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AN EMPIRICAL TEST OF THE FAMA-FRENCH FIVE-FACTOR MODEL

Applicability to Equitized State-Owned Enterprises in Vietnam

Master's Thesis
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Abstract

Research Objectives – Asset pricing is one of the most popular topics in financial economics that has been studied for decades as various theories and models were established in this field. However, most of these studies were conducted for the markets in the United States or other developed countries, which can have questionable implications in the emerging and frontier markets. Thus, this thesis aims to fill the research gap by selecting Vietnam's stock market as the market of interest. Besides, this thesis also explores a special segment pertaining to the market: equitized state-owned enterprises (SOEs) by investigating the relationship between average stock returns and state-ownership status. With respect to the model of interest, this thesis will focus on the Fama-French five-factor model and its relative performance to others including the Capital Asset Pricing Model (CAPM) and the Fama-French three-factor model. The underlying rationale for this selection is that the five-factor is a recent model, which was first introduced in 2015, and since then there have been mixed results from empirical tests of this model across different markets. Therefore, there emerges a need to conduct research on this topic, especially for a developing and under-researched market like Vietnam.

Data & Methodology – The thesis will examine monthly returns of common stocks listed on both Ho Chi Minh Stock Exchange and Hanoi Stock Exchange from July 2009 to December 2017, 102 months in total. The sample will be rebalanced annually in June from 2009 to 2017. The sample size amounts to 620 companies after the last rebalance in June 2017. Asset pricing tests will be implemented to investigate the explanatory performance of each model by regressing excess returns of test portfolios on factor returns. Besides, the factor spanning tests will help to determine whether any factor in the five-factor model is redundant by regressing each of the five factors on the other four. All regressions will be conducted using the ordinary least squares (OLS) method.

Main Findings – Regarding asset pricing tests, all models fare worst in 12 value-weighted test portfolios formed from size and state capital. Specifically, the lethal portfolio for all tested models except CAPM contains large stocks of firms with low state capital (state owns more than 0% and less than 50% of charter capital). The average adjusted R^2s of the CAPM, the three-factor model, and the five-factor model are respectively 45.6%, 69.8%, and 70.6%. Regarding the factor redundancy issue, High-Minus-Low (HML) is not a redundant factor in this empirical test. Instead, Robust-Minus-Weak (RMW) and Conservative-Minus-Aggressive (CMA) appear to be the potential candidates. In general, this thesis provides a cautious support for the superiority of the five-factor model over the CAPM and the three-factor model after assessing a combination of criteria. It is important to view the superiority of the five-factor model with caution since differences in performance between it and the three-factor model are hardly noticeable in many cases. Furthermore, despite its superior performance, the five-factor model cannot fully capture average returns in Vietnam's stock market as it fails when test portfolios are formed from state capital, which is not explicitly targeted by design.

Keywords asset pricing model, Fama French, five-factor model, three-factor model, CAPM, Vietnam, state ownership

Table of Contents

1 INTRODUCTION

1.1 Research Motivation

Asset pricing is one of the most popular topics in financial economics that has been studied for decades as various theories and models were established in this field. However, most of these studies were conducted for the markets in the United States (US) or other developed countries, which can have questionable implications in the emerging and frontier markets. Therefore, this thesis aims to fill the research gap by selecting Vietnam's stock market as the market of interest. Vietnam's stock market is currently a fledgling and small market with remarkable growth in recent years. However, compared to other markets in developed countries, it still has several limitations such as limited investing and trading products, limited transparency, or incidents related to price manipulation. Given these drawbacks and lack of research attention, it would be interesting to see whether there are any noticeable differences in the performance of asset pricing models between Vietnam's stock market and other markets.

Besides the Vietnam's stock market as a whole, this thesis also explores a special segment pertaining to the market: equitized state-owned enterprises (SOEs). In Vietnam, equitization of an SOE is defined as the act of transforming that SOE into a joint stock company. By the term "Equitized SOE", this thesis refers to a joint stock company which is a former SOE but now jointly owned by the state and the private sector. The equitization program has been a key bullet point on Vietnamese government's agenda since the 90s, with the goal to increase the efficiency of these enterprises and restructure the economy. As equitized SOEs play a crucial role in Vietnam's stock market, this segment deserves research attention from my perspective.

With respect to the model of interest, this thesis will focus on the Fama-French (henceforth FF) five-factor asset pricing model and its relative performance to others. The underlying rationale for this selection is that FF five-factor is a recent model, which was first introduced in the Journal of Financial Economics in 2015, and since then there have been mixed results from empirical tests of this model across different markets. Thus, there emerges a need to conduct research on this topic, especially for a developing and under-researched market like Vietnam.

1.2 Research Questions

In general, this thesis aims to answer three main research questions, stated as follows:

1. To what extent can Vietnam's average stock returns be explained by the five-factor model?

2. To what extent can average stock returns of Vietnamese equitized SOEs be explained by the five-factor model?
3. Is there any factor in the five-factor model whose effect is fully absorbed by other factors in the case of Vietnam's stock market?

1.3 Research Contribution

Originally developed from a sample of US stocks during 1963-2013, the Fama-French five-factor model is an empirically motivated asset pricing model, which raises concerns about data mining and thus necessitates out-of-sample tests. Therefore, the first and foremost contribution of this thesis is to provide an out-of-sample test for the model in Vietnam's stock market, adding to the comparative evidence across international markets.

Furthermore, this thesis also contributes to the existing literature regarding FF empirical tests in Vietnam's stock market in many ways. Firstly, this thesis extends the test period with much more recent data – nearly nine years from July 2009 to December 2017. Most of FF empirical tests in Vietnam's stock market are dated and cover only a short period, which results in small sample size and observation scarcity given the primitive stage of the market at that time. Secondly, this thesis also expands the test by including the recent FF five-factor model, which was firstly introduced by Fama and French in 2015. As abovementioned, the majority of FF empirical tests in Vietnam's stock market are dated and thus they only apply the FF three-factor model. Thirdly, this thesis implements a formal test, the GRS test[1], to examine models' explanatory capability. Most previous studies do not use any formal test for performance assessment but only compare average adjusted R^2s among models and count how many regression intercepts are statistically significant. Finally, this thesis explores the relationship between expected stock returns and state ownership by investigating the capability of FF models in explaining average stock returns of equitized SOEs. Forming test portfolios from state capital rather than the same variables used to construct risk factors also serves as a robust test for the models.

Besides contributing to the existing literature, the thesis also has practical implications for management. It will to help determine which model among the CAPM, the three-factor model,

[1] GRS test, derived by Gibbons, Ross, and Shanken (1989), is used to test the null hypothesis that intercepts from asset pricing regressions are jointly equal zero, implying that the asset pricing model can fully explain average returns. An asset pricing model will pass the test if this null hypothesis cannot be rejected and vice versa. Lower GRS statistic is often interpreted as better model performance.

and the five-factor model is an appropriate tool for practical applications such as portfolio performance evaluation and cost-of-equity estimation in Vietnam's stock market. For the moment, CAPM is undoubtedly the most frequently used model in these applications thanks to its elegance and parsimony, also for which it has received various criticisms both theoretically and empirically[2]. Therefore, the need for other models emerges.

1.4 Background – Vietnam's Stock Market

As Vietnam's stock market is the focus of this thesis, this section will briefly discuss the development, potential and limitation of the market as well as Vietnam's equitization program. This section aims to provide background knowledge and set the context for the study.

1.4.1 Overview and Development

Given its young age and small size, Vietnam's stock market is considered a developing market. To avoid confusion for some readers, the term "emerging market" will not be used when referring to Vietnam since it is a matter of classification that "emerging market" will be assessed differently across agencies. For example, Vietnam is considered a frontier (pre-emerging) market by Morgan Stanley Capital International (MSCI) but is included in the Emerging Markets Bond Index by J.P. Morgan.

Vietnam's stock market was officially established in July 1998, but not until July 28, 2000 did the first trading day take place with only two listed stocks. Besides its young age, Vietnam's stock market is relatively small compared to other markets in Southeast Asia. For example, market capitalization of listed domestic companies as a percentage of GDP of Vietnam in 2016 is only 32.8% while those of Singapore, Malaysia, and Thailand are respectively 215.7%, 121.4%, and 106.4% (The World Bank). **Figure 1** shows this ratio year-over-year from 1998 to 2016 of six Southeast Asian countries. From this visual representation, it is easy to notice that Vietnam lies on the lowest line in the chart.

[2] To be discussed in Section 2.3.2 and 2.3.3

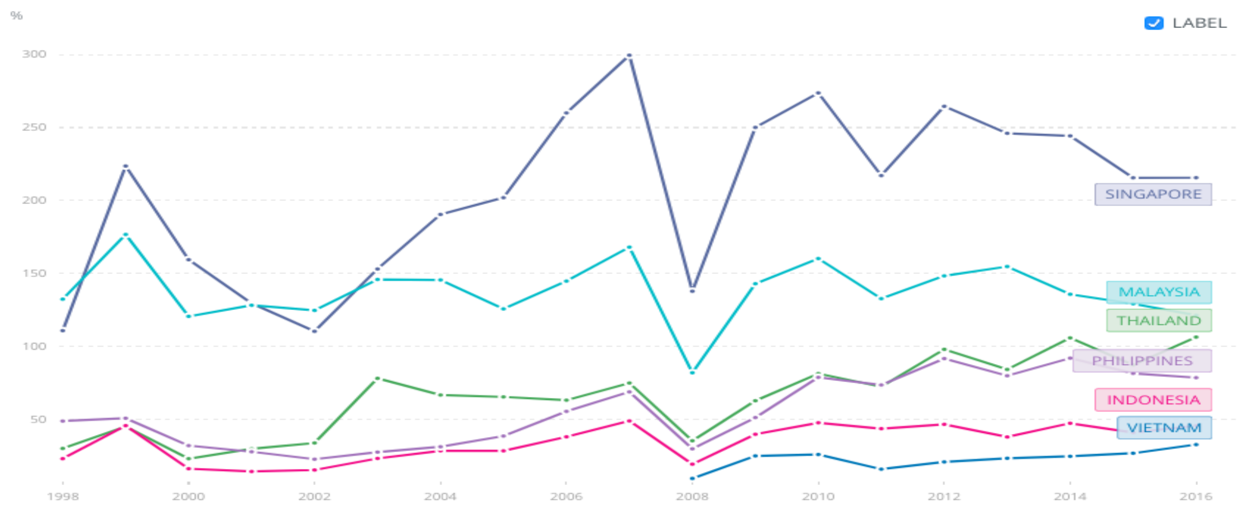

Figure 1 Market Capitalization of listed domestic companies as % of GDP (Adapted from: The World Bank - Data)

Despite its small scale, Vietnam's stock market is undoubtedly one of the fastest growing markets in the world with great potential and enormous room for improvement. According to updated information from Vietnam Ministry of Finance, Vietnam's total market capitalization reached 74.6% of GDP at the end of 2017 (VietStock, 2017). This statement can be further verified by the evolution of the Vietnam Stock Index (VN-Index), a capitalization-weighted index of all listed companies on Ho Chi Minh City Stock Exchange with a base index value of 100 as of July 28, 2000.

Figure 2 VN-Index from July 28, 2000 to December 29, 2017 (Adapted from: VNDirect)

Figure 2 shows the development of VN-Index from its inception to December 29, 2017. In the period 2000 – 2005, the market remained dormant most of the time with low trading volume.

However, starting from 2006, prices started to pick up and there was also an increase in trading volume. This uptrend was consistent until March 13, 2007 when VN-Index reached its all-time high of 1178.67 points, nearly triple in only one year. After reaching its peak, VN-Index fluctuated wildly till the end of 2007 and started to plunge throughout 2008 and the first quarter of 2009. The period from 2006 to 2008 is considered the boom-and-burst period in Vietnam's stock market that took place due to a combination of factors, including but not limited to irrationally high expectation, unstainable growth, herd mentality, and lax credit policy.

From the second quarter of 2009, Vietnam's stock market began to recover and regain investor confidence, which resulted in an increase in trading volume. However, not until 2013 did the stock market fully recuperate from the recession. Since then, VN-Index has become more stable and grown consistently over years. From Dec 28, 2012 to December 29, 2017, VN-Index grew at a CAGR of approximately 18.7%/year. In 2017, the index recorded its highest annual growth in the last 10 years of approximately 51.5%, ending the year at 10-year high.

1.4.2 Limitations and Challenges

Although having a promising future, Vietnam's stock market currently encounters numerous limitations and challenges, of which this thesis will name a few. Firstly, trading volume is low in some stocks due to small market size. Together with inadequate supervision, low liquidity has created loopholes for price manipulation. For example, in September 2017, a man was fined 550 million VND by the State Securities Commission for using 28 different trading accounts to create fake supply and demand for stock ticker VMD for five months (Bao Moi, 2017). Another major case is about a woman who was fined 600 million VND for using 42 different accounts to manipulate the price of stock ticker HNG (ibid.). While these two cases are the most recent, there are other major and minor cases in the past, which are not hard to find on the internet with the keyword "stock price manipulation" written in Vietnamese.

Another challenge that Vietnam's stock market confronts is transparency, which must be guaranteed to protect the benefits of current investors as well as to build trust and attract prospective ones. Since the inception, there has been a significant progress in ensuring information transparency in Vietnam's stock market. For example, the State Securities Commission has attempted to revise the legal framework, require listed companies to disclose information in English, and consider the application of IFRS for listed companies (VN Securities Investment, 2017). Nevertheless, there is still a huge gap compared to the international standards. Incidents related to falsified information, fake news, price manipulation, mismatch in information disclosure, or delay in disclosing financial reports still persist and happen sometimes. However, it is interesting to see how the asset pricing models perform given the presence of these factors.

1.4.3 Stock Exchanges

Vietnam has two main stock exchanges: Ho Chi Minh City Stock Exchange (HOSE or HSX) and Hanoi Stock Exchange (HNX). In addition to these two main exchanges, there is another one organized by HNX called UPCoM, short for Unlisted Public Company Market. UPCoM, founded in 2009, is an exchange where public companies that are not listed on either HOSE or HNX are traded. However, this thesis will not take UPCoM into account since it only concerns listed stocks. **Table 1** presents some key information about these two main exchanges.

Table 1 Basic information about Ho Chi Minh City Stock Exchange (HOSE) and Hanoi Stock Exchange (HNX) as at 31/12/2017 (Adapted from: hnx.vn, hsx.vn)

	HOSE	**HNX**
Year of establishment	2000	2005
Main index	VN-Index	HNX-Index
Market cap (VND billion)	2,101,209	92,796
Number of listed stocks	340	378

1.4.4 SOE Equitization Program

In the context of Vietnam's stock market, equitization can be understood as the transformation of SOEs into joint stock companies by sale of shares through public auction or by private agreement with strategic investors (Allens Linklaters, 2017). As aforementioned, equitization of SOEs has been a key bullet point on the Vietnamese government's agenda. For the past 15 years, the number of SOEs has dropped sharply from about 6,000 to over 700 (Vietnam News, 2016). From 2011 to 2015, nearly 600 SOEs were equitized, which completed 96% of the target number (ibid.).

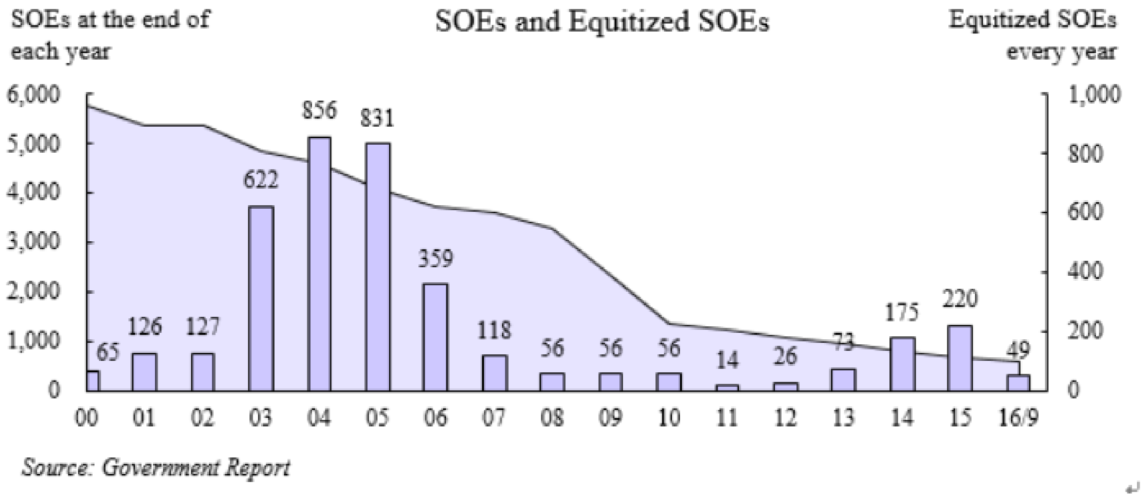

Figure 3 SOEs and Equitized SOEs from 2000 to 9/2016 (Adapted from: www.linkedin.com/pulse/equitization-state-owned-enterprises-vietnam-nhu-bui/)

For the period 2016-2020, the government has planned to expedite the equitization process by aiming to equitize additional 137 SOEs (ibid.). The main purpose of this acceleration is to restructure the industries and management, creating the engine to boost economic growth and facilitate Vietnam's integration into the world economy (Nguyen, 2015; Vietnam News, 2017).

Nevertheless, equitization process has remained slow and problematic. From 2016 to May 2017, only 5 SOEs were equitized while 38 were not approved after being evaluated and other 107 still in the evaluation process. Moreover, while 96.5% of SOEs were equitized, only 8% of government capital was privatized (VnEconomy, 2017). Therefore, assessed on the restructuring objective, SOE equitization program has been de facto inefficient in mobilizing government capital from the public sector to the private sector. The reasons for this are manifold, including but not limited to lack of legal framework, lack of transparency, complicated structure of SOEs, and unattractiveness to outside investors. In general, although SOE equitization program is deemed to be the right direction, there is still a long way ahead. Vietnamese government has to remove the hindrance to drive the program on the right track and make it work as intended.

1.5 Main Findings

There are weak patterns in average returns related to size, book-to-market, profitability, investment, and state ownership in that they are not smooth or not evident. Likewise, other than profitability factor return, all FF factor returns constructed in this empirical test demonstrate weaker or even reverse behavior compared to what Fama and French (2015) expect.

Regarding asset pricing tests, all models fare worst in 12 value-weighted test portfolios formed from size and state capital when assessed by either GRS statistics or average absolute values of intercepts. Specifically, the lethal portfolio for all tested models except CAPM contains large stocks of firms with low state capital (state owns more than 0% and less than 50% of charter capital). The average adjusted R^2s of the CAPM, the three-factor model, and the five-factor model are respectively 45.6%, 69.8%, and 70.6%.

Regarding the factor redundancy issue, High-Minus-Low (HML) is not a redundant factor in this empirical test, which is different from the conclusion of Fama and French (2015). Instead, Robust-Minus-Weak (RMW) and Conservative-Minus-Aggressive (CMA) become the potential candidates. Both RMW and CMA slopes in the five-factor regressions are mainly not statistically significant as their average returns are either largely or fully captured by exposure to other factors, especially HML. Furthermore, the five-factor model shows paltry improvement or even deterioration (assessed by average adjusted R^2) from the five-factor model that drops RMW or CMA. In the case of RMW, a possible explanation lies in the highly negative correlation between it and HML over the sample period.

