0.4614	0.7575	0.0133	0.2810
High *ROEstd*	0.60	0.55	0.54	1.55	0.78	0.0051	0.5302	0.0435	0.9831	0.0247	0.6638
Average	1.07	1.28	1.18	1.70	1.27	0.0237	0.6928	0.0486	0.6903	0.0257	0.9664
Panel B: Mean of Value-Weighted Portfolio Returns for Stocks Sorted on Difference on Return-on-equity (*DROE*)											
Low *DROE*	1.34	1.08	1.42	1.79	1.20	0.0034	0.3769	0.0259	0.2618	0.1453	0.7555
2	1.15	0.80	1.14	1.63	1.36	0.0035	0.3892	0.2879	0.2885	0.0712	0.1555
3	1.11	0.84	1.01	1.77	1.47	0.0177	0.1278	0.3588	0.6985	0.0155	0.2338
4	1.06	0.93	0.99	1.81	1.44	0.0062	0.1533	0.2647	0.8846	0.0211	0.2707
High-*DROE*	0.85	0.42	0.74	1.52	0.93	0.0012	0.6552	0.2250	0.5181	0.1132	0.3196
Average	1.10	0.86	1.17	1.73	1.25	0.0001	0.7086	0.0680	0.3342	0.0364	0.3230

2.7 The Source of the Predictive Ability of the Variation in Return-on-equity

In the previous section we have demonstrate that the market equity value and the book-to-market ratio seem to be conditional on our proxy of variation in return-on-equity. In addition, this uncertainty also governs the expected stock returns of individual company and portfolios. However, what kind of information attributes to this uncertainty is still an open question. In this section, we investigate the economic intuition behind the variation in return-on-equity based on the risk argument and the equity cash flow perspective of book-to-market ratio. Our logic relies on the negative association between uncertainty and book-to-market ratio as shown by Pástor and Veronesi (2003). The risk argument states that high book-to-market firms expose to higher risk on existing assets such that they invest less relative to firms with low book-to-market, while the cash flow perspective proposes that book-to-market predicts stock returns because book value proxies for future cash flow. Moreover, we discuss the different properties of book equity and the variation in return-on-equity to explain why they provide opposite sign to the investment and cash flow activity.

Table 5 reports the cross section regression analysis of profitability and investment. Here the profitability defines as the average return-on-equity following five years after portfolio formation year t and investment refers to the investment growth rate measured by capital expenditure at the end of fiscal year t relative to fiscal year $t-1$.[10] Consistent with the equity cash flow perspective, we find that both the volatility of return-on-equity and the level of book equity are good at predicting

[10] We also use the following alternative variables to measure firm-level investment activity, including investment growth rate between fiscal year $t-1$ and $t-2$, and investment growth rate between fiscal year $t+1$ and $t+2$. Similar results are found by using these variables.

future profitability. Panel A of Table 5 shows that the variation in return-on-equity can significantly predict future profitability with negative sign. The regression coefficient of *ROEstd* (*DROE*) alone is -0.08 (-0.04) with *t*-statistics of -7.42 (-4.58). However, the book equity significantly predicts future profitability with positive sign. If we include variation in return-on-equity and book equity in the regression analysis, both of them are still significantly associated with future profitability. Yet they still affect profitability in an opposite direction. Parameter estimated (*t*-statistics) for *ROEstd* and *BE* are -0.06 (-5.67) and 0.02 (9.95), respectively. This evidence implies that the variation in return-on-equity can forecast cash flow even though the book equity is controlled. Results are consistent with the explanation that the ability of book equity and variation in return-on-equity to predict stock returns is related to their ability to predict cash flow. We suggest that because less variation in return-on-equity predicts lower profitability in the future, the variation in return-on-equity predicts stock returns with negative sign.

Furthermore, we investigate the investment activity cross firms to conduct whether the risk argument of book-to-market describes the predictive power of variation in return-on-equity. Consistent with the risk argument of book-to-market, we find that both the variation in return-on-equity and book equity is significantly associated with investment growth rate. Panel B of Table 5 shows that the regression of investment growth rate on *ROEstd* produces an estimate of 0.70, with a *t*-statistic of 6.42. Parameter estimates (*t*- statistic) for book equity is -0.29 (-6.75). In other words, higher variation in return-on-equity induces firms to expand while higher book equity forces firms to contract. When variation in return-on-equity and book equity are both present in the regression analysis, parameter estimates for *ROEstd* and *BE* are 0.40

(4.06) and -0.22 (-8.52), respectively. We suggest that firms are willing to invest more as they have lower cost of equity or discount rate, which makes investment opportunities more attractive. Hence, variation in return-on-equity and book equity may reveal relevant

Table 5

Regression analysis about the variation in return-on-equity and book equity

This table summarizes various regressions results concerning the role of the variation in return-on-equity and book equity. Return-on-equity (ROE) is the stock's recently yearly earnings divided by the book common equity of the prior fiscal year. The standard deviation of return-on-equity (*ROEstd*) used is from the sample variance of yearly return-on-equity over the last five years before portfolio formation year t. The changes in return-on-equity (*DROE*) defines as the absolute value of difference between return-on-equity at the end of fiscal year $t-1$ and return-on-equity at the end of fiscal year $t-3$. BE is the book value of equity at the end of fiscal year $t-1$. Profitability defines as the average return-on-equity following five years after portfolio formation year t and investment refers to the investment growth rate measured by capital expenditure at the end of fiscal year t relative to fiscal year $t-1$. Growth rate of book equity, earnings, and profitability are the average annul growth rate following five years after portfolio formation year t. All dependent variables, except for investment growth rate, are defined as the natural logarithm of one plus these variables. The reported slope coefficients and their standard errors are computed from the time-series of the estimated cross-sectional slope coefficients. The *t*-statistics, adjusted for heteroskedasticity and one-year lag autocorrelation, are in the parentheses.

Panel A: Regression analysis of profitability					
ln(1+*ROEstd*)	-0.08			-0.06	
	(-7.42)			(-5.67)	
ln(1+*DROE*)		-0.04			-0.04
		(-4.58)			(-4.56)
ln(*BE*)			0.03	0.02	0.02
			(9.94)	(9.95)	(9.16)
Panel B: Regression analysis of investment activity					
ln(1+*ROEstd*)	0.70			0.40	
	(6.42)			(4.06)	
ln(1+*DROE*)		0.80			0.50
		(3.67)			(3.16)
ln(*BE*)			-0.29	-0.22	-0.26
			(-6.75)	(-8.52)	(-6.22)

Panel C: Regression analysis of growth rate of book equity					
ln(1+*ROEstd*)	0.08			0.05	
	(4.49)			(3.92)	
ln(1+*DROE*)		0.09			0.07
		(7.60)			(6.84)
ln(*BE*)			-0.02	-0.01	-0.01
			(-7.94)	(-4.26)	(-5.76)
Panel D: Regression analysis of growth rate of earnings					
ln(1+*ROEstd*)	0.08			0.02	
	(2.68)			(0.62)	
ln(1+*DROE*)		0.04			-0.01
		(2.23)			(-0.29)
ln(*BE*)			-0.03	-0.03	-0.03
			(-5.89)	(-6.22)	(-6.16)
Panel E: Regression analysis of growth rate of profitability					
ln(1+*ROEstd*)	0.11			0.05	
	(4.61)			(2.04)	
ln(1+*DROE*)		0.09			0.02
		(3.75)			(1.01)
ln(*BE*)			-0.04	-0.03	-0.04
			(-9.69)	(-9.40)	(-9.70)

information about cost of equity.[11] Another possibility is that uncertainty itself makes investment more attractive. However, a reliable association between investment and uncertainty of investment needs further research.

Now we propose some intuitions to realize why the variation in return-on-equity and book equity explain current investment activity and future cash flow with opposite sign. An possible way is to investigate their association with book-to-market ratio by means of analyzing the growth rates of book equity, earning, and profitability. As suggested by Pástor and Veronesi (2003), book-to-market ratio is related to the growth rates of book equity, earning, and profitability. Panel C to Panel E of Table 5 shows that the variation in return-on-equity is significantly positive associated with future growth rate of book equity, earning, and profitability, while book equity is significantly negative related to these growth rates. For example, the regression coefficient of growth rate in book equity on *ROEstd* is 0.08 (*t*-statistics=4.49) but it is -0.02 (*t*-statistics=-7.94) for *BE*. If we set book-to-market as the benchmark, evidence shows that the variation in return-on-equity and book equity influence this ratio in an opposite way. Most important of all, we find that the positive association between uncertainty and these growth rates remains after controlling for the known determinant of growth rates, i.e. book equity. All these evidences state that information from the variation in return-on-equity is not redundant.

