ค่าพารามิเตอร์ของตัวแบบการตั้งราคาหลักทรัพย์และปัญหาการซื้อขายเบาบางในตลาดเกิดใหม่

นางสาวนันทิพา สินทวีวัฒน์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการเงิน ภาควิชาการธนาคารและการเงิน
คณะพาณิชยศาสตร์และการบัญชี จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2549

ISBN 974-14-2755-7

ASSET PRICING MODEL PARAMETERS AND INFREQUENT TRADING IN AN EMERGING MARKET

Miss Nuntipa Sintaweewat

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Finance
Department of Banking and Finance
Faculty of Commerce and Accountancy
Chulalongkorn University
Academic Year 2006
ISBN 974-14-2755-7

Thesis Title	ASSET PRICING MODEL PARAMETERS AND INFREQUENT TRADING IN AN EMERGING MARKET
By	Miss Nuntipa Sintaweewat
Field of Study	Finance
Thesis Advisor	Manapol Ekkayokkaya, Ph.D.

Accepted by the Faculty of Commerce and Accountancy, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

.... Dean of the Faculty of Commerce and Accountancy
(Associate Professor Danuja Kunpanitchakit, Ph.D.)

THESIS COMMITTEE

.... Chairman
(Anant Chiarawongse, Ph.D.)

.... Thesis Advisor
(Manapol Ekkayokkaya, Ph.D.)

.... Committee
(Ruttachai Seelajareon, Ph.D.)

นันทิพา สินทวีวัฒน์: ค่าพารามิเตอร์ของตัวแบบการตั้งราคาหลักทรัพย์และปัญหาการซื้อขายเบาบางในตลาดเกิดใหม่. (ASSET PRICING MODEL PARAMETERS AND INFREQUENT TRADING IN AN EMERGING MARKET)
อ.ที่ปรึกษา: อ.ดร.มนพล เอกโยคยะ, 91 หน้า. ISBN 974-14-2755-7.

การศึกษาเชิงประจักษ์โดยตรงเรื่องความสัมพันธ์ระหว่างค่าพารามิเตอร์ของตัวแบบการตั้งราคาหลักทรัพย์และปัญหาการซื้อขายเบาบางในตลาดเกิดใหม่ยังมีไม่มากนัก วิทยานิพนธ์ฉบับนี้แสดงผลการศึกษาเชิงประจักษ์ถึงผลกระทบของปัญหาการซื้อขายเบาบางที่มีต่อค่าพารามิเตอร์ของตัวแบบการตั้งราคาหลักทรัพย์ในประเทศไทย ข้อมูลของประเทศสิงคโปร์ถูกนำมาใช้เพื่อแสดงเปรียบเทียบ ผลการศึกษาพบว่า ค่าแอลฟ่าที่ยังมิได้ปรับผลกระทบของปัญหาการซื้อขายเบาบาง (unadjusted alphas) มีค่าสูงกว่าความเป็นจริงและค่าเบต้าที่ยังมิได้ปรับผลกระทบ (unadjusted betas) มีค่าต่ำกว่าความเป็นจริงทั้งในตลาดไทยและสิงคโปร์ และถึงแม้ว่าผลต่างระหว่างค่าแอลฟ่าและเบต้าที่ยังมิได้ปรับผลกระทบ (unadjusted alphas และ unadjusted betas) กับค่าแอลฟ่าและเบต้าที่ปรับผลกระทบแล้ว (adjusted alphas และ adjusted betas) ไม่มีนัยสำคัญทางสถิติ แต่ผลต่างระหว่างค่าแอลฟ่าที่ยังมิได้ปรับผลกระทบ (unadjusted alphas) กับค่าแอลฟ่าที่ปรับผลกระทบแล้ว (adjusted alphas) มีนัยสำคัญทางเศรษฐศาสตร์ นอกจากนี้ภายหลังการปรับผลกระทบของปัญหาการซื้อขายเบาบาง ปัญหาสหสัมพันธ์ (serial correlation) ของผลตอบแทนจากพอร์ตการลงทุนยังลดลงอีกด้วย ผลการศึกษาแสดงให้เห็นว่ามันคุ้มค่าที่จะปรับผลกระทบของปัญหาการซื้อขายเบาบางต่อค่าพารามิเตอร์ของตัวแบบการตั้งราคาหลักทรัพย์ทั้งในประเทศไทยและสิงคโปร์

ภาควิชา การธนาคารและการเงิน ลายมือชื่อนิสิต........นันทิพา สินทวีวัฒน์..............
สาขาวิชา การเงิน ลายมือชื่ออาจารย์ที่ปรึกษา..............................
ปีการศึกษา 2549

# # 488 25415 26: MAJOR FINANCE

KEY WORD: ASSET PRICING MODEL/ RISK MEASUREMENT/ INFREQUENT TRADING/ EMERGING MARKET

NUNTIPA SINTAWEEWAT: ASSET PRICING MODEL PARAMETERS AND INFREQUENT TRADING IN AN EMERGING MARKET.

THESIS ADVISOR: MANAPOL EKKAYOKKAYA, PH.D., 91 pp. ISBN 974-14-2755-7.

Direct empirical evidence on the relationship between the asset pricing model parameters and infrequent trading in emerging markets seems sparse at best. This thesis provides empirical evidence on the potential impact of infrequent trading on the estimated asset pricing model parameters in Thailand. As a comparison sample, Singaporean data are also employed. Three main empirical results are found in this thesis. First, there is a pattern indicating that the alphas without adjusting for infrequent trading (unadjusted alphas) may be upwardly biased and the betas without adjusting for infrequent trading (unadjusted betas) may be downwardly biased in both the Thai and Singaporean markets. Second, although the differences between the unadjusted alphas and betas and the adjusted alphas and betas are statistically insignificant, the differences between the unadjusted alphas and the adjusted alphas are economically significant. Third, the serial correlation problem in portfolio returns is alleviated after adjusting for infrequent trading. Hence, it seems worthwhile to adjust for the impact of infrequent trading on the asset pricing model parameters in both Thailand and Singapore.

Department of Banking and Finance Student's signature...Nuntipa S............

Field of study Finance Advisor's signature...Manapol Ekkayokkaya

Academic Year 2006

Acknowledgements

I would like to thank many who have given me their help and support. First of all, I thank my thesis advisor, Dr. Manapol Ekkayokkaya, for his invaluable advice, guidance and encouragement throughout the completion of this thesis.

My thesis committee has been very supportive and enthusiastic. I appreciate the comments of Dr. Anant Chiarawongse, the chairman of the thesis committee, that always has been context rich and utmost valuable and the useful comments and generosity of Dr. Ruttachai Seelajareon, the committee of the thesis.

I am grateful to all of my friends in the MS Finance program for their friendship and cheerfulness. Special thanks to Mr. Pisin Bawornsupasri for his technical assistance. Last but not least, I would like to give my deepest gratitude to my family for their inspiration, encouragement and never-ending support given to me throughout my study.

Table of Contents

Page

List of Tables

Table **Page**

CHAPTER I

INTRODUCTION

1.1 Background and Problem Review

Unbiased estimation of the asset pricing model parameters, namely the alpha and the beta, remains an important issue in both academic literature and practice. This is because these estimated parameters can be used in many applications such as evaluating portfolio performance, measuring abnormal return in event studies and estimating the cost of capital. In emerging markets, however, the estimating of the unbiased parameters may be problematic because of infrequent trading which typically characterizes these markets (e.g. Antoniou et al., 1997).

Defined as the covariance of stock return and the market return divided by the variance of the market return, the beta is in practice estimated by running the stock return against the market return on an ordinary least squares (OLS) regression. One of underlying assumptions of asset pricing models such as the CAPM is the synchronous trading assumption. A stock is traded synchronously with the market portfolio. Extant evidence shows that there is a non-synchronous trading problem or infrequent trading problem in several stock markets (Bartholdy and Riding, 1994; Clare et al., 2002). In practice, therefore, the synchronous trading assumption may not always hold.

Stocks in the market are not necessarily traded at the close of each interval though they are traded in every interval. It is called non-synchronous trading or infrequent trading (Miller et al., 1994). For example, all stocks in the market may not be traded exactly at the same time when new information comes to the market. Some frequently traded stocks in the market portfolio are traded instantly reflecting new information while other infrequently traded stocks are not traded instantly to reflect new information. Therefore, the price of infrequently traded stock does not move synchronously with the price of frequently traded stock. When we use this infrequently traded stock return in the CAPM to regress against the market portfolio return, the slope coefficient of this regression, the beta or the systematic risk, is downwardly biased because the stock return does not move along with the market return. The effect of this is to underestimate the covariance between the stock return and the market portfolio return while the alpha or the abnormal return is upwardly biased (Scholes and Williams, 1977; Dimson, 1979).

Extant evidence shows that trading frequency is highly correlated with firm size. Dimson (1979) and Clare et al. (2002) found that small firms are traded less frequently than big firms. Fama and French (1993) found that stocks in the small-size and high book-to-market equity portfolio on average earn significant abnormal returns. To the extent that such small firms receive only little attention from the market, the evidence of mispricing documented in Fama and French (1993) may possibly be fundamentally attributable to the problem of infrequent trading or thin trading.

There is extensive literature on asset pricing models regarding the market risk factor or beta and other risk factors, namely size and book-to-market equity, in both the US market and non-US markets (see e.g. Fama and French, 1993, 1996; Strong and Xu, 1997; Dimson et al., 2003). Thus far, however, direct empirical evidence on the effect of infrequent trading on the asset pricing model parameters in an emerging market is almost non-existent or sparse at best. Due to the high potential rates of return, investments in emerging markets have been increasingly attractive (see e.g. Antoniou et al., 1997). Emerging markets also offer the opportunity to diversify internationally (see e.g. Divecha et al., 1992; Bekaert and Urias, 1996). Hence, unbiased estimation of the asset pricing model parameters is of great importance to both domestic and foreign investors of emerging markets. In addition, using a k-factor asset pricing model without taking into account of infrequent trading can lead to a biased result. Therefore, this thesis attempts to bridge this gap and provide a step to further research in Southeast Asian emerging markets.

Infrequent trading is a typical characteristic of emerging markets (e.g. Antoniou et al., 1997). In Thailand, this problem is explicitly recognized by the authority (see Appendix A and B). Accordingly, the Thai data presents itself as a testing ground for investigating the impact of infrequent trading on the asset pricing model parameters in an emerging market. Singaporean firms are also used in this thesis to provide a comparison sample because Singapore is in the same regional market, but more developed. Accordingly, it is expected to have a less severe infrequent trading problem than an emerging market like the Thai market (see Appendix C).

This thesis investigates the potential impact of infrequent trading on the asset pricing model parameters by comparing the estimated parameters with and without the adjustment for infrequent trading. The infrequent trading adjustment adopted in this thesis follows the procedure described in Miller et al. (1994) as it is the most recently accepted method which is used to adjust for the infrequent trading impact on portfolio returns. However, this method imposes the trading frequency across stocks in the portfolio. Specifically, this method assumes that all stocks in the portfolio have the same trading frequency as the portfolio. In practice, this assumption may not hold and may cause unnecessary noise in the analysis. For empirical purposes, I therefore apply this method at the individual-stock-level instead of the portfolio-level as was described in Miller et al. (1994). In addition, the secondary reason for employing the Miller et al. (1994) method for the Thai market comes from the results documented by Bartholdy and Riding (1994) and Arnat Leemakdej (1998). Specifically, in the New

Zealand market, Bartholdy and Riding (1994) found that OLS estimates are closer to those based on synchronous data than those estimated from the Scholes and Williams (1977) and Dimson (1979) methods. In Thailand, Arnat Leemakdej (1998) found that the Dimson (1979) method yields lower systematic risk than the traditional method in the event study. Therefore, Arnat Leemakdej (1998) argued that the Dimson (1979) method may not be suitable to solve an infrequent trading problem in Thailand.

1.2 Statement of Problem/ Research Question

Given the discussion in section 1.1, the problem to be investigated in this thesis is

What is the impact of infrequent trading on the asset pricing model parameters in an emerging market?

1.3 Objective of the Study

In the light of the problem stated above, the objective of this thesis is to empirically investigate how infrequent trading affects the parameters of the CAPM and the Fama and French (1993) three-factor model in Thailand and Singapore.

1.4 Scope of the Study

In this thesis, I investigate the impact of infrequent trading on the estimated parameters of the CAPM and the Fama and French (1993) three-factor model because these two models are extensively used as benchmarks by both scholarly researchers and practitioners. The samples of this thesis consist of all firms listed on the Stock Exchange of Thailand (SET) and on the Stock exchange of Singapore (SES) during 1993 and 2005.

1.5 Contributions

In contrast to the US and the UK, direct empirical evidence on the potential impact of infrequent trading on the estimated asset pricing model parameters in emerging markets seems sparse at best. Accordingly, this thesis contributes to the extant literature by providing direct evidence on such impact in an emerging market in relation to a comparable developed market.

CHAPTER II

LITERATURE REVIEW

This chapter is divided into four sections. Section 2.1 discusses the asset pricing model parameters and infrequent trading. Existing evidence on impacts of infrequent trading and evidence from emerging markets is presented in section 2.2 and section 2.3, respectively. The main points of this chapter are summarized in the last section.

2.1 Asset pricing model parameters and infrequent trading

This thesis attempts to investigate how infrequent trading affects the estimated parameters of the CAPM and the Fama and French (1993) three-factor model. These two asset pricing models are employed to test in this thesis because they are extensively used as benchmarks in both contemporary financial literature and practice. The parameters estimated from these models, namely the alpha and the beta, can be used in many applications in both developed and emerging markets such as evaluating portfolio performance, measuring abnormal return in event studies and estimating the cost of capital (see e.g. Cai et al., 1997; Arnat Leemakdej, 1998; Lyon et al., 1999; Cesari and Panetta, 2002; Bauer et al., 2006). However, directly applying the CAPM and the Fama and French (1993) three-factor model to estimate these parameters in emerging markets may be affected by infrequent trading and yield the biased parameters. The potential effects of infrequent trading on returns are a risk measurement error of individual stocks, mistaking for predictability that spuriously arises from serial correlation in portfolio returns which in turn leads to a false rejection of the market efficiency hypothesis. In emerging markets, for example, Arnat Leemakdej (1998) estimated abnormal returns of takeover targets in the SET by using the CAPM. Given the potential impacts of infrequent trading on the estimated parameters, the results from Arnat Leemakdej (1998) study which neglected the infrequent trading problem may be biased.

Extant evidence shows that there is the problem of infrequent trading in several stock markets. Bartholdy and Riding (1994) showed the extent of infrequent trading in the New Zealand Stock Exchange. Clare et al. (2002) also provided the evidence on the extent of non-trading in the London Stock Exchange (LSE). In addition, Clare et al. found that trading frequency is highly correlated with firm size. Specifically, small firms are traded less frequently than big firms because most small firms are normally neglected by investors. This result is consistent with the finding documented by Dimson (1979). Fama and French (1993) found that stocks in the small-size and high book-to-market equity portfolio on average earn significant abnormal returns. To the extent that such small firms receive only little attention from the market, the evidence of mispricing documented in Fama and French (1993) may possibly be fundamentally attributable to the problem of infrequent trading or thin trading.

2.2 Existing evidence on impacts of infrequent trading

A number of studies have investigated impacts of infrequent trading and discussed its consequences. One impact of infrequent trading on returns on individual stocks is the biased risk measurement stated above. A number of different methods have been suggested to correct this bias. Scholes and Williams (1977) found that a beta of the infrequently traded stock regressed from the Ordinary Least Squares (OLS) method is downwardly biased while an alpha is upwardly biased. This is because estimated variance overstates true variance while estimated covariance understates in absolute magnitude true covariance. Moreover, reported returns appear serially correlated relative to actual returns. Scholes and Williams, therefore, constructed the consistent beta that equals to sum of betas estimated by regressing stock returns against the market returns from the previous, current and subsequent periods divided by one plus twice the estimated autocorrelation coefficient for the market index. Dimson (1979) also found that the simple regression on the market model generates a downwardly biased beta and an upwardly biased alpha for the infrequently traded stock. Dimson proposed the aggregated coefficients (AC) method to estimate beta for the stock which suffers from infrequent trading by running the multiple regression of stock returns against lagged, matching and leading market returns. Then, beta is derived by sum of the slope coefficients from this regression.

Clare et al. (2002) estimated the systematic risk or beta by using the methods proposed by Scholes and Williams (1977) and Dimson (1979) to adjust for the impact of non-trading in the LSE. Clare et al. found that the estimated betas of the portfolio of large stocks are close across each estimation procedure within a particular period. In contrast, the estimated betas of the portfolio of small stocks are highly dependent on the choice of estimation procedure. Specifically, the beta of the portfolio of small stocks from the OLS method is significantly less than those from the Scholes and Williams (1977) and Dimson (1979) methods. These results suggest that the beta of the portfolio of small stocks estimated from the OLS method is downwardly biased due to the impact of infrequent trading.

Dimson and Marsh (1983) avoid downward bias in risk measures in the UK by using the trade-to-trade (TT) method. This method uses stock returns between adjacent trades to regress on the market returns measured over the same period and then beta is estimated from the slope coefficient of this regression.

For returns on portfolios or indices, they are also affected by impact of infrequent trading that induces the problem of serial correlation into these returns. For example, the serial correlation problem in the index portfolio is created by the fact that not all stocks in the index portfolio are traded in every interval, thus a market movement in one interval may not reflect the true prices of some infrequently traded stocks in the index portfolio until they are eventually traded and their prices get updated. This lagged adjustment of prices of infrequently traded stocks to new market information induces positive serial correlation in the index portfolio. Several methods have been suggested to reduce this problem. Miller et al. (1994) showed that positive first-order autocorrelation in returns on the index portfolio is due to the effect of infrequent trading, and argued that an MA(q) model can be used to adjust such effect on the index portfolio returns. Specifically, this model implies that the observed index change follows an MA(q) process which all stocks are traded at least once every q intervals. However, this means that the observed index change process depends on q different parameters which make it unwieldy. Hence, Miller et al. derived a simpler method to estimate the observed index change process by assuming that some stocks may not be traded for several consecutive intervals, though the likelihood of that event declines geometrically with the order of the lag. The result showed that the observed index change follows an AR(1) process. Accordingly, Miller et al. used an AR(1) model to adjust for the effect of infrequent trading on returns on the index portfolio and found that positive first-order autocorrelation in the index portfolio returns significantly decreases after adjusting for infrequent trading. That is, this method can alleviate the infrequent trading effect on the returns on the index portfolio. Jokivuolle (1995) found that the daily returns of the Russell 2000 index exhibit significant first-order serial correlation. As a consequence, the true index value is not directly observed. To cope with this problem, Jokivuolle suggested an infinite-order MA model, which can be estimated as an ARMA(p,q) model, to measure the unobservable true index value, uncovered by the Beveridge-Nelson decomposition, in the presence of infrequent trading. Specifically, since the innovations of both the true and observed index return process are perfectly correlated in this study, Jokivuolle showed that the Beveridge-Nelson permanent component of the log of the observed index process equals the log of the true index. In other words, the unobservable true index can be indirectly observed from the history of the observed index.