In general, this empirical test provides a cautious support for the superiority of the five-factor model over the CAPM and the three-factor model after assessing their average adjusted R^2s, GRS statistics, and average absolute values of intercepts. Particularly, the five-factor model produces the highest average adjusted R^2, lowest GRS statistics in two out of four portfolio sets, and lowest average absolute values of intercepts except in one set. It is important to view the superiority of the five-factor model with caution since differences in performance between it and the three-factor model are hardly noticeable in many cases. Furthermore, despite its superior performance, the five-factor model cannot fully capture average returns in Vietnam's stock market. The model fails when test portfolios are formed from state capital, which is not explicitly targeted by design.

1.6 Structure of the Thesis

The remainder of the thesis is structured as follows. Section 2 presents a review of the main literature relevant to the topic, including Efficient Market Hypothesis, Modern Portfolio Theory, Capital Asset Pricing Model, Fama-French Three-Factor Model, and Fama-French Five-Factor Model. Afterwards, Section 3 outlines the key hypotheses of this thesis. Section 4 continues with details about sample description, variable construction, as well as specifications of asset pricing and factor spanning tests. Subsequently, Section 5 provides a synthesis of empirical test results together with an in-depth discussion about their possible causes and implications. Finally, Section 6 concludes the thesis with summary of the main findings, limitations of the study, suggestions for further research, and concluding remarks.

2 LITERATURE REVIEW

2.1 Efficient Market Hypothesis

2.1.1 Definition and Foundation

The efficient market hypothesis (EMH) is considered not only a cornerstone but also one of the most debatable topics in the field of investment. An efficient market is defined as a market where prices always "fully reflect" available information (Fama, 1970). With this definition, the hypothesis asserts that investors cannot consistently beat the market.

According to Miller et al. (2011), the foundation of an efficient market lies at three main conditions: investor rationality, independent deviations from rationality, and arbitrage. It is important to note that rationality in this discussion only means investors do not systematically overvalue or undervalue the assets given the information they have (ibid). If the first condition is fulfilled that every investor is rational, he or she will have the same expected return for assets at the same risk level, which eventually reflects in "correct" asset prices. Hence, consistently earning excess return is extremely difficult if not improbable in this case. The second condition maintains that even if investors are irrational, the market can still be efficient when their irrationalities are not dependent and not heading in the same direction. For example, some investors may overvalue while some may undervalue a certain financial asset. Together, their contradictory valuations will offset one another and therefore irrationality will be diversified away (ibid.). Nevertheless, irrationality is not always balanced. If this is the case, the market can still be efficient if there is a group of rational investors who arbitrage away the mispricing and make the market efficient again.

2.1.2 Different Forms and Implications

Fama (1970) classifies efficient market into three forms ranked on the information set they entail, namely weak form, semi-strong form, and strong form, with the weaker nested in the stronger (see Appendix A1 for a graphical presentation of different forms of EMH).

In weak-form efficient market, the current prices fully reflect all historical information such as past prices and trading volume (ibid.), and thus the future stock prices will be independent of these historical data. In other words, weak-form of EMH implies that future price movement is unpredictable and exhibits a random walk. This implication means that technical analysis, the practice of analyzing historical trading activity to forecast future price moment, will be useless in this case.

In semi-strong-form efficient market, all publicly available information including historical data is fully reflected in the current stock prices. Put differently, the stock prices will adjust unbiasedly in a timely manner when there is new public information such as earning forecasts, annual reports, or any relevant announcement. Therefore, in this form, neither technical nor fundamental analysis will prove useful in beating the market.

In strong-form efficient market, all kind of information regardless private or public is fully reflected in the current stock prices. That is, stock prices are unpredictable in every way and even possessing insider information does not help to generate abnormal return.

2.1.3 Joint Hypothesis Problem

Although the hypothesis seems to be simple, it has been the center of disputes among academics for decades and several studies were conducted to test its validity. The results from these tests, however, are not straightforward conclusions of whether the market is efficient or not due to the joint hypothesis problem. Since an asset pricing model is needed to validate EMH, concluding that the market is inefficient can also mean the asset pricing model is mis-specified. In other words, validating EMH by using an asset pricing model becomes a joint test of both the EMH and the underlying model. Before the review of asset pricing models, it is crucial to discuss the Modern Portfolio Theory, which set the foundation for many subsequent papers on this topic.

2.2 Modern Portfolio Theory

In 1952, Markowitz introduced the Modern Portfolio Theory (MPT) for the first time in his essay “Portfolio Selection”. The theory assumes that investors are risk-averse. That is, investors will prefer a less risky portfolio to a riskier one given the same level of return or, in other words, they will prefer a portfolio with higher return given the same level of risk. Under this assumption, the theory implies that risk and return should be considered in tandem in that higher risk should correspond to higher expected return and vice versa.

By consolidating these concepts, Markowitz (ibid.) presented a framework for constructing a portfolio in which expected return is maximized for a certain level of risk. In this model, the portfolio return is defined as the mean return, which is the weighted average return of all component assets. On the other hand, the portfolio risk is defined as the portfolio variance[3], which is not the weighted average of individual assets’ variances. Instead, the portfolio

[3] Portfolio risk can be also defined as the portfolio standard deviation (the square-root of variance).

variance is calculated by taking into account the standard deviations of component assets and the correlation coefficients for each pair of assets. For example, considering a portfolio with only two assets X and Y, its expected return $E(R_p)$ and variance σ_p^2 are calculated as follows:

$$E(R_p) = w_X E(R_X) + w_y E(R_y) \quad (1)$$

$$\sigma_p^2 = w_X^2 \sigma_X^2 + w_Y^2 \sigma_Y^2 + 2 w_X w_Y \sigma_X \sigma_Y \rho_{xy} \;\; (|\rho| \leq 1) \quad (2)$$

From Equation (2), we can notice that the portfolio variance can be reduced if the correlation coefficient ρ_{xy} is much smaller than 1. A correlation coefficient of 1 means that the returns of X and Y are always heading in the same direction by the same amount. On the other hand, a correlation coefficient different than 1 means that the returns of X and Y vary in different patterns, which may offset each other and effectively reduce the combination variance. This is one of the most crucial points that Markowitz (ibid.) wants to deliver through his work. In general, Markowitz (ibid.) states that investors can lower the portfolio risk by holding a diversified combination of assets that are not perfectly and positively correlated. Thus, diversification allows a portfolio with the same level of expected return to have lower risk. Graphically, all possible combinations of risky assets that offer the highest expected return for a certain level of risk (optimal portfolios) constitute a curve called the Efficient Frontier (see Appendix A2). Any combinations that do not lie on the curve are considered sub-optimal since they have a lower expected return given the same risk level compared to the optimal portfolios. Note that risk-less asset is not on Markowitz's Efficient Frontier.

Since its introduction, the MPT became the theoretical foundation for several research papers at that time, which includes the Capital Asset Pricing Model.

2.3 Capital Asset Pricing Model

2.3.1 Core Concepts

The Capital Asset Pricing Model (CAPM) was independently developed by Sharpe (1964) and Lintner (1965), built upon the Modern Portfolio Theory of Markowitz (1952, 1959). Before discussing the model, it is necessary to review its underlying assumptions. Along with the inherent assumptions in Markowitz's model, the CAPM adds two more specialized and major assumptions. Firstly, all investors are able to borrow and lend unlimitedly at the risk-free rate of interest (Sharpe, 1964). Secondly, all investors have homogenous expectation; that is, they unanimously agree on the characteristics of different investments such as expected values, standard deviations, and correlation coefficients (ibid.).

The CAPM specifies that in equilibrium, there exists a linear relationship between the expected return of an individual asset or a portfolio and the market risk (ibid.). In general, this linear relationship can be expressed in the following formula:

$$E(R_i) = R_f + \beta\big(E(R_m) - R_f\big) \qquad (3)$$

Where R_f the risk-free rate of return, $E(R_m)$ the expected market return, and β equals:

$$\beta = \frac{Cov(R_i, R_m)}{\sigma_m^2} \qquad (4)$$

As aforementioned, the MPT shows that by holding a combination of different assets that are not perfectly positively correlated, investors can cancel out the individual risks and help to lower the overall risk of the portfolio. Nevertheless, Sharpe (ibid.) contends that this notion is only a part of the whole picture since not all the risk can be diversified away. This type non-diversifiable risk, termed systematic risk, represents the risk resulting from fluctuation in the economy and remains even in efficient portfolios. Intuitively, since an asset itself is included in the market, the asset's rate of return unavoidably expresses some correlation to the market fluctuation that cannot be diversified. The sources of systematic risk, for example, can be changes in interest rate, market collapse, economic recession, or war, which inevitably affect the whole economy and its markets.

Systematic risk is measured by the beta coefficient in the CAPM equation, which indicates the responsiveness of an asset's rate of return to changes in the economy. Since unsystematic risk can be diversified away, the CAPM maintains that only the beta coefficient is appropriate in assessing the risk of an asset (ibid.). In theory, an asset having a lower beta will have a lower expected return as it tends to be safer (less responsive to market fluctuation) than assets with higher beta.

Compared to Markowitz's MPT, Sharpe-Lintner CAPM introduces a few extensions. Firstly, CAPM can be used to determine the price of an individual asset. Secondly, the CAPM considers the inclusion of risk-less assets in the market portfolio. In this case, the efficient portfolios will lie on a straight line - Capital Market Line (CML), which is the tangent line of Markowitz's Efficient Frontier (see Appendix A3). Thirdly, the CAPM classifies risk into two categories: systematic and unsystematic. The former type of risk is related to market fluctuation and cannot be diversified away.

2.3.2 Theoretical Criticism

CAPM has undoubtedly become one of the most popular asset pricing models, which is taught in every introductory finance class and used in several real-life applications such as assessing portfolio performance, estimating cost of equity, or calculating abnormal returns. Nevertheless, like any other models, the CAPM has inevitably received various criticisms both theoretically and empirically.

From a theoretical perspective, the CAPM was criticized for its highly restrictive assumptions. For example, the assumption that investors can borrow and lend unlimitedly at the risk-free rate of return are apparently unrealistic. Likewise, unlimited short sales do not exist in real life because of regulatory framework that restricts short-selling activities. Nevertheless, some of these restrictive assumptions were relaxed in extension models (Celik, 2012). Regarding this issue, even Sharpe (1964) himself admits that his model has “highly restrictive and undoubtedly unrealistic assumptions” (p. 434). However, he also argues that a theory should be appropriately tested by the eligibility of its implications rather than the realism of its assumptions (ibid.).

2.3.3 Empirical Evidence and Anomalies

Besides theoretical criticisms, the CAPM also had questionable empirical applicability. In their article “The Capital Asset Pricing Model: Theory and Evidence”, Fama and French (2004) frankly state that Sharpe-Lintner CAPM “has never been an empirical success” (p. 43). This literature review will discuss a few prominent empirical tests of CAPM.

Among the early tests was a study conducted by Basu (1977), who investigates the relationship between Price-to-Earning (P/E) ratio and US stock returns. The author (ibid.) find that low P/E securities on average tend to have higher risk-adjusted returns than high P/E securities during April 1957 – March 1971. This phenomenon can generally be classified as value effect, which CAPM failed to explain.

Rosenberg, Reid, and Lanstein (1985) provide further evidence for value effect in US stock returns. Their research results show that during the period 1980-1984, firms with high Book-to-Market equity (B/M), on average, yield higher risk-adjusted returns than firms with low B/M. Similar to Rosenberg et al., Stattman (1980) also documents a positive relationship between average stock returns and B/M ratio in US’ stock market. Furthermore, this relationship is also discovered in Japan’s stock market by Chan, Hamao, and Lakonishok (1992).

Improving upon Basu's study (1977), Reiganum (1981) examines the relationship of Earning-to-Price (E/P) ratio, firm size, and US stock returns in the period 1962-1978. Like Basu's results, Reiganum's show that portfolios with high E/P seem to outperform ones with low E/P even after adjusting for CAPM's beta risk. Moreover, Reiganum (1981) also finds that small firms, on average, generate significantly higher returns than large firms after adjusting for beta risk for at least two years. However, the E/P effect will disappear when taking the size effect into consideration while the size effect persists after controlling for the E/P effect (ibid.). In brief, Reiganum (ibid.) concludes that the CAPM is mis-specified and the source of misspecification comes from the missing risk factors that are closely related to size effect.

Banz (1981) also investigates the relationship between size effect and US stock returns but for a much longer period (1926 - 1975) compared to Reiganum's study. Like Reiganum, the author also documents a size effect in US stock returns although this effect is unstable across sub-periods. Banz (ibid.) finds that small NYSE firms, on average, have significantly higher risk-adjusted returns than large NYSE firms over a 40-year period.

In general, all the phenomena discussed above are called anomalies, which are "empirical results that seem to be inconsistent with maintained theories of asset pricing behavior" (Schwert, 2003). Besides anomalies related to size and value, there are also other types such as momentum, reversal effect, January effect, or day-of-the-week effect. These anomalies tend to behave differently in that they might persist, attenuate, reverse or disappear over time. Due to the joint hypothesis problem, the reason for anomaly's existence can be either that the market is not efficient or that the asset pricing model is mis-specified. However, academics usually attribute anomalies to CAPM misspecification rather than market inefficiency (Basu, 1977; Ball, 1978; Reiganum, 1981; Banz, 1981; Fama and French, 1992). Regarding this issue, it is intuitive and reasonable to argue that CAPM beta is not the sole factor to explain variation in stock returns.

2.3.4 CAPM Extensions

Although having limitations, Sharpe-Lintner CAPM was undeniably the groundwork for the development of other asset pricing models, which mostly are CAPM extensions by adapting the original theoretical framework to enhance empirical applicability. These extensions are the results from various empirical tests, which discovered additional variables that help explain average stock returns in addition to CAPM beta. **Figure 4** below shows the development and extension of CAPM until 2012.

	Model	Originator(s)
	Markowitz Mean-Variance Algorithm	Markowitz (1952;1959)
Static Models	Sharpe-Lintner CAPM	Sharpe (1964), Lintner (1965), Mossin (1966)
	Black Zero-beta CAPM	Black (1972)
	The CAPM with Non-Marketable Human Capital	Mayers (1972)
	The CAPM with Multiple Consumption Goods	Breeden (1979)
	International CAPM	Solnik (1974a), Adler and Dumas (1983)
	Arbitrage Pricing Theory	Ross (1976)
	The Fame-French Three Factor Model	Fama and French (1993)
	Partial Variance Approach Model	Hogan and Warren (1974) and Bawa and Lindenberg (1977) Harlow and Rao (1989)
	The Three Moment CAPM	Rubinstein (1973), Kraus and Litzenberger (1976)
	The Four Moment CAPM	Fang and Lai (1997), Dittmar[6] (1999)
Dynamic Models	The Intertemporal CAPM	Merton (1973)
	The Consumption CAPM	Breeden (1979)
	Production Based CAPM	Lucas (1978), Brock (1979)
	Investment-Based CAPM	Cochrane (1991)
	Liquidity Based CAPM	Acharya and Pedersen (2005)
	Conditional CAPM	Jagannathan and Wang (1996)

Figure 4 Theoretical development of CAPM till 2012 (Adapted from: Celik, 2012)

2.4 Fama – French Three-Factor Model

Inspired by previous CAPM empirical tests, Fama and French (1992) attempt to evaluate how market beta, size, E/P, leverage, and B/M can jointly explain the cross-section of average stock returns. The findings show that size and B/M are the two variables that capture much of the variation in US average stock returns associated with size, E/P, leverage, and B/M for the 1963-1990 period (ibid.).

In the subsequent paper "Common risk factors in the returns on stocks and bonds", Fama and French (1993) conclude that size (measured by market equity) and value (measured by B/M) are the proxies for sensitivity to common risk factors in stock returns. The authors then incorporate these two variables in their asset pricing model, namely the Fama-French three-factor model. In general, this model can be expressed in the following time-series regression:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + e_{it} \quad (5)$$

where

R_{it}: return on security or portfolio i for period t

R_{Mt}: return on value-weighted market portfolio

R_{Ft}: risk-free return

$R_{Mt} - R_{Ft}$: market excess return (market premium)

SMB_t: size premium (small minus big)

HML_t: value premium (high minus low)

a_i: regression intercept

b_i: measure of sensitivity to market fluctuation

s_i: measure of sensitivity to size premium

h_i: measure of sensitivity to value premium

e_{it}: a zero-mean residual

The two additional variables besides market excess return are SMB – the difference between returns on diversified portfolios of small and big companies, and HML– the difference between returns on diversified portfolios of high B/M and low B/M companies. Since SMB and HML aim to mimic the risk factors in returns related to size and value respectively, they are also known as mimicking portfolios.

By regressing the excess returns of 25 test portfolios sorted by size and B/M[4] on market excess return, SMB, and HML, Fama and French find that the three-factor model outperforms CAPM since most of the intercepts from three-factor regression are close to 0 (ibid.). The authors further test the robustness of the three-factor model by regressing five portfolios formed on earning yield (E/P) and other five formed on dividend yield (D/P). The results from these regressions are equivalent to those from size – B/M portfolio regressions as the intercepts are mostly close to 0 both statistically and practically (ibid.).

2.5 Fama – French Five-Factor Model

2.5.1 Foundation

In the 2006 paper "Profitability, investment and average returns", Fama and French conduct an empirical test of the Miller Modigliani valuation formula (1961), which holds that expected stock returns are related to B/M, expected profitability, and expected investment. This formula

[4] Constructed by 5 x 5 sort based on quintiles of size and B/M.

lays the foundation for the inclusion of two new factors in the Fama – French five-factor model (2015) and it is therefore worth discussing.

To begin with, the market value of a firm's equity, as in the dividend discount model, equals the present value of expected dividends:

$$M_t = \sum_{t=1}^{\infty} E(D_{t+\tau})/(1+r)^{\tau} \quad (6)$$

where M_t is the market value of equity at time t, $E(D_{t+\tau})$ the expected dividend in the period $t+\tau$, and r the long-term average expected stock return. With clean surplus accounting, the dividend discount formula can be equivalently transformed into:

$$M_t = \sum_{t=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau} \quad (7)$$

where $Y_{t+\tau}$ is the total equity earnings for period $t+\tau$, and $dB_{t+\tau} = B_{t+\tau} - B_{t+\tau-1}$ is the change in total book equity in the period $t+\tau$. Finally, dividing Equation (7) by book equity at time t results in:

$$\frac{M_t}{B_t} = \frac{\sum_{t=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau}}{B_t} \quad (8)$$

Equation (8) can be referred as the Miller Modigliani (1961) valuation formula. In this equation, the expected total equity earning to current book equity is a measure of profitability while the expected change in total book equity to current book equity is a measure of investment. Therefore, Equation (8) generally comprises four terms: current B/M, expected profitability, expected investment, and expected stock return. Controlling for two of these four terms will demonstrate a direct relationship, either positive or negative, between the other two. Specifically, holding all else constant, there exists a positive relationship between current B/M and expected stock return, a positive relationship between expected profitability and expected stock return, and a negative relationship between expected investment and expected stock return.

Fama and French (2006) attempt to test these theoretical relationships empirically. The authors argue that although their results tend to be in line with the predicted relationships and the existing evidence from others, profitability and investment factors add little or nothing to the explanation of stock return provided by size and B/M. Nevertheless, this conclusion has received disagreement from other researchers, notably Novy-Marx (2013) and Aharoni, Grundy, and Zeng (2013).

As abovementioned, Fama and French (2006) state that profitability factor does not play an important role in enhancing the explanation of stock return provided by size and value factors. However, Novy-Marx (2013) succeed in identifying a proxy for expected profitability that is strongly related to average stock return. Concerning Fama and French's study (2006), Novy-Marx (2013) argue that the main difference is in the choice of proxy for future profitability. While Fama and French (2006) select current earning, Novy-Marx (2013) chooses gross profit as the proxy for future profitability. He maintains that gross profit is the "cleanest accounting measure of true economic profitability", which is unaffected by expensed investments such as R&D or advertisement (ibid.).

