Leverage and inefficiencies in financial markets
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Chapter 1

Introduction

1.1 Modern Asset Pricing Theory and New Challenges

Asset pricing is frequently studied in financial literature, in research that seeks to understand the rational values of financial assets, such as common shares, bonds, and derivatives. Since Jack Treynor, William F. Sharpe, and John Lintner established the first capital asset pricing model (CAPM) in 1973, many more asset pricing models have been developed to study the nature of the pricing mechanism (Acharya & Pedersen, 2005a; Breeden, 1979; Carhart, 1997a; Cochrane, 1991; Easley, Hvidkjaer & O’Hara, 2010; Fama & French, 1993a; Merton, 1973a). With these models, researchers and practitioners can better evaluate financial assets, conduct more accurate tests of market performance, and make more informed investment decisions.

Two main asset pricing approaches are prevalent in contemporary research and practice: the linear factor model and the stochastic discount factor (SDF)-based model.\(^1\) Many available linear factor models (e.g., expected returns, beta representations) are widely used for discrete time asset pricing. The CAPM is the first and most famous representative of this category. It uses just one factor to explain the expected return of an asset, decomposes total risk into systematic and unsystematic forms, and only prices systematic risk, as determined by the covariance between the market portfolio and the asset.

In contrast, multi-factor models attempt to explain assets’ expected returns

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\(^1\)Risk-neutral pricing offers another asset pricing approach, though it is more prevalent in derivative and bond pricing.
with more than one factor. For example, Fama and French’s (1993) three-factor model uses the market portfolio, the outperformance of small versus big firms (SMB), and the outperformance of high book-to-market ratio versus low book-to-market ratio firms (HML). A canonical form of a linear factor model might be written as:

$$E(R_i^o) = \beta_{1,i} \gamma_1 + \beta_{2,i} \gamma_2 + \ldots + \beta_{n,i} \gamma_n,$$

(1.1)

where $R_i^o$ is the investment return on a test asset in excess of risk-free rate $r_f$; $\gamma_k$ is the risk premium of the $k^{th}$ pricing factor $F_k$; and betas represent the regression coefficients of pricing factors.

In the SDF-based asset pricing models, theoretically, the no-arbitrage condition implies the existence of a positive-valued discount factor $M$, which is usually called the stochastic discount factor or pricing kernel. The pricing formula can be derived as

$$p = E(Mx),$$

(1.2)

where $x$ is the asset payoff, and $p$ is its present value. A key advantage of the SDF-based pricing model is its universality, such that existing pricing models for different types of assets (e.g., bonds, stocks, derivatives) can be unified by the SDF framework. In addition, different specifications of typical traders’ utility can produce various expressions of $M$. A traditional consumption-based model offers a classic example of this approach.

All linear factor models also can be viewed as special cases of an SDF model; see Cochrane (2009). In some conditions, the linear factor model even would be equivalent to a linear model of the SDF $M$, such as when

$$E(R_i^o) = \beta_{1,i} \gamma_1 + \beta_{2,i} \gamma_2 + \ldots + \beta_{n,i} \gamma_n$$

$$\iff M = a + b_1 F_1 + b_2 F_2 + \ldots + b_n F_n.$$ 

(1.3)

For example, if the value function is quadratic and only depends on a typical trader’s wealth, the SDF is an affine function of the excess returns on the market portfolio, from which we can obtain the CAPM. The intertemporal capital asset pricing model (ICAPM) similarly can be derived easily through an SDF framework.

Despite rapid growth in asset pricing models, empirical studies offer increas-
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... evidence in contrast with the predictions of prior theoretical models, producing what are known as financial puzzles, such as the equity premium puzzle, risk-free rate puzzle, excess volatility puzzle, value premium puzzle, or Halloween effect puzzle (Bouman & Jacobsen, 2002; Fama & French, 1992; Mehra & Prescott, 1985; Shiller, 1981; Weil, 1989). These puzzles challenge asset pricing theory and suggest the need to develop new models (Bansal & Yaron, 2004; Campbell & Cochrane, 1999). For example, the value premium puzzle refers to the empirical observation that high book-to-market ratio stocks have higher expected excess returns than low book-to-market ratio stocks, which cannot be explained by the classical CAPM. Although the Fama-French three-factor model attempts to use HML to reflect the value premium, the puzzle remains unsolved. We know only that the HML factor is priced, not why.