2.3 Existing evidence from emerging markets

There seem to be fewer comprehensive studies applying infrequent trading with the asset pricing model parameters in emerging markets. Antoniou et al. (1997) tested the efficiency of an emerging market, Istanbul Stock Exchange. To take into account of infrequent trading, Antoniou et al. employed the approach proposed by Miller et al. (1994) in their empirical analysis. The results from Antoniou et al. (1997) study suggested that serial correlation of adjusted returns for infrequent trading decreases, but still remains, from serial correlation of unadjusted returns. Therefore, Antoniou et al. argued that the effects of infrequent trading are more complex than is captured by this simple model. For the New Zealand market, Bartholdy and Riding (1994) employed the methods proposed by Scholes and Williams (1977) and Dimson (1979) to adjust for the infrequent trading effect on systematic risk estimations. Bartholdy and Riding found that neither of them provided incremental benefits over standard OLS estimation. For most stocks, OLS estimates are closer to those based on synchronous data.

For the Pakistan market, Iqbal and Brooks (2006) investigated the likely impact of these different betas on asset pricing models, namely the CAPM and the Fama and French (1993) three-factor model and used the Dimson (1979) and trade-to-trade methods to correct the downwardly bias in the OLS beta. Iqbal and Brooks found that although the Dimson (1979) and trade-to-trade methods appear to correct infrequent trading bias, their effects on asset pricing tests are not visible. In Thailand, Chareonsak Methanugrah (1997) estimated beta of Thai stocks by using the Scholes and Williams (1977) and Dimson (1979) approaches. The results showed that on average, beta from the market model can explain the variation in stock returns better than beta from the Scholes and Williams (1977) and Dimson (1979) approaches judged by R^2. That is, R^2 from the market model is higher than R^2 from the Scholes and Williams (1977) and Dimson (1979) approaches. Arnat Leemakdej (1998) argued that the takeover targets in the SET are infrequently traded stocks because they are small firms which are normally neglected by investors. Therefore, measuring abnormal returns of these firms by means of traditional event study is biased. To take into account of this problem, like Jokivuolle (1995), Arnat Leemakdej applied the Beveridge-Nelson decomposition method to derive the unobserved true index. Besides, the Dimson (1979) method is also used to measure systematic risk of these infrequently traded stocks. The results showed that the Beveridge-Nelson decomposition and Dimson (1979) methods yield lower systematic risk than the traditional method. Thus, Arnat Leemakdej suggested that both methods may not be suitable to solve infrequent trading problem in Thailand.

2.4 Summary

This chapter critically discusses the potential impact of infrequent trading on the asset pricing model parameters. That is, the alpha or mispricing evidence is upwardly biased while the beta or systematic risk is downwardly biased. In addition, infrequent trading also induces the serial correlation problem into portfolio returns. Existing evidence on the impact of infrequent trading from both developed and emerging markets along with several methods to correct for the bias from such impact on the asset pricing model parameters are discussed.

CHAPTER III

DATA AND METHODOLOGY

3.1 Data

The samples of this thesis consist of all firms listed on the Stock Exchange of Thailand (SET) and on the Stock exchange of Singapore (SES) during July 1993 and December 2005. The source of data is DataStream which provides the monthly total return index, the monthly market index, the monthly market value of equity, the yearly book value of equity, the saving deposit rate for Thai data and the three-month T-bill rate for Singaporean data.

3.1.1 The monthly total return index (RI)

The monthly total return index (RI) is used to calculate the return of stock i for month t (R_{it}) as follows:

$$R_{it} = (RI_{it} - RI_{it-1})*100/RI_{it-1}$$

where, RI_{it} is the total return index of stock i for month t and RI_{it-1} is the total return index of stock i for month t-1.

3.1.2 The monthly market index (MI)

The monthly market index (MI) is used to calculate the market return for month t (R_{mt}) as follows:

$$R_{mt} = (MI_t - MI_{t-1})*100/MI_{t-1}$$

where, MI_t is the market index for month t and MI_{it-1} is the market index for month t-1.

3.1.3 The monthly market value of equity (M)

The monthly market value of equity (M) is the share price multiplied by the number of ordinary stocks in issue. The monthly market value of equity for year t, measured at the end of June, is used as the size breakpoints. The size breakpoints are used to allocate stocks to the size and book-to-market equity (size-BM) portfolios which are formed by following the Fama and French (1993) mechanism. The portfolio formation is discussed in the methodology section.

3.1.4 The yearly book value of equity (B)

The yearly book value of equity (B) is the book value of common shareholders' equity, minus the common treasury stock value and the accumulated unpaid preferred dividends. The yearly book value of equity is used to calculate the book-to-market equity (BM) for year t as the book value of equity at the end of year t-1 divided by the market value of equity at the end of year t-1. The book-to-market equity is used as the BM breakpoints for allocating stocks to the size-BM portfolios.

3.1.5 The risk free rate (R_f)

Given the availability of data during the sample periods in this thesis, the saving deposit rate is used as the risk free rate for Thai data, while the three-month T-bill rate is used as the risk free rate for Singaporean data. R_{ft} represents the risk free rate for month t.

3.2 Theoretical Hypothesis

Based on the findings in previous studies in the US and the UK - Scholes and Williams (1977), Dimson (1979), and Miller et al. (1994) - the theoretical hypothesis is that infrequent trading causes a downward bias in the estimated parameters representing risk measurement, the beta in the CAPM and the factor loadings in the Fama and French (1993) three-factor model.

3.3 Methodology

3.3.1 Portfolio formation

Unlike previous studies, this thesis investigates the relationship between asset pricing model parameters and infrequent trading by using portfolio returns instead of stock returns to regress on the market returns. To obtain portfolio returns, I initially form portfolios from July 1993 to December 2005. The formation mechanism closely followed Fama and French (1993) taking into account the distribution of size and BM attributes of firms listed in Thailand and Singapore.[1] I use the nine size-BM portfolios, instead of the six size-BM portfolios of Fama and French (1993), in order to ensure that big and small firms and high-BM and low-BM firms are obviously allocated. In addition, I use the sixteen size-BM portfolios, instead of the twenty five size-BM portfolios of Fama and French (1993), to ensure that every portfolio from these sixteen portfolios has enough number of firms for calculating the average return of the portfolio (see Appendix D).

[1] In applying an asset pricing model or risk factors developed in one market to another, it is essential that adjustments are made to reflect the distribution of the fundamental characteristics of firms in the market under examination (see e.g. Dimson et al., 2003).

3.3.1.1 The nine size-BM portfolios

The nine size-BM portfolios are formed based on independent sorts on firm size (market value of equity (M)) and on book-to-market equity (BM). Only firms with non-negative book value of equity (B) are included. The market, size and book-to-market equity factors used as independent variables in the regressions are calculated from these portfolios as follows. At the end of June each year t, I form three-size groups based on end-of-June market value of equity and breakpoints at the 35^{th} and 65^{th} percentiles of ranked market value of equity, which resulted in three groups - small, moderate, and big size. I form book-to-market equity (BM) groups based on book-to-market equity of the fiscal year ending in year t-1. Breakpoints are set at the 40^{th} and 60^{th} percentiles, which resulted in three groups - low, medium, and high BM.

For the nine portfolios (S/L, S/M, S/H, M/L, M/M, M/H, B/L, B/M, B/H) resulting from the intersection of these independent sorts, I calculate value-weighted monthly returns during a 12-month period from July of year t to June of year t+1. These are the portfolios that allowed me to calculate the Fama and French (1993) SMB (small minus big) and HML (high minus low) factors, where SMB is the simple average of returns on the three small portfolios (S/L, S/M and S/H) minus the simple average of returns on the three big portfolios (B/L, B/M and B/H) and HML is the simple average of returns on the three high-BM portfolios (S/H, M/H and B/H) minus the simple average of returns on the three low-BM portfolios (S/L, M/L and B/L).

3.3.1.2 The sixteen size-BM portfolios

The sixteen size-BM portfolios are formed much like the nine size-BM portfolios, except the breakpoints for size and BM. I use the breakpoints to allocate stocks to four size quartiles and four BM quartiles. I construct the sixteen portfolios from the intersections of the size and BM quartiles and calculate value-weighted monthly returns on the portfolios from July of year t to June of year t+1. The value-weighted return on portfolio p for month t (R_{pt}) is calculated as follows:

$$R_{pt} = \sum_{i=1}^{i=n} (R_{it} * M_{it-1}) / \sum_{i=1}^{i=n} (M_{it-1})$$

where R_{it} is the stock return on portfolio p for month t, M_{it} is the market value of equity of stock i for month t-1, and n is the number of stocks in portfolio p for month t. The excess returns on these sixteen portfolios are used as dependent variables in the regressions.

3.3.2 Asset pricing models

To investigate the impact of infrequent trading on the asset pricing model parameters, I initially estimate the parameters, namely the alpha and the beta from the unadjusted capital asset pricing model (CAPM) and the alpha, the beta, the size coefficient and the BM coefficient from the unadjusted Fama and French (1993) three-factor model by running ordinary least squares (OLS) regressions on these two models.

- The unadjusted capital asset pricing model (CAPM)

$$R_{pt} – R_{ft} = \alpha_p + b_p(R_{mt} – R_{ft}) + \varepsilon_{pt} \quad (1)$$

- The unadjusted Fama and French (1993) three-factor model

$$R_{pt} – R_{ft} = \alpha_p + b_p(R_{mt} – R_{ft}) + s_pSMB_t + h_pHML_t + \varepsilon_{pt} \quad (2)$$

where R_{pt} is the value-weighted return on portfolio p for month t, R_{ft} is the risk free rate for month t, R_{mt} is the market return for month t, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, SMB_t is the difference in returns between small and big portfolios for month t, HML_t is the difference in returns between high-BM and low-BM portfolios for month t, α_p is the unadjusted alpha of portfolio p, b_p is the unadjusted beta of portfolio p, s_p is the unadjusted coefficient of the size factor (unadjusted size coefficient) of portfolio p, and h_p is the unadjusted coefficient of the BM factor (unadjusted BM coefficient) of portfolio p.

3.3.3 Infrequent trading adjustment

As regards early discussion, the implicit assumption of the CAPM and the Fama and French (1993) three-factor model is synchronous trading. If this assumption does not hold due to infrequent trading impact, the estimated parameters from equation (1) and (2) may be biased. In order to take into account of the infrequent trading problem in my empirical analysis, I apply an AR(1) model which is the methodology proposed by Miller et al. (1994) to adjust stock returns[2] as follows:

$$R_{it} = a_1 + a_2 R_{it-1} + e_{it} \qquad (3)$$

Using the residuals from the regression, the adjusted returns are estimated as follows:

$$R_{it}^{adj} = \hat{e}_{it} \,/\, (1 - \hat{a}_2) \qquad (4)$$

where R_{it} is the return on stock i for month t and R_{it}^{adj} is the return on stock i for month t adjusted for infrequent trading.

The adjusted stock returns (R_{it}^{adj}) are employed to form portfolios by the same process as the sixteen size-BM portfolios. These portfolios are used to calculate the value-weighted monthly return (R_{pt}^{adj}). In addition, the adjusted stock returns are also employed to form portfolios and calculate value-weighted monthly

[2] See the theoretical foundation of this methodology in Appendix A of Miller et al. (1994)

returns by the same process as the nine size-BM portfolios. These portfolios are used to calculate SMB_t^{adj} and HML_t^{adj} factors, where SMB^{adj} is the simple average of adjusted returns on the three small-size portfolios (S/L, S/M and S/H) minus the simple average of adjusted returns on the three big-size portfolios (B/L, B/M and B/H) and HML^{adj} is the simple average of adjusted returns on the three high-BM portfolios (S/H, M/H and B/H) minus the simple average of adjusted returns on the three low-BM portfolios (S/L, M/L and B/L).

For the market return, I directly employ the Miller et al. (1994) method to adjust the impact of infrequent trading at the portfolio-level and obtain the market return adjusted for infrequent trading (R_m^{adj}).

Then I substitute R_{pt}^{adj} and R_m^{adj} into the unadjusted CAPM, and R_{pt}^{adj}, R_m^{adj}, SMB_t^{adj} and HML_t^{adj} into the unadjusted Fama and French (1993) three-factor model (equation (1) and (2), respectively). Accordingly, the adjusted CAPM and the adjusted Fama and French (1993) three-factor model are obtained as follows:

- The adjusted capital asset pricing model (CAPM)

$$R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + \varepsilon_{pt} \qquad (5)$$

- The adjusted Fama and French (1993) three-factor model

$$R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + s_p^{adj}SMB_t^{adj} + h_p^{adj}HML_t^{adj} + \varepsilon_{pt} \qquad (6)$$

where R_{pt}^{adj} is the value-weighted return on portfolio p for month t adjusted for infrequent trading, R_{ft} is the risk free rate for month t, R_{mt}^{adj} is the market return for month t adjusted for infrequent trading, SMB_t^{adj} is the difference in adjusted returns between small and big portfolios for month t, HML_t^{adj} is the difference in adjusted returns between high-BM and low-BM portfolios for month t, α_p^{adj} is the alpha of portfolio p adjusted for infrequent trading (adjusted alpha), b_p^{adj} is the beta of portfolio p adjusted for infrequent trading (adjusted beta), s_p^{adj} is the size coefficient of portfolio p adjusted for infrequent trading (adjusted size coefficient), and h_p^{adj} is the BM coefficient of portfolio p adjusted for infrequent trading (adjusted BM coefficient).

3.3.4 Impacts of infrequent trading

Asset pricing model parameters estimated from the unadjusted models, equation (1) and (2), are compared with those from the adjusted models, equation (5) and (6), to empirically investigate how infrequent trading affects the parameters of the unadjusted CAPM and the unadjusted Fama and French (1993) three-factor model in Thailand and Singapore.

3.3.4.1 The alpha

To measure the impact of infrequent trading on the alpha (the alpha is upwardly biased), the hypothesis testing of equation (1) and (5) is given as follows:

H_0: $\hat{\alpha}_p^{adj}$ is equal to 0

H_1: $\hat{\alpha}_p^{adj}$ is not equal to 0

where, $\hat{\alpha}_p^{adj}$ is the alpha from the adjusted CAPM (adjusted alpha), and the hypothesis testing of equation (2) and (6) is given as follows:

H_0: $\hat{\alpha}_p^{adj}$ is equal to 0

H_1: $\hat{\alpha}_p^{adj}$ is not equal to 0

where, $\hat{\alpha}_p^{adj}$ is the alpha from the adjusted three-factor model (adjusted alpha).

3.3.4.2 The beta, the size coefficient and the BM coefficient

To measure the impact of infrequent trading on the beta (the beta is downwardly biased), the hypothesis testing of equation (1) and (5) is given as follows:

H_0: $\hat{b}_p^{adj}$ is greater than $\hat{b}_p$

H_1: $\hat{b}_p^{adj}$ is not equal to $\hat{b}_p$

where, $\hat{b}_p$ is the beta from the unadjusted CAPM (unadjusted beta) and $\hat{b}_p^{adj}$ is the beta from the adjusted CAPM (adjusted beta), and the hypothesis testing of equation (2) and (6) is given as follows:

H_0: $\hat{b}_p^{adj}$ is greater than $\hat{b}_p$

H_1: $\hat{b}_p^{adj}$ is not equal to $\hat{b}_p$

where, $\hat{b}_p$ is the beta from the unadjusted three-factor model (unadjusted beta) and $\hat{b}_p^{adj}$ is the beta from the adjusted three-factor model (adjusted beta).

Unlike the alpha and the beta which are expected to be upwardly and downwardly biased respectively due to the impact of infrequent trading, the unadjusted size and BM coefficients of equation (2) may be either upwardly or downwardly biased relative to the adjusted size and BM coefficients of equation (6) due to such impact. In other words, I do not expect that all size and BM coefficients either monotonically increase or decrease after adjusting for infrequent trading. Instead, the size and BM coefficients should be synchronously change in any direction that yield less biased alpha and beta after adjusting for infrequent trading. That is, the adjusted alpha is equal to zero and the adjusted beta is greater than the unadjusted beta.

3.3.4.3 Serial correlation

Considering the findings of Miller et al. (1994), I also test the null hypothesis that is the serial correlation problem in portfolio returns induced by infrequent trading seems to be alleviated after adjusting this problem by the Miller et al. (1994) method. In this thesis, I adopt the correlogram Q-statistic approach to test the serial correlation in both unadjusted and adjusted portfolio returns used in equation (1), (2), (5) and (6). This approach provides the autocorrelation coefficients (AC) of portfolio returns and p-values based on Q-statistics. If the p-value is greater than 0.05, this null hypothesis cannot be rejected. In other words, the serial correlation problem in portfolio returns does not exist after adjusting for infrequent trading. The autocorrelation coefficients (AC) of portfolio returns and p-values regressed from the unadjusted portfolio returns are compared with those from the adjusted portfolio returns. If a number of portfolios having the serial correlation problem reduce after adjusting for infrequent trading, this result will confirm that the Miller et al. (1994) method can alleviate the serial correlation problem in portfolio returns in both the Thai and Singaporean markets.

3.3.5 Differences between the unadjusted and adjusted parameters

To test the null hypothesis that is the unadjusted parameters regressed from the unadjusted CAPM and the unadjusted Fama and French (1993) three-factor model are statistically different from the adjusted parameters regressed from the adjusted CAPM and the adjusted Fama and French (1993) three-factor model, I introduce the dummy variables in equation (1) and (2) as follows:

- The capital asset pricing model (CAPM) with the dummy variable

$$R_{pt} - R_{ft} = \alpha_{1p} + \alpha_{2p}D_p + b_{1p}(R_{mt} - R_{ft}) + b_{2p}(R_{mt} - R_{ft})D_p + \varepsilon_{pt} \qquad (7)$$

- The adjusted Fama and French (1993) three-factor model with the dummy variable

$$R_{pt} - R_{ft} = \alpha_{1p} + \alpha_{2p}D_p + b_{1p}(R_{mt} - R_{ft}) + b_{2p}(R_{mt} - R_{ft})D_p + s_{1p}SMB_t + s_{2p}SMB_tD_p + h_{1p}HML_t + h_{2p}HML_tD_p + \varepsilon_{pt} \quad (8)$$

where, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, SMB_t is the difference in returns between small and big portfolios for month t, HML_t is the difference in returns between high-BM and low-BM portfolios for month t, and D_p is 1 for the adjusted return on portfolio p for month t, or 0 for the unadjusted return on portfolio p for month t.

Taking into account of the serial correlation problem in portfolio returns, I use the Newey-West (1987) method to obtain standard errors of OLS estimators that are corrected for autocorrelation and heteroscedasticity. The coefficients of equation (7) and (8) are estimated by running the OLS regressions. For each portfolio, the differences between unadjusted and adjusted alphas, betas, size coefficients and BM coefficients are estimated as follows:

3.3.5.1 The difference of alphas

The unadjusted alpha is tested significantly different from the adjusted alpha by t-statistic of $\hat{\alpha}_{2p}$ which is the coefficient of D_p or alpha-difference coefficient, where D_p is 1 for the adjusted return on portfolio p for month t or D_p is 0 for the unadjusted return on portfolio p for month t.

3.3.5.2 The difference of betas

The unadjusted beta is tested significantly different from the adjusted beta by t-statistic of $\hat{b}_{2p}$ which is the coefficient of $(R_{mt} - R_{ft})D_p$ or beta-difference coefficient, where $R_{mt} - R_{ft}$ is the market excess return for month t, and D_p

is 1 for the adjusted return on portfolio p for month t, or D_p is 0 for the unadjusted return on portfolio p for month t.