Fama and French (2006) also receive criticism in terms of methodology from Aharoni et al. (2013). In their 2006 paper, Fama and French fail to find the predicted negative relationship between expected investment and stock return as they document a positive insignificant coefficient for expected investment at the per-share level. However, Aharoni et al. (2013) argue that the valuation formula does not necessarily hold at the per-share level and thus per-share numbers can be misleading since they are influenced by changes in the number of shares (issues or repurchases). When empirically investigating the valuation formula at the firm level, Aharoni et al. (ibid.) indeed find a statistically significant negative relationship between expected investment and average stock return as predicted.

2.5.2 Model Specification

Motivated by the valuation formula and the mounting evidence that the three factors cannot explain much of the stock return variation related to profitability and investment, Fama and French (2015) decide to add profitability and investment factors to the three-factor model. In general, the Fama – French five-factor model is specified as follows:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \qquad (9)$$

where

… (similar to Equation 5)

RMW_t: profitability premium (robust minus weak)

CMA_t: investment premium (conservative minus aggressive)

r_i: measure of sensitivity to profitability premium

c_i: measure of sensitivity to investment premium

Among the two additional variables is RMW – the difference between returns on diversified portfolios of firms with robust and weak profitability, measured by operating profit (OP). However, OP in the five-factor model context is defined as revenues minus cost of goods sold (COGS), selling, general, and administrative expenses (SG&A), and interest expenses, all divided by book equity. The other additional variable is CMA – the difference between returns on diversified portfolios of firms with conservative and aggressive investment, measured by lagged total asset growth.

Regarding the sample of US stocks from July 1963 to December 2013, the five-factor model indeed outperforms both the CAPM and the three-factor model, explaining 71%-94% of the variation in stock returns. Furthermore, the five-factor model is also insensitive to the way its factors are constructed. That is, although various ways of sorting are applied to construct the explanatory variables, they all yield similar description of the average stock returns on the test portfolios. Nevertheless, the model inevitably has a few limitations. Concerning the sample of US stocks that Fama and French (2015) investigate, the five-factor model fails to explain low average returns on small stocks whose returns behave like those of companies that invest heavily despite low profitability. Moreover, HML factor appears to be redundant for describing average stock returns when RMW and CMA factors are included. As one of the research objectives, this thesis is interested in testing whether these limitations still hold and whether new limitations can be discovered in the sample of Vietnamese stocks.

2.5.3 Empirical Evidence

Empirical test results for the Fama-French five-factor model are mixed, varying across different markets and test periods. This literature review will mention a few prominent tests of the five-factor model in markets around the world.

The first empirical study to mention is the international tests of the five-factor model conducted by its own creators. Fama and French (2017) examine the global and local versions of the model for the period 1990 – 2015 with a sample of 23 developed markets, grouped into four regions: North America, Japan, Asia Pacific and Europe (ibid.). As expected, the global five-factor model, using global factor returns (combination of the four regions) to explain regional returns, fails badly due to either nonintegrated nature of the markets or wrong specification of the model. Regarding regional models, the five-factor model usually outperforms the three-factor in describing average returns. Although typically rejected in formal tests such as GRS test by Gibbon, Ross, and Shanken (1989), local versions of the five-factor model capture the majority of value, profitability, and investment patterns in average returns. As for factor spanning tests, there are variations among different regions in terms of which factor is redundant. For example, while all five factors provide unique information about North American average returns for 1990 – 2015 period, CMA is redundant for Europe, Japan, and Asia Pacific (Fama and French, 2017). However, factor spanning inferences should be taken with caution since they tend to be sample specific (ibid.). For instance, HML is redundant for describing average returns of US stocks during 1963 – 2013 but not during 1990 – 2015.

Guo, Zhang, W., Zhang, Y. and Zhang, H. (2017) conduct empirical tests of the five-factor model for the Chinese stock market from July 1995 to June 2014. The authors document strong size, value, and profitability patterns but weak investment pattern in average returns. Regarding asset pricing tests, the five-factor model clearly outperforms the three-factor as the profitability factor, RMW, strongly enhances the description of average returns. For example, the five-factor model passes GRS test most of the time while the three-factor do not. Moreover, average absolute value of intercepts from the five-factor model is also much lower than that from the three-factor. Nevertheless, the authors find that the difference in performance between the five-factor model and the five-factor model dropping CMA is hardly noticeable (ibid.). From the factor spanning test results, Guo et al. (ibid.) conclude that CMA is redundant in describing average returns of Chinese stock market as its returns are captured by exposure to other factors. The redundancy of CMA is consistent with the asset pricing test results and similar to the findings of Fama and French (2017) in Europe, Japan, and Asia Pacific.

Foye (2017) provides an out-of-sample test for the five-factor model by examining UK stock market during 1989 – 2016 period. However, instead of using operating profit to form RWM as in the original work of Fama and French (2015), the author applies alternative profitability proxies including gross profit, net income, and free cash flow. Foye (2017) find that both the three-factor and the original five-factor model have trouble describing cross-sectional returns as HML and CMA have low explanatory power. Nevertheless, when the five-factor model is respecified with a profitability factor formed from gross profit, the size, value, profitability, and investment factors are all statistically significant (ibid.). To provide a possible explanation for this finding, Foye (ibid) argues that the problem lies in Fama and French's use of operating profit, which subtracts interest expense in the calculation process. Therefore, this formation of profitability factor will directly affect both RMW and CMA when companies' aggressive capital expenditure is financed by borrowing (ibid.). Moreover, the results from the empirical test show that only the size and profitability factors are consistently priced while the explanatory power of investment and value factors is unstable, depending on how the test portfolios are formed (ibid.). In brief, Foye (ibid.) seriously calls the applicability of the three- and five-factor models in the UK into question and warns researchers and practitioners about the use of these models as a risk benchmark.

Chiah, Chia, Zhong, and Li (2016) investigate the five-factor model and its comparative performance to other models for the Australian stock market over 1982 – 2013 period. In short, the finding supports the superiority of the five-factor model to other competing models (specifications of the three-factor and the Carhart four-factor models) as it can explain more asset pricing anomalies. Furthermore, Chiah et al. (ibid.) find that the value factor remains important in the presence of the profitability and investment factors, unlike the result of Fama and French (2015). The authors also conduct a robustness analysis and find that this result is robust to alternative factor construction, proxies for profitability, and formation of test portfolios (ibid.). Despite the superiority of the five-factor model, Chiah et al. (ibid.) still conclude that the model cannot fully explain average returns and call for a better model for the Australian stock market.

Like Chiah et al. (2016), Huynh (2017) also studies the applicability of the five-factor model in the Australian stock market but extends their work to cover 16 anomalies, including those not previously examined in Australia. He maintains that using these anomalies that are not explicitly targeted by the model instead of regular sorted portfolios will mitigate the “home game” problem. Although Chiah et al. (2016) consider test portfolios sorted from an extended range of variables, Huynh (2017) argues that some variables are just alternative versions of profitability and thus their analysis does not stray too far from “home”. By implementing asset pricing tests, Huynh (2017) find that the number of anomalies persists after risk adjustment drops under the five-factor model. Furthermore, the five-factor model also has lower average absolute value of intercepts than that of the three-factor model in 11 out of 16 cases. While the extent of this reduction in alpha is small, it is statistically significant in several cases. However, the improvement in average adjusted R^2 from the three-factor to the five-factor model seems paltry, around only 1% (ibid.). Huynh (2017) concludes that both the three-factor and five-factor models are unable to fully describe average returns in the Australian stock market since they both fail the GRS test. In short, the author provides “cautious support” for the superiority of the five-factor model but also suggests a search for a better model, consistent with the concluding remarks from Chiah et al. (2016).

To sum up, the Fama-French five-factor model, since its inception, has been empirically tested in several markets under alternative specifications, factor construction, and portfolio formation over multiple periods. Most studies support the superiority of the five-factor model to the three-factor model and CAPM in explaining average stock returns. Nevertheless, the five-factor model still has questionable practical applicability as it is not able to fully capture expected returns in many cases. Furthermore, the contribution of each factor in the five-factor model seems to be sample specific since it is not consistent across markets and test periods. Therefore, most researchers have called for a better asset pricing model.

2.6 Previous Studies on Fama – French Models in Vietnam's Stock Market

Empirical tests of FF factor models in Vietnam's stock market date back to 2008. For example, Vuong and Ho's study (2008) is one of the earliest FF empirical tests in Vietnam, covering 2005-2008 period with a modest sample size of only 28 stocks. They find that three-factor coefficients are statistically significant at 5% significance level and three-factor intercepts are not statistically distinguishable from zero for all 4 test portfolios (ibid.). Furthermore, the average adjusted R^2s of CAPM and the three-factor model are respectively 62.5% and 86.8%, showing a large improvement of 24.6% (ibid.).

Subsequent studies including Nguyen and Tran (2012), Hang Nguyen and Hiep Nguyen (2012), and Le (2015) show seemingly consistent results with the average adjusted R^2 range of 81%-85% for the three-factor model. CAPM, on the other hand, exhibits a wider range of average adjusted R^2 across studies, approximately 61% - 75.6%. This discrepancy in the explanatory power of CAPM can be justified by differences in sample period, stock selection, sorting criteria, and portfolio construction. Having said that, these studies have some common characteristics. Firstly, they have short sample period and small sample size due to the primitive stage of the market (except Le, 2015). Secondly, they only cover the Fama-French three-factor model and CAPM since the five-factor model was not available at that time. Thirdly, they do not implement any formal test to assess the models' performance when only comparing average adjusted R^2 among models and counting how many regression intercepts are statistically significant. Therefore, the majority of earlier studies on FF models in Vietnam's stock market have questionable reliability and validity.

Nguyen, Ulku, and Zhang (2015) are among the first to conduct empirical tests of the Fama-French five-factor model in Vietnam's stock market. Compared to the abovementioned studies, Nguyen et al.'s study covers an updated and extended sample period with the inclusion of the five-factor model. Furthermore, they also implement GRS test and use GRS statistics to examine the models' relative performance. In brief, Nguyen et al. (ibid.) find that GRS test fails to reject the null hypothesis that intercepts from the asset pricing regressions are jointly equal zero for all tested models (CAPM, the three-factor model, the five-factor model without HML and the five-factor model). Moreover, the authors find that the five-factor model produces the lowest GRS statistic, which supports its superior performance over other tested models' in explaining average returns (ibid.). Assessed by average adjusted R^2, the five-factor model maintains its superiority, showing a large improvement of 16.5% from CAPM but a paltry improvement of only 0.9% from the three-factor model. The average adjusted R^2 range from Nguyen et al. (ibid.) is in line with that of previous studies.

Besides regular testing, Nguyen et al. (ibid.) also investigate the relationship between state-ownership status and average stock returns. The authors conclude that all the tested models fail to capture the average returns of equitized SOEs over the sample period (ibid.). Assessed by the research scale and scope, the study of Nguyen et al. (ibid) is the closest paper to this thesis, and as such our work will be frequently discussed and compared in subsequent sections.

Table 2 presents a finding summary of previous studies on FF models in Vietnam's stock market that have been discussed in this section.

Table 2 Finding summary of previous studies on Fama-French models regarding Vietnam's stock market (CAPM: Capital asset pricing model; FF3F: Fama-French three-factor model; FF5F: Fama-French five-factor model)

Author(s)	Models	Data	Results
Vuong and Ho, 2008	CAPM FF3F	**Weekly returns** of 28 stocks listed on HOSE from 02/01/2005 to 26/3/2008	• **CAPM** For all 4 test portfolios (2x2 sort), beta coefficients are statistically significant at 5% significance level and intercepts are not statistically different from zero **Average adjusted R-squared: 0.625** • **FF3F** For all 4 test portfolios, three-factor coefficients are statistically significant at 5% significance level and three-factor intercepts are not statistically different from zero **Average adjusted R-square: 0.868**
Nguyen and Tran, 2012	CAPM FF3F	**Monthly returns** of stocks listed on HNX and HOSE from 01/01/2007 to 12/03/2011 **Sample size**[5] 2007: 162 2008: 204 2009: 308 2010: 382 2011: 382	• **CAPM** For all 6 test portfolios (2x3 sort), beta coefficients are statistically significant at 1% significance level and intercepts are not statistically different from zero **Average adjusted R-squared: 0.756** • **FF3F** Most of the three-factor coefficients are statistically significant at 1% significance level except for those of B/M and B/H portfolios. HML coefficients from the regressions of B/M and B/H portfolios are both statistically insignificant. **Average adjusted R-squared: 0.810**
Hang Nguyen and Hiep Nguyen, 2012	CAPM FF3F	**Weekly returns** of stocks listed on HOSE in 2 periods: **(1)** 7/2007 - 26/3/2008 **(2)** 18/8/2008 - 6/2012 **Sample size** 2007: 68	**PERIOD (1)** • **CAPM** Beta coefficients for all 8 test portfolios (3x3 sort)[6] are statistically significant at the 1% level. However, 3 out of 8 portfolios have intercept statistically different from zero. **Average adjusted R-squared: 0.75** • **FF3F** Beta coefficients are statistically significant at 1% significance level across all test portfolios. 2 out of 8 SML/HML coefficients are statistically insignificant. Only 1 out of 8 test portfolios has intercept statistically different from zero and the average absolute value of intercepts is smaller than that of CAPM.

[5] The number of companies
[6] In Period (1), 3x3 sort only generates 8 portfolios due to scarcity of observations

		… 2012: 235	**Average adjusted R-squared: 0.85** **PERIOD (2)** • **CAPM** Beta coefficients for all 9 test portfolios (3x3 sort) are statistically significant at the 1% level. However, 6 out of 9 portfolios have intercept statistically different from zero. **Average adjusted R-squared: 0.71** • **FF3F** Beta coefficients are statistically significant at 1% significance level across all test portfolios. 1 out of 9 SML/HML coefficients is statistically insignificant. However, 8 out of 9 test portfolios has intercept statistically different from zero. **Average adjusted R-squared: 0.85**
Le, 2015	CAPM FF3F	**Monthly returns** of stocks listed on HOSE and HNX from 07/2006 to 10/2014 **Sample size** as of 10/2014: 651	• **CAPM** For all 16 test portfolios (4x4 sort), beta coefficients are statistically significant at 1% significance level and intercepts are not statistically different from zero. **Average adjusted R-squared: 0.61** • **FF3F** Beta coefficients are statistically significant at 1% significance level across all test portfolios. 11 out of 16 SML coefficients are statistically significant. 8 out of 16 HML coefficients are statistically significant. No test portfolio has intercept statistically different from zero. **Average adjusted R-squared: 0.84**
Nguyen, Ulku, and Zhang, 2015	CAPM FF3F FF5F	**Monthly returns** of stocks listed on HOSE and HNX (inclusive of UPCoM) from 07/2007 to 08/2015 **Sample size** 2007: 135 … 2015: 438	• **GRS test** fails to reject the null hypothesis that regression intercepts are jointly equal zero for all tested models (CAPM, FF3F, and FF5F). GRS test statistics are lower in FF5F compared to those of CAPM and FF3F • **Average adjusted R-squared** (27 test portfolios by using three sets of 3x3 sort) - **CAPM**: 0.740 - **FF3F** : 0.896 - **FF5F** : 0.905 • **HML's effect** is not absorbed by RMW and CMA in the five-factor regression. • **FF5F** cannot explain variation in returns of portfolio with average B/M and profitability and portfolio with average investment ratio.

3 HYPOTHESES

As mentioned previously in Section 1.2, one of the key research questions is to assess the explanatory capability of the Fama-French five-factor model on Vietnam's average returns. This question is examined by investigating both the absolute and relative performances of the five-factor model. Different models (the CAPM, the three-factor model, and the five-factor model) will be empirically tested on Vietnam's stock data to determine whether they can explain average returns of portfolios sorted by different criteria. If an asset pricing model fully captures expected returns, the regression intercept will be indistinguishable from zero (Fama and French, 2015). Therefore, the first hypothesis set is as follows:

H1a: *The intercepts from CAPM regressions are jointly indistinguishable from zero.*

H1b: *The intercepts from Fama-French three-factor regressions are jointly indistinguishable from zero.*

H1c: *The intercepts from Fama-French five-factor regressions are jointly indistinguishable from zero.*

In terms of this first set, GRS statistics from the GRS test by Gibbons, Ross, and Shanken (1989) are used for hypothesis testing and performance comparison.

Inspired by Nguyen et al. (2015), this thesis explores a special segment pertaining to Vietnam's stock market – equitized SOEs. Specifically, the thesis will investigate the relationship between state-ownership status and average stock returns by applying asset pricing models on portfolios sorted by state capital. In their study, Nguyen et al. (ibid) conclude that the CAPM, the three-factor model, and the five-factor model fail to capture expected stock returns of equitized SOEs. The second hypothesis set, on the other hand, states that there is no difference in explanatory power of these models between stocks of private companies and those with state capital. Details are as follows:

H2a: *There is no difference in explanatory power of CAPM between stocks of private companies and those with state capital.*

H2b: *There is no difference in explanatory power of Fama-French three-factor model between stocks of private companies and those with state capital.*

H2c: *There is no difference in explanatory power of Fama-French five-factor model between stocks of private companies and those with state capital.*

The third hypothesis is related to the factor redundancy issue. In their original paper on the five-factor model, Fama and French (2015) conclude that HML becomes redundant for describing average returns of US stocks when RMW and CMA come into play, at least during 1963 – 2013. However, they later find that HML is not redundant for US stock data during 1990 – 2015 (Fama and French, 2017). As discussed previously in Section 2.5.3, empirical tests in different markets yield different conclusions about which factor is redundant. Therefore, this thesis is interested in how the situation in Vietnam's stock market looks like in terms of the factor redundancy issue. The third hypothesis is stated as follows:

H3: *No factor among the five-factor model is fully explained by any of the other four.*

4 DATA AND METHODOLOGY

4.1 Sample Description

The empirical test will examine monthly returns of common stocks listed on both HOSE and HNX (excluding UPCoM) from July 2009 to December 2017, 102 months in total. Although a longer period will enhance statistical power of the test, it can cause other problems. Firstly, for a stock to be included in the sample of year *t,* it must have *Total Assets* numbers at the year ending $t-2$ and $t-1$ as prescribed by Fama and French (2015). Since there are relatively few listed companies prior to 2007, data scarcity issue will emerge, which is exacerbated by the sorting process and likely to result in undiversified test portfolios. Secondly, the period from 2006 to 2008 is considered the boom-and-burst period, which is characterized by high volatility and relatively low trading volume (Figure 2). Therefore, the empirical test will examine stock returns from 2009 onwards when the market became more stable.

The sample will be rebalanced annually in June from 2009 to 2017. For a stock to be included in the sample of year t, it must sufficiently have accounting data as required by Fama and French (1993, 2015). Moreover, stocks that are delisted during the test period will be excluded from this sample. Furthermore, the sample will include only non-financial companies because FF5F variables are not suitable for banks and financial companies. Relevant data about the stocks and the companies (adjusted closing prices, market capitalization, B/M, revenue, COGS, SG&A, interest expense, total assets) are retrieved from Thomson Reuters Datastream.

State-ownership status is retrieved from VNDirect[7] database as it cannot be found on Datastream for Vietnam's stock market. State-ownership status will depend on the percentage of the charter capital that the state owns in the company. Since ownership data on VNDirect only reflect the current situation, current state-ownership status is used as a proxy for historical status. That is, if a company has state capital in 2017, it will also have state capital in the past. This argument is reasonable as we are safe to assume that the government only divests itself of state holdings.

The sample size amounts to 620 companies after the last rebalance in June 2017. The sample size by rebalance periods is showed in **Table 3**.

[7] VNDirect is one of the most reputable securities companies in Vietnam, founded in 2006.