Therefore, as a key contribution of this dissertation, in Chapter 2, I attempt to resolve the value premium puzzle by acknowledging the co-movement between firms’ leverage ratios and the market risk premium. In addition, in Chapter 3, I report a new puzzle affecting Chinese stock markets, namely, the overnight return puzzle, and I offer a potential explanation. Lastly, in Chapter 4, I conclude that oil stocks tend to be overpriced after negative oil price shocks based on various factor pricing models. This result also can be viewed as a financial anomaly that partially violates the efficient market hypothesis.

1.2 Outline of The Thesis

This thesis collects several research papers, addressing pertinent asset pricing topics. In particular, Chapter 2 reports an empirical test of an unlevered version of the CAPM and the impact of the leverage movement on time-varying beta and unconditional tests of the traditional CAPM. A notable feature of the unlevered version of the CAPM is that it is a simple single factor model. This feature is in line with my belief that asset pricing research does not necessarily progress by making the models more and more complicated. Chapter 3 features a new financial puzzle; this empirical study of the T + 1 trading rule’s effect on asset prices uses data from Chinese stock markets. It is worth to note that this puzzle is unique in Chinese stock markets. However, I believe that for a research paper it is not always necessary to be general, but it should address an interesting question clearly. With Chapter 4, I attempt to understand market efficiency in pricing oil and gas stocks under different types of oil price changes. Chapter 5...
develops a simple stock return prediction model based on the unlevered CAPM and tests it empirically. Finally, Chapter 6 concludes.

In more detail, the empirical study of the unlevered version of the CAPM (UCAPM) in Chapter 2 proposes a new method to calculate unlevered returns. In economic downturns when the risk premium is high, leverage ratios of value portfolios increase, leading to an increase in equity betas, whereas growth portfolios are both less levered and less sensitive to economic conditions. The interaction between the time-varying market premium and financial leverage can obfuscate the expected return-beta relationship in unconditional tests of the CAPM. After developing the unlevered CAPM, a straightforward model to remove the interaction between the time-varying market premium and financial leverage, I conduct an unconditional test to explain cross-sectional variation in the average unlevered stock returns of 7563 U.S. firms and a variety of test portfolios, for the period 1952-2014. I also apply classic tests proposed by Gibbons et al. (1989a) and Fama & MacBeth (1973). The findings indicate that firms’ financial leverage can largely explain the value effect, yet the expected return-beta relationship of equity in unconditional tests of the CAPM generally is distorted by leverage. I address the implications for levered returns with a two-beta model that accounts for the leverage-risk premium interaction.

Chapter 3 reports on a new financial puzzle. The daily return on an asset can be decomposed into overnight and daytime returns. The average overnight returns are reported with data from various stock markets. I find that the average overnight return on a market portfolio is significantly negatively in Chinese stock markets, whereas the average overnight returns on various stock indices from other markets are consistently positive. To explain this puzzle, I note a unique trading rule in China, the T + 1 trading rule, and test it empirically, using an econometric model. Both the theoretical and empirical results indicate that the T + 1 trading rule generates a discount in the daily opening price.

Chapter 4 proposes a two-stage analysis method to study pricing efficiency for pricing oil stocks following different kinds of oil shocks. In the first stage, a quantile regression defines moderate oil price changes, positive oil price changes, and negative oil price shocks. Through this approach, I exclude expected or relatively insignificant oil price changes. Then I develop a general form of interval-valued factor pricing models and show how various factor pricing models can be derived from it, including the CAPM, the Fama-French (1993) three-factor model, and the Fama-French (2015) five-factor model. Finally, the empirical
test of the model relies on data from the WTI oil price and a composite index of oil and gas industry players in U.S. stock markets, which reveals some notable results.

Finally, Chapter 5 develops a simple stock return prediction model based on the unlevered CAPM and tests it empirically. First, I derive the prediction model with a transformation of the unlevered CAPM; it indicates that firms’ leverage ratios are potential predictors of equity returns. Second, I construct a panel data set of 25 portfolios of U.S. stocks, from 1951 to 2013. The firms are sorted such that the unlevered beta of each portfolio is roughly equal to one. In turn, I have clear theoretical priors for the estimated effect of the lagged leverage ratio on the portfolio returns: Each portfolio should have the same estimated coefficient, and the magnitude of the coefficient should be roughly equal to the average historical risk premium. Finally, I test the model using both fixed and random effect panel regressions. I also report evidence from an out-of-sample test.