3.3.5.3 The difference of size coefficients

The unadjusted size coefficient is tested significantly different from the adjusted size coefficient by t-statistic of $\hat{s}_{2p}$ which is the coefficient of SMB_tD_p or size-difference coefficient, where SMB_t is the difference in returns between small and big portfolios for month t, and D_p is 1 for the adjusted return on portfolio p for month t, or D_p is 0 for the unadjusted return on portfolio p for month t.

3.3.5.4 The difference of BM coefficients

The unadjusted BM coefficient is tested significantly different from the adjusted BM coefficient by t-statistic of $\hat{h}_{2p}$ which is the coefficient of HML_tD_p or BM-difference coefficient, where HML_t is the difference in returns between high-BM and low-BM portfolios for month t, and D_p is 1 for the adjusted return on portfolio p for month t, or D_p is 0 for the unadjusted return on portfolio p for month t.

CHAPTER IV

RESULTS

The main objective of this thesis is to investigate the impacts of infrequent trading on the asset pricing model parameters of the CAPM and the Fama and French (1993) three-factor model in the Thai and Singaporean markets. This chapter is divided into three key findings consisting of Descriptive statistics for the nine and sixteen portfolios, The serial correlation problem in portfolio returns and Impacts of infrequent trading on the asset pricing model parameters of the Thai market. In addition, empirical results of the Singaporean market are presented to provide a comparison sample in the last section of this chapter.

4.1 Descriptive statistics for the nine and sixteen portfolios of the Thai market

Table 1A presents descriptive statistics for the nine portfolios formed on firm size (market value of equity or M) and book-to-market equity (BM) of the Thai market. These nine portfolios are used to form portfolios meant to mimic the underlying risk factors in returns related to firm size (SMB_t) and book-to-market equity (HML_t). The results show that big firms represent 88.71% of the total market capitalization of the entire market while small firms represent only 2.36%[3]. Hence, it is clear that big firms are obviously distinguished from small firms. The average BM of the low-BM firms is 0.48 while the average BM of the high-BM firms is 2.52. Thus, low-BM firms are also apparently distinguished from high-BM firms.

---

[3] The distribution of aggregate market value across portfolios is relatively similar to the distribution in the US and UK. Specifically, big firms in the US represent 90.66% of the total market capitalization of the entire market while small firms represent only 8.74% (Fama and French, 1993), and big firms in the UK represent 94.28% of the total market capitalization while small firms represent only 5.28% (Dimson et al., 2003).

For average number of firms, 64 firms in the small and high BM portfolio represent only 0.69% of the total market capitalization whereas 63 firms in the big and low-BM portfolio represent about 43.33%. This result confirms that firms in each portfolio substantially differ in both size and BM dimensions.

As expected, the average return without adjusting for the infrequent trading (unadjusted return) of the small and high-BM portfolio is highest at 2.57% per month while the average unadjusted return of the big and low-BTM portfolio is quite low, at 0.57% per month. On average, the average unadjusted returns of the small portfolios are higher than those of the big portfolios while the average unadjusted returns on the high-BM portfolios are higher than those of the low-BM portfolios.

Table 2A shows descriptive statistics for the sixteen portfolios formed on firm size and BM. The excess returns on these sixteen portfolios are used as a dependent variable in the time-series regressions. The results of this table are consistent with those of table 1A. Big firms represent 83.94% of the total market capitalization of the entire market while small firms represent only 1.29%. The average BM of the low-BM firms is 0.35 while the average BM of the high-BM firms is 3.26. For average number of firms, 35 firms in the small and high-BM (14) portfolio represent only 0.28% of the total market capitalization whereas 34 firms in the big and low-BM (41) portfolio represent about 33.69%. The bottom of table 2A also indicates the negative relation between firm size and average unadjusted return, but the positive relation between BM and average unadjusted return.

Table 3A summarizes the autocorrelation coefficients (AC) for the first 12 lags of unadjusted portfolio returns for Thai firms. There are 12 portfolios that have the serial correlation problem in portfolio returns (significant at 5%) while the market portfolio returns are not serially correlated. The small portfolios seem to have more severe problem than the big portfolios. These results imply that if we directly use the unadjusted returns to estimate the parameters, namely the alpha and the beta, their statistic values, such as standard errors, may be biased and wrongly lead to the acceptance or rejection of the significance of these estimated parameters hypothesis.

Table 4A summarizes the autocorrelation coefficients (AC) for the first 12 lags of adjusted portfolio returns for Thai firms. Compared with table 3A, a number of portfolios having the serial correlation problem decrease from 12 to 7. Especially for portfolio 24 and 34 of which returns of the entire 12 lags are serially correlated before adjusting for infrequent trading, their returns become serially correlated only after the eighth lag when taking infrequent trading into consideration. Hence, the Miller et al. (1994) method seems to alleviate the problem of serial correlation in portfolio returns in Thailand. However, it should be noted that the serial correlation in portfolio returns still remains after adjusting for infrequent trading. That is, the serial correlation problem cannot be distributed only to infrequent trading (see e.g. Miller et al., 1994; Clare et al., 2002). The implication is that if we use the adjusted returns to estimate the parameters, namely the alpha and the beta, their statistic values, such as standard errors, may be less biased relative to those estimated from the unadjusted returns and the acceptance or rejection of the significance of these parameters hypothesis is likely to be more accurate. The next section presents impact of infrequent trading on the parameters estimated from the CAPM and the Fama and French (1993) three-factor model.

Table 1A Descriptive statistics for 9 portfolios formed on firm size and book-to-market equity: Thailand 1993-2005

The nine size-BM portfolios are formed based on independent sorts on firm size (market capitalization) and on book-to-market equity (BM). Only firms with non-negative book value of equity (B) are included. Market value of equity (M) is the share price multiplied by the number of ordinary stocks in issue. Book value of equity (B) represents common shareholders' investment in a firm excluding common treasury stock value and accumulated unpaid preferred dividends.

The market, size and book-to-market equity factors used as independent variables in the regressions are calculated from these portfolios as follows. At the end of June each year t, I form three-size groups based on end-of-June market value of equity (M) and breakpoints at the 35th and 65th percentiles of ranked M, which resulted in three groups - small, moderate, and big size. I form book-to-market equity (BM) groups based on BM of the fiscal year ending in year t-1. Breakpoints are set at the 40th and 60th percentiles, which resulted in three groups - low, medium, and high BM.

For the nine portfolios (S/L, S/M, S/H, M/L, M/M, M/H, B/L, B/M, B/H) resulting from the intersection of these independent sorts, I calculate value-weighted monthly returns during a 12-month period from July of year t to June of year t+1. These are the portfolios that allowed us to calculate the Fama and French (1993) SMB (small minus big) and HML (high minus low) factors, where SMB is the simple average of the returns on the three small portfolios (S/L, S/M and S/H) minus the simple average of the returns on the three big portfolios (B/L, B/M and B/H) and HML is the simple average of the returns on the three high-BM portfolios (S/H, M/H and B/H) minus the simple average of the returns on the three low-BM portfolios (S/L, M/L and B/L).

The descriptive statistics are computed when the portfolios are formed in June of each year, 1993-2005, and are then averaged across the 13 years.

	Firm size						
BM	Small	Moderate	Big	Small	Moderate	Big	Average
	Percent of average M (%)			Average BM			
Low	0.84	3.19	43.33	0.49	0.51	0.43	0.48
Medium	0.83	2.97	28.56	0.98	0.97	0.96	0.97
High	0.69	2.77	16.82	2.93	2.31	2.33	2.52
Total	2.36	8.93	88.71				
	Average number of firms			Average Unadjusted return (%)			
Low	18	31	63	0.91	0.43	0.57	
Medium	16	20	20	0.66	1.53	1.20	
High	64	32	16	2.57	1.23	1.10	

Table 2A Descriptive statistics for 16 portfolios formed on firm size and book-to-market equity: Thailand 1993-2005

The sixteen size-BM portfolios are formed based on independent sorts on firm size (market capitalization) and on book-to-market equity (BM). Only firms with non-negative book value of equity (B) are included. Market value of equity (M) is the share price multiplied by the number of ordinary stocks in issue. Book value of equity (B) represents common shareholders' investment in a firm excluding common treasury stock value and accumulated unpaid preferred dividends.

The excess returns on the sixteen portfolios used as dependent variables in the regressions are calculated from these portfolios as follows. At the end of June each year t, I form four-size groups based on end-of-June market value of equity (M) which resulted in four groups – 1 (small), 2, 3, and 4 (big) size. I form book-to-market equity (BM) groups based on BM of the fiscal year ending in year t-1. Breakpoints are set at the four size quartiles, which resulted in four groups – 1 (low), 2, 3, and 4 (high) BM.

For the sixteen portfolios resulting from the intersection of these independent sorts, I calculate value-weighted monthly returns during a 12-month period from July of year t to June of year t+1. These are the portfolios that allowed us to calculate portfolio returns. The excess returns on the sixteen portfolios are calculated as the portfolio returns deducted by the risk free rate.

The descriptive statistics are computed when the portfolios are formed in June of each year, 1993-2005, and are then averaged across the 13 years.

	Firm size								
BM	1	2	3	4	1	2	3	4	Average
	Percent of average M (%)				Average BM				
1	0.35	0.96	3.12	33.69	0.33	0.38	0.38	0.31	0.35
2	0.34	0.96	2.87	22.70	0.78	0.75	0.74	0.72	0.75
3	0.32	0.89	2.52	17.63	1.31	1.30	1.23	1.20	1.26
4	0.28	0.89	2.56	9.92	3.59	3.32	3.46	2.67	3.26
Total	1.29	3.70	11.07	83.94					
	Average number of firms				Average Unadjusted return (%)				
1	6	11	19	34	1.13	-0.68	-0.12	0.46	
2	9	18	23	20	1.32	0.53	0.93	1.30	
3	20	20	18	13	1.55	1.12	0.93	1.66	
4	35	21	11	4	2.75	1.89	2.00	0.22	

Table 3A The Autocorrelation coefficients (AC) of the unadjusted portfolio returns: Thailand 1993-2005

This table presents the autocorrelation coefficients (AC) for the first 12 lags of the unadjusted portfolio returns. The p-value based on Q-statistic tests the serial correlation problem induced by infrequent trading in portfolio returns. If the p-value is higher than 0.05, the null hypothesis that is the unadjusted portfolio returns do not serially correlated cannot be rejected.

Lag	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio												
11	0.185[a]	0.063	-0.036	-0.221[a]	-0.138[a]	0.105[a]	0.117[a]	-0.118[a]	-0.029[a]	-0.086[a]	-0.026[a]	0.001[a]
	(0.022)	(0.054)	(0.110)	(0.009)	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)	(0.007)	(0.012)	(0.019)
12	-0.116	0.176[a]	0.103[a]	-0.129[a]	0.177[a]	-0.073[a]	0.185[a]	-0.047[a]	0.104[a]	0.084[a]	0.016[a]	0.055[a]
	(0.152)	(0.033)	(0.038)	(0.026)	(0.007)	(0.010)	(0.002)	(0.004)	(0.004)	(0.004)	(0.008)	(0.010)
13	0.266[a]	0.050[a]	0.019[a]	-0.039[a]	-0.003[a]	-0.004	0.044	0.114	-0.003	-0.107	-0.097	-0.087
	(0.001)	(0.004)	(0.010)	(0.022)	(0.042)	(0.074)	(0.107)	(0.085)	(0.126)	(0.108)	(0.100)	(0.100)
14	0.136	-0.057	0.002	-0.142	-0.050	-0.035	0.046	0.311[a]	0.095[a]	0.004[a]	0.002[a]	-0.016[a]
	(0.092)	(0.189)	(0.344)	(0.167)	(0.231)	(0.316)	(0.389)	(0.003)	(0.004)	(0.007)	(0.011)	(0.018)
21	0.192[a]	0.075[a]	0.045	-0.046	-0.044	0.052	-0.025	-0.051	0.007	-0.178	0.003	-0.061
	(0.018)	(0.039)	(0.078)	(0.128)	(0.189)	(0.247)	(0.334)	(0.395)	(0.494)	(0.195)	(0.259)	(0.290)
22	0.192[a]	0.105[a]	0.101[a]	0.035	0.021	0.021	0.020	-0.056	0.059	0.086	0.073	-0.021
	(0.018)	(0.026)	(0.031)	(0.059)	(0.103)	(0.161)	(0.232)	(0.280)	(0.322)	(0.316)	(0.332)	(0.406)
23	-0.068	0.115	-0.068	-0.089	-0.051	0.017	0.117	0.102	0.130	-0.079	-0.067	0.000
	(0.403)	(0.254)	(0.326)	(0.319)	(0.403)	(0.524)	(0.396)	(0.342)	(0.229)	(0.239)	(0.264)	(0.336)
24	0.216[a]	-0.044[a]	-0.073[a]	-0.185[a]	-0.044[a]	0.013[a]	0.225[a]	0.352[a]	0.023[a]	-0.115[a]	-0.107[a]	-0.110[a]
	(0.007)	(0.024)	(0.041)	(0.009)	(0.016)	(0.030)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
31	0.135	0.037	-0.037	-0.064	0.031	-0.020	0.177	0.138	0.007	0.019	-0.077	-0.118
	(0.095)	(0.224)	(0.362)	(0.427)	(0.550)	(0.668)	(0.247)	(0.146)	(0.206)	(0.273)	(0.283)	(0.217)
32	-0.055	0.140	-0.086	-0.055	0.041	-0.186	0.144[a]	0.071	0.070	-0.001	-0.086	0.060
	(0.499)	(0.174)	(0.200)	(0.275)	(0.371)	(0.092)	(0.048)	(0.059)	(0.071)	(0.106)	(0.108)	(0.128)

30

33	0.024	0.207[a]	-0.062	0.033	-0.067	0.047	0.059	0.085	-0.025	-0.120	-0.085	-0.027
	(0.769)	(0.035)	(0.063)	(0.114)	(0.148)	(0.204)	(0.248)	(0.249)	(0.324)	(0.242)	(0.240)	(0.301)
34	0.232[a]	0.002[a]	-0.051[a]	-0.205[a]	-0.149[a]	0.063[a]	0.195[a]	0.290[a]	0.096[a]	-0.100[a]	-0.152[a]	-0.093[a]
	(0.004)	(0.016)	(0.034)	(0.004)	(0.002)	(0.004)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
41	-0.060	0.082	0.019	-0.084	-0.044	0.060	0.114	0.039	0.070	0.064	-0.156	0.082
	(0.455)	(0.450)	(0.647)	(0.599)	(0.691)	(0.726)	(0.574)	(0.653)	(0.663)	(0.686)	(0.409)	(0.404)
42	0.099	0.102	-0.171	-0.109	-0.079	0.080	0.045	0.051	0.019	0.022	-0.143	0.011
	(0.219)	(0.210)	(0.054)	(0.050)	(0.063)	(0.075)	(0.108)	(0.142)	(0.199)	(0.263)	(0.152)	(0.204)
43	0.180[a]	0.081	-0.110[a]	-0.004	0.053	0.088	0.100	0.059	0.009	-0.049	-0.106	-0.022
	(0.026)	(0.051)	(0.049)	(0.097)	(0.141)	(0.147)	(0.135)	(0.167)	(0.233)	(0.281)	(0.239)	(0.303)
44	0.060	0.068	-0.064	-0.106	-0.097	0.241[a]	0.004[a]	0.205[a]	0.077[a]	-0.088[a]	-0.152[a]	0.020[a]
	(0.460)	(0.534)	(0.595)	(0.454)	(0.399)	(0.026)	(0.045)	(0.007)	(0.009)	(0.010)	(0.004)	(0.007)
m	-0.002	0.100	-0.063	-0.114	-0.053	0.057	0.125	0.027	0.065	0.015	-0.181	0.045
	(0.980)	(0.460)	(0.540)	(0.383)	(0.465)	(0.527)	(0.368)	(0.461)	(0.492)	(0.584)	(0.241)	(0.288)

Figures in parentheses are the p-values based on Q-statistics.
[a] denotes statistically significant at 5% level of significance.
m represents the market portfolio.

Table 4A The Autocorrelation coefficients (AC) of the adjusted portfolio returns: Thailand 1993-2005

This table presents the autocorrelation coefficients (AC) for the first 12 lags of the adjusted portfolio returns. The p-value based on Q-statistic tests the serial correlation problem induced by infrequent trading in portfolio returns. If the p-value is higher than 0.05, the null hypothesis that is the adjusted portfolio returns do not serially correlated cannot be rejected.