Table 3 Sample size by rebalance periods

The sample will be rebalanced annually in June from 2009 to 2017. For a stock to be included in the sample of year t, it must sufficiently have accounting data as required by Fama and French (1993, 2015). Delisted stocks and stocks of banks and financial companies are not included in the sample.

Year	Sample Size
2009	234
2010	332
2011	460
2012	502
2013	519
2014	533
2015	552
2016	598
2017	620

4.2 Variable Construction

The regression model's variables, both independent and dependent, will be constructed mainly based on the methodology of Fama and French (1993, 2015).

4.2.1 Independent variables

The first independent variable, or factor, is market excess return ($R_{Mt} - R_{Ft}$), which equals the value-weighted return on the "market portfolio" minus the risk-free rate at time t. The "market portfolio" in this case contains all available stocks listed on HNX and HOSE, including those that are filtered out from the sample. For instance, the "market portfolio" will cover stocks of banks, financial companies, and companies which are traded but not qualified to be included in the sample that year. As for the risk-free rate, this empirical test will use Vietnam 1-year government bond yield converted to monthly rate as the proxy.

The remaining four factors are constructed by independent 2 x 3 sorts and the reason for this selection is two-fold. Firstly, the model is not sensitive to how its factors are defined and secondly, 2 x 3 sort is flexible in accommodating more or fewer factors (Fama and French, 2015). In each sort, size always takes one side with the other side being either B/M, operating profit, or investment. The sorts will be implemented after the sample is rebalanced in June each year from 2009 to 2017. The construction of size (SMB), value (HML), profitability (RMW), and investment (CMA) factors is detailed as follows.

SMB and HML factors are formed using independent sorts of the sample stocks into two Size groups (Small, Big) and three B/M groups (High, Neutral, Low). For the sorts in June year t, we will use market capitalization in month-end June year t for Size sort and B/M ratio in month-end December year $t-1$ for B/M sort. The size breakpoint is the median market capitalization and the B/M breakpoints are the 30th and 70th percentiles of the sample stocks. The intersections from these sorts generate six value-weighted portfolios. The value factor HML equals the average of two high-B/M portfolios' returns (Small/High and Big/High) minus that of two low-B/M portfolios' returns (Small/Low and Big/Low). The size factor based on Size-B/M sort ($SMB_{B/M}$) equals the average of three small stock portfolios' returns minus that of three big stock portfolios' returns.

The profitability and investment factors are formed in the same 2 x 3 sort process except B/M is now replaced by Operating profit (OP) and Investment (Inv) respectively on the other side. Similarly, the profitability factor RMW equals the average of three robust (high) OP portfolios' returns minus that of three weak (low) OP portfolios' returns. The investment factor CMA equals the average of three conservative (low) Inv portfolios' returns minus that of three aggressive (high) Inv portfolios' returns. The 2 x 3 sorts used to form RMW and CMA generate two additional size factors, namely SMB_{OP} and SMB_{Inv}. The size factor SMB equals the average of $SMB_{B/M}$, SMB_{OP}, and SMB_{Inv}.

Table 4 details the definition of Size, B/M, OP, and Inv as well as the construction of SMB, HML, RMW, and CMA.

Table 4 Sort process and construction of SMB, HML, RMW, and CMA.

Independent sorts are used to assign stocks to two Size groups and three B/M, OP, and Inv groups. The intersections of Size groups and the other groups define double-sorted portfolios used to construct the factors. These portfolios are labeled with two letters. The first letter always describes the size groups: Small (S) or Big (B). The second letter describes the B/M groups: High (H), Neutral (N), or Low (L); the OP groups: Robust (R), Neutral (N), or Weak (W); or the Inv groups: Conservative (C), Neutral (N), or Aggressive (A). For example, SH portfolio comprises Small (S) stocks with and High (H) B/M.

Sort criteria and breakpoints (sort in June year t)	**Factor construction**
Size sorted by: $\boldsymbol{Market\ cap_t}$ (month-end June year t) Size breakpoint: sample median	$SMB_{B/M} = (SH + SN + SL)/3 - (BH + BN + BL)/3$ $SMB_{OP} = (SR + SN + SW)/3 - (BR + BN + BW)/3$ $SMB_{Inv} = (SC + SN + SA)/3 - (BC + BN + BA)/3$ $\boldsymbol{SMB = (SMB_{B/M} + SMB_{OP} + SMB_{Inv})/3}$
Value sorted by: $\boldsymbol{B/M_{t-1} = \frac{Book-equity_{t-1}}{Market\ cap_{t-1}}}$ Value breakpoints: 30th and 70th percentiles	$\boldsymbol{HML = (SH + BH)/2 - (SL + BL)/2}$
Profitability sorted by: $\boldsymbol{OP_{t-1} = \frac{Rev_{t-1} - COGS_{t-1} - SG\&A_{t-1} - Interest_{t-1}}{Book-equity_{t-1}}}$ Profitability breakpoints: 30th and 70th percentiles	$\boldsymbol{RMW = (SR + BR)/2 - (SW + BW)/}2$
Investment sorted by: $\boldsymbol{Inv_{t-1} = \frac{Total\ Assets_{t-1} - Total\ Assets_{t-2}}{Total\ Assets_{t-2}}}$ Investment breakpoints: 30th and 70th percentiles	$\boldsymbol{CMA = (SC + BC)/2 - (SA + BA)/2}$

4.2.2 Dependent variable

The dependent variable, $\mathrm{R_{it}} - \mathrm{R_{Ft}}$, is the value-weighted return on the test portfolio i minus Vietnam 1-year bond yield converted to monthly rate at time t. The test portfolios are constructed by similar but finer double-sorting process than the one used to form the factors. To be specific, in June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and four B/M groups (High to Low). The breakpoints are sample quartiles of size and B/M. The intersection of these two sorts will generate 16 VW Size-B/M portfolios. Similarly, by replacing B/M with OP and Inv on the other side, the 4 x 4 sort will produce 16 VW Size-OP and 16 VW Size-Inv portfolios respectively.

Furthermore, 12 VW portfolios will be formed based on 4x3 sort on size and state-ownership status, namely Size-SO portfolios. State-ownership status will be divided into three groups based on the percentage of charter capital that the state owns. The three groups are (in ascending order of the state capital): Private (no state capital), Low, and High. The breakpoints used for sorting are detailed in **Table 5**. The state capital at the companies can be either directly owned by local authorities or State Capital and Investment Corporation (SCIC) or indirectly owned by wholly state-owned enterprises.

Table 5 State-ownership status (SO) groups and their breakpoints

Group	**State owns X% of charter capital**
Private	$X = 0$
Low	$0 < X \leq 50\%$
High	$X > 50\%$

This sort method is selected because it will not only generate ample test portfolios but also ensure that these test portfolios are adequately diversified. In summary, we have 60 VW test portfolios in total.

4.3 Asset Pricing Tests

After variable construction, the asset pricing tests will be implemented based on CAPM, FF three-factor, and FF five-factor. Besides, the tests also consider a set of three FF four-factor versions that combine $\mathrm{R_M} - \mathrm{R_F}$, SMB, and pairs of HML, RMW, and CMA. This set of four-factor models aims to test whether HML is a redundant factor when RMW and CMA come into play as it is the case in Fama and French (2015). In general, this phase aims to investigate the performance of each model specification in capturing average returns in Vietnam's stock market. The regressions will be conducted using ordinary least squares (OLS) method. Specifications of asset pricing tests are detailed in **Table 6**.

Table 6 Specifications of Asset Pricing Tests
Rm-Rf is the value-weighted return on the market portfolio of all sample stocks minus Vietnam 1-year government bond yield converted to monthly basis; SMB (small-minus-big) is the size factor; HML (high-minus-low) is the value factor; RMW (robust-minus-weak) is the profitability factor; and CMA (conservative-minus-aggressive) is the investment factor. All the factors (except Rm-Rf) are constructed from independent sorts of stocks into two Size groups and three B/M groups, three OP groups, or three Inv groups.

Model	**Regression equation**
Capital Asset Pricing Model	$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + e_{it}$
Fama – French Three-Factor Model	$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + e_{it}$
Fama – French Five-Factor Model	$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}$
Fama – French Four-Factor (combine $\mathbf{R_M} - \mathbf{R_F}$, SMB, and pairs of HML, RMW, and CMA)	(1) $R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + e_{it}$ (2) $R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + c_i CMA_t + e_{it}$ (3) $R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + r_i RMW_t + c_i CMA_t + e_{it}$

4.4 Factor Spanning Tests

The factor spanning tests will help to determine whether any factor in the FF five-factor model can be fully explained by other factors regarding Vietnam's stock market. Specifically, the tests will regress each of the five factors on the other four by using OLS method. Specifications of factor spanning tests are detailed in **Table 7**.

Table 7 Specifications of Factor Spanning Tests

Rm-Rf is the value-weighted return on the market portfolio of all sample stocks minus Vietnam 1-year government bond yield converted to monthly basis; SMB (small-minus-big) is the size factor; HML (high-minus-low) is the value factor; RMW (robust-minus-weak) is the profitability factor; and CMA (conservative-minus-aggressive) is the investment factor. All the factors (except Rm-Rf) are constructed from independent sorts of stocks into two Size groups and three B/M groups, three OP groups, or three Inv groups.

Dependent variable	**Regression equation**
$\boldsymbol{R_{Mt} - R_{Ft}}$	$R_{Mt} - R_{Ft} = a_i + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}$
$\boldsymbol{SMB}$	$SMB_t = a_i + b_i(R_{Mt} - R_{Ft}) + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}$
$\boldsymbol{HML}$	$HML_t = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + r_i RMW_t + c_i CMA_t + e_{it}$
$\boldsymbol{RMW_t}$	$RMW_t = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + c_i CMA_t + e_{it}$
$\boldsymbol{CMA}$	$CMA_t = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + e_{it}$

5 FINDINGS AND DISCUSSION

The findings and discussion part begins with Section 5.1 – "The Playing Field", which examines the patterns in average returns as well as in book-to-market, operating profitability, and investment. Subsequently, Section 5.2 and 5.3 respectively present summary statistics of factor returns and correlations among different factors. Section 5.4 continues with findings from the primary task of the thesis - testing how well different asset pricing models explain average returns in Vietnam' stock market. Finally, Section 5.5 shows factor spanning test results and discusses which factor is redundant.

5.1 The Playing Field

This thesis aims to investigate the capability of the FF five-factor model and models that include subsets of its factors in explaining variation in Vietnam stock returns. Before discussing the regression results, we will examine the patterns in average returns as well as in B/M, OP, and Inv of 60 VW test portfolios. Patterns in average returns are usually referred to as effects. For instance, size effect is the size pattern in average returns. Section 5.1.1 to 5.1.5 will discuss the five effects: size, value, profitability, investment, and state-ownership status. Section 5.1.6 will discuss other patterns in B/M, OP, and Inv. **Table 8** shows time-series averages of monthly excess returns, B/M, OP, and Inv of 60 VW test portfolios.

It is important to note that this section only discusses univariate characteristics. Therefore, interpretation in this section should be taken with caution as univariate characteristics can differ from multivariate regression slopes, which estimate marginal effects holding other explanatory variables constant (Fama and French, 2015). However, it is interesting to see whether factor slopes line up with these univariate characteristics.

5.1.1 Size Effect

For 16 VW Size-B/M portfolios, the size effect is not obvious as average returns do not typically fall from small stocks to big stocks. That is, average return pattern from small to big stocks varies across different B/M groups. For example, in the lowest B/M column, stocks in the 3rd size group have the lowest average return. However, in the highest B/M column, stocks in this size group have the second highest average return. Although average returns do not monotonously decrease from small to big stocks for our 16 VW Size-B/M portfolios, the smallest size portfolios almost always earn the highest average return (with the exception in 2nd B/M group). Thus, size effect still occurs to a weak extent for Size-B/M portfolios.

For 16 VW Size-OP portfolios, we observe the most evident size effect in the weakest profitability column, where average return monotonously decreases with size. For the remaining three profitability columns, the pattern varies but, like Size-B/M portfolios, stocks in the smallest size group always earn the highest average return. For 16 VW Size-Inv portfolios, size effect is only evident for the first three size groups (first three rows) as average returns always declines with size. However, the biggest size group do not follow this pattern. Stocks in this size group usually show decent average returns (except Conservative investment column), which are 0.27% - 0.37% higher than those of the 3rd size group. For example, stocks of companies that invest most aggressively and are in the biggest size group earn 0.61% average monthly excess return, higher than any other size groups in the same column.

For 12 VW Size-SO portfolios, there is no clear size pattern in average returns. Nevertheless, we find an interesting point. In the same biggest size group, stocks of companies that are in Low column (less than 50% of charter capital owned by the state) earn the highest average excess return while those in High column (more than 50% of charter capital owned by the state) earn the lowest among 12 Size-SO portfolios.

In brief, size effect seems to be weak in this sample. Average returns do not usually increase as size decreases. However, stocks in the smallest size groups almost always earn highest average return. These observations are different from what Fama and French (2015) find in US stock market, which exhibits a strong size effect in Size-B/M, Size-OP, and Size-Inv portfolios.

Table 8 Time-series averages of excess returns, B/M, OP, and Inv of 60 VW test portfolios formed on Size and B/M, OP, Inv, or SO; July 2009 - December 2017, 102 months.

The table rows always refer to size quartiles while the table columns refer to B/M, profitability, investment, and state-ownership groups. Both rows and columns are in ascending order; for Size: Small to Big; for B/M: Low to High; for OP: Weak to Robust; for Inv: Conservative (Cons.) to Aggressive (Aggr.); and for SO: Private (Priv.) to High. The intersections of rows and columns form double-sorted portfolios. Panel A presents average excess return of 60 VW test portfolios; monthly excess return is equal to monthly return minus Vietnam 1-year government bond yield converted to monthly basis. Panel B presents average B/M of 60 VW test portfolios; B/M is equal to book equity divided by market capitalization. Panel C presents average OP; OP is equal to revenue minus COGS, SG&A, and interest expense, all divided by book equity. Panel D presents average Inv; Inv is equal to total asset growth rate.

	Book-to-Market (B/M)				**Profitability (OP)**				**Investment (Inv)**				**State-ownership (SO)**		
	Low	2	3	High	Weak	2	3	Robust	Cons.	2	3	Aggr.	Priv.	Low	High
Panel A: Excess return															
Small	0.86	0.66	1.03	0.79	1.05	0.46	0.39	1.26	0.76	0.91	0.72	0.59	1.02	0.23	0.28
2	-0.01	0.82	0.44	0.01	0.06	0.12	0.70	0.60	0.20	0.44	0.35	0.23	0.47	-0.10	0.09
3	-0.19	-0.06	0.14	0.74	0.01	0.01	0.04	0.15	-0.05	0.12	-0.07	-0.24	-0.01	0.31	-0.09
Big	0.53	0.06	0.28	0.16	-0.70	0.23	0.10	0.64	-0.24	0.48	0.20	0.61	0.49	1.36	-0.32
Panel B: Book-to-Market (B/M)															
Small	0.66	1.07	1.51	2.72	2.27	1.97	1.52	1.38	2.00	1.87	1.77	1.84	1.95	1.71	2.05
2	0.62	1.02	1.53	2.51	2.00	1.65	1.36	1.23	1.62	1.75	1.51	1.46	1.66	1.39	1.46
3	0.59	1.02	1.53	2.42	1.83	1.34	1.09	0.92	1.35	1.31	1.18	1.13	1.27	1.10	1.25
Big	0.56	1.01	1.43	2.36	1.36	1.10	0.98	0.68	1.12	1.11	0.93	0.86	0.98	0.90	1.01
Panel C: Profitability (OP)															
Small	0.24	0.16	0.16	0.08	-0.06	0.12	0.23	0.46	0.07	0.13	0.20	0.19	0.13	0.14	0.13
2	0.18	0.22	0.16	0.12	-0.07	0.13	0.23	0.48	0.10	0.16	0.21	0.21	0.14	0.18	0.25
3	0.32	0.24	0.18	0.13	-0.02	0.13	0.23	0.50	0.18	0.24	0.25	0.27	0.19	0.21	0.38
Big	0.28	0.19	0.16	0.10	-0.06	0.12	0.24	0.43	0.14	0.22	0.25	0.24	0.18	0.26	0.29
Panel D: Investment (Inv)															
Small	0.04	0.14	0.10	0.07	0.05	0.08	0.15	0.15	-0.12	0.04	0.16	0.57	0.12	0.07	0.07
2	0.17	0.14	0.14	0.09	0.11	0.17	0.14	0.15	-0.11	0.04	0.16	0.54	0.15	0.13	0.11
3	0.24	0.15	0.16	0.10	0.18	0.20	0.15	0.17	-0.10	0.04	0.15	0.57	0.20	0.13	0.13
Big	0.27	0.22	0.19	0.11	0.30	0.26	0.20	0.22	-0.09	0.04	0.15	0.59	0.30	0.18	0.13

5.1.2 Value Effect

Value effect, the relation between B/M and average returns, is not evident in 16 VW Size-B/M portfolios. If value effect takes place, average return should increase with B/M in each size group. In these Size-B/M portfolios, only stocks in the 3rd size group exhibit a strong value effect as average return increases monotonously with B/M. However, other size groups seem to display a reverse value effect as average return decrease with B/M. Specifically, stocks in the highest B/M group earn the second lowest average returns in the remaining three size groups. This finding is in contradiction to what Fama and French (2015) observe.

5.1.3 Profitability Effect

Profitability effect, the relation between OP and average returns, is intuitive in a sense that stocks of companies with robust profit should earn higher average return than those with weak profit. This effect seems to reflect in our 16 VW Size-OP portfolios. Although the effect is not smooth, Weak OP column tends to have lower average returns than the Robust one. Furthermore, stocks in the Robust column almost always gain the highest average returns – three out of four size groups. Nevertheless, there exists a glaring outlier in Small-Weak portfolio, which earns the second highest average return among all Size-OP portfolios, only lower than that of the Small-Robust stocks.

5.1.4 Investment Effect

In Fama and French's sample (2015), stocks of companies that invest aggressively tend to have lower average returns than those with conservative investment level, measured by lagged asset growth. This negative relationship between investment and average stock return is also implied in the Miller Modigliani valuation formula (**Equation 8**). However, this pattern is not consistent in our sample and reversal happens in some instances. For example, stocks in the 2nd investment quartile tend to have the largest average return (three out of four size groups) while those in the 1st investment quartile, the most conservative, have the lowest average return in two out of four size groups. In the biggest size group, average return even monotonously increases with investment. In this size group, stocks of companies in the 4th investment quartile, the most aggressive, earn the highest average monthly excess return of 0.61% – a wide spread of 0.85% with the 1st investment quartile.

5.1.5 State-ownership Effect

State-ownership effect will be examined in 12 VW Size-SO portfolios. Like some effects discussed above, state-ownership pattern in average returns is not consistent and varies across size groups. In the 1st and 2nd size quartile, stocks of private companies earn the highest average return while those of low-state-capital companies earn the lowest. However, this pattern reverses in the 3rd and 4th size quartile, where stocks in the low-state-capital group gain the highest average return. As for stocks of high-state-capital companies, they usually have relatively low average return across all size quartiles.

5.1.6 Other Patterns

There exists a strong pattern between B/M and OP: lower B/M tends to associate with higher OP and vice versa. For example, in 16 VW Size-BM portfolios, OP gradually decreases as B/M increases from the 1st to the 4th quartile in nearly all size groups except the second one. In the second size group, the trend is not smooth but it persists. This negative relation between OP and B/M can be observed in both Size-OP and Size-B/M portfolios. That is, profitability pattern in B/M (**Table 8** Panel B of Size-OP portfolios) is equivalent to B/M pattern in profitability (**Table 8** Panel C of Size-B/M portfolios). Investment also exhibits a negative relation with B/M in that more aggressive investment level usually comes with lower B/M, which is reflected in both Size-Inv and Size-B/M portfolios.