1.3 Main Contributions

The aim of this thesis is to test the empirical performance of existing asset pricing models, or else establish new models to explain financial puzzles. The thesis includes four independent chapters, and each chapter individually contributes to at least one research topic related to this aim.

Chapter 2 offers three notable contributions. First, I propose the unlevered CAPM and test its performance empirically. Both the GRS test and Fama-Macbeth two-step regression show that the unlevered CAPM outperforms the traditional CAPM and the Fama-French (1993) three-factor model with a lower GRS test statistic and larger cross-sectional fit. The result is robust to various portfolios and individual firms. Second, and perhaps even more important, this finding implies that the value premium puzzle might be explained by co-movement between firms’ financial leverage and the market risk premium. Third, with a two-beta model, I can capture assets’ beta-premium sensitivity. These findings and proposed models help to enrich asset pricing theory.

Reporting on an interesting puzzle in Chinese stock markets, Chapter 3 makes four main contributions. First, I identify a new financial puzzle: The average overnight return on the market portfolio is significantly negative in Chinese stock markets. This puzzle is unique in China. Second, I present a
potential solution, which is based on the $T + 1$ trading rule. Third, with an econometric model, I show empirically that the average $T + 1$ discount is around 14 basis points, almost two times the average overnight fundamental return. Fourth, this chapter reveals that the impact of the $T + 1$ trading rule on market volatility is positive, despite it was introduced with the belief it would reduce volatility. This study is helpful for financial regulators and practitioners to better understand the adverse effect of $T+1$ trading rule.

Chapter 4 proposes a two-stage procedure to examine stock market efficiency in pricing oil stocks in response to different types of crude oil price changes. There are two advantages of this two-stage procedure. First, it can reflect both of the two main attributions of oil price shocks, as revealed in existing literature, instead of just one of them. Second, the interval-valued factor pricing models that evaluate market efficiency in this study are superior to traditional point-valued factor pricing models, in that they produce more efficient estimations due to the gain in information they offer. The empirical study offers the interesting result that oil stocks tend to be overpriced after negative oil price shocks but efficiently priced after moderate oil price changes or positive oil price shocks. This finding partially violates the efficient market hypothesis and put forward the future research direction of market efficiency during oil shocks.

With two main contributions, Chapter 5 starts by developing a stock return prediction model, with a strong theoretical foundation. This proposed model is consistent with traditional financial theory, including asset pricing theory, capital structure theory and the efficient market hypothesis. In addition, I propose a novel portfolio construction method to construct a number of portfolios with roughly the same unlevered betas, such that it circumvents many of the econometric issues associated with more agnostic hypotheses that appear in joint tests of return predictability in panel data settings. This study helps to enrich the methodology of the tests on stock return predictability.

1.4 Limitations and Future Research

Although this thesis offers significant contributions involving interesting topics related to asset pricing, it still has several drawbacks that suggest routes for further research.

First, the unlevered version of the CAPM introduced in Chapter 2 might be
intended as an approximation of an option pricing approach. I value equity as a forward contract on the securitized total assets of the firm, which offers the advantage of using a linear transformation to move levered to unlevered returns. But shareholders have limited liability, and as such, equity should be viewed as an option on total assets with a dynamic strike. In turn, the transformation generally is not linear. Pricing errors thus might be large for highly levered firms that are close to being "at the money."

Second, Chapter 3 proposes an econometric model to solve the overnight return puzzle. It is a heuristic model, instead of a general equilibrium one. By solving a dynamic programming problem for a typical trader with selling constraints, it may be possible to find the general equilibrium price at the market opening in a T + 1 environment. This question remains open for continued investigation.

Third, Chapter 4 shows that oil stocks tend to be overpriced after negative oil price shocks, using various pricing models. However, all tests of market efficiency inevitably confront the challenge of joint tests of the efficient market hypothesis (EMH) and asset pricing models. That is, to compare the observed price with the fundamental value, it is necessary to establish the fundamental value of those oil stocks first, which requires a general equilibrium (pricing) model. When the asset is mispriced though, it is hard to know whether the market is inefficient or the models used for the analysis are wrong.

Lastly, Chapter 5 proposes a stock return prediction model with the assumption of constant market risk premium. However, previous studies have shown that the market risk premium is lower during expansion periods compared to recession periods. Thus, the dynamics of the market risk premium may help to improve the performance of our prediction model. We will leave this question open for future research.