Lag	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio												
11	-0.005	0.040	-0.012	-0.206	-0.131	0.121	0.128[a]	-0.138[a]	0.008[a]	-0.082[a]	-0.010	-0.014
	(0.947)	(0.882)	(0.965)	(0.142)	(0.088)	(0.065)	(0.043)	(0.025)	(0.041)	(0.045)	(0.068)	(0.097)
12	0.019	0.181	0.110	-0.098	0.152[a]	-0.033	0.178[a]	-0.015[a]	0.116[a]	0.101[a]	0.031[a]	0.049[a]
	(0.818)	(0.079)	(0.074)	(0.077)	(0.034)	(0.058)	(0.016)	(0.027)	(0.022)	(0.020)	(0.031)	(0.042)
13	0.006	-0.023	0.018	-0.049	0.008	-0.017	0.020	0.119	-0.005	-0.094	-0.057	-0.042
	(0.944)	(0.957)	(0.987)	(0.973)	(0.992)	(0.997)	(0.999)	(0.941)	(0.969)	(0.931)	(0.938)	(0.953)
14	0.011	-0.078	0.032	-0.142	-0.028	-0.037	0.010	0.301[a]	0.053[a]	-0.009[a]	0.004	-0.006
	(0.894)	(0.624)	(0.778)	(0.377)	(0.502)	(0.603)	(0.713)	(0.014)	(0.021)	(0.034)	(0.052)	(0.076)
21	-0.007	0.033	0.047	-0.052	-0.047	0.065	-0.029	-0.053	0.054	-0.194	0.048	-0.030
	(0.932)	(0.915)	(0.914)	(0.918)	(0.936)	(0.924)	(0.955)	(0.960)	(0.964)	(0.520)	(0.576)	(0.647)
22	-0.012	0.053	0.085	0.012	0.010	0.013	0.028	-0.077	0.057	0.066	0.065	-0.030
	(0.880)	(0.797)	(0.664)	(0.808)	(0.899)	(0.949)	(0.972)	(0.951)	(0.955)	(0.951)	(0.948)	(0.966)
23	0.006	0.107	-0.072	-0.100	-0.064	0.027	0.127	0.122	0.132	-0.080	-0.072	-0.013
	(0.945)	(0.414)	(0.464)	(0.390)	(0.445)	(0.560)	(0.386)	(0.279)	(0.182)	(0.190)	(0.207)	(0.269)
24	0.020	-0.080	-0.028	-0.177	-0.009	-0.027	0.164	0.330[a]	-0.029[a]	-0.108[a]	-0.066[a]	-0.066[a]
	(0.800)	(0.590)	(0.759)	(0.198)	(0.304)	(0.408)	(0.167)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
31	-0.003	0.025	-0.035	-0.066	0.042	-0.049	0.168	0.118	-0.015	0.029	-0.066	-0.088
	(0.972)	(0.954)	(0.962)	(0.916)	(0.941)	(0.952)	(0.531)	(0.405)	(0.501)	(0.583)	(0.605)	(0.576)
32	0.007	0.135	-0.090	-0.056	0.020	-0.174	0.140	0.085	0.075	-0.008	-0.082	0.047
	(0.930)	(0.245)	(0.255)	(0.338)	(0.466)	(0.153)	(0.086)	(0.092)	(0.105)	(0.150)	(0.155)	(0.192)

32

33	-0.007	0.208[a]	-0.070	0.036	-0.074	0.049	0.057	0.086	-0.024	-0.118	-0.081	-0.021
	(0.934)	(0.036)	(0.060)	(0.108)	(0.134)	(0.184)	(0.230)	(0.231)	(0.303)	(0.231)	(0.236)	(0.299)
34	0.013	-0.042	-0.006	-0.180	-0.130	0.058	0.131	0.251[a]	0.060[a]	-0.098[a]	-0.122[a]	-0.026[a]
	(0.877)	(0.865)	(0.961)	(0.256)	(0.157)	(0.204)	(0.129)	(0.006)	(0.009)	(0.009)	(0.007)	(0.011)
41	0.001	0.076	0.001	-0.090	-0.067	0.069	0.126	0.056	0.074	0.056	-0.147	0.063
	(0.990)	(0.639)	(0.827)	(0.706)	(0.723)	(0.730)	(0.525)	(0.578)	(0.585)	(0.628)	(0.400)	(0.432)
42	-0.010	0.112	-0.179	-0.087	-0.084	0.088	0.033	0.047	0.011	0.033	-0.149	0.027
	(0.906)	(0.381)	(0.076)	(0.090)	(0.103)	(0.110)	(0.160)	(0.207)	(0.281)	(0.349)	(0.196)	(0.250)
43	-0.009	0.073	-0.137	0.006	0.039	0.067	0.081	0.045	0.006	-0.036	-0.099	0.015
	(0.915)	(0.658)	(0.294)	(0.445)	(0.556)	(0.587)	(0.575)	(0.646)	(0.738)	(0.795)	(0.730)	(0.797)
44	-0.004	0.069	-0.064	-0.097	-0.106	0.249[a]	-0.023[a]	0.202[a]	0.070[a]	-0.084[a]	-0.149[a]	0.034[a]
	(0.959)	(0.697)	(0.718)	(0.589)	(0.468)	(0.026)	(0.044)	(0.007)	(0.010)	(0.011)	(0.005)	(0.008)
m	-0.001	0.100	-0.073	-0.115	-0.063	0.061	0.128	0.031	0.065	0.013	-0.180	0.042
	(0.990)	(0.463)	(0.502)	(0.352)	(0.412)	(0.467)	(0.314)	(0.399)	(0.434)	(0.526)	(0.216)	(0.263)

Figures in parentheses are the p-values based on Q-statistics.
[a] denotes statistically significant at 5% level of significance.
m represents the market portfolio.

4.2 Impacts of infrequent trading on the asset pricing model parameters in Thailand

4.2.1 The CAPM

In table 5A, panel I and II present the unadjusted alphas or abnormal returns ($\hat{\alpha}_p$) and the unadjusted betas or systematic risks ($\hat{b}_p$) regressed from the unadjusted CAPM for Thai firms respectively. The results show that most of the unadjusted alphas are not statistically different from zero. Only 6 unadjusted alphas are statistically significant. In contrast, all unadjusted betas are statistically significant at 1% and appear to increase with firm size. Interestingly, the unadjusted alpha of the small and high-BM (14) portfolio is significantly higher than that of the big and low-BM (41) portfolio which is equal to zero. In other words, there appears mispricing evidence of portfolio 14 while there is no mispricing evidence of portfolio 41. Moreover, the unadjusted beta of portfolio 14 is lower, instead higher to reflect higher risk, than that of portfolio 41. These symptoms of the unadjusted alpha and beta of portfolio 14 suggest that the small and high-BM firms are subject to the problem of infrequent trading. One possible explanation for these findings is that the small and high-BM firms receive only little attention from the market and they are likely to be distress firms. The results are in line with the findings of Fama and French (1993). That is, stocks in the small and high-BM portfolio have significant abnormal returns.[4]

Panel III presents the adjusted-R^2s of the unadjusted CAPM. The adjusted-R^2s range from 18% to 92% and increase monotonically from smaller to bigger portfolios. However, the adjusted-R^2s are near 90% for only 2 big and low-BM portfolios that are portfolio 41 and 42. For the other portfolios, the adjusted-R^2s are

---

[4] According to Fama and French (1993) interpretation, this premium is called the financial distress premium. That is, the premium for small and high-BM firms that are expected to yield higher premium than big and strong firms to compensate for higher risk.

less than 70%. Especially the small portfolios of which adjusted-R^2 are not above 30%. The possible reason for explaining this result is that the small portfolios do not move synchronously with the market portfolio because of infrequent trading.

In table 6A, panel I presents the adjusted alphas ($\hat{\alpha}_p^{adj}$) regressed from the adjusted CAPM for Thai firms. The results show that all adjusted alphas are not statistically significant. In other words, alphas or abnormal returns seem to disappear after adjusting for infrequent trading. The results are in line with the symptom of upwardly biased alphas as in Scholes and Williams (1977). Specifically, alphas of infrequently traded stocks estimated from the traditional method are upwardly biased. After they adjusted impact of infrequent trading on returns in their study, the alphas of infrequently traded stocks decrease.

Panel II shows the adjusted betas ($\hat{b}_p^{adj}$) regressed from the adjusted CAPM. Compared with table 5A, 12 adjusted betas increase from unadjusted betas of the unadjusted CAPM between 3% and 39% while only 4 adjusted betas decrease from unadjusted betas of the unadjusted CAPM, in narrower range, between 6% and 14%. Specifically, except that of portfolio 12, all small portfolios' adjusted betas increase from unadjusted betas of the unadjusted CAPM. In addition, all big portfolios' adjusted betas also increase from unadjusted betas except for the beta of portfolio 41 which slightly decreases. These results also confirm the pattern of downwardly biased betas as in Scholes and Williams (1977) and Dimson (1979). That is, the traditional approach generates downwardly biased betas for infrequently traded stocks. After they adjusted impact of infrequent trading on returns in their studies, the betas of infrequently traded stocks increase.

Panel III summarizes the adjusted-R^2 for the adjusted CAPM. The adjusted-R^2s range from 16% to 93% and increase monotonically from smaller to bigger portfolios. The adjusted-R^2s of the adjusted CAPM change from those of the unadjusted CAPM in narrow range, only between 0.4% and 4%. Thus, taking into account of infrequent trading does not seem to increase much explanatory power of the adjusted CAPM relative to the unadjusted CAPM.

In table 7A, panel I presents the coefficients of differences between unadjusted alphas of the unadjusted CAPM and adjusted alphas of the adjusted CAPM ($\hat{\alpha}_{2p}$ or alpha-difference coefficient) for Thai firms. The result shows that only one pair of unadjusted and adjusted alphas of portfolio 14 is significantly different. That is, most unadjusted alphas are not significantly different from adjusted alphas. However, the size of the absolute alpha-difference is quite big ranging from 0.093% to 2.471% per month and the average absolute alpha-difference is about 0.947% per month or 11.364% per year. Hence, the alpha-differences of the CAPM are economically significant though they are statistically insignificant.

Panel II shows the coefficients of differences between unadjusted betas of the unadjusted CAPM and adjusted betas of the adjusted CAPM ($\hat{b}_{2p}$ or beta-difference coefficient). There is only the coefficient of portfolios 42 that is statistically significant. The other unadjusted betas are not significantly different from adjusted betas. The size of the absolute beta-difference ranges from 0.023% to 0.296% per month and the absolute average beta-difference is around 0.124% per month or 1.488% per year. Hence, the beta-differences of the CAPM are both statistically and economically insignificant.

Considering the results of adjusted alphas and betas in table 6A and 7A, although most of the differences between unadjusted and adjusted alphas and betas are statistically insignificant, the differences between unadjusted and adjusted alphas are economically significant. In addition, there is a pattern that the unadjusted alphas may be upwardly biased and the unadjusted betas may be downwardly biased. Hence, it seems worthwhile to adjust for the impact of infrequent trading on the alphas and betas when using the CAPM to estimate these parameters.

Table 5A The unadjusted parameters regressed from the unadjusted CAPM: Thailand 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the unadjusted CAPM: $R_{pt} - R_{ft} = \alpha_p + b_p(R_{mt} - R_{ft}) + \varepsilon_{pt}$, where R_{pt} is the value weighted return on portfolio p for month t, R_{ft} is the risk free rate for month t, R_{mt} is the market return for month t, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t. Panel I shows the unadjusted alpha ($\hat{\alpha}_p$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the unadjusted beta or the factor loading of the market factor ($\hat{b}_p$). The t-statistic tests the significance of unadjusted alpha and beta. Adjusted-R^2 for each portfolio is also shown in Panel III.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Unadjusted Alpha ($\hat{\alpha}_p$)				t ($\hat{\alpha}_p$)			
1	0.780	-1.000	-0.481	0.075	0.564	-1.569	-0.828	0.270
2	0.999	0.202	0.574	0.889[b]	1.172	0.314	1.347	2.460
3	1.222	0.769[c]	0.570	1.274[b]	1.205	1.723	1.082	2.011
4	2.402[a]	1.533[c]	1.613[b]	-0.211	2.769	1.774	2.130	-0.240
Panel II	Unadjusted Beta ($\hat{b}_p$)				t ($\hat{b}_p$)			
1	0.710[a]	0.458[a]	0.782[a]	0.991[a]	3.177	6.887	10.350	22.596
2	0.460[a]	0.452[a]	0.688[a]	1.178[a]	4.995	7.412	12.267	24.043
3	0.508[a]	0.640[a]	0.765[a]	0.962[a]	6.092	8.015	9.235	9.020
4	0.631[a]	0.753[a]	0.973[a]	1.393[a]	5.136	5.884	7.476	8.757

Panel III	Adjusted R^2 (%)			
1	18.06	31.57	54.27	92.27
2	17.61	32.54	58.90	89.62
3	18.37	54.56	62.73	71.93
4	27.34	38.04	56.87	61.68

[a] denotes statistically significant at 1% level of significance.
[b] denotes statistically significant at 5% level of significance.
[c] denotes statistically significant at 10% level of significance.

Table 6A The adjusted parameters regressed from the adjusted CAPM: Thailand 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the adjusted CAPM: $R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + \varepsilon_{pt}$, where R_{pt}^{adj} is the value weighted return on portfolio p for month t adjusted for infrequent trading, R_{ft} is the risk free rate for month t, R_{mt}^{adj} is the market return for month t adjusted for infrequent trading, R_{pt}^{adj}-R_{ft} is the excess return on portfolio p for month t adjusted for infrequent trading, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading. Panel I shows the adjusted alpha ($\hat{\alpha}_p^{adj}$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the adjusted beta or the factor loading of the market factor ($\hat{b}_p^{adj}$). The t-statistic tests the significance of adjusted alpha and beta. Adjusted-R^2 for each portfolio is also shown in Panel III.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Adjusted Alpha ($\hat{\alpha}_p^{adj}$)				t ($\hat{\alpha}_p^{adj}$)			
1	-0.047	-0.121	-0.024	-0.017	-0.032	-0.183	-0.040	-0.061
2	-0.164	-0.118	-0.096	0.086	-0.191	-0.178	-0.220	0.235
3	-0.080	-0.111	-0.057	0.047	-0.074	-0.244	-0.105	0.068
4	-0.069	-0.003	0.073	0.134	-0.074	-0.003	0.087	0.148
Panel II	Adjusted Beta ($\hat{b}_p^{adj}$)				t ($\hat{b}_p^{adj}$)			
1	0.827[a]	0.555[a]	0.913[a]	0.937[a]	3.079	6.856	9.916	23.217
2	0.394[a]	0.564[a]	0.648[a]	1.312[a]	4.917	7.820	12.115	25.007
3	0.707[a]	0.592[a]	0.788[a]	1.172[a]	6.113	8.180	9.151	9.774
4	0.747[a]	0.989[a]	1.269[a]	1.492[a]	5.214	6.206	7.909	8.606
Panel III	Adjusted R^2 (%)							
1	16.75	31.21	56.11	92.92				
2	16.17	34.38	57.91	90.63				
3	20.61	53.11	63.10	73.82				
4	29.02	42.08	59.91	62.40				

[a] denotes statistically significant at 1% level of significance.

Table 7A The differences between the unadjusted and adjusted CAPM parameters: Thailand 1993-2005

This table presents the differences between the unadjusted and adjusted CAPM parameters. The dummy variables are introduced in the CAPM for the presence of infrequent trading adjustment: $R_{pt} - R_{ft} = \alpha_{1p}+\alpha_{2p}D_p+ b_{1p}(R_{mt} - R_{ft})+ b_{2p}(R_{mt}^{adj} - R_{ft})D_p + \varepsilon_{pt}$, where, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading, and D_p is 1 for adjusted return on portfolio p for month t ,or 0 for unadjusted return on portfolio p for month t. Panel I shows the alpha-difference coefficient ($\hat{\alpha}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted alphas. Panel II shows the beta-difference coefficient ($\hat{b}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted betas. The t-statistic tests the null hypothesis that is the unadjusted parameters regressed from the unadjusted CAPM are statistically different from the adjusted parameters regressed from the adjusted CAPM.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Alpha-Difference Coefficient ($\hat{\alpha}_{2p}$)				t ($\hat{\alpha}_{2p}$)			
1	-0.827	0.879	0.457	-0.093	-0.425	0.968	0.553	-0.234
2	-1.164	-0.320	-0.670	-0.805	-0.953	-0.347	-1.128	-1.564
3	-1.302	-0.881	-0.628	-1.228	-0.889	-1.417	-0.835	-1.269
4	-2.471[b]	-1.536	-1.540	0.344	-1.980	-1.204	-1.389	0.280
Panel II	Beta-Difference Coefficient ($\hat{b}_{2p}$)				t ($\hat{b}_{2p}$)			
1	0.117	0.097	0.131	-0.054	0.340	0.919	1.116	-0.889
2	-0.066	0.113	-0.040	0.134[c]	-0.541	1.201	-0.515	1.829
3	0.199	-0.048	0.023	0.210	1.459	-0.446	0.189	1.318
4	0.116	0.236	0.296	0.098	0.620	1.158	1.434	0.406

[b] denotes statistically significant at 5% level of significance.
[c] denotes statistically significant at 10% level of significance.

4.2.2 The Fama and French (1993) three-factor model

In table 8A, panel I and II show the unadjusted alphas ($\hat{\alpha}_p$) and unadjusted betas ($\hat{b}_p$) regressed from the unadjusted three-factor model for Thai firms respectively. Interestingly, although I use the unadjusted three-factor model, instead of the unadjusted CAPM, the mispricing evidence of portfolio 14 still exists. In addition, the unadjusted beta of portfolio 14 is still lower than that of portfolio 41. In other words, the symptoms that the alpha and the beta of portfolio 14 are subject to infrequent trading seem to remain even using the unadjusted three-factor model instead of the unadjusted CAPM.

SMB_t, the mimicking return for the size factor, captures variation in returns missed by the market factor and HML_t or the BM factor. Panel III reports the unadjusted coefficients of SMB_t ($\hat{s}_p$ or unadjusted size coefficient) regressed from the unadjusted three-factor model. The results show that unadjusted size coefficients appear to decrease with firm size. In every BM quartile, the unadjusted size coefficient decreases monotonically when firm size increases.[5]

Similarly, HML_t, the mimicking return for the BM factor, captures variation in returns missed by the market factor and SMB_t or the size factor. Panel IV shows the unadjusted coefficients of HML_t ($\hat{h}_p$ or unadjusted BM coefficient) regressed from the unadjusted three-factor model. The results suggest that unadjusted BM coefficients appear to increase with BM. In every size quartile, the unadjusted

[5] According to Fama and French (1993) interpretation, this premium is known as size premium. That is, the premium compensating investors for bearing risk of investing in small firms relative to big firms.

BM coefficient increases monotonically from negative value for the low-BM quartile to strongly positive value for the high-BM quartile.[6]

Given the strong size and BM coefficients, it is not surprising that adding these two factors to the regressions results in large increasing of adjusted-R^2s compared with those from the unadjusted CAPM in table 5A. Panel V presents the adjusted-R^2s for the unadjusted three-factor model. There are 6 portfolios of which adjusted-R^2s are greater than 80% while using the market factor alone produces only 2 portfolios of which adjusted-R^2s are greater than 80%. For the portfolios in the small-size quartile, the adjusted-R^2s increases from 18%-27%, in case of the unadjusted CAPM, to 45%-85%, in case of the unadjusted three-factor model. Especially for portfolio 14, its adjusted-R^2 largely increases from 27% to 85% while the adjusted-R^2 of portfolio 41 increases only 3% from 92% to 95%.

In table 9A, panel I presents the adjusted alphas ($\hat{\alpha}_p^{adj}$) regressed from the adjusted three-factor model for Thai firms. As expected, there is no alpha or abnormal return after adjusting for infrequent trading. Like the adjusted CAPM, the mispricing evidence of portfolio 14 vanishes after I use the adjusted three-factor model instead of the unadjusted three-factor model. Therefore, not only the CAPM, the three-factor model also seems to have the symptom of upwardly biased alpha.

Panel II shows the adjusted betas ($\hat{b}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8A, 9 adjusted betas increase from unadjusted betas of the unadjusted three-factor model between 7% and 16%, while 7 betas decrease from unadjusted betas of the unadjusted three-factor model between 1% and 17%. Especially for portfolio 14, rather than increases, its beta decreases. In

[6] Fama and French (1993) interpreted this premium as the financial distress premium.

other words, there is no discernible pattern of downwardly biased betas of the three-factor model.

Panel III shows the adjusted size coefficients ($\hat{s}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8A, only 2 adjusted size coefficients increase from unadjusted size coefficients of the unadjusted three-factor model between 3% and 8%, while 12 adjusted size coefficients decrease from unadjusted size coefficients of the unadjusted three-factor model between 1% and 26%. Remarkably, most size coefficients decrease, instead of changing unsystematically as expected, after adjusting for infrequent trading. Thus, there is a pattern indicating that size coefficients may be upwardly biased.

Panel IV shows the adjusted BM coefficients ($\hat{h}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8A, only 3 adjusted BM coefficients increase from unadjusted BM coefficients of the unadjusted three-factor model between 4% and 37%, while 9 adjusted BM coefficients decrease from unadjusted BM coefficients of the unadjusted three-factor model between 0.6% and 33%. Noticeably, most BM coefficients decrease, instead of changing unsystematically as expected, after adjusting for infrequent trading. Hence, like size coefficients, there is a pattern indicating that BM coefficients may be upwardly biased.

Panel V presents the adjusted-R^2 for the adjusted three-factor model. The adjusted-R^2s range from 38% to 95% and increase monotonically from smaller to bigger portfolios. However, compared with table 8A, the adjusted- R^2s of the adjusted three-factor model change from those of the unadjusted three-factor model only between 0.4% and 4%. Hence, the results suggest that the infrequent trading adjustment does not seem to increase much explanatory power of the adjusted three-factor model relative to the unadjusted three-factor model.