Unlike the previous two relations, the relation between profitability and investment is not straightforward. While profitability pattern in investment is not clear (**Table 8** Panel D of Size-OP portfolios), investment pattern in profitability seems to be strong (**Table 8** Panel C of Size-Inv portfolios). For 16 VW Size-Inv portfolios, companies that invest more aggressively tend to have more robust profitability. All these observations on the relations between B/M, OP, and Inv are consistent with what Fama and French (2015) find in their US sample.

When examining 12 VW Size-SO portfolios, we find no evident pattern between ownership status and B/M. However, when it comes to profitability and investment, companies that have state capital tend to have more robust profitability but lower investment level than private ones. Nguyen et al. (2015), on the other hand, find that private companies tend to have higher B/M, stronger profitability, and more aggressive investment level. This disparity can be attributed to difference in state-ownership classfication, data source, and test period.

5.2 Summary Statistics for Factor Returns

Table 9 presents the summary statistics for each factor. The range (max minus min) and standard deviation of these factors do not differ significantly from one another except for CMA, which has the smallest range and standard deviation. Among all the five factors, RMW has the highest average return of 0.738% per month. This phenomenon is consistent with our previous univariate analysis that there is a strong profitability effect in the sample.

Table 9 Summary Statistics for Factor Returns; July 2009 - December 2017, 102 months

This table presents time-series mean, median, standard deviation, min, and max of different factor percent returns. Rm-Rf is the value-weighted return on the market portfolio of all sample stocks minus Vietnam 1-year government bond yield converted to monthly basis; SMB (small-minus-big) is the size factor; HML (high-minus-low) is the value factor; RMW (robust-minus-weak) is the profitability factor; and CMA (conservative-minus-aggressive) is the investment factor. All the factors (except Rm-Rf) are constructed from independent sorts of stocks into two Size groups and three B/M groups, three OP groups, or three Inv groups.

	Mean	Median	SD	Min	Max
$R_M - R_F$	0.306	0.747	5.131	-14.00	12.83
SMB	0.174	0.162	4.200	-11.74	14.44
HML	0.060	-0.905	4.852	-10.00	14.04
RMW	0.738	1.266	4.161	-10.88	10.69
CMA	-0.126	-0.247	2.664	-6.31	7.53

Other FF factors (SMB, HML, and CMA) show a relatively low average return over the test period. For example, HML shows a close-to-zero average return of 0.06% per month, meaning there is little difference in return between low and high B/M stocks on average. CMA, on the other hand, even exhibits a negative monthly average return of -0.126%. This negative number indicates that stocks of companies that invest aggressively on average perform better than those with conservative investment level, which differs from with what Fama and French (2015) find in US stock market. Besides the summary statistics table, we can also study the behavior of different factors through their cumulative returns over the test period (**Figure 5**).

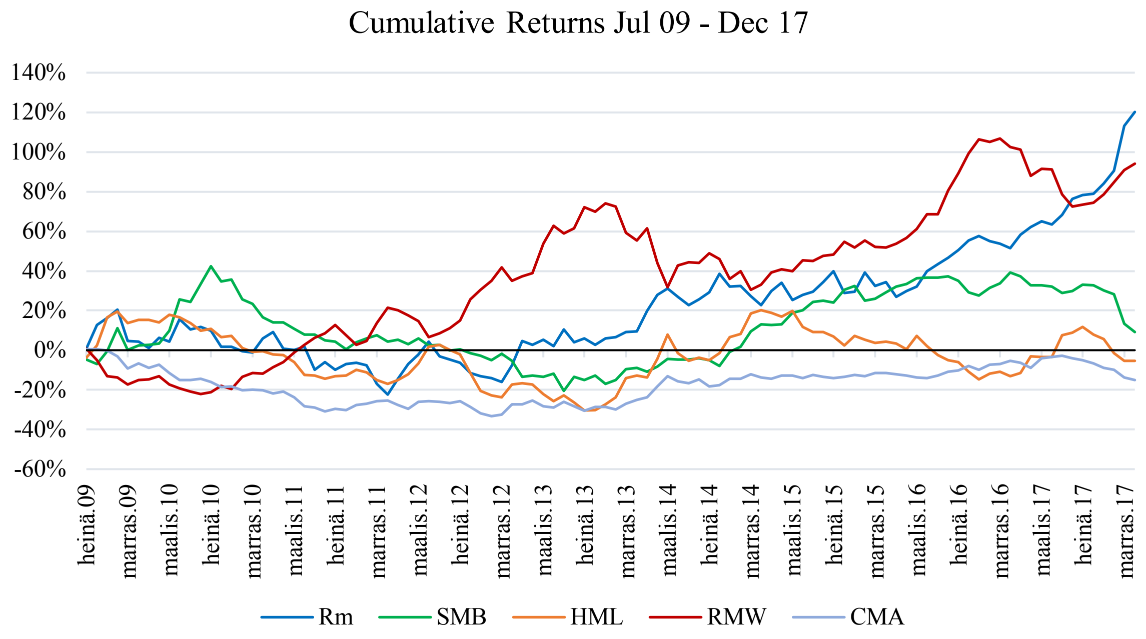

Figure 5 Cumulative returns of the market and four Fama-French factors (profit reinvested); July 2009 - December 2017, 102 months in total

Among the four FF factors, RMW has the highest cumulative return over the test period, which is above the market cumulative return most of the time. At the end of December 2017, RMW cumulative return is approximately 94%.

During the test period, SMB cumulative return reached its highest point of 42.4% in June 2010 and then began to decline to below zero until gaining back since September 2014. However, this factor cumulative return started to plunge again in October 2017, ending the test period with only 9.3%.

The cumulative return of HML exhibits a generally similar pattern to that of SMB until March 2015 when the two lines diverged. HML cumulative return ends the period below zero at -5.4% with the lowest point at -30.4% in July 2013.

Among all factors, CMA has the lowest cumulative return as it always stays below zero throughout the test period. This phenomenon provides evidence that stocks of companies with aggressive investment tend to perform better than those with conservative investment. If CMA is called investment premium, this means that investment premium is negative in Vietnam stock market, at least during this test period.

In summary, other than RMW, all FF factors constructed in this empirical test of Vietnam stock market demonstrate weaker or even reverse behavior compared to what Fama and French (2015) expect.

5.3 Correlations between Factors

Table 10 below shows the correlation matrix of the five factors. The absolute values of correlation coefficients between different factors are mainly from 0.19 to 0.27. However, there are three extreme cases in which the coefficients are outside of this range: HML-RMW, HML-CMA, and RMW-CMA.

The first case, HML-RMW, exhibits an extremely negative correlation of -0.79, indicating that high B/M companies tend to have weak profitability and vice versa. This phenomenon is consistent with the univariate analysis discussed previously, which documents a strong negative relation between B/M and OP. Relatively high correlation coefficients of HML-CMA and RMW-CMA also reflect the evident univariate patterns between B/M-Inv and OP-Inv respectively. Likewise, lower correlation coefficients of the other pairs are in line with their weak or unclear univariate patterns.

Table 10 Correlations between different factors; July 2009 - December 2017, 102 months.

Rm-Rf is the value-weighted return on the market portfolio of all sample stocks minus Vietnam 1-year government bond yield converted to monthly basis; SMB (small-minus-big) is the size factor; HML (high-minus-low) is the value factor; RMW (robust-minus-weak) is the profitability factor; and CMA (conservative-minus-aggressive) is the investment factor. All the factors (except Rm-Rf) are constructed from independent sorts of stocks into two Size groups and three B/M groups, three OP groups, or three Inv groups.

	$R_M - R_F$	SMB	HML	RMW	CMA
$R_M - R_F$	1				
SMB	-0.199	1			
HML	0.266	0.254	1		
RMW	-0.233	-0.254	-0.790	1	
CMA	0.109	0.164	0.484	-0.371	1

Consistent with Fama and French (2015) and Nguyen et al. (2015), RMW is negatively correlated with all other factors. These negative relations can be partly observed from **Figure 8**, which shows that RMW tends to move in an opposite direction with SMB, HML, and CMA especially during April 2012 – November 2014. Although the correlation degrees are different, all the coefficients in **Table 10** hold the same sign as Nguyen et al.'s result (2015), except the one between CMA and market excess return.

5.4 Asset Pricing Test Results

This section will focus on the primary task of the thesis, testing how well different asset pricing models explain average excess returns of Vietnam's stock market. Section 5.4.1 will evaluate different models on a general level by examining their GRS statistics, average absolute values of the intercepts, and average adjusted R^2s. Subsequently, Section 5.4.2 to 5.4.5 will present multivariate regression results for different types of test portfolios.

5.4.1 Overview

The empirical test considers six asset pricing models: Capital Asset Pricing Model (CAPM), Fama-French three-factor model, Fama-French five-factor model, and three four-factor models that combine $R_M - R_F$, SMB, and pairs of HML, RMW, and CMA. In a regression of an asset's excess returns on a model's factor returns, if the asset pricing model completely captures expected returns, the intercept will be indistinguishable from zero (Fama and French, 2015). To assess this condition, the empirical test will use three statistics: (i) GRS statistic, (ii) average absolute value of regression intercepts – $\mathbf{A|a_i|}$, and (iii) average adjusted R^2. GRS statistic, derived by Gibbons, Ross, and Shanken (1989), is used to test the null hypothesis that the intercepts from the asset pricing regressions are jointly equal zero. Average absolute value of the intercepts is used to evaluate whether the regression intercepts are close to zero. Furthermore, average adjusted R^2 is used to see how much variation in average returns is explained by each model. These three metrics will be compared among different asset pricing models to assess their relative performance. **Table 11** presents GRS statistics, their corresponding p-values, and average absolute values of the intercepts for different models and types of test portfolios.

Table 11 Summary statistics for tests of CAPM and three-, four-, and five-factor models; July 2009 - December 2017, 102 months.

The table presents GRS statistics, GRS p-values, and average absolute values of intercepts $A|a_i|$ for 60 VW test portfolios: 16 Size-B/M portfolios (Panel A), 16 Size-OP portfolios (Panel B), 16 Size-Inv portfolios (Panel C), and 12 Size-SO portfolios (Panel D). GRS statistic, derived by Gibbons, Ross, and Shanken (1989), is used to test the null hypothesis that the intercepts from the asset pricing regressions are jointly equal zero. Average absolute value of the intercepts is used to evaluate whether the regression intercepts are close to zero.

	GRS statistic	**GRS p-value**	$A\|a_i\|$
Panel A: 16 Size-B/M portfolios			
CAPM	1.03	0.43	0.0037
FF3F	1.31	0.21	0.0034
FF4F: HML RMW	0.97	0.49	0.0032
FF4F: HML CMA	1.28	0.23	0.0033
FF4F: RMW CMA	1.11	0.36	0.0046
FF5F	0.95	0.52	0.0031
Panel B: 16 Size-OP portfolios			
CAPM	1.07	0.40	0.0039
FF3F	1.54	0.11	0.0036
FF4F: HML RMW	0.92	0.55	0.0025
FF4F: HML CMA	1.54	0.11	0.0035
FF4F: RMW CMA	1.25	0.25	0.0030
FF5F	0.92	0.55	0.0025
Panel C: 16 Size-Inv portfolios			
CAPM	0.76	0.73	0.0029
FF3F	0.79	0.69	0.0029
FF4F: HML RMW	0.99	0.48	0.0027
FF4F: HML CMA	0.92	0.56	0.0027
FF4F: RMW CMA	0.95	0.52	0.0030
FF5F	1.03	0.43	0.0026
Panel D: 12 Size-SO portfolios			
CAPM	1.53	0.13	0.0036
FF3F	2.40	0.01	0.0039
FF4F: HML RMW	1.78	0.06	0.0038
FF4F: HML CMA	2.54	0.01	0.0038
FF4F: RMW CMA	1.75	0.07	0.0040
FF5F	1.87	0.05	0.0037

In brief, GRS test shows failure to reject all models except in the 12 Size-SO case. That is, we cannot reject the null hypothesis that regression intercepts are jointly equal zero for Size-B/M, Size-OP, and Size-Inv portfolios. This finding is in contradiction to the result from Fama and French (2015), in which GRS test rejects all models. In this empirical test, we interpret lower GRS statistic as better model performance and vice versa. Assessed by GRS statistics, the models fare best in the tests on 16 Size-Inv and worst in those on 12 Size-SO portfolios.

The five-factor model has the lowest GRS statistic in two out of four sets of test portfolios, which are Size-B/M and Size-OP. However, as for Size-Inv portfolios, the five-factor model becomes the one with the highest GRS statistic. Judged by GRS statistics, the five-factor model shows the largest improvement from the original three-factor in 16 Size-OP portfolios. However, it is the opposite situation for 16 Size-Inv portfolios, in which the five-factor model shows worse performance than the three-factor. When taking CAPM into consideration, we find an interesting result. Assessed by GRS statistics, CAPM tends to fare relatively well since it performs better than the three-factor and the five-factor in four and two sets of test portfolios respectively.

For the three four-factor models that combine $\mathrm{R_M} - \mathrm{R_F}$, SMB, and pairs of HML, RMW, and CMA, the model with HML-RMW pair tends to have better performance than the other two when assessed by GRS statistic. On the other hand, the model with HML-CMA pair usually has inferior performance among the three. Compared their GRS statistics with other asset pricing models (CAPM, FF3F, and FF5F), these three do not show any consistent outperformance or underperformance as they vary across portfolio sets.

Like the general finding from GRS test, the six models fare best in 16 Size-Inv and worst in 12 Size-SO portfolios when assessed by average absolute values of regression intercepts. However, this number demonstrates a different pattern from GRS statistic as it tends to get smaller when we add more factors. Across four sets of test portfolios, the five-factor model always has the lowest average absolute value of regression intercepts except in 12 Size-SO portfolios. The model shows the largest improvement from the three-factor and the CAPM in 16 Size-OP portfolios. The worst performing model when assessed by average absolute values of intercepts is the four-factor model with RMW-CMA pair since it has the highest values in three of out four sets of test portfolios.

As abovementioned, the most troublesome portfolio set is 12 Size-SO portfolios as all models fare poorly in these portfolios when judged by either GRS statistic or average absolute value of intercepts. For example, GRS test rejects all models except CAPM at 10% significance level. The three-factor model and four-factor model with HML-CMA pair can even be rejected at 1% significance level. Besides, the average absolute values of intercepts in this test portfolio set are higher than those in other sets. This finding suggests that our six asset pricing models have trouble explaining average returns of portfolios formed on size and state-ownership status.

Table 12 Average adjusted R^2s for tests of six asset pricing models (CAPM and three-, four-, and five-factor models) across four sets of test portfolios (Size-B/M, Size-OP, Size-Inv, and Size-SO); July 2009 - December 2017, 102 months.

	Size-B/M	Size-OP	Size-Inv	Size-SO	Average
CAPM	0.459	0.443	0.458	0.463	**0.456**
FF3F	0.727	0.689	0.683	0.692	**0.698**
FF5F	0.728	0.703	0.698	0.696	**0.706**
FF4F (HML-RMW)	0.727	0.704	0.685	0.696	**0.703**
FF4F (HML-CMA)	0.728	0.687	0.697	0.693	**0.701**
FF4F (RMW-CMA)	0.699	0.690	0.684	0.687	**0.690**

Table 12 presents average adjusted R^2s for different models and portfolio sets. Across portfolio sets, there seems to be no significant disparity in average adjusted R^2 for different models. Across models, the average adjusted R^2 shows large improvement from CAPM to the three-factor model (24.18% on average). However, there is minor improvement from the three-factor to the five-factor model (0.88% on average). As for the three four-factor models, there is minor enhancement or even deterioration (RMW-CMA pair) in average adjusted R^2 from the three-factor model. Compared with the five-factor model, these four-factor models have lower average adjusted R^2 but the difference is paltry. Much of these phenomena can be attributed to relatively high correlation among HML, RMW, and CMA. For example, since there exists extremely high correlation between HML and RMW (-0.79), replacing one factor with the other does not significantly affect explanatory power of the model.

In brief, this analysis of average adjusted R^2 only describes the aggregate level as it overlooks variation within each group. In Section 5.4.2 – 5.4.5, we will discuss regression results in depth for each type of model and test portfolio. However, these sections only present the results for CAPM, the three-factor model, and the five-factor model since the empirical test focuses on these three models. Moreover, because there are 60 VW test portfolios with six asset pricing models in total, this will make displaying the results more manageable and concise.

5.4.2 Size – B/M Portfolios

At first glance, we can clearly see extremely low adjusted R^2 for stocks in Small-Low group. This phenomenon happens because this group is an undiversified portfolio consisting of small and thinly traded stocks. Therefore, we will skip this portfolio in our analysis. **Table 13** and **Table 14** present adjusted R^2 and regression results (intercepts, factor slopes, and their t-statistics), respectively, of each model for 16 Size-B/M test portfolios.

Assessed by adjusted R^2, CAPM seems to have problems with small stocks, especially those in the lowest B/M quartile. Therefore, adjusted R^2 of CAPM tends to increase from small to big stocks across B/M quartiles. This can also be observed from the regression results where t-statistics of b usually increase with size. This phenomenon is not surprising because CAPM only considers the responsiveness of an asset's return to market fluctuation. Intuitively, since an asset itself is included in the market, the asset's return unavoidably expresses some correlation to the market fluctuation that cannot be diversified. Therefore, bigger stocks will have bigger weights in the total market capitalization and their returns tend to be largely explained by the market return, leading to larger adjusted R^2 in CAPM regressions. Despite the problem, the intercepts of 16 regressions are not statistically significant.

The three-factor model, which augments CAPM with the size (SMB) and value (HML) factors, seems to alleviate this trouble with small stocks as t-statistics of b do not fluctuate among size quartiles. Observed from Table 14, t-statistics of SMB slopes tend to decrease with size. For example, SMB slopes of the largest stocks in the 2^{nd} and 4^{th} B/M quartile even become statistically indistinguishable from zero. As for HML slopes, their t-statistics increase with B/M quartiles. The magnitude and sign of SMB and HML slopes provide information about portfolio tilts as expected. That is, smaller portfolios have larger SMB slopes while bigger ones have lower or negative slopes. Likewise, lower-B/M portfolios are associated with lower HML and vice versa.

The five-factor model augments the three-factor with profitability (RMW) and investment (CMA) factors. However, in the five-factor regression result, factor slopes have weaker statistical significance than those in the three-factor while the intercepts are still indistinguishable from zero. For example, nearly all RMW and CMA slopes are not statistically significant. This phenomenon can probably be explained by the presence of multicollinearity in the data, which reflects in high correlation in HML-RMW (-0.79), HML-CMA (-0.48), and RMW-CMA (-0.37). Results from the factor tests, to be discussed in Section 5.5, will provide more evidence on this issue. Although RMW and CMA slopes are mainly indistinguishable from zero, their magnitude and sign can still provide information about portfolio tilts. When controlling for other factors, we find that these RMW and CMA slopes do not follow any evident pattern across B/M quartiles, which does not line up with univariate characteristics discussed in Section 5.1.6. However, there is no reason to expect multivariate regression slopes, which estimate marginal effect holding other factors constant, will be consistent with univariate characteristics (Fama and French, 2015).

Table 13 Adjusted R^2 of CAPM, FF3F, and FF5F for 16 VW Size-B/M portfolios; July 2009 – December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and four B/M groups (High to Low). The breakpoints are sample quartiles of size and B/M. The intersection of these two sorts will generate 16 VW Size-B/M portfolios. Small-Low portfolio has extremely low adjusted R^2 across all three models because it is an undiversified portfolio consisting of small and thinly traded stocks. Therefore, we will skip this portfolio in our analysis.