2.8 Conclusion

Previous research investigates that the valuation of a firm is related to the uncertainty

[11] Chan, Lakonishok, and Sougiannis (2001) find that there is a positive relation between firm return volatility and R&D intensity.

about future profitability by means of the growth rate on book equity (Pástor and Veronesi (2003)). The rational pricing model has proposed that stock return volatility increases with this variation in return-on-equity. However, the association between expected stock returns and the variation in return-on-equity is an open question.

In this paper, we empirically investigate the implication of Pástor and Veronesi (2003) that volatility of return-on-equity and book-to-market ratio are correlated, and this implication on expected stock returns. Two empirical findings emerge from our study. First, we investigate the empirical association between the uncertainty bout profitability, market value, and book-to-market. We find that portfolios classified as low book-to-market (following Fama and French method) experience high variation in return-on-equity prior to portfolio formation, while high book-to-market stocks face less variation in return-on-equity. Valuation is not independent to the behavior of earnings as argued by Fama and French (1995).

Second, we form portfolios based on the volatility of return-on-equity and find that the subsequence stock returns decrease monotonically with the variation in return-on-equity. In the cross-sectional regression analysis, we examine that the uncertainty variable is significant in explaining stock returns. In analyzing portfolio returns, we find the value effect becomes weak within the uncertainty group. However, what kind of information is embodied in the uncertainty variable to make it useful in explaining expected stock returns remains a question. To investigate this issue, we rely on the equity cash flow perspective and the risk argument that are used to explain the value effect. As argued in Clubb and Naffi (2007), we find that the cash flow perspective and the risk perspective of book-to-market are consistent as they are from rational pricing. In particular, both propositions provide reasonable explanations to examine why variation in return-on-equity can forecast stock returns. Volatility of profitability not only has great impact on return variance but also has the ability to explain subsequence stock returns. Although considerable research has examined the association between return volatility and expected return, time-series and cross-section, our paper provides a new concept to investigate this issue through the analysis of profitability. However, we needs future research to detect its effectiveness.

Finally, our analysis also provides support for the issue about the association between uncertainty and investment (McDonald and Siegel, 1986; Pindyck, 1991; Minton and Schrand, 1999; and Boyle and Guthrie, 2003). Although a large number of studies have investigated the investment-uncertainty relationship based on aggregate data,[12] empirical evidence from firm level is rare. In addition, the empirical evidence for this relationship is inconclusive. Minton and Schrand (1999) investigate the association between cash flow volatility and investment for U.S. firms from 1989 to 1994. From risk management point of view, they state cash flow volatility is costly as a firm is more likely to experience cash flow shortfall such that higher cash flow volatility is associated with lower investment and higher cost of capital. Boyle and Guthrie (2003) propose an opposite possibility that volatile cash flow increases current investment because more volatility in the firm's future cash flow raises the possibility of shortfall which in turn lowering the value of waiting and increasing investment. Our evidence only provides a brief support to their theoretical statement that the relationship between investment and uncertainty could be positive. Analysis that is more complete needs further research.

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[12] See Carruth, Dickerson, and Henley (2000) for a literature review and a recent contribution.

Chapter 3

How Expected Earning Volatility Affects Stock Returns

3.1 Abstract

This paper theoretically investigates the effect of uncertainty about future investment on the expected stock returns. Based on a real options framework, we incorporate the learning-by-doing effect to analyze the irreversible investment problem. In our investment decision framework, the timing of expansion is endogenous and results from value-maximizing decision. In addition, there are two important implications of our framework. First, we show that an increase in the relative valuation ratio, proxy of book-to-market ratio, raises the average stock returns. This positive relationship helps to explain the value premium. Second, we investigate that how uncertainty about investment affects expected stock returns. Based on the closed-form solution in our framework, we suggest that less uncertainty about investment induces lower expected stock returns. Using U.S. data, we apply expected earning volatility as proxy of investment uncertainty to confirm our theoretical findings. We find that there is a significant positive relation between expected earning volatility and stock returns when market size is controlled. In addition, we find higher expected earning volatility induce firms to exercise more growth options.

3.2 Introduction

Recently, a number of theorists have noted that corporate investment is critical in examining the valuation of a firm and the cross-section stock returns (Berk, Green, and Naik, 1999; Zhang, 2005; and Cooper, 2006). Meanwhile, some research finds that expansion activity and the uncertainty about investment are related (McDonald and Siegel, 1986). How the uncertainty about investment affects the dynamics of stock returns, however, remains a controversial issue. Because of irreversibility, investment decision and the value of growth options vary with the uncertainty about investment (McDonald and Siegel, 1986). According to Berk, Green, and Naik (1999), a firm has two kinds of assets: assets in place that generate cash flows now and growth options that makes positive net present value investment in the future. Thus, the average systematic risks of a firm are conditional on cash flows from existing or new projects in the subsequence periods. We suggest that if making profitable investment changes a firm's systematic risks and expected returns, varying investment uncertainty should alter the value of the firm and its return dynamics.

In this study we attempt to investigate the association between investment uncertainty and expected stock returns. This issue is related to two literatures. On the one hand, recently financial economics counts on investment activities to examine the value effect, theoretically and empirically. Researchers state that profitable investment is useful to reduce the risks of a company. On the other hand, from macroeconomics, literature explores the relationship between investment uncertainty and investment by means of real options framework. However, the issue about association between investment uncertainty and stock return has rarely been touched. One related discussion is about the relationship cash flow volatility and expected stock returns because in finance the uncertainty about investment is always proxy by the cash flow volatility. However, there is still difference between these two issues because investment problem is often ignored in the analysis of cash flow volatility.[13] Ignoring the channel of investment may lose the possibility to discuss liquidity issue.[14]

If we analyze the association between investment uncertainty and stock returns through means of investment, this connection may be inclusive. Our intuition is from arguments of two literatures. First, we can discuss effects of investment on expected stock returns from two distinct aspects. According to the work of Berk, Green, and Naik (1999), a company holds the real options to invest such that it can reduce systematic risks by investing profitable projects. As growth firms hold profitable investment opportunities, they have lower risks as well as have lower expected stock returns. On the contrary, Zhang (2005) and Cooper (2006) rely on the risks of assets in place to explain the relation between investment and stock returns. Based on the irreversibility problem emphasized on macroeconomics, they state that value firms are riskier than growth firms because they have more assets in place that are costly to contract. Value firms with more existing assets are not eager to investment because they have excess capacity or their productivity is low. In brief, these studies prove that there is a negative association between investment and stock returns.

Second, we also can investigate the relationship between investment uncertainty and investment through two schemes. According to the real options framework of McDonald and Siegel (1986), an increase in investment uncertainty not only raises the value of investment options but also defers the optimal timing of investment. Literature shows that the relationship between investment and uncertainty is inclusive if capital

[13] To prevent unnecessary complexity, Pástor and Veronesi (2003) ignore the investment issue in their analysis of return behaviors.
[14] Another possibility is to investigate debt in the analysis.

market is friction. Minton and Schrand (1999) argue that due to the costly cash flow volatility, cash flow volatility is associated with lower investment and with high costs of accessing external capital. With the dynamic relation between investment and liquidity, Boyle and Guthrie (2003) state that more volatility in future cash flow raises the risk of future funding shortfalls such that lowers the value of growth options and increases current investment. When firms face financing problem in expansion, however, uncertainty provides an opposite effect to the value of waiting. In the presence of a financing constraint, greater cash flow volatility eliminates the value of investment options because it increases the possibility of a future cash flow shortfall and therefore leads to suboptimal investment decision. When liquidity is under consideration, the association between investment and cash flow volatility is not clear, that explains why there is little empirical evidence to support the positive relation of uncertainty and investment.

Although the association between investment and future stock returns is reliable, the relation between uncertainty and investment is inclusive. That provides a basic understanding why it is difficult to examine the relation between investment uncertainty and future stock returns through means of investment. Empirically, we face more difficulty because the well-known measure of volatility is likely to contain of both cash flow and financing uncertainty. The goal of this paper is to provide a simple real options framework to help us to understand the relation between investment uncertainty and average stock returns by means of investment. This channel is critical because it reflects the ability of financing and investing.