In table 10A, panel I presents the coefficients of differences between unadjusted alphas of the unadjusted three-factor model and adjusted alphas of the adjusted three-factor model ($\hat{\alpha}_{2p}$ or alpha-difference coefficient) for Thai firms. The results show that only the coefficient of portfolio 31 is statistically significant. However, the size of the absolute alpha-difference is fairly big ranging from 0.001% to 1.186% per month and the average absolute alpha-difference is about 0.577% per month or 6.924% per year. Hence, the alpha-differences of the three-factor model are economically significant though they are statistically insignificant.

Panel II reports the coefficients of differences between unadjusted betas of the unadjusted three-factor model and adjusted betas of the adjusted three-factor model ($\hat{b}_{2p}$ or beta-difference coefficient). The results show that there is no coefficient that is statistically significant. The size of the absolute beta-difference ranges from 0.018% to 0.217% per month and the average absolute beta-difference is about 0.097% per month or 1.164% per year. Hence, the beta-differences of the three-factor model are both statistically and economically insignificant.

Panel III shows the coefficients of differences between unadjusted size coefficients of the unadjusted three-factor model and adjusted size coefficients of the adjusted three-factor model ($\hat{s}_{2p}$ or size-difference coefficient). There is no coefficient that is statistically significant. The size of the absolute size-difference ranges from 0.001% to 0.206% per month and the average absolute size-difference is around 0.059% per month or 0.708% per year. Hence, the size-differences of the three-factor model are both statistically and economically insignificant.

Panel IV presents the coefficients of differences between unadjusted BM coefficients of the unadjusted three-factor model and adjusted BM coefficients of the adjusted three-factor model ($\hat{h}_{2p}$ or BM-difference coefficient). There is only the coefficient of portfolio 41 that is statistically significant. The size of the absolute BM-difference ranges from 0.006% to 0.130% per month and the average absolute BM-difference is around 0.062% per month or 0.744% per year. Hence, the BM-differences of the three-factor model are both statistically and economically insignificant.

Given the results of the adjusted alphas, betas, size coefficients and BM coefficients in table 9A and 10A, although most of the differences between the unadjusted and adjusted alphas and betas are statistically insignificant, the differences between the unadjusted and adjusted alphas are economically significant. In addition, though there is no discernible pattern that the unadjusted betas are downwardly biased, there is evidence indicating that the unadjusted alphas are upwardly biased. Thus, it seems worthwhile to adjust for the impact of infrequent trading on the alphas, betas, size coefficients and BM coefficients when using the three-factor model to estimate these parameters.

Table 8A The unadjusted parameters regressed from the unadjusted three-factor model: Thailand 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the unadjusted three-factor model: $R_{pt}–R_{ft} = \alpha_p+b_p(R_{mt}–R_{ft})+ s_pSMB_t+ h_pHML_t+ \varepsilon_{pt}$, where R_{pt} is the value weighted return on portfolio p for month t, R_{ft} is the risk free rate for month t, R_{mt} is the market return for month t, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t , SMB_t is the difference in returns between small and big portfolios for month t, and HML_t is the difference in returns between high-BM and low-BM portfolios for month t.

Panel I shows the unadjusted alpha ($\hat{\alpha}_p$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the unadjusted beta or the factor loading of the market factor ($\hat{b}_p$). Panel III shows the unadjusted size coefficient or the coefficient of the size factor ($\hat{s}_p$). Panel IV shows the unadjusted BM coefficient or the coefficient of the BM factor ($\hat{h}_p$). The t-statistic tests the significance of unadjusted alpha, beta, size coefficient and BM coefficient. Adjusted-R^2 for each portfolio is also shown in Panel V.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Unadjusted Alpha ($\hat{\alpha}_p$)				t ($\hat{\alpha}_p$)			
1	0.870	-1.179[b]	-1.111[a]	0.366	0.879	-2.148	-2.622	1.518
2	0.688	0.071	0.303	0.854[b]	0.953	0.122	0.839	2.269
3	-0.002	0.301	0.030	0.927[b]	-0.005	0.843	0.082	1.995
4	0.868[b]	0.000	0.398	-1.094	2.136	0.000	0.885	-1.404
Panel II	Unadjusted Beta ($\hat{b}_p$)				t ($\hat{b}_p$)			
1	1.335[a]	0.648[a]	1.032[a]	1.017[a]	6.290	6.563	12.001	32.543
2	0.897[a]	0.617[a]	0.825[a]	1.084[a]	8.450	5.262	10.858	19.045
3	0.878[a]	0.842[a]	0.997[a]	0.758[a]	7.648	9.386	12.423	9.755
4	0.989[a]	1.012[a]	1.070[a]	1.360[a]	11.097	22.626	11.340	6.933
Panel III	Unadjusted Size Coefficient ($\hat{s}_p$)				t ($\hat{s}_p$)			
1	1.171[a]	0.389[a]	0.574[a]	0.002	4.541	3.065	6.822	0.043
2	0.877[a]	0.335[b]	0.303[a]	-0.173[a]	5.580	2.125	3.656	-2.831
3	0.897[a]	0.457[a]	0.526[a]	-0.331[a]	6.158	4.689	11.571	-2.907
4	0.923[a]	0.737[a]	0.378[a]	0.079	9.230	13.301	3.190	0.619

Panel IV	Unadjusted BM Coefficient ($\hat{h}_p$)				t ($\hat{h}_p$)			
1	-0.659[c]	-0.008	0.357[b]	-0.293[a]	-1.853	-0.062	2.453	-7.886
2	-0.112	-0.030	0.126	0.120[b]	-0.691	-0.275	1.303	2.429
3	0.799[a]	0.250[b]	0.289[a]	0.510[a]	4.365	2.296	2.959	4.220
4	1.099[a]	1.187[a]	1.041[a]	0.852[a]	7.701	19.100	6.396	4.241

Panel V	Adjusted R^2 (%)			
1	45.23	41.32	71.52	94.96
2	47.09	39.99	64.44	90.67
3	61.81	70.11	79.44	82.19
4	84.51	88.55	83.40	69.29

[a] denotes statistically significant at 1% level of significance.
[b] denotes statistically significant at 5% level of significance.
[c] denotes statistically significant at 10% level of significance.

Table 9A The adjusted parameters regressed from the adjusted three-factor model: Thailand 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the adjusted three-factor model: $R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + s_p^{adj} SMB_t^{adj} + h_p^{adj} HML_t^{adj} + \varepsilon_{pt}$, where R_{pt}^{adj} is the value weighted return on portfolio p for month t adjusted for infrequent trading, R_{ft} is the risk free rate for month t, R_{mt}^{adj} is the market return for month t adjusted for infrequent trading, R_{pt}^{adj} -R_{ft} is the excess return on portfolio p for month t adjusted for infrequent trading, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading, SMB_t^{adj} is the difference in adjusted returns between small and big portfolios for month t, and HML_t^{adj} is the difference in adjusted returns between high-BM and low-BM portfolios for month t.

Panel I shows the adjusted alpha ($\hat{\alpha}_p^{adj}$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the adjusted beta or the factor loading of the market factor ($\hat{b}_p^{adj}$). Panel III shows the adjusted size coefficient or the coefficient of the size factor ($\hat{s}_p^{adj}$). Panel IV shows the adjusted BM coefficient or the coefficient of the BM factor ($\hat{h}_p^{adj}$). The t-statistic tests the significance of unadjusted alpha, beta, size coefficient and BM coefficient. Adjusted-R^2 for each portfolio is also shown in Panel V.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Adjusted Alpha ($\hat{\alpha}_p^{adj}$)				t ($\hat{\alpha}_p^{adj}$)			
1	0.151	-0.070	0.034	-0.003	0.131	-0.122	0.076	-0.014
2	-0.070	-0.077	-0.069	0.057	-0.094	-0.127	-0.173	0.163
3	0.000	-0.074	-0.013	-0.034	0.000	-0.203	-0.034	-0.063
4	-0.015	0.023	0.054	0.093	-0.033	0.064	0.098	0.125
Panel II	Adjusted Beta ($\hat{b}_p^{adj}$)				t ($\hat{b}_p^{adj}$)			
1	1.552[a]	0.742[a]	1.123[a]	0.986[a]	5.566	6.853	10.182	34.609
2	0.743[a]	0.715[a]	0.746[a]	1.209[a]	8.028	5.745	10.265	18.907
3	0.998[a]	0.728[a]	0.951[a]	0.876[a]	6.585	8.529	10.649	9.794
4	0.946[a]	1.086[a]	1.200[a]	1.342[a]	9.710	18.134	10.406	5.995
Panel III	Adjusted Size Coefficient ($\hat{s}_p^{adj}$)				t ($\hat{s}_p^{adj}$)			
1	1.201[a]	0.355[a]	0.544[a]	0.017	4.058	2.761	7.015	0.627
2	0.671[a]	0.267[b]	0.225[a]	-0.175[a]	5.535	1.960	3.450	-2.970
3	0.968[a]	0.352[a]	0.442[a]	-0.397[a]	5.717	4.073	10.320	-3.954
4	0.872[a]	0.728[a]	0.335[a]	0.027	9.051	12.688	2.808	0.224

Panel IV	Adjusted BM Coefficient ($\hat{h}_p^{adj}$)				t ($\hat{h}_p^{adj}$)			
1	-0.588[c]	-0.054	0.259[b]	-0.184[a]	-1.686	-0.380	2.021	-7.915
2	-0.075	-0.083	0.057	0.075[c]	-0.662	-0.732	0.823	1.669
3	0.828[a]	0.167[c]	0.245[a]	0.443[a]	4.607	1.890	2.722	4.812
4	1.024[a]	1.160[a]	1.036[a]	0.722[a]	8.039	16.731	5.195	3.561

Panel V	Adjusted R^2 (%)			
1	40.90	38.28	71.06	94.52
2	45.06	38.48	62.09	91.58
3	61.25	67.13	79.02	82.92
4	84.00	86.95	82.32	68.94

[a] denotes statistically significant at 1% level of significance.
[b] denotes statistically significant at 5% level of significance.
[c] denotes statistically significant at 10% level of significance.

Table 10A The differences between the unadjusted and adjusted three-factor model parameters: Thailand 1993-2005

This table presents the differences between the unadjusted and adjusted three-factor model parameters. The dummy variables are introduced in the three-factor model for the presence of infrequent trading adjustment: $R_{pt} - R_{ft} = \alpha_{1p} + \alpha_{2p}D_p + b_{1p}(R_{mt} - R_{ft}) + b_{2p}(R_{mt}^{adj} - R_{ft})D_p + s_{1p}SMB_t + s_{2p}SMB_t^{adj}D_p + h_{1p}\ HML_t + h_{2p}HML_t^{adj}D_p + \varepsilon_{pt}$, where, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading, SMB_t is the difference in returns between small and big portfolios for month t, SMB_t^{adj} is the difference in adjusted returns between small and big portfolios for month t, HML_t is the difference in returns between high-BM and low-BM portfolios for month t, HML_t^{adj} is the difference in adjusted returns between high-BM and low-BM portfolios for month t, and D_p is 1 for adjusted return on portfolio p for month t ,or 0 for unadjusted return on portfolio p for month t.

Panel I shows the alpha-difference coefficient ($\hat{\alpha}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted alphas. Panel II shows the beta-difference coefficient ($\hat{b}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted betas. Panel III shows the size-difference coefficient ($\hat{s}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted size factors. Panel IV shows the BM-difference coefficient ($\hat{h}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted BM factors. The t-statistic tests the null hypothesis that is the unadjusted parameters regressed from the unadjusted three-factor model are statistically different from the adjusted parameters regressed from the adjusted three-factor model.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Alpha-Difference Coefficient ($\hat{\alpha}_{2p}$)				t ($\hat{\alpha}_{2p}$)			
1	-0.721	1.109	1.143[c]	-0.370	-0.513	1.415	1.856	-1.058
2	-0.759	-0.148	-0.373	-0.797	-0.727	-0.178	-0.707	-1.530
3	0.001	-0.376	-0.044	-0.961	0.001	-0.742	-0.083	-1.331
4	-0.884	0.022	-0.344	1.186	-1.482	0.049	-0.490	1.155
Panel II	Beta-Difference Coefficient ($\hat{b}_{2p}$)				t ($\hat{b}_{2p}$)			
1	0.217	0.095	0.092	-0.030	0.617	0.631	0.663	-0.695
2	-0.154	0.098	-0.080	0.125	-1.137	0.566	-0.741	1.415
3	0.120	-0.114	-0.046	0.118	0.638	-0.914	-0.373	0.965
4	-0.042	0.074	0.130	-0.018	-0.320	0.987	0.868	-0.060
Panel III	Size-Difference Coefficient ($\hat{s}_{2p}$)				t ($\hat{s}_{2p}$)			
1	0.029	-0.035	-0.030	0.015	0.073	-0.189	-0.271	0.293
2	-0.206	-0.068	-0.078	-0.001	-1.033	-0.316	-0.739	-0.018
3	0.071	-0.106	-0.083	-0.066	0.319	-0.804	-1.349	-0.423
4	-0.051	-0.009	-0.043	-0.052	-0.366	-0.117	-0.255	-0.285

Panel IV	BM-Difference Coefficient ($\hat{h}_{2p}$)				t ($\hat{h}_{2p}$)			
1	0.071	-0.045	-0.098	0.109[b]	0.142	-0.233	-0.495	2.519
2	0.036	-0.053	-0.069	-0.045	0.184	-0.334	-0.579	-0.673
3	0.029	-0.083	-0.045	-0.067	0.112	-0.578	-0.328	-0.434
4	-0.074	-0.027	-0.006	-0.130	-0.389	-0.286	-0.022	-0.454

[b] denotes statistically significant at 5% level of significance.

[c] denotes statistically significant at 10% level of significance.

4.3 Descriptive statistics for the nine and sixteen portfolios of the Singaporean market

Not only Thai firms, I also use Singaporean firms to provide a comparison sample in this thesis because Singapore is in the same regional market but more developed**.** Hence, the problem of infrequent trading is expected to be less severe in Singapore than in Thailand. Empirical evidence shows that, on average, the turnover of the Singaporean market is higher than that of the Thai market. Thus, as expected, the Singaporean market has more liquidity than the Thai market (see Appendix C).

Table 1B presents descriptive statistics for the nine portfolios formed on firm size and BM of the Singaporean market. The results show much like those of Thai firms in table 1A. Big firms represent 89.07% of the total market capitalization of the entire market while the small firms represent only 2.40%. Hence, it is clear that big firms are obviously distinguished from small firms. The average BM of the low-BM firms is 0.43 while the average BM of the high-BM firms is 1.65. Thus, low-BM firms are also apparently distinguished from high-BM firms. For average number of firms, 48 firms in the small and high-BM portfolio represent only 0.76% of the total market capitalization whereas 50 firms in the big and low-BM portfolio represent about 45.85%. This result confirms that firms in each portfolio substantially differ in both size and BM dimensions.

For the average unadjusted return, instead of the small and high-BM portfolio, the big and high BM portfolio has the highest average unadjusted return at 1.52% per month. On average, the average unadjusted returns on the high-BM portfolios are higher than those of the low-BM portfolios. However, there is no clear relation between firm size and average unadjusted return.

Table 2B shows descriptive statistics for the sixteen portfolios formed on firm size and BM. The results are in line with those of table 1B and much like those of

Thai firms in table 2A. Big firms represent 85.09% of the total market capitalization of the entire market while small firms represent only 1.32%. The average BM of the low-BM firms is 0.34 while the average BM of the high-BM firms is 1.95. For average number of firms, 21 firms in the small and high-BM (14) portfolio represent only 0.35% of the total market capitalization whereas 25 firms in the big and low-BM (41) portfolio represent about 34.87%. The bottom of table 2B also suggests that there is no clear relation between firm size and average unadjusted return, but the positive relation between BM and average unadjusted return.

Table 3B summarizes the autocorrelation coefficients (AC) for the first 12 lags of unadjusted portfolio returns for Singaporean firms. There are 14 portfolios that have the serial correlation problem in portfolio returns (significant at 5%) while the market portfolio returns are not serially correlated. The small portfolios seem to have more severe problem than the big portfolios. These results imply that if we directly use the unadjusted returns to estimate the parameters, namely the alpha and the beta, their statistic values, such as standard errors, may be biased and wrongly lead to the acceptance or rejection of the significance of these estimated parameters hypothesis.

Table 4B summarizes the autocorrelation coefficients (AC) for the first 12 lags of adjusted portfolio returns for Singaporean firms. Compared with table 3B, a number of portfolios having the serial correlation problem decrease from 14 to 10. Especially for portfolio 12 of which its returns of the entire 12 lags are serially correlated before adjusting for infrequent trading, its returns do not serially correlated after taking infrequent trading into account. Hence, the Miller et al. (1994) method seems to alleviate the problem of serial correlation in portfolio returns in Singapore. However, it should be noted that the serial correlation in portfolio returns still remains after adjusting for infrequent trading. That is, the serial correlation problem cannot be distributed only to infrequent trading (see e.g. Miller et al., (1994); Clare et al., 2002). The implication is that if we use the adjusted returns to estimate the parameters, namely the alpha and the beta, their statistic values, such as standard errors, may be less biased relative to those estimated from the unadjusted returns and the acceptance or rejection of the significance of these parameters hypothesis is likely to be more accurate.

Table 1B Descriptive statistics for 9 portfolios formed on firm size and book-to-market equity: Singapore 1993-2005

The nine size-BM portfolios are formed based on independent sorts on firm size (market capitalization) and on book-to-market equity (BM). Only firms with non-negative book value of equity (B) are included. Market value of equity (M) is the share price multiplied by the number of ordinary stocks in issue. Book value of equity (B) represents common shareholders' investment in a firm excluding common treasury stock value and accumulated unpaid preferred dividends.

The market, size and book-to-market equity factors used as independent variables in the regressions are calculated from these portfolios as follows. At the end of June each year t, I form three-size groups based on end-of-June market value of equity (M) and breakpoints at the 35th and 65th percentiles of ranked M, which resulted in three groups - small, moderate, and big size. I form book-to-market equity (BM) groups based on BM of the fiscal year ending in year t-1. Breakpoints are set at the 40th and 60th percentiles, which resulted in three groups - low, medium, and high BM.

For the nine portfolios (S/L, S/M, S/H, M/L, M/M, M/H, B/L, B/M, B/H) resulting from the intersection of these independent sorts, I calculate value-weighted monthly returns during a 12-month period from July of year t to June of year t+1. These are the portfolios that allowed us to calculate the Fama and French (1993) SMB (small minus big) and HML (high minus low) factors, where SMB is the simple average of the returns on the three small portfolios (S/L, S/M and S/H) minus the simple average of the returns on the three big portfolios (B/L, B/M and B/H) and HML is the simple average of the returns on the three high-BM portfolios (S/H, M/H and B/H) minus the simple average of the returns on the three low-BM portfolios (S/L, M/L and B/L).

The descriptive statistics are computed when the portfolios are formed in June of each year, 1993-2005, and are then averaged across the 13 years.