Panel A: CAPM

	Low	2	3	High
Small	0.02	0.26	0.32	0.29
2	0.28	0.46	0.40	0.45
3	0.47	0.55	0.51	0.47
Big	0.74	0.66	0.63	0.41

Panel B: FF3F

Small	0.01	0.57	0.74	0.74
2	0.59	0.76	0.78	0.83
3	0.63	0.67	0.76	0.75
Big	0.79	0.76	0.75	0.76

Panel C: FF5F

Small	-0.01	0.57	0.74	0.74
2	0.60	0.75	0.79	0.84
3	0.62	0.66	0.76	0.75
Big	0.80	0.79	0.76	0.76

Table 14 Regression results (intercepts, factor slopes, and their t-statistics) of CAPM, FF3F, and FF5F for 16 VW Size-B/M portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and four B/M groups (High to Low). The breakpoints are sample quartiles of size and B/M. The intersection of these two sorts will generate 16 VW Size-B/M portfolios. Small-Low portfolio is an undiversified portfolio consisting of small and thinly traded stocks and thus it will be excluded from our analysis. *Italic*, ***Bold-Italic***, and **Bold** font styles represent statistical significance at the 10%, 5%, and 1% levels, respectively.

B/M	Low	2	3	High	Low	2	3	High
Panel A: CAPM								
	a				*t(a)*			
Small	0.008	0.004	0.008	0.006	0.72	0.67	1.21	0.90
2	-0.002	0.005	0.002	-0.003	-0.41	0.91	0.28	-0.53
3	-0.005	-0.004	-0.001	0.004	-0.93	-0.80	-0.31	0.64
Big	0.002	-0.003	-0.001	-0.002	0.82	-0.69	-0.24	-0.29
	b				*t(b)*			
Small	*0.34*	**0.76**	**0.86**	**0.78**	1.68	6.02	7.02	6.43
2	**0.72**	**1.02**	**0.93**	**1.04**	6.39	9.37	8.34	9.10
3	**0.95**	**0.98**	**0.94**	**1.13**	9.48	11.14	10.26	9.43
Big	**0.96**	**1.08**	**1.32**	**1.21**	16.99	13.90	13.15	8.38
Panel B: FF3F								
	a				*t(a)*			
Small	0.007	0.002	0.006	0.004	0.67	0.42	1.46	1.04
2	-0.005	0.003	0.000	-0.005	-1.05	0.83	-0.05	-1.41
3	-0.006	-0.004	-0.002	0.004	-1.41	-1.15	-0.71	0.84
Big	0.003	-0.002	0.000	-0.001	1.11	-0.69	-0.11	-0.31
	b				*t(b)*			
Small	*0.38*	**0.90**	**0.89**	**0.75**	1.71	8.69	10.89	9.59
2	**0.94**	**1.10**	**0.95**	**0.98**	10.17	13.94	12.98	14.40
3	**0.99**	**0.98**	**0.88**	**0.96**	10.89	11.99	12.78	10.80
Big	**0.94**	**0.92**	**1.10**	**0.86**	17.07	13.29	12.42	8.64
	s				*t(s)*			
Small	0.23	**1.00**	**0.92**	**0.79**	0.83	7.94	9.23	8.30
2	**0.98**	**0.89**	**0.83**	**0.68**	8.74	9.23	9.32	8.24
3	**0.58**	**0.41**	**0.44**	***0.26***	5.21	4.08	5.19	2.43
Big	**-0.25**	*-0.15*	**-0.29**	*-0.20*	-3.65	-1.82	-2.71	-1.68
	h				*t(h)*			
Small	-0.01	0.09	**0.48**	**0.61**	-0.02	0.80	5.51	7.24

2	***-0.23***	**0.24**	**0.45**	**0.70**	-2.36	2.81	5.77	9.53
3	***0.23***	**0.27**	**0.50**	**0.87**	2.37	3.04	6.79	9.21
Big	*-0.11*	**0.51**	**0.69**	**1.29**	-1.84	6.90	7.24	12.09

Panel C: FF5F

	a				*t(a)*			
Small	0.004	0.001	*0.007*	0.004	0.40	0.26	1.77	0.94
2	-0.002	0.004	0.002	-0.003	-0.48	0.95	0.50	-0.76
3	-0.007	-0.004	-0.001	0.004	-1.46	-0.95	-0.34	0.88
Big	0.003	0.000	0.002	-0.002	1.02	0.00	0.44	-0.37
	b				*t(b)*			
Small	*0.40*	**0.90**	**0.88**	**0.75**	1.76	8.65	10.78	9.48
2	**0.93**	**1.10**	**0.94**	**0.97**	10.15	13.75	13.15	14.43
3	**0.99**	**0.98**	**0.88**	**0.95**	10.80	11.83	12.71	10.65
Big	**0.94**	**0.92**	**1.09**	**0.86**	17.42	13.81	12.40	8.56
	s				*t(s)*			
Small	0.25	**1.01**	**0.91**	**0.79**	0.89	7.94	9.06	8.17
2	**0.96**	**0.88**	**0.82**	**0.67**	8.55	9.02	9.36	8.12
3	**0.58**	**0.40**	**0.42**	***0.26***	5.19	3.97	5.01	2.36
Big	**-0.24**	***-0.18***	**-0.32**	-0.20	-3.64	-2.21	-2.93	-1.61
	h				*t(h)*			
Small	0.18	0.18	**0.37**	**0.62**	0.48	1.02	2.66	4.58
2	**-0.46**	0.18	**0.33**	**0.55**	-2.94	1.32	2.68	4.74
3	*0.30*	0.21	**0.39**	**0.84**	1.90	1.50	3.25	5.47
Big	-0.05	***0.27***	**0.46**	**1.34**	-0.58	2.36	3.08	7.80
	r				*t(r)*			
Small	0.36	0.05	-0.21	0.02	0.85	0.26	-1.38	0.12
2	-0.26	-0.08	***-0.29***	***-0.27***	-1.50	-0.52	-2.16	-2.12
3	0.05	-0.06	-0.11	-0.05	0.31	-0.37	-0.87	-0.30
Big	-0.03	*-0.21*	-0.26	0.02	-0.31	-1.71	-1.58	0.12
	c				*t(c)*			
Small	0.17	-0.23	-0.10	-0.01	0.38	-1.09	-0.62	-0.09
2	0.24	0.03	-0.24	-0.09	1.28	0.17	-1.65	-0.66
3	-0.12	0.06	0.17	0.00	-0.67	0.37	1.20	0.00
Big	**-0.29**	**0.41**	0.21	-0.15	-2.63	3.02	1.15	-0.75

5.4.3 Size – OP Portfolios

Table 15 and **Table 16** present adjusted R^2s and regression results (intercepts, factor slopes, and their t-statistics), respectively, of each model for 16 Size-OP test portfolios. Similar to Size-B/M portfolios, adjusted R^2 of CAPM tends to increase from small to big stocks across OP quartiles. As adjusted R^2 of CAPM is relatively high for big stocks, the three-factor model shows lower improvement from CAPM for big stocks than for smaller ones. This phenomenon is also reflected in the negative relation between t-statistics of SMB slopes and size, which is similar to Size-B/M case.

The intercepts of 16 CAPM regressions are not statistically significant except for the largest stocks in weak OP quartile. Although the three-factor model mitigates the problem with small stocks, the trouble with big stocks in weak OP quartile remains and is resolved only when profitability and investment factors are added. Implied from RMW and CMA slopes, this portfolio is dominated by big stocks whose returns behave like those of unprofitable firms that invest aggressively. It is intuitive that the three-factor model falls short on portfolios formed from size and profitability, which is not included in the model. However, apart from this troublesome portfolio of big stocks with weak profitability, the five-factor model shows minor improvement or even deterioration in adjusted R^2 from the three-factor as more than half of RMW and all of CMA slopes are not statistically significant. Like other Size-B/M portfolios, multivariate regression slopes tend not to line up with univariate characteristics since there is no clear pattern in RMW and CMA across size and OP quartiles.

Table 15 Adjusted R^2 of CAPM, FF3F, and FF5F for 16 VW Size-OP portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and four OP groups (Weak to Robust). The breakpoints are sample quartiles of size and OP. The intersection of these two sorts will generate 16 VW Size-OP portfolios.

Panel A: CAPM

	Weak	2	3	Robust
Small	0.24	0.22	0.32	0.28
2	0.43	0.43	0.38	0.46
3	0.38	0.56	0.47	0.52
Big	0.54	0.63	0.59	0.63

Panel B: FF3F

Small	0.67	0.64	0.70	0.47
2	0.80	0.78	0.76	0.76
3	0.70	0.74	0.62	0.67
Big	0.71	0.69	0.60	0.72

Panel C: FF5F

Small	0.68	0.64	0.69	0.51
2	0.83	0.79	0.76	0.76
3	0.72	0.74	0.61	0.66
Big	0.82	0.70	0.59	0.74

Table 16 Regression results (intercepts, factor slopes, and their t-statistics) of CAPM, FF3F, and FF5F for 16 VW Size-OP portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and four OP groups (Weak to Robust). The breakpoints are sample quartiles of size and OP. The intersection of these two sorts will generate 16 VW Size-OP portfolios. *Italic*, ***Bold-Italic***, and **Bold** font styles represent statistical significance at the 10%, 5%, and 1% levels, respectively.

OP	Weak	2	3	Robust	Weak	2	3	Robust
Panel A: CAPM								
	a				*t(a)*			
Small	0.008	0.002	0.002	*0.010*	0.87	0.37	0.31	1.67
2	-0.003	-0.002	0.004	0.003	-0.44	-0.32	0.82	0.62
3	-0.003	-0.003	-0.002	-0.002	-0.46	-0.65	-0.49	-0.33
Big	***-0.010***	-0.001	-0.002	0.004	-2.01	-0.31	-0.48	1.10
	b				*t(b)*			
Small	**0.97**	**0.72**	**0.73**	**0.76**	5.76	5.51	6.92	6.33
2	**1.06**	**1.01**	**0.83**	**0.92**	8.86	8.84	7.91	9.25
3	**1.08**	**1.03**	**0.90**	**0.99**	7.93	11.28	9.48	10.50
Big	**1.12**	**1.21**	**0.97**	**0.88**	11.04	13.10	12.14	13.25
Panel B: FF3F								
	a				*t(a)*			
Small	0.005	0.000	0.000	0.009	0.95	0.08	-0.10	1.65
2	-0.004	-0.004	0.002	0.001	-1.14	-0.99	0.66	0.40
3	-0.004	-0.004	-0.003	-0.003	-0.82	-1.04	-0.80	-0.69
Big	***-0.010***	-0.001	-0.002	0.004	-2.46	-0.22	-0.38	1.47
	b				*t(b)*			
Small	**0.93**	**0.77**	**0.83**	**0.83**	7.69	8.06	11.01	7.46
2	**1.00**	**1.02**	**0.97**	**0.99**	13.06	13.27	13.69	13.98
3	**0.92**	**0.96**	**0.90**	**1.03**	8.91	12.70	10.26	12.10
Big	**0.93**	**1.07**	**0.91**	**0.88**	10.66	11.61	10.57	14.19
	s				*t(s)*			
Small	**1.01**	**0.97**	**0.91**	**0.71**	6.87	8.29	9.85	5.20
2	**0.70**	**0.82**	**1.00**	**0.82**	7.53	8.75	11.51	9.42
3	**0.41**	**0.34**	**0.44**	**0.55**	3.24	3.64	4.14	5.35
Big	-0.07	*-0.19*	*-0.18*	**-0.28**	-0.66	-1.69	-1.69	-3.72
	h				*t(h)*			
Small	**0.83**	**0.40**	***0.16***	0.17	6.46	3.91	2.02	1.41
2	**0.68**	**0.47**	0.09	**0.24**	8.31	5.68	1.21	3.18
3	**0.91**	**0.50**	**0.30**	***0.20***	8.21	6.14	3.22	2.16
Big	**0.70**	**0.44**	0.14	**-0.21**	7.52	4.48	1.55	-3.10

Panel C: FF5F

	a				*t(a)*			
Small	0.008	0.002	-0.002	0.004	1.35	0.40	-0.40	0.74
2	0.001	-0.001	0.002	0.000	0.23	-0.27	0.54	-0.04
3	0.001	-0.004	-0.004	-0.004	0.17	-0.92	-0.82	-1.04
Big	-0.002	0.002	-0.002	0.002	-0.70	0.49	-0.52	0.59

	b				*t(b)*			
Small	**0.91**	**0.77**	**0.84**	**0.86**	7.65	7.95	11.03	7.94
2	**0.98**	**1.01**	**0.97**	**1.00**	13.97	13.31	13.57	14.03
3	**0.90**	**0.96**	**0.90**	**1.03**	9.09	12.54	10.15	12.13
Big	**0.89**	**1.05**	**0.91**	**0.89**	13.04	11.75	10.49	14.75

	s				*t(s)*			
Small	**0.99**	**0.96**	**0.92**	**0.75**	6.80	8.13	9.84	5.66
2	**0.66**	**0.80**	**1.00**	**0.83**	7.70	8.61	11.41	9.53
3	**0.36**	**0.34**	**0.45**	**0.57**	2.99	3.58	4.10	5.44
Big	-0.13	*-0.21*	-0.17	**-0.26**	-1.61	-1.95	-1.61	-3.50

	h				*t(h)*			
Small	**0.67**	*0.29*	*0.25*	**0.54**	3.28	1.77	1.90	2.91
2	***0.28***	***0.26***	0.14	**0.38**	2.30	2.00	1.10	3.10
3	**0.47**	**0.50**	***0.33***	***0.33***	2.78	3.78	2.19	2.29
Big	0.09	0.22	0.20	0.01	0.81	1.41	1.37	0.09

	r				*t(r)*			
Small	*-0.38*	-0.22	0.15	**0.61**	-1.72	-1.23	1.07	3.03
2	**-0.61**	***-0.33***	0.01	0.17	-4.67	-2.32	0.09	1.25
3	**-0.55**	-0.04	0.03	0.20	-2.95	-0.29	0.18	1.25
Big	**-1.00**	***-0.43***	0.08	**0.31**	-7.86	-2.57	0.49	2.77

	c				*t(c)*			
Small	-0.32	-0.13	0.06	0.11	-1.33	-0.66	0.36	0.49
2	0.03	-0.02	-0.13	-0.11	0.23	-0.15	-0.92	-0.76
3	0.31	-0.09	-0.04	-0.03	1.56	-0.61	-0.23	-0.19
Big	-0.18	-0.21	-0.04	-0.04	-1.27	-1.14	-0.20	-0.34

5.4.4 Size – Inv Portfolios

Table 17 and **Table 18** present adjusted R^2s and regression results (intercepts, factor slopes, and their t-statistics), respectively, of each model for 16 Size-Inv test portfolios. In general, the multivariate regression results for Size-Inv portfolios are somewhat similar to the previous two cases. To begin with, adjusted R^2 of CAPM also increases from small to big stocks across Inv quartiles and the three-factor model shows lower improvement from CAPM for big stocks than for smaller ones. Furthermore, the five-factor model shows minor improvement or even deterioration in adjusted R^2 from the three-factor as the majority of RMW and CMA slopes are not statistically significant. Finally, multivariate regression slopes do not line up with univariate characteristics since there is no clear pattern in HML and RMW slopes across size and Inv quartiles.

Table 17 Adjusted R^2 of CAPM, FF3F, and FF5F for 16 VW Size-Inv portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups, Small to Big, and four Inv groups, Conservative (Cons.) to Aggressive (Aggr.). The breakpoints are sample quartiles of size and Inv. The intersection of these two sorts will generate 16 VW Size-Inv portfolios.

Panel A: CAPM

	Cons.	2	3	Aggr.
Small	0.30	0.21	0.20	0.41
2	0.49	0.38	0.40	0.42
3	0.46	0.52	0.50	0.53
Big	0.60	0.64	0.69	0.56

Panel B: FF3F

Small	0.69	0.56	0.54	0.70
2	0.83	0.77	0.71	0.71
3	0.66	0.73	0.71	0.66
Big	0.69	0.68	0.69	0.59

Panel C: FF5F

Small	0.71	0.55	0.55	0.73
2	0.83	0.78	0.71	0.73
3	0.66	0.73	0.71	0.65
Big	0.74	0.68	0.70	0.71

Table 18 Regression results (intercepts, factor slopes, and their t-statistics) of CAPM, FF3F, and FF5F for 16 VW Size-Inv portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups, Small to Big, and four Inv groups, Conservative (Cons.) to Aggressive (Aggr.). The breakpoints are sample quartiles of size and Inv. The intersection of these two sorts will generate 16 VW Size-Inv portfolios. *Italic*, ***Bold-Italic***, and **Bold** font styles represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Inv	Cons	2	3	Aggr	Cons	2	3	Aggr
Panel A: CAPM								
		a				*t(a)*		
Small	0.005	0.007	0.005	0.002	0.86	1.18	0.79	0.37
2	-0.001	0.002	0.001	-0.001	-0.22	0.30	0.11	-0.13
3	-0.001	-0.003	-0.002	-0.004	-0.17	-0.74	-0.38	-0.77
Big	-0.006	0.001	-0.001	0.003	-1.28	0.32	-0.36	0.91
		b				*t(b)*		
Small	**0.78**	**0.63**	**0.67**	**1.12**	6.65	5.26	5.18	8.45
2	**1.07**	**0.88**	**0.93**	**1.01**	9.90	7.87	8.32	8.67
3	**0.87**	**0.97**	**1.01**	**1.10**	9.41	10.57	10.16	10.74
Big	**1.08**	**1.13**	**1.12**	**0.85**	12.37	13.49	15.01	11.39
Panel B: FF3F								
		a				*t(a)*		
Small	0.003	0.006	0.003	0.000	0.83	1.27	0.67	0.09
2	-0.003	0.000	-0.001	-0.003	-0.97	-0.13	-0.22	-0.60
3	-0.001	-0.005	-0.003	-0.005	-0.38	-1.34	-0.79	-1.06
Big	-0.005	0.002	-0.001	0.004	-1.27	0.44	-0.26	1.09
		b				*t(b)*		
Small	**0.82**	**0.62**	**0.72**	**1.17**	9.73	6.41	6.84	11.52
2	**1.11**	**0.98**	**0.93**	**1.06**	16.34	13.28	11.11	11.77
3	**0.80**	**0.98**	**1.00**	**1.05**	10.01	13.19	12.18	11.14
Big	**0.91**	**1.01**	**1.08**	**0.82**	10.96	11.90	13.46	10.50
		s				*t(s)*		
Small	**0.86**	**0.68**	**0.87**	**0.94**	8.43	5.82	6.75	7.60
2	**0.87**	**0.99**	**0.72**	**0.83**	10.50	11.02	7.02	7.59
3	**0.30**	**0.56**	**0.55**	**0.35**	3.11	6.20	5.49	3.07
Big	***-0.26***	-0.15	*-0.17*	***-0.25***	-2.60	-1.49	-1.73	-2.61
		h				*t(h)*		
Small	**0.40**	**0.48**	**0.35**	**0.41**	4.47	4.63	3.06	3.79
2	**0.39**	**0.24**	**0.45**	**0.35**	5.38	3.06	5.05	3.62
3	**0.49**	**0.33**	**0.39**	**0.43**	5.70	4.21	4.44	4.27

Big	**0.48**	**0.35**	0.04	-0.04	5.41	3.81	0.47	-0.52

Panel C: FF5F

	a				*t(a)*			
Small	0.006	0.005	0.001	-0.001	1.54	1.05	0.11	-0.27
2	-0.001	0.002	0.000	-0.001	-0.37	0.45	0.06	-0.15
3	0.000	-0.004	-0.004	-0.005	0.06	-1.18	-0.88	-0.97
Big	-0.002	0.003	-0.002	0.005	-0.62	0.75	-0.41	1.50
	b				*t(b)*			
Small	**0.81**	**0.62**	**0.73**	**1.17**	9.99	6.38	6.99	12.06
2	**1.10**	**0.97**	**0.92**	**1.05**	16.35	13.38	11.01	11.99
3	**0.79**	**0.98**	**1.00**	**1.05**	9.89	13.02	12.07	11.00
Big	**0.91**	**1.01**	**1.08**	**0.81**	11.96	11.81	13.66	12.19
	s				*t(s)*			
Small	**0.83**	**0.69**	**0.90**	**0.97**	8.40	5.77	7.01	8.13
2	**0.85**	**0.97**	**0.71**	**0.82**	10.31	10.89	6.91	7.69
3	**0.29**	**0.56**	**0.55**	**0.35**	2.94	6.06	5.46	3.00
Big	**-0.30**	-0.17	*-0.17*	**-0.24**	-3.19	-1.62	-1.73	-3.02
	h				*t(h)*			
Small	0.11	**0.53**	**0.62**	**0.65**	0.76	3.17	3.44	3.92
2	*0.22*	0.03	**0.38**	*0.25*	1.87	0.28	2.67	1.66
3	***0.35***	***0.30***	**0.45**	***0.42***	2.52	2.37	3.14	2.53
Big	0.17	0.21	0.05	0.00	1.27	1.41	0.35	-0.02
	r				*t(r)*			
Small	*-0.29*	0.09	0.28	0.10	-1.88	0.50	1.44	0.54
2	-0.21	-0.22	-0.17	*-0.31*	-1.65	-1.59	-1.09	-1.90
3	-0.20	-0.03	0.05	-0.01	-1.36	-0.21	0.35	-0.06
Big	-0.21	-0.14	0.13	***-0.26***	-1.45	-0.90	0.88	-2.10
	c				*t(c)*			
Small	***0.43***	0.03	-0.34	**-0.67**	2.58	0.16	-1.58	-3.41
2	0.15	*0.25*	-0.16	***-0.39***	1.10	1.71	-0.94	-2.19
3	0.03	0.04	-0.08	0.04	0.21	0.28	-0.47	0.18
Big	**0.70**	0.18	*0.30*	**-0.81**	4.54	1.02	1.83	-6.00

5.4.5 Size – SO Portfolios

As previously discussed, the most troublesome portfolio set is 12 VW Size-SO portfolios as all three models fare worst in these portfolios when judged on either GRS statistic or average absolute value of intercepts. For instance, GRS test rejects all models except CAPM at 5% significance level. Furthermore, the average absolute values of intercepts in this test portfolio set are higher than those in other sets. This finding suggests that CAPM, the three-factor model, and the five-factor model have trouble explaining average returns of portfolios formed from size and state capital. **Table 19** and **Table 20** present adjusted R^2s and regression results (intercepts, factor slopes, and their t-statistics), respectively, of each model for 12 VW Size-SO test portfolios.