First, by introducing learning-by-doing effect, we identify that investment is triggered by the relative valuation ratio, which is defined as the ratio of value of existing assets to value of new project. Moreover, we demonstrate that the level of relative valuation ratio contains crucial information about the value of growth options and the dynamics of stock returns. We prove that investment is triggered only when the profitability of existing assets reaches an upper threshold. This statement is consistent with the concept of Cooper (2006). This implies that only when a firm has no problems in idle capacity, new investment can be triggered. Consistent with Berk, Green, and Naik (1999), our model shows that the decision to invest can change a firm's systematic risks if investment is irreversible. We derive that if a firm's systematic risks are conditional on assets that it has hold, the expected stock returns are higher when the firm has a higher relative valuation ratios. More specifically, undertaking profitable investment helps to reduce average systematic risks of the firm's future cash flows, as suggested by Berk, Green, and Naik (1999). To finance new investment, however, we need a higher relative valuation ratio to make existing assets as profitable as new projects. Hence, when the relative valuation ratio increases, new investment becomes less profitable and makes firms to face higher systematic risks as well as higher returns. In brief, our framework proposes that the average stock returns increase with the relative valuation ratios, proxy of the book-to-market ratios. We provide a possible explanation to the so-called value premium by means of future expansion options and the learning-by-doing effect.

Second, based on options to investment, we examine how the uncertainty about investment affects the expected stock returns. We find that greater uncertainty about investment induces higher average stock returns. In the classical literature of investment under uncertainty (McDonald and Siegel, 1986), greater uncertainty about investment postpones the timing of expansion and increases the value of growth options. However, some research argues that when firms face financing constraint on future investment, greater volatility in cash flows reduces the value of investment options (Boyle and Guthrie, 2003). In our framework, although investment irreversibility forces firms to delay profitable investment when uncertainty is high, uncertainty about investment also destroys the value of growth options because of the learning-by-doing effect. Our intuition is that the productivity of existing assets cannot improve because investment is postponed. That will provide a negative effect to the value of waiting. When a firm's systematic risks are conditional on assets that it holds, greater uncertainty about investment from existing and/or new assets will reduce the value of growth options and increase the corresponding average stock returns. In addition, because investment is irreversible, making suboptimal investment decision also increases its systematic risks. In short, we find a positive relationship between the uncertainty about investment and the expected stock returns.

Through analyzing the characteristics of cross-section stock returns, our framework prediction is confirmed when market size is controlled. We apply the expected earning volatility as our proxy for investment uncertainty. Our cross-section evidence shows that, controlling the market size, there is positive relation between expected earning volatility and monthly stock returns among firms. Moreover, controlling market size, we find higher expected earning volatility induce firms to exercise more growth options. This evidence confirms our proposition that investment uncertainty increases the possibility of cash flow shortfall so that liquidity constraint firms (small market size firms) are forced to make suboptimal investment decision. Making a suboptimal investment decision may increase firm's risks.

In sum, our framework is close to Cooper (2006) in that the firm's investment decision does rely on the profitability of its assets in place and is thus path dependent. That is, the value of existing assets can affect investment decision and the value of growth options. Moreover, when the firm's assets in place become more profitable, the value of growth options increases and the probability that the firm undertakes investment also increases. Most importantly, the average stock returns increases with the relative valuation ratio and the uncertainty about investment.

Our analysis proceeds as follows. In Section 3, we provide some literature review to introduce our motivation and intuition of this study. We investigate our real options framework to evaluate the value of a firm and growth opportunity in Section 4. Based on our closed-form solution, we discuss the optimal investment strategy of a firm in Section 5. Section 6 focuses on the analysis of stock returns. In Section 7 we provide some proxy of uncertainty to commit our theoretical results. Section 8 contains some concluding remarks.

3.3 Literature Review

Our study relates to two areas of research on financial economics. One relates to the issue about investment under uncertainty, and the other discusses the dynamics of stock returns by means of optimal corporate investment. More specifically, our research examines the association between uncertainty about investment and stock returns. In this section, we discuss previous literature and its implications for our investigation.

To analyze the relationship between investment and uncertainty, McDonald and Siegel (1986) apply the real options model to discuss the optimal timing of investment. In that model, the firm has perpetual rights to a new project and seeks to choose the optimal investment timing that maximizes the expected payoff. They assume both the benefits from the project and investment costs follow continuous-time stochastic process, and investment decision is independent to the financing decision. Because the expected payoff from the new project is uncertain and the investment is irreversible, the optimal corporate policy is to invest only when the project's NPV exceeds a positive threshold. Based on their real options framework, both the value of the growth options and the investment threshold are increasing functions of the uncertainty about investment. Consistent with McDonald and Siegel (1986) model that benefits and costs of new investment are path dependent, Hackbarth and Morellec (2006) extend this setup to allow for a linear connection between gains and costs of new expansion. They assume that after expansion the value of the firm increases by a constant fraction at a cost proportional to the valuation of new investment. According to Hackbarth and Morellec (2006), because control transactions (takeover, expansion, and disinvestment) generally create values for the firm, they can affect firm-level betas as well as stock returns.

Shleifer and Vishny (2003) and Morellec and Zhdanov (2005) apply similar linear setting to investigate the synergy from takeovers, another kind of investment. Shleifer and Vishny (2003) suggest that if two firms merge, the market value of new equity is the sum of capital stocks from target and acquiring firms. Morellec and Zhdanov (2005) extend their linear setting to allow for asymmetric information between outside investors and inside managers. They assume a part of the synergy from takeover is not observable to outside shareholders. However, investors can update their information according to the behavior of participating firms.

Recent theoretical literature have stressed the association between firm-level investment, valuation, and expected stock returns. An innovative work of Berk, Green, and Naik (1999) relates average stock returns, systematic risks, and firm properties such as firm size and book-to-market ratio. In this model, the value of the firm is composed of the value of assets in place and growth options. They suggest that making a profitable investment will reduce the average systematic risks of the firm's cash flows in subsequence periods, which in turn leads to lower stock returns. Based on Berk, Green, and Naik (1999), further studies incorporate the costly reversibility problem into investment decisions to examine the linkage between firm-level investment and stock returns. Zhang (2005) develops a neoclassical industry equilibrium framework with aggregate uncertainty about profitability and shows that firms' optimal investment can generate the observed value premium, if investment is costly reversible and the price of risk is countercyclical. More specifically, he demonstrates that the asymmetric convex adjustment costs of investment gives rise to cyclical behavior of value and growth betas. In economic downturn, capital invested is riskier than growth options because it is difficult to disinvest, while growth options are as risky as assets in place in economic booms because growth firms invest more at this situation. Hence, assets in place are riskier that growth options especially in bad times.

Cooper (2006) develops a dynamic real options model to examine the relationship between book-to-market ratio and investment that accounts for the value premium. If capital investment is largely irreversible, the book value of assets of a distressed firm remains constant but its market value falls when facing adverse profitability shocks. That is if a firm has idle physical capacity, it is very sensitive to the aggregate productivity shock to make it has a higher book-to-market ratios. Its excess installed capital capacity allows it to gain from positive aggregate shocks without undertaking new costly investment, thus providing a high return to stockholders. In contrast, a low book-to-market firm would have to undertake investment to gain from positive shocks. Hence, it is less sensitive to economics shocks and has lower systematic risks. He suggests that a firm undertakes new investment only when profitability is higher enough. Model also shows that irreversibility of investment, not costly reversibility, is the driving force behind the value premium. In sum, our contribution is that we help to fill the gap between expected stock returns and uncertainty about investment. Our framework shows that uncertainty about investment not only governs the optimal timing of expansion but also affects the expected stock returns.

3.4 The Model

In this paper, we apply the rational real-option approach to analyzing investment decision under uncertainty for all-equity firm. In this static framework, uncertainty of the economy is from a complete probability space $(\Omega, \mathbb{F}, \mathrm{P})$. Using linear setting as our valuation benchmark (Berk, Green, and Naik, 1999, and Shleifer and Vishny, 2003), we develop two assets model to investigate investment decision problems. In contrast to previous literature that is limited to discuss only the value of new capital stocks, we argue that both the value of new capital and the value of existing capital have apparent effects on the expansion decision. In this section, we build our basic two assets model and briefly introduce the interaction between existing assets and investment.

According to Berk, Green, and Naik (1999), we assume that assets in place and new investment create the value of the firm in this framework. Moreover, investment is irreversible, so that it cannot be used for any other purpose. Managers can postpone the expansion options until new information about the valuation of existing and new capital is revealed. Hence, investment decision can hinge on the valuation of both assets. We further assume that the all-equity firm only has one investment opportunity, but the optimal investment scale can be distinct among firms. In addition, we assume that the irreversible investment option is infinite-lived.