	Firm size						
BM	Small	Moderate	Big	Small	Moderate	Big	Average
	Percent of average M (%)			Average BM			
Low	0.83	2.85	45.85	0.46	0.44	0.40	0.43
Medium	0.81	2.97	27.16	0.85	0.85	0.85	0.85
High	0.76	2.71	16.06	1.68	1.71	1.57	1.65
Total	2.40	8.53	89.07				
	Average number of firms			Average Unadjusted return (%)			
Low	33	35	50	0.90	0.27	0.48	
Medium	22	17	19	0.46	0.64	1.06	
High	48	36	34	1.15	0.87	1.52	

Table 2B Descriptive statistics for 16 portfolios formed on firm size and book-to-market equity: Singapore 1993-2005

The sixteen size-BM portfolios are formed based on independent sorts on firm size (market capitalization) and on book-to-market equity (BM). Only firms with non-negative book value of equity (B) are included. Market value of equity (M) is the share price multiplied by the number of ordinary stocks in issue. Book value of equity (B) represents common shareholders' investment in a firm excluding common treasury stock value and accumulated unpaid preferred dividends.

The excess returns on the sixteen portfolios used as dependent variables in the regressions are calculated from these portfolios as follows. At the end of June each year t, I form four-size groups based on end-of-June market value of equity (M) which resulted in four groups – 1 (small), 2, 3, and 4 (big) size. I form book-to-market equity (BM) groups based on BM of the fiscal year ending in year t-1. Breakpoints are set at the four size quartiles, which resulted in four groups – 1 (low), 2, 3, and 4 (high) BM.

For the sixteen portfolios resulting from the intersection of these independent sorts, I calculate value-weighted monthly returns during a 12-month period from July of year t to June of year t+1. These are the portfolios that allowed us to calculate portfolio returns. The excess returns on the sixteen portfolios are calculated as the portfolio returns deducted by the risk free rate.

The descriptive statistics are computed when the portfolios are formed in June of each year, 1993-2005, and are then averaged across the 13 years.

	Firm size								
BM	1	2	3	4	1	2	3	4	Average
	Percent of average M (%)				Average BM				
1	0.32	1.01	2.39	34.87	0.35	0.36	0.33	0.30	0.34
2	0.33	0.96	2.47	26.30	0.67	0.67	0.68	0.65	0.67
3	0.32	0.95	2.47	12.75	1.06	1.04	1.05	1.05	1.05
4	0.35	1.02	2.32	11.17	2.11	1.86	2.04	1.78	1.95
Total	1.32	3.94	9.65	85.09					
	Average number of firms				Average Unadjusted return (%)				
1	13	15	21	25	0.88	-0.05	0.26	0.47	
2	17	20	17	19	1.30	0.12	0.55	0.86	
3	23	19	16	16	0.89	0.35	0.96	1.06	
4	21	20	20	14	1.20	1.04	1.14	1.49	

Table 3B The Autocorrelation coefficients (AC) of the unadjusted portfolio returns: Singapore 1993-2005

This table presents the autocorrelation coefficients (AC) for the first 12 lags of the unadjusted portfolio returns. The p-value based on Q-statistic tests the serial correlation problem induced by infrequent trading in portfolio returns. If the p-value is higher than 0.05, the null hypothesis that is the unadjusted portfolio returns do not serially correlated cannot be rejected.

Lag	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio												
11	0.214[a]	0.092[a]	0.015[a]	-0.035	0.014	0.030	0.006	0.030	-0.160	-0.140	-0.163[a]	-0.067[a]
	(0.008)	(0.015)	(0.039)	(0.073)	(0.126)	(0.189)	(0.272)	(0.352)	(0.161)	(0.093)	(0.038)	(0.046)
12	0.261[a]	0.073[a]	-0.067[a]	-0.109[a]	-0.050[a]	0.054[a]	0.139[a]	0.150[a]	-0.149[a]	-0.190[a]	-0.168[a]	-0.115[a]
	(0.001)	(0.004)	(0.008)	(0.008)	(0.014)	(0.023)	(0.013)	(0.006)	(0.003)	(0.001)	(0.000)	(0.000)
13	0.207[a]	0.071[a]	-0.097[a]	-0.100[a]	-0.016	0.093	0.123[a]	0.186[a]	-0.147[a]	-0.154[a]	-0.205[a]	-0.138[a]
	(0.010)	(0.025)	(0.032)	(0.035)	(0.065)	(0.067)	(0.048)	(0.011)	(0.006)	(0.003)	(0.000)	(0.000)
14	0.050	0.081	-0.051	0.000	0.001	0.039	0.098	0.145	-0.147	-0.119	-0.108	-0.077
	(0.533)	(0.495)	(0.612)	(0.770)	(0.874)	(0.915)	(0.826)	(0.539)	(0.312)	(0.235)	(0.195)	(0.205)
21	0.066	0.153	-0.099	-0.060	-0.034	0.050	0.169	0.109	-0.073	-0.094	-0.179[a]	-0.121[a]
	(0.414)	(0.118)	(0.122)	(0.174)	(0.257)	(0.326)	(0.119)	(0.099)	(0.113)	(0.108)	(0.034)	(0.025)
22	0.165[a]	0.056	-0.180[a]	-0.098[a]	-0.051[a]	0.092[a]	0.213[a]	0.191[a]	-0.167[a]	-0.141[a]	-0.212[a]	-0.118[a]
	(0.042)	(0.099)	(0.022)	(0.025)	(0.041)	(0.044)	(0.005)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
23	0.226[a]	0.046[a]	-0.124[a]	-0.106[a]	-0.021[a]	0.062[a]	0.238[a]	0.089[a]	-0.208[a]	-0.161[a]	-0.178[a]	-0.130[a]
	(0.005)	(0.017)	(0.015)	(0.015)	(0.030)	(0.044)	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
24	0.067	0.217[a]	-0.123[a]	0.081[a]	-0.034[a]	0.097[a]	0.037	0.015	-0.164[a]	-0.087[a]	-0.152[a]	-0.059[a]
	(0.405)	(0.019)	(0.016)	(0.024)	(0.043)	(0.044)	(0.068)	(0.105)	(0.041)	(0.043)	(0.020)	(0.026)
31	0.152	0.046	-0.088	-0.113	-0.053	0.034	0.253[a]	0.130[a]	-0.140[a]	-0.100[a]	-0.198[a]	-0.130[a]
	(0.061)	(0.146)	(0.168)	(0.132)	(0.186)	(0.261)	(0.013)	(0.008)	(0.005)	(0.005)	(0.001)	(0.001)
32	0.182[a]	0.069	-0.153[a]	-0.145[a]	-0.067[a]	0.088[a]	0.192[a]	0.117[a]	-0.118[a]	-0.191[a]	-0.182[a]	-0.106[a]
	(0.024)	(0.055)	(0.024)	(0.013)	(0.020)	(0.023)	(0.005)	(0.004)	(0.003)	(0.001)	(0.000)	(0.000)

57

33	0.156	0.018	-0.098	-0.084	-0.067	0.108	0.248[a]	0.211[a]	-0.236[a]	-0.179[a]	-0.240[a]	-0.118[a]
	(0.054)	(0.153)	(0.155)	(0.175)	(0.217)	(0.179)	(0.009)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
34	0.152	0.047	-0.116	-0.068	-0.054	0.115	0.239[a]	0.218[a]	-0.179[a]	-0.167[a]	-0.202[a]	-0.091[a]
	(0.060)	(0.143)	(0.113)	(0.153)	(0.210)	(0.160)	(0.010)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
41	-0.110	0.208[a]	-0.158[a]	0.092[a]	-0.035[a]	0.008[a]	0.042[a]	0.037[a]	0.005	0.009	-0.162	0.054
	(0.172)	(0.014)	(0.006)	(0.008)	(0.016)	(0.030)	(0.047)	(0.071)	(0.107)	(0.153)	(0.066)	(0.083)
42	0.095	0.068	-0.006	-0.017	-0.034	-0.022	0.096	0.119	-0.104	-0.065	-0.133	0.003
	(0.242)	(0.353)	(0.554)	(0.711)	(0.804)	(0.880)	(0.797)	(0.631)	(0.545)	(0.572)	(0.405)	(0.489)
43	0.037	-0.064	-0.132	-0.083	-0.098	0.172	0.203[a]	0.151[a]	-0.174[a]	-0.142[a]	-0.135[a]	-0.086[a]
	(0.646)	(0.657)	(0.315)	(0.328)	(0.294)	(0.094)	(0.015)	(0.007)	(0.002)	(0.001)	(0.001)	(0.001)
44	0.090	-0.040	-0.133	0.038	-0.066	0.122	0.201[a]	0.171[a]	-0.209[a]	-0.143[a]	-0.165[a]	-0.059[a]
	(0.266)	(0.477)	(0.240)	(0.350)	(0.400)	(0.278)	(0.052)	(0.017)	(0.002)	(0.001)	(0.000)	(0.001)
m	0.025	0.155	-0.075	0.030	-0.020	0.063	0.098	0.060	-0.107	-0.083	-0.180	0.009
	(0.762)	(0.149)	(0.196)	(0.306)	(0.430)	(0.480)	(0.426)	(0.473)	(0.397)	(0.393)	(0.147)	(0.198)

Figures in parentheses are the p-values based on Q-statistics.
[a] denotes statistically significant at 5% level of significance.
m represents the market portfolio.

58

Table 4B The Autocorrelation coefficients (AC) of the adjusted portfolio returns: Singapore 1993-2005

This table presents the autocorrelation coefficients (AC) for the first 12 lags of the adjusted portfolio returns. The p-value based on Q-statistic tests the serial correlation problem induced by infrequent trading in portfolio returns. If the p-value is higher than 0.05, the null hypothesis that is the adjusted portfolio returns do not serially correlated cannot be rejected.

Lag	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio												
11	-0.012	0.048	-0.008	-0.042	0.006	0.024	-0.009	0.074	-0.148	-0.078	-0.131	-0.029
	(0.880)	(0.828)	(0.943)	(0.956)	(0.985)	(0.993)	(0.998)	(0.990)	(0.822)	(0.805)	(0.631)	(0.699)
12	-0.001	0.029	-0.065	-0.093	-0.037	0.038	0.102	0.174	-0.159	-0.130	-0.107	-0.089
	(0.991)	(0.938)	(0.853)	(0.711)	(0.798)	(0.859)	(0.754)	(0.340)	(0.158)	(0.105)	(0.089)	(0.089)
13	-0.008	0.053	-0.101	-0.083	-0.026	0.082	0.073	0.211	-0.169	-0.091	-0.159[a]	-0.100[a]
	(0.925)	(0.804)	(0.569)	(0.543)	(0.669)	(0.641)	(0.646)	(0.141)	(0.052)	(0.052)	(0.022)	(0.021)
14	-0.003	0.082	-0.054	0.004	0.003	0.033	0.090	0.147	-0.149	-0.107	-0.099	-0.065
	(0.975)	(0.595)	(0.685)	(0.828)	(0.914)	(0.948)	(0.890)	(0.604)	(0.354)	(0.296)	(0.265)	(0.292)
21	-0.013	0.155	-0.110	-0.056	-0.046	0.044	0.158	0.111	-0.081	-0.077	-0.167	-0.103
	(0.871)	(0.156)	(0.135)	(0.195)	(0.270)	(0.350)	(0.154)	(0.125)	(0.134)	(0.146)	(0.058)	(0.052)
22	-0.004	0.061	-0.183	-0.064	-0.051	0.069	0.178	0.193[a]	-0.184[a]	-0.085[a]	-0.180[a]	-0.084[a]
	(0.962)	(0.751)	(0.127)	(0.174)	(0.239)	(0.276)	(0.085)	(0.018)	(0.004)	(0.005)	(0.001)	(0.002)
23	0.000	0.026	-0.124	-0.083	-0.017	0.019	0.228	0.095	-0.217[a]	-0.086[a]	-0.127[a]	-0.101[a]
	(0.995)	(0.949)	(0.477)	(0.469)	(0.608)	(0.722)	(0.104)	(0.101)	(0.013)	(0.015)	(0.010)	(0.009)
24	-0.016	0.222[a]	-0.146[a]	0.093[a]	-0.053[a]	0.099[a]	0.030[a]	0.026	-0.162[a]	-0.066[a]	-0.143[a]	-0.047[a]
	(0.842)	(0.022)	(0.012)	(0.016)	(0.027)	(0.027)	(0.045)	(0.071)	(0.028)	(0.036)	(0.019)	(0.027)
31	-0.005	0.038	-0.083	-0.097	-0.046	0.007	0.239	0.121	-0.152[a]	-0.052[a]	-0.171[a]	-0.088[a]
	(0.953)	(0.893)	(0.731)	(0.600)	(0.687)	(0.797)	(0.095)	(0.070)	(0.033)	(0.045)	(0.015)	(0.016)
32	-0.008	0.069	-0.150	-0.113	-0.061	0.071	0.167	0.112	-0.113	-0.148[a]	-0.139[a]	-0.068[a]
	(0.921)	(0.691)	(0.241)	(0.185)	(0.238)	(0.272)	(0.101)	(0.082)	(0.066)	(0.034)	(0.019)	(0.024)

59

33	0.000	0.010	-0.093	-0.062	-0.076	0.085	0.209	0.221[a]	-0.254[a]	-0.111[a]	-0.205[a]	-0.076[a]
	(1.000)	(0.992)	(0.719)	(0.748)	(0.727)	(0.680)	(0.142)	(0.017)	(0.001)	(0.001)	(0.000)	(0.000)
34	-0.003	0.044	-0.118	-0.045	-0.062	0.091	0.199	0.218[a]	-0.194[a]	-0.117[a]	-0.172[a]	-0.069[a]
	(0.971)	(0.863)	(0.488)	(0.602)	(0.648)	(0.591)	(0.143)	(0.018)	(0.004)	(0.003)	(0.001)	(0.001)
41	0.020	0.183	-0.129	0.072	-0.027	0.009	0.048	0.044	0.009	-0.009	-0.158	0.019
	(0.804)	(0.075)	(0.051)	(0.073)	(0.123)	(0.192)	(0.249)	(0.312)	(0.403)	(0.495)	(0.264)	(0.332)
42	-0.006	0.061	-0.011	-0.013	-0.031	-0.028	0.088	0.122	-0.111	-0.044	-0.129	0.019
	(0.944)	(0.751)	(0.898)	(0.961)	(0.979)	(0.989)	(0.952)	(0.807)	(0.688)	(0.743)	(0.573)	(0.652)
43	0.005	-0.061	-0.126	-0.076	-0.095	0.169	0.193[a]	0.145[a]	-0.174[a]	-0.130[a]	-0.128[a]	-0.079[a]
	(0.954)	(0.748)	(0.385)	(0.416)	(0.376)	(0.132)	(0.028)	(0.014)	(0.004)	(0.003)	(0.002)	(0.002)
44	0.006	-0.034	-0.135	0.057	-0.074	0.110	0.178	0.169[a]	-0.210[a]	-0.112[a]	-0.150[a]	-0.047[a]
	(0.938)	(0.912)	(0.394)	(0.480)	(0.501)	(0.397)	(0.127)	(0.045)	(0.006)	(0.005)	(0.003)	(0.004)
m	-0.006	0.156	-0.081	0.033	-0.024	0.062	0.095	0.062	-0.107	-0.075	-0.178	0.016
	(0.945)	(0.153)	(0.191)	(0.296)	(0.415)	(0.469)	(0.426)	(0.470)	(0.393)	(0.405)	(0.158)	(0.210)

Figures in parentheses are the p-values based on Q-statistics.
[a] denotes statistically significant at 5% level of significance.
m represents the market portfolio.

4.4 Impacts of infrequent trading on the asset pricing model parameters in Singapore

4.4.1 The CAPM

In table 5B, panel I presents the unadjusted alphas ($\hat{\alpha}_p$) regressed from the unadjusted CAPM for Singaporean firms. Unlike the Thai market, there is no mispricing evidence of portfolio 14 and only 2 unadjusted alphas of portfolios 43 and 44 are statistically significant in the Singaporean market. One possible reason is that the Singaporean market is more developed and likely to have less severe infrequent trading problem than the Thai market.

Panel II shows the unadjusted betas ($\hat{b}_p$) regressed from the unadjusted CAPM. All unadjusted betas are statistically significant at 1% and the distribution of unadjusted betas is in narrow range, only between 0.891 and 1.307. The relation between unadjusted beta and firm size, as well as unadjusted beta and BM, is not discernible.

Panel III reports the adjusted-R^2 for the unadjusted CAPM. The adjusted-R^2s range from 29% to 81% and increase monotonically from smaller to bigger portfolios. Except those of the small portfolios, the adjusted-R^2s of all portfolios value from 60% to 80%. For the small portfolios, their adjusted-R^2s are between 29% and 48% which are significantly lower than those of the other bigger portfolios. The possible explanation is that the small portfolios do not move synchronously with the market portfolio due to infrequent trading.

In table 6B, panel I reports the adjusted alphas ($\hat{\alpha}_p^{adj}$) regressed from the adjusted CAPM for Singaporean firms. The results show that all adjusted alphas are not statistically significant. Accordingly, the mispricing evidence of portfolios 43 and 44 disappears after adjusting for infrequent trading. Like the Thai market, the results seem to confirm the pattern of upwardly biased alphas for infrequently traded stocks as in Scholes and Williams (1977).

Panel II shows the adjusted betas ($\hat{b}_p^{adj}$) regressed from the adjusted CAPM. Compared with table 5B, 15 adjusted betas increase from unadjusted betas of the unadjusted CAPM between 1% and 28%, while the only 1 adjusted beta of portfolio 41 decreases from that of the unadjusted CAPM about 12%. Like the Thai market, the results seem to be in accordance with the pattern of downwardly biased betas of infrequently traded stocks as in Scholes and Williams (1977) and Dimson (1979).

Panel III summarizes the adjusted-R^2 for the adjusted CAPM. The adjusted-R^2s range from 26% to 80% and increase monotonically from smaller to bigger portfolios. Compared with table 5B, the adjusted-R^2s of 4 portfolios of the adjusted CAPM increase from those of the unadjusted CAPM between 0.2% and 1%, whereas the others decrease from those of the unadjusted CAPM between 0.4% and 3%. Hence, adjusting for infrequent trading does not seem to increase much explanatory power to the unadjusted CAPM.

In table 7B, panel I presents the alpha-difference coefficients of the CAPM ($\hat{\alpha}_{2p}$) for Singaporean firms. The result shows that only the coefficient of portfolio 44 is statistically significant. That is, most unadjusted alphas are not significantly different from adjusted alphas. However, the size of the absolute alpha-difference is rather big ranging from 0.028% to 0.927% per month and the average absolute alpha-difference is about 0.437% per month or 5.244% per year. Hence, the alpha-differences of the CAPM are economically significant though they are statistically insignificant.

Panel II shows the beta-difference coefficients of the CAPM ($\hat{b}_{2p}$). There is no coefficient that is statistically significant. The size of the absolute beta-difference ranges from 0.016% to 0.291% per month and the average absolute beta-difference is around 0.141% per month or 1.692% per year. Hence, the beta-differences of the CAPM are both statistically and economically insignificant.

Considering the results of adjusted alphas and betas in table 6B and 7B, although most of the differences between unadjusted and adjusted alphas and betas are statistically insignificant, the differences between unadjusted and adjusted alphas are economically significant. In addition, there is a pattern that the unadjusted alphas may be upwardly biased and the unadjusted betas may be downwardly biased. Hence, like the Thai market, it seems worthwhile to adjust for the impact of infrequent trading on the alphas and betas when using the CAPM to estimate these parameters in Singapore.