Specifically, these three models on average fare poorly in stocks with low state capital as average adjusted R^2 for this group is the lowest across state-ownership groups. The root cause lies in stocks from the largest quartile with low state capital. The regression intercept for this portfolio is statistically (at 5% significance level) and economically (about 1% per month) significant for all three models. Implied from the factor slopes, this portfolio is dominated by big stocks whose returns behave like those of profitable firms that invest aggressively. On the other hand, judged on average adjusted R^2, the models have the best performance in stocks of private companies among 12 VW Size-SO portfolios.

For reference, Nguyen et al. (2015) find that the CAPM, the three-factor model, and the five-factor model fail to capture the average returns of Vietnamese equitized SOEs over the sample period. However, these authors have a different way of forming SO test portfolios from ours in that they sort the stocks into only two groups (SOE and non-SOE), which themselves become the two test portfolios. This empirical test, on the other hand, sorts the stocks into three SO groups (Private, Low, and High) and constructs 12 VW Size-SO test portfolios from 4x3 sort on size and state-ownership status. By doing this way, our empirical test has created more test portfolios, providing perspectives of variation across size and state-ownership groups as well as enabling more meaningful GRS tests. In general, our finding is somewhat consistent with Nguyen et al (ibid.) as the models also fare poorly in stocks of equitized SOEs. Nevertheless, this empirical test has taken one step further to specifically point out the lethal portfolio for all tested models except CAPM contains large stocks of firms with low state capital.

Apart from abovementioned observations, 12 Size-SO portfolios also exhibit somewhat similar results as other portfolio sets. For example, adjusted R^2 of CAPM also increases from small to big stocks and the three-factor model shows larger improvement from CAPM for smaller stocks than for bigger ones. Moreover, the five-factor model shows minor improvement or even deterioration in adjusted R^2 from the three-factor as RMW and CMA slopes are mostly not statistically indistinguishable from zero. Finally, multivariate regression slopes do not line up with univariate characteristics since there is no clear pattern in HML, RMW, and CMA slopes across size and state-ownership groups.

Table 19 Adjusted R^2 of CAPM, FF3F, and FF5F for 12 VW Size-SO portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and three SO groups (Private, Low, and High). The size breakpoints are sample quartiles while SO breakpoints are based on the percentage of charter capital that the state owns. Stocks of companies that have no state capital are assigned to group Private. Stocks of companies that have no more than 50% state capital are assigned to group Low. Stocks of companies that have greater than 50% state capital are assigned to group High. The intersection of these two sorts will generate 12 VW Size-SO portfolios.

Panel A: CAPM

	Private	Low	High
Small	0.31	0.36	0.18
2	0.45	0.46	0.44
3	0.56	0.43	0.50
Big	0.67	0.49	0.70

Panel B: FF3F

Small	0.79	0.66	0.57
2	0.85	0.74	0.77
3	0.78	0.58	0.65
Big	0.69	0.52	0.72

Panel C: FF5F

Small	0.79	0.66	0.59
2	0.85	0.74	0.77
3	0.78	0.57	0.65
Big	0.72	0.52	0.72

Table 20 Regression results (intercepts, factor slopes, and their t-statistics) of CAPM, FF3F, and FF5F for 12 VW Size-SO portfolios; July 2009 - December 2017, 102 months.

In June each year after rebalancing the sample, stocks are independently sorted into four size groups (Small to Big) and three SO groups (Private, Low, and High). The size breakpoints are sample quartiles while SO breakpoints are based on the percentage of charter capital that the state owns. Stocks of companies that have no state capital are assigned to group Private. Stocks of companies that have no more than 50% state capital are assigned to group Low. Stocks of companies that have greater than 50% state capital are assigned to group High. The intersection of these two sorts will generate 12 VW Size-SO portfolios. *Italic*, ***Bold-Italic***, and **Bold** font styles represent statistical significance at the 10%, 5%, and 1% levels, respectively.

SO	Private	Low	High	Private	Low	High
Panel A: CAPM						
		a			*t(a)*	
Small	0.008	0.000	0.001	1.21	0.01	0.16
2	0.002	-0.004	-0.002	0.29	-0.76	-0.33
3	-0.003	0.000	-0.004	-0.70	0.08	-0.78
Big	0.002	***0.011***	*-0.007*	0.49	2.52	-1.72
		b			*t(b)*	
Small	**0.84**	**0.72**	**0.59**	6.86	7.63	4.87
2	**1.01**	**0.96**	**0.79**	9.22	9.40	8.93
3	**1.00**	**0.88**	**1.00**	11.34	8.85	10.10
Big	**1.01**	**0.85**	**1.18**	14.23	9.88	15.34
Panel B: FF3F						
		a			*t(a)*	
Small	0.006	-0.002	-0.001	1.61	-0.46	-0.19
2	0.000	-0.006	-0.003	-0.10	-1.59	-1.03
3	-0.004	0.000	-0.005	-1.26	-0.09	-1.20
Big	0.002	**0.012**	-0.006	0.62	2.70	-1.62
		b			*t(b)*	
Small	**0.85**	**0.81**	**0.64**	11.56	10.85	6.65
2	**1.04**	**1.05**	**0.83**	16.50	13.59	13.53
3	**0.95**	**0.85**	**1.02**	14.07	9.17	11.40
Big	**0.93**	**0.84**	**1.14**	12.46	9.30	14.24
		s			*t(s)*	
Small	**0.92**	**0.75**	**0.84**	10.28	8.28	7.20
2	**0.89**	**0.83**	**0.69**	11.54	8.82	9.23
3	**0.42**	**0.38**	**0.53**	5.09	3.39	4.90
Big	*-0.17*	***-0.22***	**-0.29**	-1.87	-1.99	-3.01
		h			*t(h)*	

Small	**0.56**	*0.15*	**0.37**	7.08	1.82	3.58
2	**0.45**	***0.19***	**0.28**	6.71	2.28	4.30
3	**0.48**	**0.35**	**0.27**	6.64	3.52	2.87
Big	**0.21**	-0.11	-0.02	2.68	-1.18	-0.24

Panel C: FF5F

	a			*t(a)*		
Small	0.005	-0.001	0.003	1.27	-0.26	0.58
2	0.002	-0.004	-0.002	0.56	-1.11	-0.71
3	-0.004	0.001	-0.005	-1.03	0.12	-1.14
Big	0.004	***0.009***	-0.006	1.16	2.02	-1.44
	b			*t(b)*		
Small	**0.85**	**0.81**	**0.62**	11.57	10.82	6.61
2	**1.03**	**1.05**	**0.82**	16.62	13.46	13.38
3	**0.95**	**0.84**	**1.02**	13.93	9.04	11.27
Big	**0.92**	**0.85**	**1.14**	12.96	9.47	14.11
	s			*t(s)*		
Small	**0.93**	**0.74**	**0.81**	10.35	8.13	7.02
2	**0.87**	**0.82**	**0.68**	11.47	8.63	9.06
3	**0.41**	**0.38**	**0.53**	4.95	3.29	4.84
Big	***-0.18***	*-0.20*	**-0.30**	-2.09	-1.79	-3.02
	h			*t(h)*		
Small	**0.67**	0.06	0.07	5.28	0.49	0.40
2	**0.30**	0.07	***0.23***	2.81	0.52	2.14
3	**0.42**	*0.28*	*0.29*	3.62	1.77	1.89
Big	0.12	0.10	-0.07	0.98	0.66	-0.49
	r			*t(r)*		
Small	0.09	-0.04	***-0.43***	0.63	-0.31	-2.45
2	***-0.27***	-0.20	-0.12	-2.33	-1.38	-1.02
3	-0.05	-0.14	-0.02	-0.36	-0.80	-0.14
Big	***-0.31***	*0.30*	-0.02	-2.32	1.80	-0.15
	c			*t(c)*		
Small	-0.20	0.21	0.08	-1.34	1.39	0.44
2	-0.08	-0.04	-0.08	-0.63	-0.25	-0.62
3	0.11	-0.09	-0.13	0.76	-0.50	-0.70
Big	**-0.40**	-0.07	0.13	-2.79	-0.38	0.77

5.5 Factor Spanning Test Results

Table 21 shows the results from regressing each of the five factor return on the other four. As expected from the highly negative correlation coefficient, both HML and RMW slopes in RMW and HML regression respectively are negative and statistically significant (t-stat = -10.16). These two factor regressions also show relatively high adjusted R^2. Besides RMW, average HML return is also captured by CMA as CMA slope in HML regression is statistically different from zero. However, the intercept from HML regression is still statistically (t-stat = 2.24) and economically (1% a month) significant, similar to the intercept from RMW regression. On the other hand, average CMA return is fully captured by its exposure to other factors, especially HML (t-stat = 3.42), since CMA regression intercept is indistinguishable from zero.

As for the market excess return and SMB regressions, their adjusted R^2s are relatively low, approximately 12%. Nevertheless, the intercepts from both regressions are not statistically different from zero. SMB slope in market excess return regression is statistically significant as market excess return slope in SMB regression, both with t-stat around 0.88-0.89.

Table 21 Factor Test Results

Using four factors in regressions to explain average returns on the fifth: July 2009 - December 2017, 102 months.

Rm-Rf is the value-weighted return on the market portfolio of all sample stocks minus Vietnam 1-year government bond yield converted to monthly basis; SMB (small-minus-big) is the size factor; HML (high-minus-low) is the value factor; RMW (robust-minus-weak) is the profitability factor; and CMA (conservative-minus-aggressive) is the investment factor. All the factors are constructed from independent sorts of stocks into two Size groups and three B/M groups, three OP groups, or three Inv groups.

	Int	$\mathbf{R_M - R_F}$	**SMB**	**HML**	**RMW**	**CMA**	$\mathbf{Adj. R^2}$
$\mathbf{R_M - R_F}$							
Coefficient	0.004		-0.36	0.28	-0.13	-0.02	0.12
t-Statistic	0.88		-2.99	1.61	-0.67	-0.07	
SMB							
Coefficient	0.004	-0.24		0.16	-0.16	0.08	0.12
t-Statistic	0.89	-2.99		1.10	-1.06	0.46	
HML							
Coefficient	0.01	0.09	0.08		-0.78	0.39	0.66
t-Statistic	2.24	1.61	1.10		-10.16	3.42	

RMW							
Coefficient	0.01	-0.04	-0.07	-0.66		0.03	0.61
t-Statistic	3.12	-0.67	-1.06	-10.16		0.25	
CMA							
Coefficient	0.002	0.00	0.03	0.28	0.02		0.20
t-Statistic	-0.66	-0.07	0.46	3.42	0.25		

In the spirit of Huberman and Kandel (1987), the factor spanning tests suggest that adding HML will improve the mean-variance-efficient tangency portfolio by combining the risk-free asset, the market portfolio, SMB, RMW, and CMA. That is, HML is not a redundant factor as Fama and French (2015) find in US data for 1963–2013. This finding is consistent with that from Nguyen et al. (2015) and many other empirical tests in different markets discussed in Section 2.5.3. In this empirical test, adding HML to a two-factor model that includes market excess return and SMB will improve the average adjusted R^2 by approximately 7%.

If a factor must be chosen as the redundant one, CMA appears to be the most promising candidate. Firstly, the intercept from CMA regression is not distinguishable from zero as average CMA return is fully absorbed by its exposure to other factors, especially HML. Secondly, the majority of CMA slopes in the five-factor regressions are not statistically significant. Thirdly, the five-factor model shows minuscule improvement or even deterioration in the description of average returns (assessed by average adjusted R^2) from the five-factor model that drops CMA (**Table 12**). The redundancy of CMA is similar to the findings of Guo et al. (2017) in Chinese market during 1995 -2014 and those of Fama and French (2017) in Europe, Japan, and Asia Pacific during 1990 -2015.

Another potential candidate is RMW. Although the intercept from RMW regression is statistically significant at 1% significance level, average RMW return is largely explained by its exposure to HML, mainly due to the highly negative correlation between these two factors of –0.79. When not simultaneously included in a model, HML and RMW do equally well in enhancing the description of average returns. Specifically, a three-factor model that replaces HML with RMW produces almost the same average adjusted R^2 of approximately 69.4%. However, when both HML and RMW are incorporated, the majority of HML slopes are statistically significant while most RMW slopes are not. Furthermore, the five-factor model also exhibits paltry improvement (assessed by average adjusted R^2) from the five-factor model that drops RMW.

The remaining two factors, market excess return and SMB, do a plausible job in improving the description of average returns. Excess market return on its own captures 45.6% of variation in stock returns on average and SMB improves this statistic by 17.2% to 62.8% when incorporated. In brief, the findings from both asset pricing tests and factor spanning tests suggest that the value factor, HML, does not become redundant when profitability, RMW, and investment, CMA, factors are added into the model. Instead, RMW and CMA factor returns are largely absorbed by their exposure to HML. However, it is important to note that factor spanning inferences should be taken with caution since they tend to be sample specific (Fama and French, 2017).

6 CONCLUSION

6.1 Main Findings

There are weak patterns in average returns related to Size, B/M, profitability, investment, and state ownership in that they are not smooth or not evident. Likewise, other than RMW, all FF factors constructed in this empirical test demonstrate weaker or even reverse behavior compared to what Fama and French (2015) expect. For example, we document negative cumulative return of CMA throughout the test period from June 2009 to December 2017, which means stocks of companies that invest aggressively tend to outperform those with conservative investment level. **Table 22** summarizes the expectation and empirical results of the patterns in average returns.

Table 22 Patterns in Average Returns: Expectation and Empirical Result

Pattern in average returns	Expectation	Empirical Result
Size effect	Average return decreases with Size	Average returns do not usually decrease with size. However, smallest stocks almost always earn the highest average returns.
Value effect	Average return increases with B/M	No clear pattern
Profitability effect	Average return increases with OP	Weak OP tends to have lower average returns than Robust OP. However, the effect is not smooth
Investment effect	Average return decreases with Inv	No clear pattern. Reversal happens in some instances
State-ownership effect		• For small stocks (1st & 2nd size quartile), stocks of private companies earn the highest average returns • For big stocks (3rd & 4th size quartile), stocks of low-state-capital companies earn the highest average returns • Stocks of high-state-capital companies have relatively low average return across all size quartiles.

Regarding asset pricing tests, the GRS test fails to reject all models except in 12 VW Size-SO portfolios. This finding is in contradiction to the result from Fama and French (2015) but consistent with that from Nguyen et al. (2015). Judged on either GRS statistics or average absolute values of intercepts, all models fare worst in these 12 VW Size-SO portfolios, suggesting that our asset pricing models have trouble explaining average returns of portfolios formed from size and state-ownership status. Indeed, we can conclude that the lethal portfolio for all tested models except CAPM contains large stocks of firms with low state capital (more than 0 and less than 50% of charter capital). Particularly, the regression intercept for this portfolio is statistically (at 5% significance level) and economically (about 1% per month) significant for all three models. The average adjusted R^2s of the CAPM, the three-factor model, and the five-factor model are respectively 45.6%, 69.8%, and 70.6%.

Regarding factor redundancy issue, HML is not a redundant factor in this empirical test. Instead, RMW and CMA appear to be the potential candidates. Firstly, both RMW and CMA slopes in the five-factor regressions are mainly not statistically significant as their average returns are either largely or fully captured by exposure to other factors, especially HML. Secondly, the five-factor model shows paltry improvement or even deterioration (assessed by average adjusted R^2) from the five-factor model that drops RMW or CMA. In the case of RMW, a possible explanation lies in the highly negative correlation between it and HML. When not simultaneously included in a model, HML and RMW do equally well in enhancing the description of average returns. Specifically, a three-factor model that replaces HML with RMW produces almost the same average adjusted R^2 of approximately 69.4%. Nevertheless, when both HML and RMW are incorporated, the majority of HML slopes are statistically significant while most RMW slopes are not.

In terms of relative model performance, this empirical test provides a cautious support for the superiority of the five-factor model over the CAPM and the three-factor model after examining their average adjusted R^2s, GRS statistics, and average absolute values of intercepts. Specifically, the five-factor model produces the highest average adjusted R^2, lowest GRS statistics in two out of four portfolio sets, and lowest average absolute values of intercepts except in Size-SO set. It is important to view the superiority of the five-factor model with caution since differences in performance between it and the three-factor model are hardly noticeable in many cases. **Table 23** presents the hypotheses and their respective findings.