Moreover, we presume that productivity of existing and new capital stocks are different but can affect each other. This is the so-called learning-by-doing effect. The simplest case of learning-by-doing is when learning occurs as a side effect of the production of new capital. Given G_t and H_t, which represent the present value of future cash flows per unit of existing and new capital, respectively, after investment the valuation per unit of capital can be shown as :

$$\overline{G_t} = G_t + I_t^G\left(G_t, H_t\right) \quad \text{and} \quad \overline{H_t} = H_t + I_t^H\left(G_t, H_t\right). \tag{1}$$

In equation(1), $\overline{G}$ represents the valuation per unit of existing assets, and $\overline{H}$ stands for the valuation per unit of newly investing capital. Suppose that the valuation of each asset has two components. The first factor is the present value of the future cash flows generated by their original operation, G_t and H_t; the second factor is the potential extra benefits created by new investment waiting to implement. We assert that assets in place benefit from new investment and the synergy from new investment is conditional on the valuation of existing assets. Therefore, the implicit value of each asset is dependent. In brief, if the learning-by-doing effect is under consideration, the valuations of existing and new capital stocks are related and cannot evaluate separately.

If the capital stocks of existing and new assets are K_1 and K, respectively, the value of the firm is given by

$$V\left(G,H\right) = \left(K_1 + K\right)\left[(\lambda + \alpha)G + \left(1 - \lambda - \alpha + \alpha\beta\right)H\right], \tag{2}$$

where $\lambda = K_1 / \left(K_1 + K\right)$. λ refers to called book ratio and is applied to capture the relative importance of existing and new capital stocks. We further assume the learning-by-doing effect is distinct among new and existing capital stock. In such setting, it is easy to identify what kind of driving force, improvement on productivity of existing capital stocks or improvement on productivity of new capital stocks, is behind investment decision. In our model, α, and β are parameters describing the improvement on productivity from expansion for existing and new capital stocks, in which α is shared by both assets but β is only beneficial to new capital stocks. In addition, α is observable to all outside investors but β is only observable to inside managers. From equation(2), we assert that given an investment option the productivity of these two capital stocks will change in a predictable way if both α and β are observable. For simplicity, we do not discuss the heterogeneous investor problem in this model and assume that all investors have the same opinion about these changes. Thus the information parameters α and β are constant for all investors but can vary among firms to investigate heterogeneous productivity.

The source of investment uncertainty in our framework is the future cash flows generated by these two assets. Prior to investment, we assume the present value of these cash flows evolve as follows:

$$dG / G = \mu_G dt + \sigma_G dW_G, \tag{3}$$

$$dH / H = \mu_H dt + \sigma_H dW_{H.} \tag{4}$$

μ_i and σ_i are, respectively, the drift and volatility of the growth rate of i, $i = G, H$. W_i is the standard Brownian motion on $(\Omega, \mathbb{F}, \mathrm{P})$. Besides, W_G and W_H are two dependent standard Brownian motions with constant correlation ρ. Furthermore, by setting $\rho < 1$, our model captures the feature that changes in the value of existing asset can be the results of economic shocks other than those driving new investment.

When growth options are under consideration, the synergy created by the new project can be expressed as:

$$\begin{aligned} I(G,H) &= V(G,H) - GK_1 - HK \\ &= \alpha(K_1+K)\left[G+(\beta-1)H\right], \end{aligned} \tag{5}$$

where HK is the cost of investment and it is time-varying to verify the importance of timing to investment. Once the firm undertakes new investment, it is irreversible in that the project cannot be abandoned. However, we need two additional assumptions, $\alpha > 0$ and $\beta > 1$, to make sure $I_G = \partial I/\partial G > 0$ and $I_H = \partial I/\partial H > 0$. In other word, we need the value of the firm and the value of growth options can increase with the valuation of existing and new capital stocks. Equation(5) shows that the more improvement on productivity, α and β, the larger synergy that new project can create for this company. If the synergy created by new investment is less than zero, the firm will not undertake any investment as it need internal funds to finance new projects. This criterion is not valid, however, especially when investment is irreversible and faces uncertainty. The following proposition shows the optimal timing of investment and the corresponding value of this growth options when investment is irreversible.

Proposition 1: *Suppose that the true value of the synergy parameter is* $\beta = \beta^*$. *The optimal investment strategy of a firm is to expand when the relative valuation ratio,* $R = G/H$, *is at or above this level*

$$R^* = \frac{\eta}{1-\eta}\left(\beta^* - 1\right). \tag{6}$$

Moreover, the corresponding value of this growth options is

$$
\begin{aligned}
O(G,H) &= HAR^{\eta} \\
&= H\frac{1}{\eta}\left(R^{*}\right)^{-\eta}\alpha\left(K_{1}+K\right)\left[R+\left(\beta^{*}-1\right)\right]R^{\eta},
\end{aligned}
\tag{7}
$$

where η *denotes the positive root of the following familiar quadratic equation*

$$
\frac{1}{2}\left(\sigma_{G}^{2}-2\rho\sigma_{G}\sigma_{H}+\sigma_{H}^{2}\right)\eta(\eta-1)+\left(\mu_{G}-\mu_{H}\right)\eta+\left(\mu_{H}-r\right)=0, \tag{8}
$$

in which $\eta < 1$.[15]

As shown in Proposition 1, a firm's optimal investment policy is governed by a constant threshold R^{*}. The value-maximizing expansion policy is to expand when the relative valuation ratio reaches this cutoff level. This implies that only when the existing capital stocks have higher profitability or there is no idle capacity problem, then new capital is valuable. Our investment decision model differs from the previous studies in which assets in place do not affect the firm's investment decisions, such as Berk, Green, and Naik (1999). However, our work is close to Cooper (2006) that the optimal timing of expansion dose depends on the profitability of the firm's existing assets. He suggests that investment is triggered only when the productivity is high enough relative to the stocks of existing capital, so that the benefits of adjusting the capital stock cover the costs by doing so. Prior to investment, the value of the growth options will depend on the timing of expansion and contain uncertainty. In the following sections, we will discuss the implications of this optimal investment strategy.

3.5 The Optimal Investment Strategy

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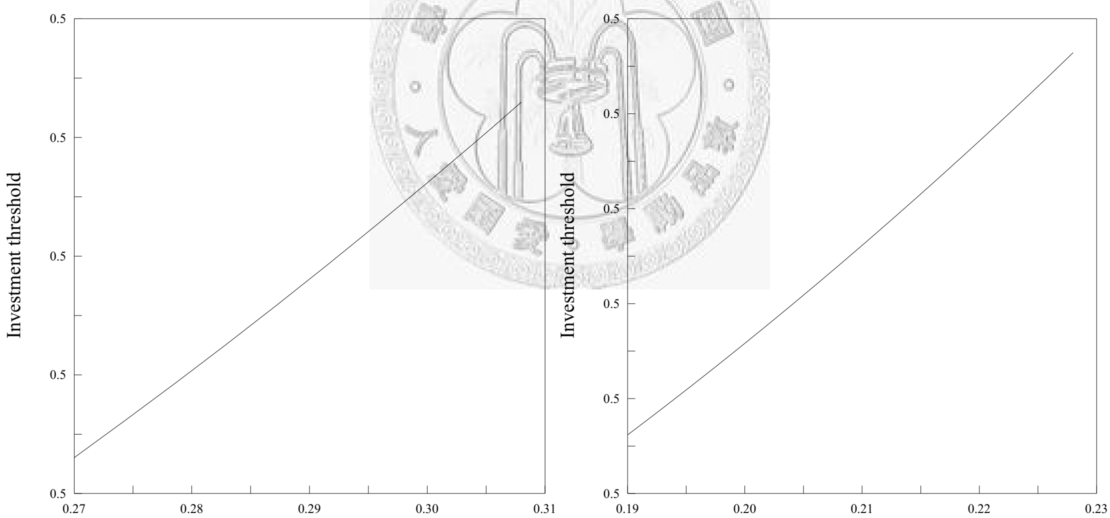
[15] We choose $\eta < 1$ as possible solution because it is reasonable to assume that the value of growth option is increasing function of R but the increasing speed is declining with R because the value of this options cannot go to infinite.

This section investigates the optimal investment activity of the firm derived in Proposition 1. From equation(6), we find that the firm's investment decision involves two sources of uncertainty: the information set about improvement on productivity, and the dynamics of future cash flows. In this section, we discuss the impact of these two characteristics on optimal investment.