Table 5B The unadjusted parameters regressed from the unadjusted CAPM: Singapore 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the unadjusted CAPM: $R_{pt} – R_{ft} = \alpha_p + b_p(R_{mt} – R_{ft}) + \varepsilon_{pt}$, where R_{pt} is the value weighted return on portfolio p for month t, R_{ft} is the risk free rate for month t, R_{mt} is the market return for month t, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t. Panel I shows the unadjusted alpha ($\hat{\alpha}_p$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the unadjusted beta or the factor loading of the market factor ($\hat{b}_p$). The t-statistic tests the significance of unadjusted alpha and beta. Adjusted-R^2 for each portfolio is also shown in Panel III.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Unadjusted Alpha ($\hat{\alpha}_p$)				t ($\hat{\alpha}_p$)			
1	0.362	-0.573	-0.210	0.067	0.353	-0.992	-0.513	0.275
2	0.847	-0.391	0.069	0.371	1.094	-0.810	0.168	1.309
3	0.358	-0.139	0.445	0.585[c]	0.518	-0.298	0.922	1.723
4	0.681	0.568	0.619	0.974[a]	1.218	1.201	1.245	2.713
Panel II	Unadjusted Beta ($\hat{b}_p$)				t ($\hat{b}_p$)			
1	1.257[a]	1.291[a]	1.112[a]	0.891[a]	6.439	14.712	12.187	12.328
2	1.048[a]	1.250[a]	1.140[a]	1.161[a]	5.681	10.438	9.359	13.616
3	1.307[a]	1.190[a]	1.262[a]	1.134[a]	5.653	9.804	7.449	9.347
4	1.265[a]	1.114[a]	1.272[a]	1.285[a]	6.202	7.643	8.270	7.935
Panel III	Adjusted R^2 (%)							
1	28.81	62.75	66.90	76.45				
2	34.50	60.71	62.00	80.86				
3	44.91	62.53	64.09	67.16				
4	47.72	59.03	62.93	65.16				

[a] denotes statistically significant at 1% level of significance.
[c] denotes statistically significant at 10% level of significance.

Table 6B The adjusted parameters regressed from the adjusted CAPM: Singapore 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the adjusted CAPM: $R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + \varepsilon_{pt}$, where R_{pt}^{adj} is the value weighted return on portfolio p for month t adjusted for infrequent trading, R_{ft} is the risk free rate for month t, R_{mt}^{adj} is the market return for month t adjusted for infrequent trading, R_{pt}^{adj}-R_{ft} is the excess return on portfolio p for month t adjusted for infrequent trading, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading. Panel I shows the adjusted alpha ($\hat{\alpha}_p^{adj}$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the adjusted beta or the factor loading of the market factor ($\hat{b}_p^{adj}$). The t-statistic tests the significance of adjusted alpha and beta. Adjusted-R^2 for each portfolio is also shown in Panel III.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Adjusted Alpha ($\hat{\alpha}_p^{adj}$)				t ($\hat{\alpha}_p^{adj}$)			
1	0.058	0.044	0.033	-0.028	0.053	0.074	0.074	-0.120
2	0.043	0.054	0.041	0.031	0.050	0.103	0.087	0.109
3	0.070	0.057	0.055	0.019	0.090	0.111	0.103	0.054
4	0.037	0.020	0.056	0.046	0.060	0.040	0.103	0.115
Panel II	Adjusted Beta ($\hat{b}_p^{adj}$)				t ($\hat{b}_p^{adj}$)			
1	1.458[a]	1.348[a]	1.254[a]	0.784[a]	6.171	14.537	13.089	12.949
2	1.340[a]	1.428[a]	1.322[a]	1.249[a]	6.306	11.284	10.415	12.992
3	1.552[a]	1.452[a]	1.434[a]	1.150[a]	5.852	10.633	8.064	9.368
4	1.292[a]	1.160[a]	1.442[a]	1.364[a]	6.247	7.585	8.780	8.178
Panel III	Adjusted R^2 (%)							
1	26.33	63.12	65.86	77.45				
2	34.74	59.72	60.66	81.32				
3	43.70	61.73	63.47	67.45				
4	47.21	58.68	62.50	64.44				

[a] denotes statistically significant at 1% level of significance.

Table 7B The differences between the unadjusted and adjusted CAPM parameters: Singapore 1993-2005

This table presents the differences between the unadjusted and adjusted CAPM parameters. The dummy variables are introduced in the CAPM for the presence of infrequent trading adjustment: $R_{pt} - R_{ft} = \alpha_{1p}+\alpha_{2p}D_p+ b_{1p}(R_{mt} - R_{ft})+ b_{2p}(R_{mt}^{adj} - R_{ft})D_p + \varepsilon_{pt}$, where, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading, and D_p is 1 for adjusted return on portfolio p for month t ,or 0 for unadjusted return on portfolio p for month t. Panel I shows the alpha-difference coefficient ($\hat{\alpha}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted alphas. Panel II shows the beta-difference coefficient ($\hat{b}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted betas. The t-statistic tests the null hypothesis that is the unadjusted parameters regressed from the unadjusted CAPM are statistically different from the adjusted parameters regressed from the adjusted CAPM.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Alpha-Difference Coefficient ($\hat{\alpha}_{2p}$)				t ($\hat{\alpha}_{2p}$)			
1	-0.305	0.618	0.242	-0.094	-0.205	0.741	0.420	-0.290
2	-0.804	0.446	-0.028	-0.340	-0.715	0.644	-0.047	-0.884
3	-0.287	0.196	-0.390	-0.566	-0.283	0.285	-0.547	-1.227
4	-0.644	-0.548	-0.564	-0.927[c]	-0.780	-0.808	-0.789	-1.782
Panel II	Beta-Difference Coefficient ($\hat{b}_{2p}$)				t ($\hat{b}_{2p}$)			
1	0.201	0.058	0.142	-0.107	0.656	0.453	1.077	-1.132
2	0.291	0.178	0.183	0.088	1.041	1.030	1.050	0.667
3	0.245	0.262	0.171	0.016	0.695	1.440	0.711	0.093
4	0.026	0.045	0.170	0.079	0.092	0.210	0.753	0.341

[c] denotes statistically significant at 10% level of significance.

4.4.2 The Fama and French (1993) three-factor model

In table 8B, panel I summarizes the unadjusted alphas ($\hat{\alpha}_p$) regressed from the unadjusted three-factor model for Singaporean firms. The results show that only 2 unadjusted alphas of portfolios 12 and 41 are statistically significant. Surprisingly, the mispricing evidence appears in portfolio 41 when using the unadjusted three-factor model to estimate the alpha while there is no mispricing evidence of this portfolio when using the unadjusted CAPM to estimate[7]. However, like the unadjusted CAPM, the mispricing evidence of portfolio 14 does not exist.

Panel II presents the unadjusted betas ($\hat{b}_p$) regressed from the unadjusted three-factor model. The results are in line with the unadjusted betas of the unadjusted CAPM in table 5B and much like those of Thai firms in table 8A. Specifically, all unadjusted betas are statistically significant at 1% and there is no discernible pattern between unadjusted beta and firm size, as well as unadjusted beta and BM.

Panel III shows the unadjusted size coefficients ($\hat{s}_p$) regressed from the unadjusted three-factor model. The results suggest that, like the Thai market, there is a negative relation between unadjusted size coefficient and firm size. The unadjusted size coefficients of the small portfolios, which are greater than 1, seem to be different from those of the big portfolios, which are less than 0.4.

Panel IV presents the unadjusted BM coefficients ($\hat{h}_p$) regressed from the unadjusted three-factor model. The results show that unadjusted BM coefficients appear to increase with BM as in the Thai market. Specifically, there are strongly

[7] These findings have not occurred in the US and UK, hence to test this pattern of the big and low-BM portfolio and find out the reason for explaining it in other Asia Pacific countries is interesting. But, this issue is beyond the scope of this thesis. Hence, I leave it for further research and hope that it will be fruitful for further research.

negative BM coefficients for low-BM portfolios, but strongly positive BM coefficients for high-BM portfolios.

Panel V reports adjusted-R^2 for the unadjusted three-factor model. The adjusted-R^2s are between 73% and 90%. Given the strong size and BM coefficients, it is not surprising that adding these two factors to the regressions results in large increasing of adjusted-R^2 compared with those of the unadjusted CAPM. For the small portfolios, the adjusted-R^2 significantly increase from 29%-48%, in case of the unadjusted CAPM, to 73%-90%, in case of the unadjusted three-factor model. Especially for portfolio 14, its adjusted-R^2 increases from 48% to 85%.

In table 9B, panel I reports the adjusted alphas ($\hat{\alpha}_p^{adj}$) regressed from the adjusted three-factor model for Singaporean firms. As expected, all alphas or abnormal returns seem to vanish after adjusting for infrequent trading. That is, mispricing evidence of portfolio 12 and 41 disappears. Therefore, not only the CAPM, the three-factor model also seems to have the symptom of upwardly biased alphas.

Panel II shows the adjusted betas ($\hat{b}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8B, 8 adjusted betas increase from unadjusted betas of the unadjusted three-factor model between 2% and 11%, while 8 adjusted betas decrease from unadjusted betas of the unadjusted three-factor model between 0.9% and 13%. These results suggest that there is no discernible pattern of downwardly biased betas of the three-factor model.

Panel III presents the adjusted size coefficients ($\hat{s}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8B, only 4 adjusted size coefficients slightly increase from unadjusted size coefficients of the unadjusted three-factor model between 2.6% and 3.3%, while 10 adjusted size coefficients decrease from unadjusted size coefficients of the unadjusted three-factor model between 0.8% and 18%. Remarkably, most size coefficients decrease, instead of changing unsystematically as expected, after adjusting for infrequent trading. Thus, there is a pattern indicating that size coefficients may be upwardly biased.

Panel IV shows the adjusted BM coefficients ($\hat{h}_p^{adj}$) regressed from the adjusted three-factor model. Compared with table 8B, only 3 adjusted BM coefficients slightly increase from unadjusted BM coefficient of the unadjusted three-factor model between 3% and 6%, while 8 adjusted BM coefficients decrease from unadjusted BM coefficient of the unadjusted three-factor model between 6% and 14%. Noticeably, most BM coefficients decrease, instead of changing unsystematically as expected, after adjusting for infrequent trading. Hence, there is a pattern indicating that BM coefficients may be upwardly biased.

Panel V summarizes the adjusted-R^2 for the adjusted three-factor model. The adjusted-R^2s range from 70% to 89%. Compared with table 8B, the adjusted-R^2s of the adjusted three-factor model change from those of the unadjusted three-factor model only between 0.1% and 3%. Therefore, like the CAPM, the results suggest that the infrequent trading adjustment does not seem to increase much explanatory power of the three-factor model.

In table 10B, panel I presents the alpha-difference coefficients of the three-factor model ($\hat{\alpha}_{2p}$) for Singaporean firms. The result shows that only the alpha-difference coefficient of portfolio 12 is statistically significant. However, the size of the absolute alpha-difference is quite big ranging from 0.007% to 1.140% per month and the average absolute alpha-difference is about 0.340% per month and 4.080% per year. Hence, the alpha-differences of the three-factor model are economically significant though they are statistically insignificant.

Panel II reports the beta-difference coefficients of the three-factor model ($\hat{b}_{2p}$). There is only 1 coefficient of portfolio 41 that is statistically significant. The size of the absolute beta-difference ranges from 0.009% to 0.144% per month and the average absolute beta-difference is about 0.061% per month or 0.732% per year. Hence, the beta-differences of the three-factor model are both statistically and economically insignificant.

Panel III shows the size-difference coefficients of the three-factor model ($\hat{s}_{2p}$). There is the only one coefficient of portfolio 14 that is statistically significant. The size of the absolute size-difference ranges from 0.003% to 0.186% per month and the average absolute size-difference is around 0.042% per month or 0.504% per year. Hence, the size-differences of the three-factor model are both statistically and economically insignificant.

Panel IV presents the BM-difference coefficients of the three-factor model ($\hat{h}_{2p}$). There is no coefficient that is statistically significant. The size of the absolute BM-difference ranges from 0.008% to 0.144% per month and the average absolute BM-difference is around 0.064% per month or 0.768% per year. Hence, the BM-differences of the three-factor model are both statistically and economically insignificant.

Given the results of the adjusted alphas, betas, size coefficients and BM coefficients in table 9B and 10B, although most of the differences between the unadjusted and adjusted alphas and betas are statistically insignificant, the differences between the unadjusted and adjusted alphas are economically significant. In addition, though there is no discernible pattern that the unadjusted betas are downwardly biased, there is evidence indicating that the unadjusted alphas are upwardly biased. The results are much like those of the Thai market. Thus, it also seems worthwhile to adjust for the impact of infrequent trading on the alphas, betas, size coefficients and BM coefficients when using the three-factor model to estimate these parameters in Singapore.

Table 8B The unadjusted parameters regressed from the unadjusted three-factor model: Singapore 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the unadjusted three-factor model: $R_{pt}–R_{ft} = \alpha_p+b_p(R_{mt}–R_{ft})+ s_pSMB_t+ h_pHML_t+ \varepsilon_{pt}$, where R_{pt} is the value weighted return on portfolio p for month t, R_{ft} is the risk free rate for month t, R_{mt} is the market return for month t, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t , SMB_t is the difference in returns between small and big portfolios for month t, and HML_t is the difference in returns between high-BM and low-BM portfolios for month t.

Panel I shows the unadjusted alpha ($\hat{\alpha}_p$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the unadjusted beta or the factor loading of the market factor ($\hat{b}_p$). Panel III shows the unadjusted size coefficient or the coefficient of the size factor ($\hat{s}_p$). Panel IV shows the unadjusted BM coefficient or the coefficient of the BM factor ($\hat{h}_p$). The t-statistic tests the significance of unadjusted alpha, beta, size coefficient and BM coefficient. Adjusted-R^2 for each portfolio is also shown in Panel V.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Unadjusted Alpha ($\hat{\alpha}_p$)				t ($\hat{\alpha}_p$)			
1	0.817	-0.258	-0.039	0.358[c]	1.197	-0.629	-0.134	1.726
2	1.131[b]	-0.246	0.054	0.151	2.463	-0.840	0.170	0.531
3	0.328	-0.265	0.028	0.148	1.007	-0.897	0.098	0.506
4	0.465	0.387	0.291	0.471	1.576	1.511	0.900	1.342
Panel II	Unadjusted Beta ($\hat{b}_p$)				t ($\hat{b}_p$)			
1	1.072[a]	1.227[a]	1.051[a]	0.936[a]	12.271	13.660	21.405	22.735
2	0.896[a]	1.142[a]	1.055[a]	1.132[a]	13.931	26.494	13.976	17.341
3	1.113[a]	1.079[a]	1.133[a]	1.079[a]	17.581	17.448	17.725	12.409
4	1.087[a]	0.998[a]	1.144[a]	1.174[a]	18.919	12.273	20.340	16.357
Panel III	Unadjusted Size Coefficient ($\hat{s}_p$)				t ($\hat{s}_p$)			
1	1.619[a]	0.685[a]	0.554[a]	-0.071[b]	9.272	7.940	9.453	-2.279
2	1.258[a]	0.848[a]	0.558[a]	0.027	7.979	9.263	6.572	0.422
3	1.291[a]	0.653[a]	0.538[a]	0.023	13.221	7.814	6.340	0.265
4	1.035[a]	0.646[a]	0.609[a]	0.346[a]	13.622	6.875	9.414	3.197

Panel IV	Unadjusted BM Coefficient ($\hat{h}_p$)				t ($\hat{h}_p$)			
1	-0.156	-0.267[a]	-0.079	-0.502[a]	-0.753	-2.754	-0.726	-5.097
2	-0.009	0.070	0.227	0.369[a]	-0.072	0.611	1.151	3.264
3	0.518[a]	0.443[a]	0.878[a]	0.724[a]	6.188	3.837	5.350	7.602
4	0.729[a]	0.531[a]	0.759[a]	0.949[a]	7.147	3.354	8.923	6.134

Panel V	Adjusted R^2 (%)			
1	73.12	79.11	81.95	84.97
2	80.89	86.81	76.95	83.42
3	89.84	83.95	86.86	75.92
4	84.87	83.32	85.30	82.29

[a] denotes statistically significant at 1% level of significance.
[b] denotes statistically significant at 5% level of significance.
[c] denotes statistically significant at 10% level of significance.

Table 9B The adjusted parameters regressed from the adjusted three-factor model: Singapore 1993-2005

This table presents the asset pricing model parameters estimated by running OLS regression on the adjusted three-factor model: $R_{pt}^{adj} - R_{ft} = \alpha_p^{adj} + b_p^{adj}(R_{mt}^{adj} - R_{ft}) + s_p^{adj}SMB_t^{adj} + h_p^{adj}HML_t^{adj} + \varepsilon_{pt}$, where R_{pt}^{adj} is the value weighted return on portfolio p for month t adjusted for infrequent trading, R_{ft} is the risk free rate for month t, R_{mt}^{adj} is the market return for month t adjusted for infrequent trading, $R_{pt}^{adj} - R_{ft}$ is the excess return on portfolio p for month t adjusted for infrequent trading, $R_{mt}^{adj} - R_{ft}$ is the market excess return for month t adjusted for infrequent trading, SMB_t^{adj} is the difference in adjusted returns between small and big portfolios for month t, and HML_t^{adj} is the difference in adjusted returns between high-BM and low-BM portfolios for month t.

Panel I shows the adjusted alpha ($\hat{\alpha}_p^{adj}$) which is the abnormal return of the model and indicate mispricing evidence on the market. Panel II shows the adjusted beta or the factor loading of the market factor ($\hat{b}_p^{adj}$). Panel III shows the adjusted size coefficient or the coefficient of the size factor ($\hat{s}_p^{adj}$). Panel IV shows the adjusted BM coefficient or the coefficient of the BM factor ($\hat{h}_p^{adj}$). The t-statistic tests the significance of unadjusted alpha, beta, size coefficient and BM coefficient. Adjusted-R^2 for each portfolio is also shown in Panel V.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Adjusted Alpha ($\hat{\alpha}_p^{adj}$)				t ($\hat{\alpha}_p^{adj}$)			
1	-0.005	0.024	0.014	-0.022	-0.007	0.057	0.046	-0.117
2	-0.008	0.021	0.017	0.026	-0.019	0.076	0.046	0.097
3	0.010	0.025	0.021	0.008	0.029	0.075	0.066	0.029
4	-0.007	-0.010	0.022	0.020	-0.023	-0.034	0.065	0.059
Panel II	Adjusted Beta ($\hat{b}_p^{adj}$)				t ($\hat{b}_p^{adj}$)			
1	0.961[a]	1.191[a]	1.105[a]	0.832[a]	7.903	13.700	18.470	23.518
2	0.935[a]	1.168[a]	1.135[a]	1.209[a]	12.802	20.936	14.499	16.344
3	1.075[a]	1.193[a]	1.168[a]	1.069[a]	15.253	14.132	16.535	11.849
4	0.942[a]	0.924[a]	1.172[a]	1.160[a]	12.853	12.994	16.899	14.752
Panel III	Adjusted Size Coefficient ($\hat{s}_p^{adj}$)				t ($\hat{s}_p^{adj}$)			
1	1.587[a]	0.576[a]	0.511[a]	-0.029	9.711	8.487	10.612	-1.246
2	1.291[a]	0.810[a]	0.537[a]	0.014	8.173	10.006	6.156	0.250
3	1.281[a]	0.674[a]	0.540[a]	0.029	14.269	8.504	6.688	0.446
4	0.849[a]	0.564[a]	0.594[a]	0.333[a]	15.714	6.138	9.715	3.852

Panel IV	Adjusted BM Coefficient ($\hat{h}_p^{adj}$)				t ($\hat{h}_p^{adj}$)			
1	-0.131	-0.259[a]	-0.139	-0.358[a]	-0.565	-2.589	-1.180	-4.834
2	-0.108	-0.006	0.124	0.323[a]	-0.659	-0.042	0.575	2.999
3	0.581[a]	0.383[a]	0.827[a]	0.646[a]	6.238	2.776	4.841	6.706
4	0.687[a]	0.487[a]	0.717[a]	0.876[a]	6.667	3.504	7.792	5.691

Panel V	Adjusted R^2 (%)			
1	70.37	79.54	81.06	84.17
2	80.14	86.60	74.86	83.38
3	89.47	82.69	85.97	76.11
4	82.81	83.41	84.77	81.53

[a] denotes statistically significant at 1% level of significance.