Table 23 Hypotheses and Findings

Hypotheses	Findings
H1a: *The intercepts from CAPM regressions are jointly indistinguishable from zero.* ***H1b:*** *The intercepts from Fama-French three-factor regressions are jointly indistinguishable from zero.* ***H1c:*** *The intercepts from Fama-French five-factor regressions are jointly indistinguishable from zero.*	• GRS test fails to reject the null hypothesis that the intercepts are jointly indistinguishable from zero for the CAPM, the three-factor model, and the five-factor model, except in 12 VW Size-SO portfolios. • The average adjusted R^2s of the CAPM, the three-factor model, and the five-factor model are respectively 45.6%, 69.8%, and 70.6%.
H2a: *There is no difference in explanatory power of CAPM between stocks of private companies and those with state capital.* ***H2b:*** *There is no difference in explanatory power of Fama-French three-factor model between stocks of private companies and those with state capital.* ***H2c:*** *There is no difference in explanatory power of Fama-French five-factor model between stocks of private companies and those with state capital.*	• GRS test easily rejects all models except CAPM in 12 VW Size-SO portfolios at 5% significance level. • Judged on either GRS statistics or average absolute values of intercepts, all models fare worst in 12 VW Size-SO portfolios. • Judged on average adjusted R^2, the models have the best performance on stocks of private companies among 12 VW Size-SO portfolios. • The lethal portfolio for all tested models except CAPM contains large stocks of firms with low state capital.
H3: *No factor among the five-factor model is fully explained by any of the other four.*	HML is not a redundant factor in this empirical test. Instead, RMW and CMA are the potential candidates because of the following reasons: • RMW/CMA slopes in the five-factor regressions are mostly not statistically significant. • Average RMW/CMA return is largely absorbed by its exposure to HML. • The five-factor model shows paltry improvement or even deterioration in the description of average returns (assessed by average adjusted R^2) from the five-factor model that drops RMW/CMA.

6.2 Limitation and Suggestion for Further Research

Like any other studies, this thesis inevitably has its own limitations. Firstly, although the period of 102 months is considered relatively long when compared with other empirical tests in Vietnam so far, it falls short when compared with other tests in markets around the world. For instance, Fama and French (2015), Foye (2017), Huynh (2017), and Guo et al. (2017) respectively cover 606 months, 324 months, 276 months, and 240 months for markets in the US, the UK, Australia, and China. Therefore, our test period of 102 months is considered relatively short when assessed by the typical duration of FF empirical tests, raising concerns about the statistical power and reliability of the test. Nevertheless, this issue is difficult to avoid since Vietnam's stock market is currently a fledgling market with small size and young age. As such, a longer period will enhance the test in terms of statistical power but it can cause other problems such as data scarcity and undiversified test portfolios given the primitive stage of the market in earlier years. This problem will be gradually lessened by further research in the future when the market becomes more mature. Moreover, it would be interesting to extend the test to cover the Carhart four-factor model or a six-factor model that adds the momentum factor as it is a well-documented anomaly in various markets.

Secondly, our robustness analysis only includes test portfolios formed from size and state-ownership status. Hence, it is unclear whether the models fall short due to some special characteristics of equitized SOEs or any other way of forming the test portfolios rather than the same variables used to construct the risk factors will lead to the same result. More extensive robustness tests of factor models in Vietnam are needed to validate our conclusion. For example, further research can examine how the models perform when test portfolios are anomalies not explicitly targeted by design or when the risk factors are constructed differently from the original approach.

Thirdly, our way of classifying state-ownership groups has some flaws. As mentioned earlier, state-ownership status will be assigned into three groups based on the percentage of charter capital that the state owns. Since ownership data on VNDirect only reflect the current situation, current state-ownership status is used as a proxy for historical status. That is, if a company has state capital in 2017, it will also have state capital in the past. This argument is reasonable as we are safe to assume that the government only divests itself of state holdings. However, the percentage of charter capital owned by the state can change during the test period and directly affect which group the stocks will be assigned. For instance, Company A currently has 45% state capital in 2017 and is assigned to group "Low" based on the breakpoint table (**Table 5**).

However, in 2015, Company A had 52% state capital, meaning the state has divested 7% since 2015. As such, Company A should be assigned to group “High” in 2015 but as we do not have adequate data, it is still in group “Low” in 2015. Likewise, there are possibilities that some firms currently assigned to group “Private” were state-owned in the past. Although we will not be able to identify all these cases due to lack of data, there are not many of them since equitization process has remained slow and problematic.

6.3 Concluding Remarks

This empirical test provides cautious support for the superiority of the five-factor model over the CAPM and the three-factor model. Still, the five-factor model cannot fully explain average returns in Vietnam’s stock market since it fails when test portfolios are formed from state capital, which is not explicitly targeted by design. With updated data, the five-factor model can explain 70.6% of variation in stock returns, which is lower than the average adjusted R^2 levels of previous studies in Vietnam’s stock market (e.g.: 81%-85% for the three-factor model) and other markets. Besides, there exists a multicollinearity issue, reflected in the highly negative correlation between HML and RMW of – 0.79. Hence, further research is essential to verify these findings and to provide more extensive robustness analyses.

Does the five-factor model have any useful application in Vietnam’s stock market? Despite its shortfalls, the answer is yes. Less-than-perfect models can provide meaningful descriptions of average returns since creating an impeccable model is impossible (Fama and French, 2017). Factor models are often used as a tool for portfolio performance evaluation, portfolio design, and cost-of-equity estimation. Regarding the first use where abnormal returns (measured by alphas) are the sole interest, this empirical test suggests that the three-factor model will fare better than the CAPM and as well as the five-factor model due to the potential redundancy of RMW and CMA. Nevertheless, if one also cares about portfolio tilts toward size, value, profitability, and investment premiums, the five-factor model should be selected as it can provide more useful information via its factor slopes. With respect to the third use, the ability of the five-factor model to estimate the cost of equity is full of doubt as it is the case for other factor models (ibid.). The reason for this argument is that standard errors of factor premium estimates are usually substantial, let alone their time variation characteristic. On the other hand, evaluating portfolio performance can evade part of these problems since this task does not require the estimates of expected factor premiums.

After all, the Fama-French five-factor model is an empirical asset pricing model, originally created to capture well-documented anomalies in the US stock market. Therefore, some adjustments or even replacements in factor construction might be necessary for it to be more applicable in Vietnam's stock market. The findings from this empirical test suggest a quest for a better asset pricing model for pricing Vietnamese equities.

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8 APPENDICES

Appendix A

List of Illustrative Figures for the Literature Review

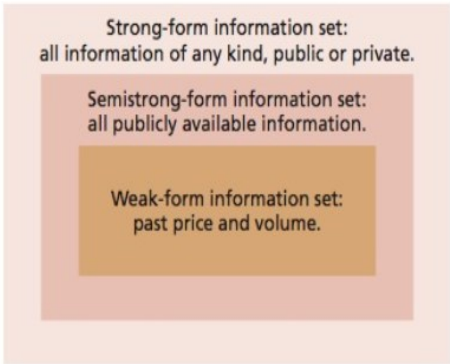


Figure A1 Different forms of Efficient Market (Adapted from: Miller, Dolvin, and Jordan, 2011)

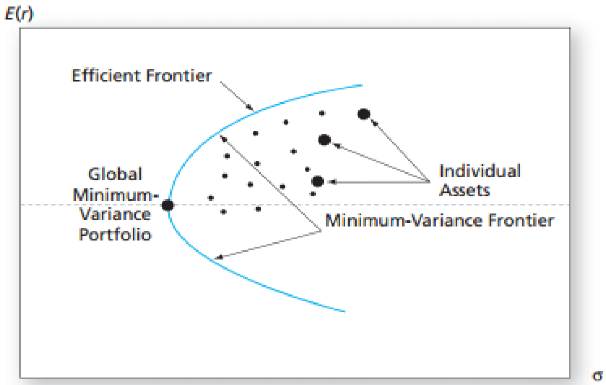


Figure A2 Markowitz's Efficient Frontier (Adapted from: Bodie et al., 2014)

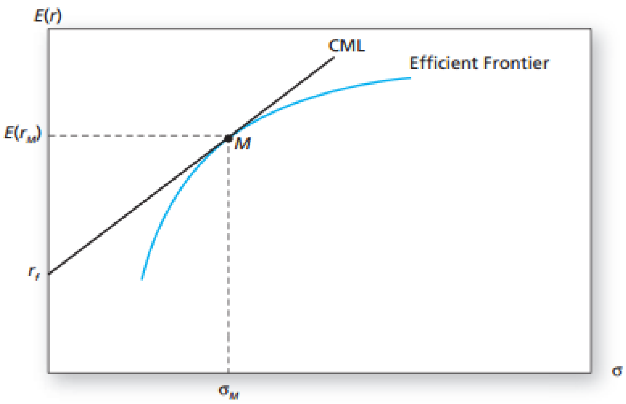
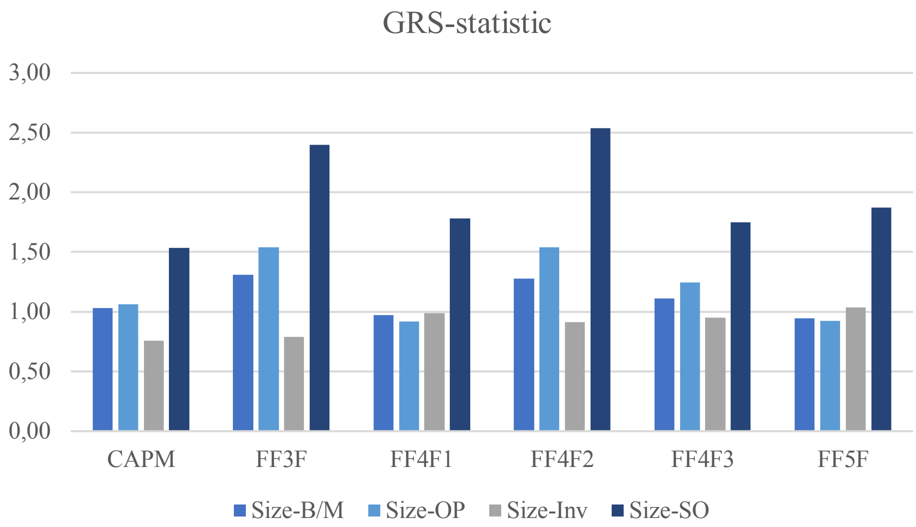
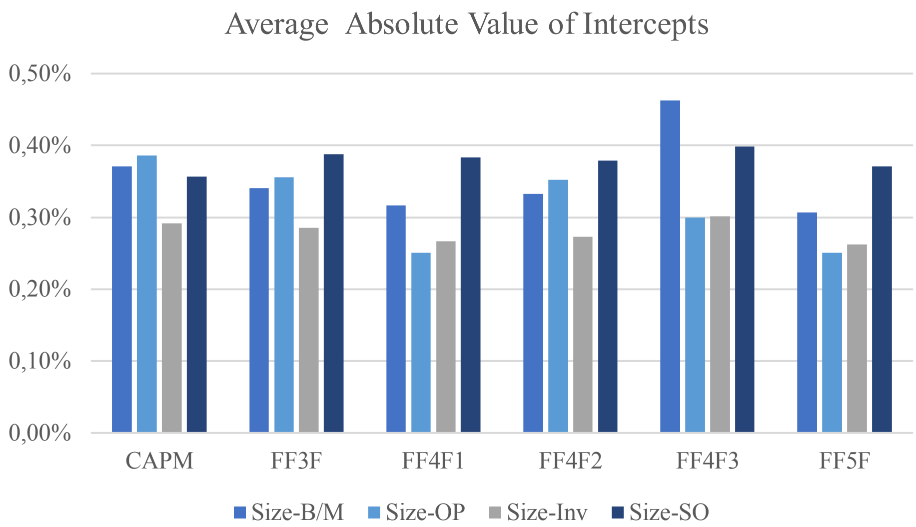


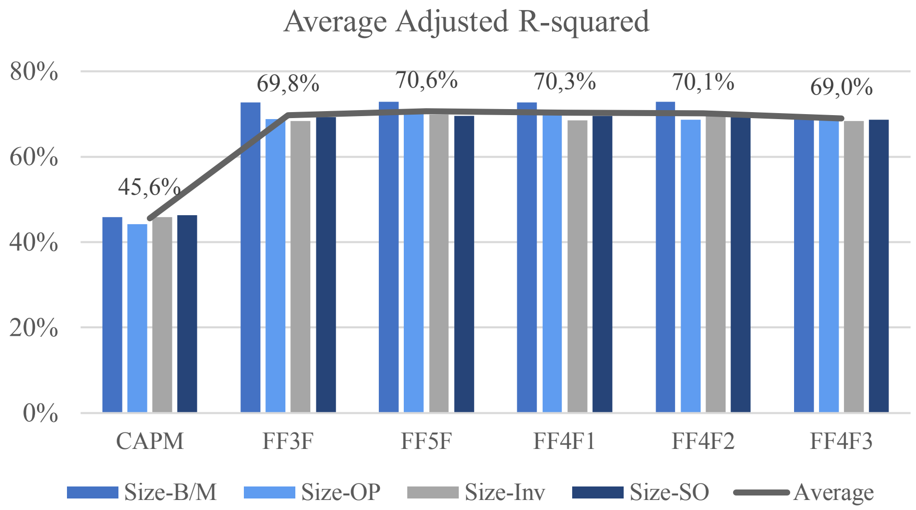
Figure A3 Capital Market Line and Efficient Frontier (Adapted from: Bodie et al., 2014)

Appendix B

Asset Pricing Test Overview

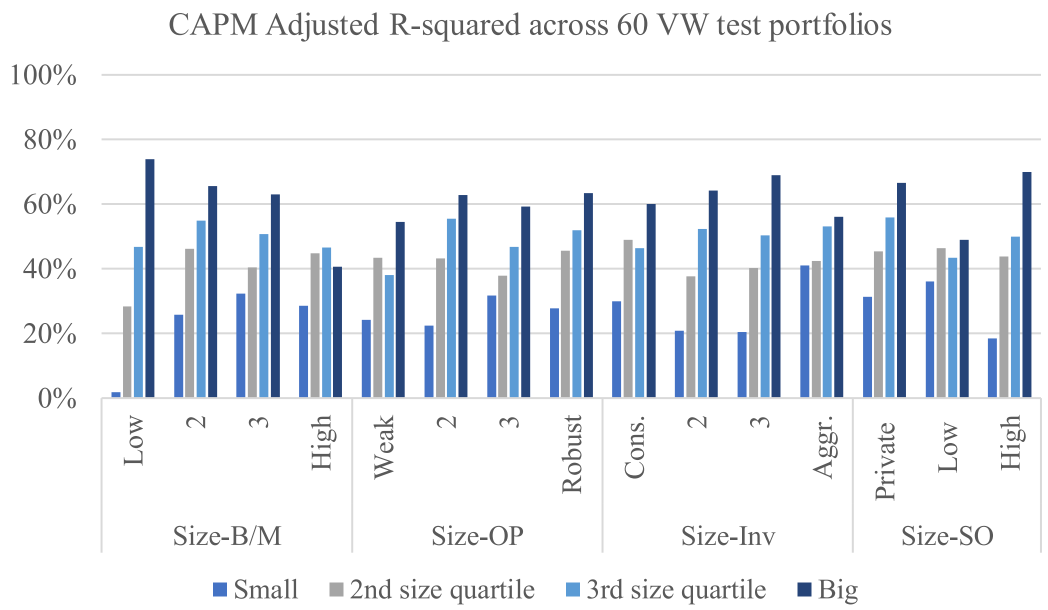


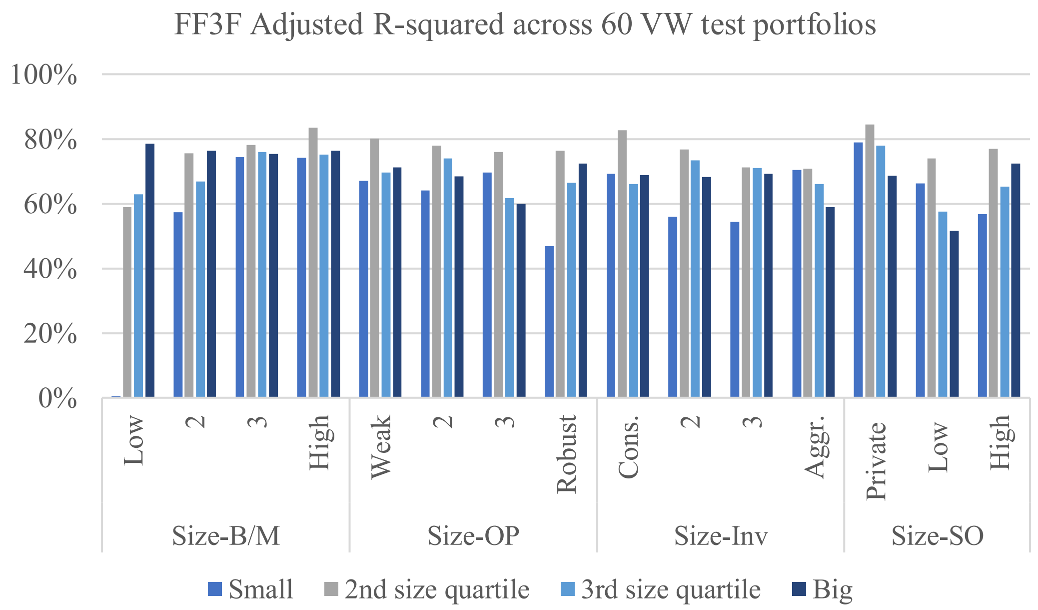


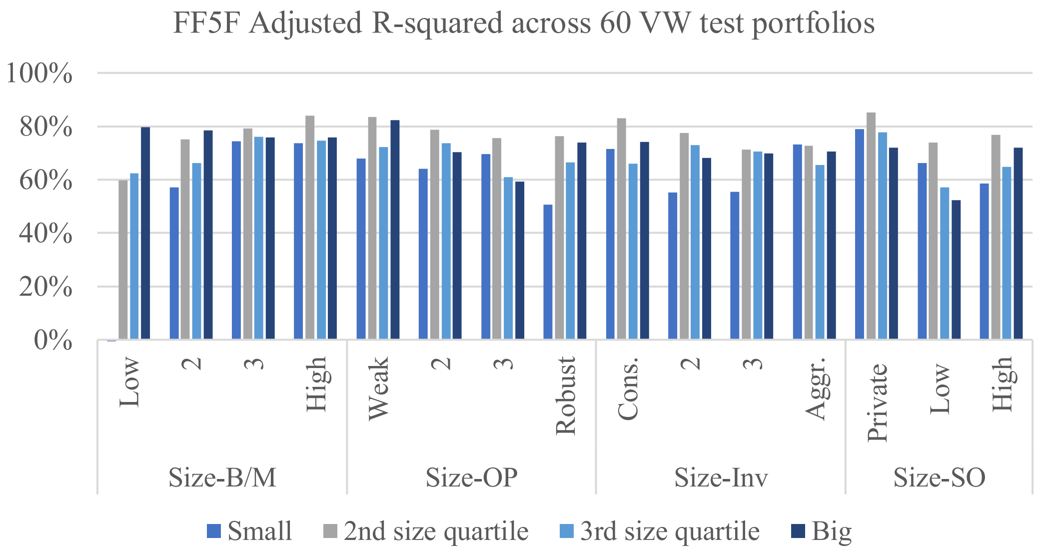

Average Adjusted R-squared
80%
60%
40%
20%
0%
45,6%
69,8%
70,6%
70,3%
70,1%
69,0%
CAPM
FF3F
FF5F
FF4F1
FF4F2
FF4F3
Size-B/M
Size-OP
Size-Inv
Size-SO
Average

Appendix C

Adjusted R-squared across three asset pricing models (CAPM, FF three-factor, FF five-factor) and 60 VW test portfolios






FF5F Adjusted R-squared across 60 VW test portfolios
100%
80%
60%
40%
20%
0%
Low
2
3
High
Weak
2
3
Robust
Cons.
2
3
Aggr.
Private
Low
High
Size-B/M
Size-OP
Size-Inv
Size-SO
Small
2nd size quartile
3rd size quartile
Big