First, from our closed-form solution in equation(6), we find that only the unknown productivity parameter β is critical to the timing of expansion. Our intuition is that because α is observable and shared by both assets, it cannot reveal any useful information to the dynamics of relative valuation ratio R. Hence, only the unrevealed information has impact on the optimal timing of investment. In addition, because the relative valuation ratio is non-negative, the constant investment threshold should be positive. From equation(6), we can verify that $\partial R^{*}/\partial\beta > 0$. That is the firm that creates large learning-by-doing effect through investment is not eager to chase profitable investment by setting a strict threshold. Our explanation is that if the improvement on productivity is large, the firm will hold the growth options to maximize the value of waiting to invest. Because β is not observable to the outside investors, managers will hold the growth options until existing capital has higher valuation. In brief, waiting becomes more valuable to managers because this growth options can make existing assets more valuable.

Next, we discuss how the dynamics about cash flows affect the investment threshold. Figure 3 shows some comparative static to discuss the effects of cash flows dynamics in our framework. First, we present a number of key model parameters used in our analysis. The mean and volatility of cash flows from new projects are 5% and 21%, respectively, from Ang and Liu (2004). The volatility of cash flows from existing capital stock is 29% to match the standard deviation of the annual earnings growth of U.S. corporate earnings in the period 1929 to 2001 as reported by Longstaff and Piazzesi (2004). The drift of existing capital stock is set to 12%. This implies that the average of equity return is 8.5%, consistent with the equity premium data from Campbell, Lo, and MacKinlay (1997). The appropriate discount rate is equal to 8% to keep firms holding the options. The investment ratio $1-\lambda$ is equal to 15% from Abel and Eberly (2001). The correlation between existing and new capital stocks is set to 0.1. The improvement on productivity of new capital stocks β is 1.3, which is consistent with the estimated reported by Hennessy (2004). Finally, because α is irrelevant to the investment threshold, we set it equal to one.



Panel A: The volatility of cash flow from existing assets

Panel B: The volatility of cash flow from new assets

Figure 3: The effect of cash flows' volatility on the investment threshold.

This figure shows the comparative static of investment threshold. Two driving forces are discussed here including the volatility of cash flows from existing assets (Panel A) and the volatility of cash flows from new assets (Panel B). Input parameter values are set from previous research as described in the article.

Figure 3 presents the comparative static of the investment threshold. We demonstrate that cash flows uncertainty would time investment because of irreversibility. When a firm faces a higher uncertainty about investment, proxy by σ_H, it would prefer to hold this growth options and wait to invest. This finding is consistent with the previous research that a higher level of uncertainty will increase the critical investment trigger level (Sarkar, 2000). Greater uncertainty increases the incentive to keep the growth options in order to obtain more information about future prices and market conditions. Most importantly, we find that uncertainty about profitability from existing assets also times investment. Because of learning-by-doing, the valuation of existing assets also has impact on the synergy of expansion. When the profitability of existing capital stocks contains more uncertainty, managers will set a stricter investment threshold to expand latter.

Next, Figure 4 shows the impact of the cash flows volatility on the value of growth options. We find that the higher uncertainty about profitability from existing or new capital stocks reduces the value of growth options. This finding is opposite to the real options literature that a higher level of uncertainty increases options value (McDonald and Siegel, 1986). However, according to Boyle and Guthrie (2003), if capital market has frictions such that a firm's investment decision is subject to its internal funds, then greater cash flows volatility reduces the value of the expansion options because the firm has to choose the suboptimal investment timing. Consistent with Boyle and Guthrie (2003), we argue that because of learning-by-doing and the assumption of all-equity firm, the value of growth options depends on the valuation of existing and new capital stocks. Uncertainty about profitability reduces the value of a firm's investment opportunity and makes its market value go down. Thus, waiting is still worth when investment is irreversible, but gains from delaying expansion decrease as profitability become more uncertain.

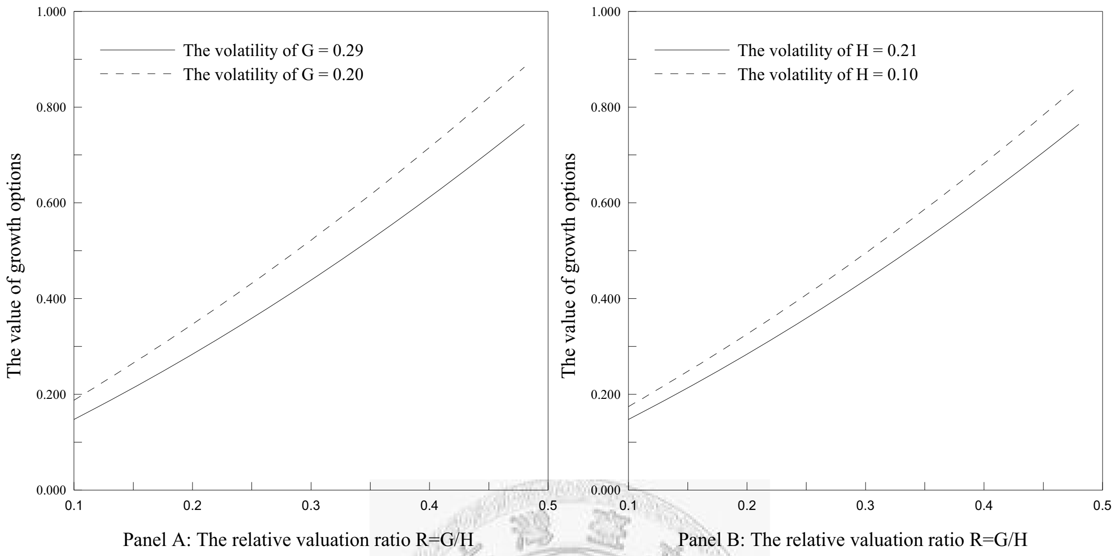


Figure 4: The effect of cash flows' volatility on the value of growth options.
This figure shows the comparative static of the value of growth options. Two driving forces are discussed here including the volatility of cash flows from existing assets (Panel A) and the volatility of cash flows from new assets (Panel B). Input parameter values are set from previous research as described in the article. Total amount of capital stocks, $K_1 + K$, is one.

3.6 The Behavior of Stock Returns

In this section, we derive the dynamics of the value of a firm when it has options to expand. Although there are two different sources of uncertainty in our framework, we only discuss the effect of uncertainty about profitability and assume the improvement on profitability is given. First, we derive the expected stock returns in a closed-form expression. Based on this solution, we then do some comparative static analysis.

Consistent with Berk, Green, and Naik (1999), in our framework the value of firm has two components, assets in place and growth options. In the previous section we derive that the optimal investment activity under uncertainty and the value of the options to invest. Thus, prior to investment the firm's intrinsic value expresses as

$$V(G,H) = K_1 G + O(G,H), \tag{9}$$

where $O(G,H)$ is defined in equation(7). If we assume that there is no private information about profitability, the implied value of the firm depends on the market valuation of these two kinds of capital. Applying Ito's lemma, we obtain the expected rate of returns in Proposition 2.

Proposition 2: *Suppose that the true value of the synergy parameter is* $\beta = \beta^*$. *The expected rate of stock returns can be shown as:*

$$\begin{aligned} E\left(\frac{dV}{V}\right) &= \mu_G + \frac{O(G,H)}{V}(r - \mu_G) \\ &= r + \frac{\lambda R}{\lambda R + \bar{A}R^{\eta}}(\mu_G - r). \end{aligned} \tag{10}$$

The first equality of equation(10) shows that the expected stock returns are the value-weighted return of two kinds of assets, existing and new capital stocks. μ_G is the expected rate of return from existing assets while r is the discounted normal rate of return from holding the growth options. Given that $\eta < 1$ from equation(8), it is easy to derive $\mu_G > r$. Given that $\mu_G > r$, we find that the expected stock returns decrease with the proportion of the value of growth options to the total value of the firm.

The second equality of equation(10) shows that the expected rate of returns can relate to the firm's characteristics such as the book ratio and the relative valuation ratio.

Each of them accounts for the change in the expected rate of returns in a predictable way. Figure 5 shows some comparative static to summarize these characteristics of expected stock returns prior to investment in our framework. All parameters are identical to those in the previous section. We find the expected stock returns increase as R rises. Our explanation is that when R increases, the value of assets in place dominates the total value of the firm. Then returns from existing assets dominate the expected rate of returns. Note that the relative valuation ratio is positively related to the firm's book-to-market ratio. The numerator of R, G, can be viewed as the firm's book value of asset, and the denominator of R, H, is positively related to the firm's market value of equity. Thus, if the firm has higher R or book-to-market ratio, its expected stock returns are also higher. In addition, Panel A of Figure 5 shows that the average stock returns increase with the book ratio, $K_1/(K_1+K)$. That is if a large proportion of the firm's capital stocks is from existing assets, its expected stock returns are also higher. Consistent with the previous research about value premium, we find that the firm with higher relative valuation ratio and/or higher book ratio earns higher expected stock returns.

Panel B and Panel C of Figure 5 show that the expected stock returns increase with uncertainty about investment. A higher volatility of cash flows from existing assets (Panel B) or new capital stocks (Panel C) produces higher average returns. Our explanation is that when uncertainty from investment is high, the value of growth options declines such that profits from existing assets dominate total value of the firm. Thus, assets in place mainly govern the firm's systematic risks. In other word, when the firm faces higher uncertainty about investment, it will postpone the expansion project so that risks from existing assets contribute a lot to its systematic risks. In brief,

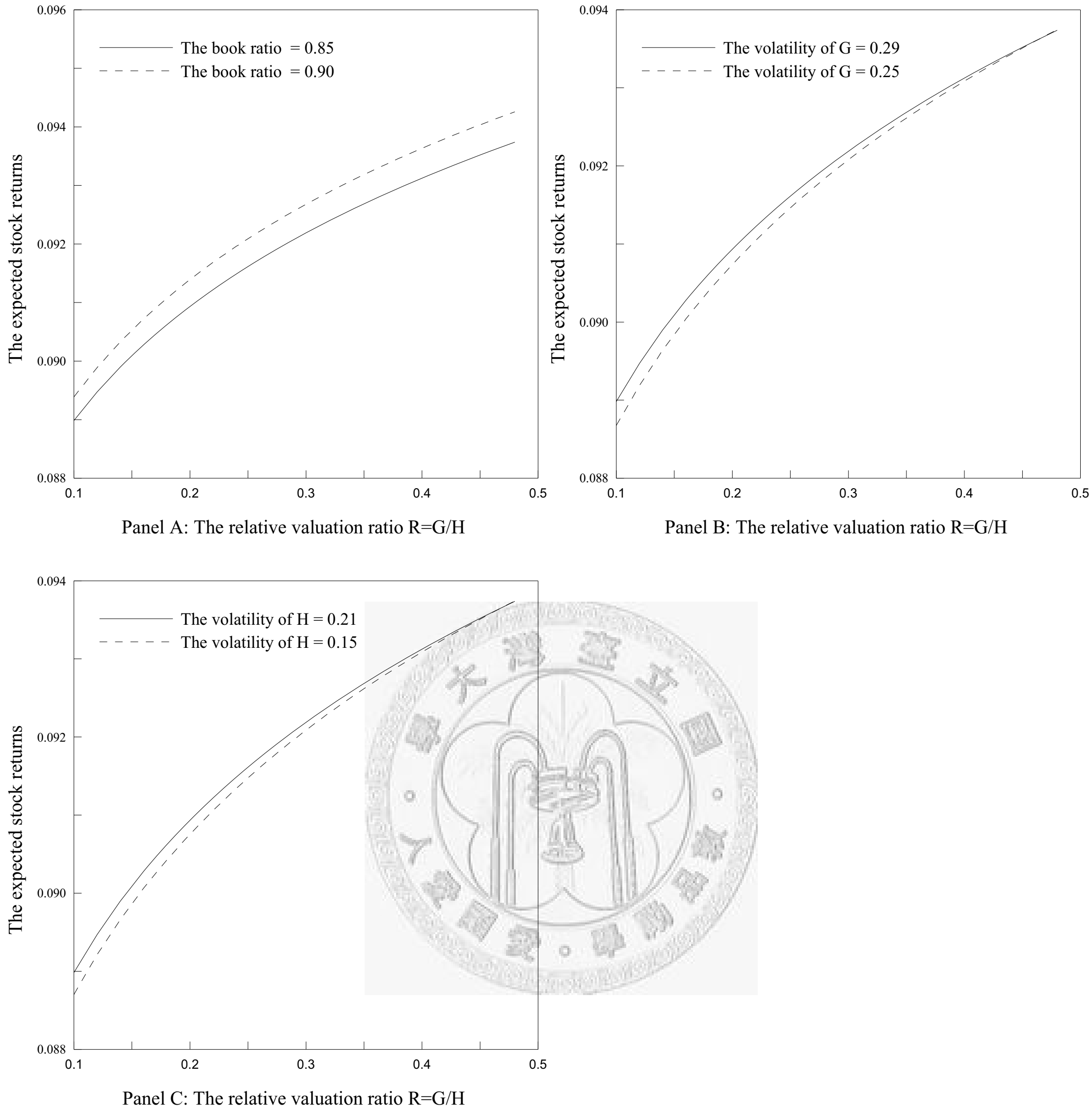


Figure 5: The effect of book ratio and cash flows' volatility on the expected stock returns.

This figure shows the comparative static of the average stock returns. Three driving factors are discussed here, including the volatility of cash flows from existing assets (Panel A), the volatility of cash flows from new assets (Panel B), and the book ratio, which captures the ratio of the capital stocks of existing assets to that of new assets (Panel C). Input parameter values are set from previous papers as described in the article. Total amount of capital stocks, $K_1 + K$, is one.

by introducing learning-by-doing effect and irreversible investment, we find the expected stock returns are positively related to the uncertainty about investment.

3.7 Empirical Evidence

This section describes our empirical methodology in detail and al so provides an overview of our data sources and main results. The essence of our strategy is to investigate the effect of investment uncertainty on expected stock returns through means of investment policy and financing issue. This channel is critical to realize why the investment uncertainty needs to be priced because this uncertainty relates to systematic risks. As we have stated in the previous section, we attempt to examine that there is a positive relation between investment uncertainty and expected stock returns because financing constraint force firms to choose suboptimal investment timing. If investment is irreversible, then increasing suboptimal investment will increase its systematic risks. In our analysis investment uncertainty and financing constraint are both from uncertainty about future revenue.

We use stock price data from the Center for Research on Securities Prices (CRSP) and financial statement data from COMPUSTAT from 1980 to 2001 to detect relationships between investment uncertainty and firms' characteristics. Only nonfinancial firms (SIC other than in the 6000) and firms with ordinary common equity (security type 10 or 11 in CRSP) are discussed in our study. In addition, we also require each firm to have a strictly positive book value prior to portfolio formation year. We focus on expected stock returns of portfolios formed by the widely accepted Fama-French method of classifying stocks based on their market size and investment uncertainty. We apply the expected earning volatility as our proxy of investment uncertainty. We do not observe the true value of the volatility of future cash flow, but we can use the realized earning volatility between year $t+1$ and $t+5$ as our proxy for future earning volatility in our analysis. When expectations are rational, future earning volatility should be captured reasonably well by the ex post realized value. Because this variable is likely to include aspects of both revenue and financing uncertainty, we use market size to control financing constraints. The precise definition of variables used below is shown in the appendix. Below we show some properties among portfolios to confirm our inferences.

We follow the methods of Fama and French (1992, 1993) in sorting stocks into portfolios and investigating the influence of firm-specific characteristics on stock returns. Monthly portfolio returns are computed from July of each year *t* to June of year *t*+1. According to Myers (1998), we apply growth rate in capital expenditures to proxy for the exercise of growth options.

Table 6 reports some summary statistics of various characteristics computed across firms in the same expected earning volatility portfolio. Median capital expenditure growth rate first increases with the expected earning volatility from 8.44% in the lowest group to 19.01% in the eighth high quintile. Higher expected earning volatility seems to have large market size. According to Fama and French (1992), we apply two leverage variables, including the ratio of book assets to market equity, *A/ME*, and the ratio of book assets to book equity, *A/BE*. *A/ME* is interpreted as a measure of market leverage while *A/BE* is a measure of book leverage. The book-to-market ratio, BM, and the market leverage, AME, are rather flat across expected earning volatility. Monthly stock returns slowly increases with the expected earning volatility while stock return volatility declines with this proxy.

Table 6

Summary Statistics

The table summarizes various statistics for groups of firms of the same expected earning volatility, where expected earning volatility is measured by the variance of earning from year *t*+1 to year *t*+5. Year *t* is the portfolio formation year. This table reports the medians across firms of the characteristics listed in the row label. Return volatility (sigma) and stock return are monthly data and express in percentages. The market size reports by millions. The capital expenditure growth rate, CEGR, is defined during year *t* to year *t*+1 and reported in percentage.

Volatility	1	2	3	4	5	6	7	8	9	10
ME	9	16	27	43	68	102	176	321	765	2960
BM	0.90	0.93	0.85	1.10	1.07	1.18	1.23	1.39	1.40	1.37
AME	1.16	1.16	1.13	1.11	1.18	1.12	1.12	1.14	1.24	1.38
ABE	1.63	1.70	1.73	1.74	1.79	1.83	1.88	1.96	2.04	2.17
CEGR	8.44	6.27	11.12	17.59	12.57	13.86	18.88	19.01	16.78	12.38
Return	0.90	0.93	0.85	1.10	1.07	1.18	1.23	1.39	1.40	1.37
sigma	-2.86	-0.22	2.48	2.88	5.56	5.70	7.01	8.99	7.35	6.55

Table 7 shows that the expected earning volatility, our proxy for the investment uncertainty, varies positively with realized monthly stock returns. We have stated in previous section that if investment is constrained, higher uncertainty has two opposite effects on investment. On the one hand, based on real options framework, higher uncertainty increases the investment threshold and the value of waiting. On the other hand, the risks of future funding shortfall lower the optimal investment threshold and encourage firms to accelerate investment. This provides a possible explanation to the finding of Whited (2002) that small firms (and presumably more financially constrained) firms invest more than big, safer, and less financially constrained firms. Intuitively, uncertainty should have a larger impact on the risk and investment characteristics of small rather than large firms. That is what we find in Table 7, where we examine the association between the expected earning volatility and stock returns, controlling for market value of equity. Stocks are first classified into five groups based on market size each June, and then into five quintile portfolios based on the expected earning volatility.

Panel A of Table 7 shows that for the year after portfolio formation, average monthly stock returns are increasing with the expected earning volatility. In the smallest market size quintile, average monthly returns are 1.92% for the lowest earning volatility portfolio versus 3.96% for the highest volatility portfolio. Moreover, the return difference (*t*-statistics) between the highest and lowest volatility groups is 2.04% (7.15) for smallest stocks, 1.62% (2.45) for midsize stocks, and 1.00% (0.06) for the larger size stocks. Hence, higher expected earning volatility has higher average stock returns especially among small size firms.

Panel B of Table 7 shows results when returns are value weighted within portfolios on a monthly basis. Similar results are found in such analysis. Evidence shows that higher volatility follows higher stock returns. In particular, returns increase monotonically with expected earning volatility among smallest size firms. The return difference (*t*-statistics) between the extreme volatility groups are 2.53% (9.45) in the smallest size group, 1.96% (3.03) in the midsize group, and 1.29% (3.09) in the second to largest group. These evidences confirm our argument that small size firms have liquidity constraint so that they bear more risks from volatile cash flow and have higher return difference.

Finally, Panel C of Table 7 reports the investment activities among different volatility groups, controlling market equity size. Evidence confirms our prediction that more volatility in the firm's future cash flow raises the risk of future funding shortfall and increases current investment. This property is critical to explain why higher expected earning volatility is associated with higher stock returns. In particular, we suggest that potential future financing restrictions encourage acceleration of investment beyond the first-best level such that forces firms to face higher risks. Because of irreversibility, suboptimal investment decision makes firms have higher systematic risks.

Table 7

Monthly Stock Returns and Investment for Quintile Portfolios Based on Expected Earning Volatility

At the end of June of each year t, $t = 1980$ to 2001, five portfolios are formed on the basis of ranked values of expected earning volatility, *EAsigma*. Quintile portfolios are ranked in ascending order. Firm size (*ME*, market value of equity) is measured in June of year t. Returns are computed over the 12 months following portfolio formation (total of 264 months). The monthly value-weighted returns are based on monthly rebalancing. The last column of Panel A and B presents the average monthly return difference between high and low quintile portfolios (*t*-statistics in parentheses). In Panel C the reported median of capital expenditure growth rate is from year *t* to year *t*+1. The last column of Panel C reports Wilcoxon rank-sum Z-statistics testing the equality of distributions between the two groups, high and low quintile stocks. All entries are reported in percentages. "-" denotes no observations.

	Low *EAsigma*	2	3	4	High *EAsigma*	High-Low *EAsigma*
Panel A: Average Equally Weighted Monthly Returns						
Small *ME*	1.92	1.92	2.27	2.80	3.96	2.04 (7.15)
2	0.22	0.61	0.66	0.96	2.11	1.90 (6.03)
3	-0.22	0.14	0.37	0.39	1.44	1.62 (2.45)
4	-0.68	2.25	-0.81	0.15	1.21	1.30 (0.06)
Large *ME*	-	-1.90	-1.22	-1.22	1.22	-
Panel B: Average Value-Weighted Monthly Returns						
Small *ME*	0.54	0.91	1.25	1.98	3.08	2.53 (9.45)
2	-0.30	0.34	0.38	0.79	2.13	2.43 (6.80)
3	-0.47	-0.04	0.13	0.26	1.49	1.96 (3.03)
4	-0.08	1.15	-0.70	-0.07	1.21	1.29 (3.09)
Large *ME*	-	-0.26	-0.11	-0.45	1.16	-
Panel C: Capital Expenditure Growth rate						
Small *ME*	-4.99	0.39	-2.62	0	4.14	2.973
2	0	-5.54	-0.26	2.52	2.80	2.008
3	-12.09	7.18	2.11	6.10	5.34	1.984
4	-49.80	1.08	11.67	7.48	7.81	2.242
Large *ME*	-	51.00	-1.62	2.01	6.97	-

Next, we investigate association between firm-level book-to-market, size, earning volatility, and average stock returns using regression analysis of monthly returns. Table 8 reports inference based on the style of Fama and MacBeth (1973). The reported slope coefficients are time-series average of the estimated cross-sectional slope coefficients. The reported *t*-statistics in the parentheses are adjusted for autocorrelation and conditional heteroskedasticity. Table 8 confirms the previous prediction that higher expected earning volatility has higher stock returns. The coefficient of *EAsigma* is significantly positive in all specifications. When controlling market size and book-to-market, the *EAsigma* coefficient is 0.83 with *t*-statistics 8.10. In particular, we find the value effect disappears when we include *EAsigma* in the regression analysis. On the contrary, the size effect becomes apparent. Our evidence suggests that even controlled proxy of financial distress variable, market size and book-to-market, the coefficient of *EAsigma* is still positively significant. Similar results are found when we replace book-to-market with market and book leverage and when we divide two sample periods.

Table 8

Average Parameter Values from Cross-Sectional Regressions of Monthly Returns on Market Size, Book-to-market, and Expected Earning Volatility

Monthly returns are regressed on *ME*, *BE/ME*, proxy of leverage (*A/ME* and *A/BE*), and the expected earning volatility. *BE* is the book value of equity at the end of fiscal year $t-1$. *A* is total book assets from the latest fiscal year ending in calendar year $t-1$. The accounting ratios are measured using market value of equity *ME* at the end of December of calendar year $t-1$. Firm size (*ME*) is measured as the market value of equity (price times share outstanding) at the end of June of each year t, $t = 1980$ to 2001. Year t is the formation year. Expected earning volatility, *EAsigma*, is measured by the variance of earning from year *t*+1 to year *t*+5. The reported slope coefficients and their standard errors are computed from the time-series of the estimated cross-sectional slope coefficients. The *t*-statistics, adjusted for heteroskedasticity and one-year lag autocorrelation, are in the parentheses. Ln denotes natural logarithm. To avoid spurious inferences from extreme values, the smallest and largest 1% of the observations for each explanatory variable are replaced by the 1% and 99% values.

Ln(*ME*)	Ln(*BE/ME*)	Ln(*A/ME*)	Ln(*A/BE*)	Ln(1+*EAsigma*)
Panel A: Full samples				
-0.75	0.15			0.83
(-5.52)	(0.95)			(8.10)
-0.79		0.09	-0.40	0.89
(-5.53)		(0.58)	(-4.43)	(7.22)
Panel B: Sub-sample 1980-1990				
-0.46	0.57			0.53
(-3.39)	(1.02)			(4.77)
-0.51		0.13	-0.45	0.61
(-3.58)		(0.74)	(-3.37)	(4.87)
Panel C: Sub-sample 1991-2001				
-1.04	0.11			1.13
(-4.52)	(0.46)			(6.86)
-1.07		0.06	-0.36	1.18
(-4.19)		(0.22)	(-2.87)	(5.67)

3.8 Conclusion

Considerable research has found corporate investment can explain the conditional dynamics in expected stock returns (Zhang (2005), and Cooper (2006)). In addition, a number of studies state that uncertainty about investment affects the timing and the amount of investment because of irreversibility (McDonald and Siegel (1986)). Meanwhile, literature shows that the relationship between investment and uncertainty is inclusive if firms also face financing constraint (Minton and Schrand (1999), and Boyle and Guthrie (2003)). Yet, despite the substantial development of these two literatures, it is still unclear how the uncertainty about investment affects stock returns. This paper develops a real options model to relate the value of growth options and the value of the firm to the uncertainty about investment, in which uncertainty refers to the volatility of growth rates in cash flows. Because investment is irreversible, the uncertainty about investment affects firms' expansion plans by changing the investment threshold. By introducing the learning-by-doing effect, the value of growth options declines with uncertainty. Our contribution is that we find a positive relationship between investment uncertainty and expected stock returns by means of learning-by-doing.

A related issue of our study can refer to Gomes, Yaron, and Zhang (2006). They incorporate costly external finance into the investment-based asset pricing model and examine whether financing frictions help in explaining the expected stock returns. Minton and Schrand (1999) also have noted that cash flow volatility is positive related to the costs of accessing external capital. Our analysis differs with these studies in that we not only investigate financing problem but also potential gains from investing. As a result, we find the higher expected earning volatility induces firms to increase current investment, while they sate that higher cash flow volatility is associated with lower level of investment.

Although our framework links asset prices to learning effect, we need some empirical research to support our theoretical findings. Another limitation of our work is that we only discuss one possible expansion options. An obvious extension of our work would analyze the more general case that the firm has many projects, in which the learning effect could alter with the number of projects. Besides, if the firm is not all-equity, debts may affect its investment decision and average stock returns. In such case, investment would alter the distribution of future cash flows so that a firm’s ability to commit its future payment also changes. Further analysis of this complex problem has the potential to yield additional insights.

Chapter 4

Conclusion

In this thesis we provide two different schemes to investigate the behavior of stock returns. Based on the rational pricing framework of Pástor and Veronesi (2003), we state that the market equity value is from profitability such that the book-to-market ratio and the evolution of stock return are governed by return-on-equity. It is plausible to examine stock return through means of profitability. In particular, Wei and Zhang (2006) state that the variation in return-on-equity is useful to capture the idiosyncratic return volatility. As a result, it is reasonable to apply the variation in return-on-equity as proxy for idiosyncratic volatility risks in predicting stock returns. Evidence shows that higher variation in return-on-equity predicts lower average stock returns. To explain this negative relation, we count on the cash flow perspective and the risk argument of book-to-market.

Next we introduce the learning-by-doing effect in the real options model to examine the investing and liquidity impacts on stock returns. Although literature has noted the financing constraint to investment, it only focuses on the negative impact of cash flow volatility on expansion. Actually, uncertainty about investment has two opposite impacts on investment. On the one hand, more investment uncertainty increases the value of waiting if investment is irreversible. On the other hand, uncertainty raises the possibility of cash flow shortfall and lowers the value of growth options. The logic of this study is as follows: if investment is irreversible, liquidity constraint will force firms to make a suboptimal investment decision and to bear more systematic risks. Evidence shows that expected earning volatility is positively related to stock returns.

This thesis may attribute to the recent literature that idiosyncratic risks need to be priced. In addition to size and value effect, we find firms' fundamentals provide some critical information in examining stock returns. Profitability and investment both attribute to idiosyncratic risks of the firm. Even though equity market size and book-to-market ratio are controlled, our evidence is still significant. In particular, we provide the liquidity issue though means of investment. However, this liquidity problem cannot represent the financial distress risk. The problem about debt issue or debt valuation needs further research.

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Appendix A: Data

Annual data for the year 1980 to 2001 are extracted from the CRSP/Compustat database. Following Fama and French (1993), book equity is constructed as stockholders' equity plus balance sheet deferred taxes and investment tax credit (Compustat item 35) minus the book value of preferred stock. Depending on availability, stockholders' equity is computed as Compustat item 216, or 60+130, or 6-181, in that order, and preferred stock is computed as item 56, or 10 , or 130, in that order. Market equity value is computed by stock price times share outstanding from CRSP. Earnings are defined as income before extraordinary items, available to common stockholders (item 237), plus deferred taxes from the income statement (item 50), plus investment tax credit (item 51). Assets are total assets (item 6). Capital expenditure is from item 128. We eliminate the value of total assets smaller that $25 million, and the value of stockholder's equity smaller than zero.

Appendix B: The value of growth options

Given the benefits of the new project defined in equation (7), we can apply the real options approach to evaluate this option to invest denoted by $O(G,H)$. Under the assumption of no-arbitrage condition, the value of this growth option $O(G,H)$ must satisfy the following partial differential equation:

$$r\,O = G\,\mu_G\,O_G + H\,\mu_H\,O_H + \frac{1}{2}\left[G^2\,\sigma_G^2\,O_{GG} + H^2\,\sigma_H^2\,O_{HH}\right] + G\,H\sigma_G\,\sigma_H\,O_{GH}, \quad \text{(A1)}$$

where for any value function O, O_i and O_{ii} are the first and second order partial derivative of O respect to i. r represents the appropriate discount rate assumed to be given.[i] While the left-hand side of equation (A1) represents the normal rate of return that an investor would require from holding this option, the right-hand side of equation (A1) is the expected rate of return or expected capital appreciation from holding this option.

This value of option to invest under the optimal investment rule must also satisfy the following boundary conditions:

$$O(G,H) = I(G,H), \quad \text{(A2)}$$

$$O_G(G,H) = I_G(G,H), \quad \text{(A3)}$$

$$O_H(G,H) = I_H(G,H). \quad \text{(A4)}$$

Equation (A2) is the value-matching condition to ensure equality between the value of this option and the payoff when the optimal investment is exercised. Equation (A3) and (A4) are the smooth-pasting conditions to impose the continuity conditions for the value function $O(.)$. There is one additional boundary condition given by

$$\lim_{(G/H)\to 0} \frac{O(G,H)}{H} = 0. \qquad \text{(A5)}$$

It is required that as the ratio of the asset prices increases, the value of this growth option would decline, even to zero, if the relatively price ratio goes to infinite. Hence, if the price of new capital is sufficiently smaller than that of existing assets, the option to invest will be valueless.

From equation (A2) to equation (A4) it is easily seen that the optimal investment rule is governed by existing and new capital as discussed below. Equation (A2) shows that the value of option to invest is linear and homogeneous of degree one in G and H. So the option value or the optimal investment rule can be represented as a function of R, which represents the relative price of existing and new capital. It is worth to note that R is positively related to the firm's book-to-market ratio as proven below. While the numerator of R, G, is proportional to the firm's book value, the denominator of R, H, is positive related the firm's growth options and market value. By changing variables, the value of the growth options can be represented as the function of R. Hence, it is possible to investigate the optimal investment activity of the firm and the value of this growth options on the space of R. Given the partial differential equation defined in equation (A1) and the boundary conditions assumed in equation (A2) to equation (A5), we can derive the optimal investment threshold and the corresponding value of growth options as shown in Proposition 1.

Appendix C: The evolution of the value of the firm

Note that the value of the firm, V, is cum dividend. Because the value of a firm, $V(G,H)$, is homogeneous of degree one in G and H, we can rewrite its value as

$$M(R)=\frac{V}{H}=K_1R+A^*R^\eta. \tag{A6}$$

It can easily be seen that M is a function of R. Applying Ito's lemma, we can get the evolution of V as

$$\frac{dV}{V}=\frac{dM}{M}+\frac{dH}{H}+\frac{dM}{M}\frac{dH}{H}. \tag{A7}$$

Again applying Ito's lemma to $M(R)$ implies the dynamics,

$$\begin{aligned}\frac{dM(R)}{M(R)}&=\frac{K_1G}{V}\left(\mu_R dt+\sigma_R dW_R\right)\\&+\frac{HAR^\eta}{V}\left[\eta\left(\mu_R dt+\sigma_R dW_R\right)+\frac{1}{2}\eta(\eta-1)\sigma_R^2 dt\right].\end{aligned} \tag{A8}$$

Substituting the dynamics of M and H into equation (A7) gets the dynamics of V.

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[i] The condition $r<\mu_G$ must be true to satisfy finite growth.