Table 10B The differences between the unadjusted and adjusted three-factor model parameters: Singapore 1993-2005

This table presents the differences between the unadjusted and adjusted three-factor model parameters. The dummy variables are introduced in the three-factor model for the presence of infrequent trading adjustment: $R_{pt} - R_{ft} = \alpha_{1p} + \alpha_{2p}D_p + b_{1p}(R_{mt} - R_{ft}) + b_{2p}(R_{mt}^{adj} - R_{ft})D_p + s_{1p}SMB_t + s_{2p}SMB_t^{adj}D_p + h_{1p}\ HML_t + h_{2p}HML_t^{adj}D_p + \varepsilon_{pt}$, where, R_{pt}-R_{ft} is the excess return on portfolio p for month t, R_{mt}-R_{ft} is the market excess return for month t, R_{mt}^{adj}-R_{ft} is the market excess return for month t adjusted for infrequent trading, SMB_t is the difference in returns between small-size and big-size portfolios for month t, SMB_t^{adj} is the difference in adjusted returns between small and big portfolios for month t, HML_t is the difference in returns between high-BM and low-BM portfolios for month t, HML_t^{adj} is the difference in adjusted returns between high-BM and low-BM portfolios for month t, and D_p is 1 for adjusted return on portfolio p for month t ,or 0 for unadjusted return on portfolio p for month t.

Panel I shows the alpha-difference coefficient ($\hat{\alpha}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted alphas. Panel II shows the beta-difference coefficient ($\hat{b}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted betas. Panel III shows the size-difference coefficient ($\hat{s}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted size factors. Panel IV shows the BM-difference coefficient ($\hat{h}_{2p}$) which is the coefficient of the difference between unadjusted and adjusted BM factors. The t-statistic tests the null hypothesis that is the unadjusted parameters regressed from the unadjusted three-factor model are statistically different from the adjusted parameters regressed from the adjusted three-factor model.

	Firm size							
BM	1	2	3	4	1	2	3	4
Panel I	Alpha-Difference Coefficient ($\hat{\alpha}_{2p}$)				t ($\hat{\alpha}_{2p}$)			
1	-0.822	0.283	0.052	-0.379	-0.857	0.477	0.129	-1.415
2	-1.140[c]	0.268	-0.037	-0.125	-1.886	0.678	-0.077	-0.332
3	-0.318	0.288	-0.007	-0.139	-0.662	0.652	-0.015	-0.355
4	-0.473	-0.397	-0.269	-0.450	-1.123	-1.042	-0.584	-0.897
Panel II	Beta-Difference Coefficient ($\hat{b}_{2p}$)				t ($\hat{b}_{2p}$)			
1	-0.111	-0.035	0.054	-0.103[b]	-0.722	-0.287	0.710	-1.961
2	0.039	0.026	0.080	0.078	0.400	0.357	0.746	0.789
3	-0.038	0.114	0.035	-0.009	-0.400	1.058	0.377	-0.077
4	-0.144	-0.074	0.028	-0.014	-1.559	-0.664	0.322	-0.130
Panel III	Size-Difference Coefficient ($\hat{s}_{2p}$)				t ($\hat{s}_{2p}$)			
1	-0.032	-0.110	-0.043	0.041	-0.131	-1.012	-0.568	1.038
2	0.032	-0.037	-0.021	-0.013	0.145	-0.304	-0.169	-0.147
3	-0.010	0.022	0.003	0.006	-0.073	0.180	0.022	0.057
4	-0.186[b]	-0.081	-0.015	-0.013	-1.976	-0.614	-0.163	-0.092

Panel IV	BM-Difference Coefficient ($\hat{h}_{2p}$)				$t(\hat{h}_{2p})$			
1	0.025	0.008	-0.060	0.144	0.078	0.057	-0.371	1.112
2	-0.099	-0.076	-0.103	-0.047	-0.488	-0.421	-0.348	-0.295
3	0.063	-0.060	-0.052	-0.078	0.520	-0.337	-0.215	-0.569
4	-0.043	-0.043	-0.042	-0.073	-0.298	-0.204	-0.329	-0.330

[b] denotes statistically significant at 5% level of significance.

[c] denotes statistically significant at 10% level of significance.

CHAPTER V

CONCLUSION AND AREAS FOR FUTURE RESEARCH

5.1 Conclusion

Infrequent trading is one of the typical characteristics of emerging markets. In Thailand, an infrequent trading problem is explicitly recognized by the authority. Using a k-factor asset pricing model without taking into account of infrequent trading can lead to a biased result. However, direct empirical evidence on the relationship between the asset pricing model parameters and infrequent trading in emerging markets seems sparse at best. Hence, this thesis attempts to directly examine the potential impact of infrequent trading on the estimated asset pricing model parameters in an emerging market, namely Thailand. As a comparison sample, Singaporean data are also employed. The empirical results show that, in both the Thai and Singaporean markets, the results adjusted for infrequent trading are consistent with previous studies. Both alphas and betas in the CAPM show a discernible pattern that these parameters estimated by the traditional method are biased and subject to infrequent trading. Specifically, unadjusted alphas of infrequently traded stocks are upwardly biased while unadjusted betas are downwardly biased. After adjusting for the infrequent trading impact on these parameters by using the Miller et al. (1994) method, all alphas or mispricing evidence seem to disappear while adjusted betas increase relative to unadjusted betas. Moreover, the Miller et al. (1994) method seems to alleviate the problem of serial correlation in portfolio returns. Although most of the differences between unadjusted and adjusted alphas and betas are statistically insignificant, the differences between unadjusted and adjusted alphas are economically significant. Thus, it seems worthwhile to adjust for the impact of infrequent trading on the alphas and betas when using the CAPM to estimate these parameters in both Thailand and Singapore.

For the adjusted three-factor model, the results are much like those with application to the CAPM in both the Thai and Singaporean markets. Specifically, the results suggest that there is a discernible pattern of upwardly biased alphas though there is no discernible pattern of downwardly biased betas. Moreover, the Miller et al. (1994) method seems to alleviate the problem of serial correlation in portfolio returns. Although most of the differences between the unadjusted and adjusted alphas and betas are statistically insignificant, the differences between the unadjusted and adjusted alphas are economically significant. Thus, not only for the CAPM, it seems worthwhile to adjust the impact of infrequent trading on the alphas, betas, size and BM coefficients when using the three-factor model to estimate these parameters in both Thailand and Singapore.

The results of addressing the problem of infrequent trading on the asset pricing model parameters in the Thai market are in line with those of the Singaporean market. The implication is that the problem of infrequent trading seems to affect the estimated parameters in both an emerging market (i.e. Thailand), and a more developed market (i.e. Singapore). Accordingly, it seems worthwhile to adjust for the impact of infrequent trading on the estimated parameters when using the CAPM and the three-factor model in both Thailand and Singapore.

5.2 Areas for future research

Like other research in finance, this thesis also has a limitation. This thesis is subject to time constraint. Thailand is only one of several emerging markets in Asia Pacific. Applying the theoretical framework and methodology adopted in this thesis to other emerging markets in this region will provide evidence that will supplement the analysis conducted in this thesis.

Another interesting finding in this thesis is the mispricing evidence of the big and low-BM (41) portfolio in the Singaporean market, which contradicts with the US and UK markets in which the mispricing evidence occurs in the small and high-BM (14) portfolio. Hence, this finding challenges the future research to find out that whether or not this mispricing evidence also occurs in both other emerging and developed markets in the Asia Pacific region. This will potentially yield new important insights into the return generating process in the region.

References

Antoniou, A., Ergul, N., and Holmes, P. 1997. Market efficiency, thin trading and non-linear behaviour: evidence from an emerging market. European Financial Management 3: 175-190.

Arnat Leemakdej. 1998. Measuring abnormal return of infrequently traded stock in event study: Case study of takeover targets in Stock Exchange of Thailand. Working paper. Faculty of Commerce and Accountancy, Thammasat University.

Bartholdy, J., and Riding, A. 1994. Thin trading and the estimation of betas: The efficacy of alternative techniques. Journal of Financial Research 17: 241-254.

Bauer, R., Otten, R., and Rad, A.T. 2006. New Zealand mutual funds: measuring performance and persistence in performance. Accounting and Finance 46: 347-363.

Bekaert, G., and Urias, M.S. 1996. Diversification, integration and emerging market closed-end funds. Journal of Finance 51: 835-869.

Cai, J., Chan, K.C., and Yamada, T. 1997. The performance of Japanese mutual funds. Review of Financial Studies 10: 237-274.

Cesari, R., and Panetta, F. 2002. The performance of Italian equity funds. Journal of Banking and Finance 26: 99-126.

Chareonsak Methanugrah. 1997. Estimating beta for Thai stock. Master's Thesis. Department of Banking and Finance, Faculty of Commerce and Accountancy, Chulalongkorn University.

Clare, A., Morgan, G., and Thomas, S. 2002. Direct evidence of non-trading on the London Stock Exchange. Journal of Business Finance and Accounting 29: 29-53.

Dimson, E. 1979. Risk measurement when shares are subject to infrequent trading. Journal of Financial Economics 7: 197-226.

Dimson, E., and Marsh, P.R. 1983. The stability of UK risk measures and the problem of thin trading. Journal of Finance 38: 753-783.

Dimson, E., Nagel, S., and Quigley, G. 2003. Capturing the value premium in the United Kingdom. Financial Analysts Journal (November/December): 35-44.

Divecha, A.B., Drach, J., and Stefek, D. 1992. Emerging markets: A quantitative perspective. Journal of Portfolio Management 19: 41-50.

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

Fama, E.F., and French, K.R. 1993. Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33: 3-56.

Fama, E.F., and French, K.R. 1996. Multifactor explanations of asset pricing anomalies. Journal of Finance 51: 55-84.

Iqbal, J., and Brooks, R. 2006. Alternative beta risk estimators and asset pricing tests in emerging markets: The case of Pakistan. Journal of Multinational Financial Management, forthcoming.

Jokivuolle, E. 1995. Measuring true stock index value in the presence of infrequent trading. Journal of financial and quantitative analysis 30: 455-464.

Lyon, J.D., Barber, B.M., and Tsai, C.L. 1999. Improved methods for tests of long-run abnormal stock returns. Journal of Finance 54: 165-201.

Miller, M.H., Muthuswamy, J., and Whaley, R.E. 1994. Mean reversion of Standard & Poor's 500 index basis changes: Arbitrage-induced or statistical illusion?. Journal of Finance 49: 479-513.

Mitchell, M.L., and Stafford, E. 2000. Managerial decisions and long-term stock price performance. Journal of Business 73: 287-329.

Scholes, M., and Williams, J. 1977. Estimating betas from nonsynchronous data. Journal of Financial Economics 5: 309-327.

Strong, N., and Xu, X.G. 1997. Explaining the cross-section of UK expected stock returns. British Accounting Review 29: 1-23.

Appendices

Appendix A

An example of infrequent trading recognized by the Stock Exchange of Thailand (SET)

ทุนวิจัย

ผลงานวิจัยที่ได้รับทุน | สนใจขอรับทุน

โครงการสนับสนุนงานวิจัยด้านตลาดทุน

วัตถุประสงค์

1. เพื่อส่งเสริมให้มีการจัดทำงานวิจัยในสาขาต่าง ๆ ที่เกี่ยวข้องกับตลาดทุน และเสริมสร้างความเข้าใจในตลาดทุนโดยรวม
2. เพื่อนำผลการวิจัยที่ได้มาใช้ประโยชน์สำหรับการพัฒนาตลาดทุนไทยโดยรวม หรือใช้ประโยชน์เชิงนโยบายของ ตลท.

ประโยชน์ที่คาดว่าจะได้รับ

- สามารถกระตุ้นให้มีการผลิตผลงานวิจัยด้านตลาดทุนและตลาดหลักทรัพย์มากขึ้น ทั้งในระดับนิสิต/นักศึกษา และอาจารย์หรือนักวิจัยทั่วไป
- สามารถเสริมสร้างขีดความสามารถในการจัดทำงานวิจัยด้านตลาดทุน โดยการสนับสนุนนักวิจัยรุ่นใหม่
- ผลงานวิจัยด้านตลาดทุนได้รับการเผยแพร่เป็นที่รู้จัก ซึ่งจะก่อให้เกิดกระบวนการเรียนรู้และใช้ประโยชน์จากผลงานวิจัยอย่างกว้างขวางยิ่งขึ้น

รูปแบบ

ให้ทุนส่งเสริมการทำวิจัย โดยแบ่งเป็น 2 ประเภท

1. ทุนระดับนักศึกษา
2. ทุนงานวิจัยทั่วไป

กลุ่มเป้าหมาย	นิสิต/นักศึกษาในระดับปริญญาเอก -โทคณะพาณิชย์ศาสตร์และการบัญชี และคณะเศรษฐศาสตร์ ผู้จัดทำวิทยานิพนธ์/ สารนิพนธ์/ การค้นคว้าแบบอิสระ (Independent Study) และดุษฎีนิพนธ์
รูปแบบ	ให้ทุนใน**หัวข้อที่เกี่ยวกับตลาดทุนไทย**จำนวน 5 ทุน ทุนละ 50,000 บาท โดยผู้วิจัยสามารถเสนอหัวข้อที่สนใจได้แต่ถ้าศึกษาในหัวข้อที่กำหนดจะได้รับ การพิจารณาเป็นพิเศษ
ระยะเวลาสมัคร	ตลอดทั้งปีหรือจนกว่าทุนจะหมด โดยมีรอบการปิดรับเพื่อเข้าสู่การพิจารณาของคณะทำงานทุนวิจัย ทุก 3 เดือน (28 ก.พ. 31 พ.ค. 31 ส.ค. 30 พ.ย.)
แนวทางการพิจารณา	พิจารณาจาก proposal ที่ผ่านความเห็นชอบจากคณะกรรมการวิทยานิพนธ์ของคณะฯแล้ว

หัวข้อที่จะได้รับการพิจารณาพิเศษ

หัวข้อ	จำนวนผู้สมัคร	สถานะ	ผู้ได้รับคัดเลือก
1. ปัญหาสภาพคล่องในตลาดหลักทรัพย์และปัจจัยที่มีผล ต่อสภาพคล่อง	-	เปิด	-
2.พฤติกรรมการลงทุนของนักลงทุนต่างชาติและผลกระทบต่อตลาดหลักทรัพย์ไทย	2	เปิด	-
3. ผลกระทบของการเปลี่ยนแปลงในโครงสร้าง ประชากรต่อระดับการออมของประเทศ	-	เปิด	-
4. พฤติกรรมการจัดสรรเงินออมและการกระจายเงิน ลงทุนในสินทรัพย์ต่าง ๆ ของผู้มีเงินออม	1	ปิด	นางวันดี ทองงอก
5. แรงจูงใจและปัจจัยที่มีผลต่อการสร้างบรรษัทภิบาล ในบริษัทจดทะเบียนไทย	2	เปิด	-
6. อื่นๆ	2	เปิด	

Source : www.set.or.th

Appendix B

Summary of percentage of infrequently traded stocks on the SET (Examples for the period 2000-2005)

For each month cohort from January 2000 to December 2005, I count the number of stocks that do not experience a monthly price change as infrequently traded stocks. Suspended (SP) stocks are excluded from my samples. This following table summarizes percentage of infrequently traded stocks in each month for the Thai market. To illustrate, there is about 7.39% of all stocks in the market which are not traded in January 2005, and the average percentage of infrequently traded stocks for the year 2005 is 8.41. The results show that the monthly average percentage of infrequently traded stocks is between 6.32 and 12.61. Surprisingly, these results show that the infrequent trading problem in Thailand appears to be less severe than in the UK which has the average percentage of non-trading stocks around 43.69 (see Clare et al., 2002).

Unit: percent (%)

Month/Year	2000	2001	2002	2003	2004	2005
Jan	9.46	13.25	9.62	15.52	7.65	7.39
Feb	7.09	11.51	7.03	8.61	7.30	7.64
Mar	8.70	13.91	7.05	5.04	6.74	4.36
Apr	10.10	12.91	6.05	5.29	8.04	5.31
May	10.07	14.52	11.39	6.76	5.56	9.09
Jun	12.16	9.87	7.62	5.29	8.71	11.08
July	14.19	7.62	8.75	4.39	12.93	7.19
Aug	17.23	9.60	7.79	4.06	8.16	8.55
Sep	15.54	6.25	7.14	5.49	5.99	7.09
Oct	15.49	10.20	11.42	5.76	7.42	10.14
Nov	16.39	9.18	9.54	5.11	8.38	9.60
Dec	14.95	7.77	9.48	4.49	10.92	13.49
Average	12.61	10.55	8.57	6.32	8.15	8.41

Appendix C

Comparative total turnovers of the SET and the SES, 2001-2005

Total turnover (million Baht)	SET	SES*
2001	1,577,758	3,230,062
2002	2,047,442	2,910,426
2003	4,670,281	3,970,860
2004	5,024,399	4,497,280
2005	4,031,240	5,030,363
Average	3,470,224	3,927,798
Avg. Daily T/O**	14,164	15,711

Note: 1. * Using BOT exchange rate as of 30/12/2005 (S$1: Baht 24.5187)

2. ** Avg. Daily T/O stands for Average Daily Turnover.

3. Average daily turnover is equal to average turnover divided by numbers of trading day which are 245 for the SET and 250 for the SES.

This table presents total turnovers of the Stock Exchange of Thailand (SET) and the Stock Exchange of Singapore (SES) for the year 2001-2005. The results show that, on average, the SES's turnover is higher than SET's turnover although the turnovers of the SET for the year 2003 and 2004 are higher than those of the SES. The SES's average daily turnover is also higher than the SET's average daily turnover. Hence, one would expect the Singaporean market to have more liquidity than the Thai market. This seems to suggest that the Singaporean market has a less severe infrequent trading problem than the Thai market.

Appendix D

The distribution of firms in the firm size-BM portfolios Thailand, 1993-2005

Panel A: The nine size-BM portfolios

Port	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
SL	26	24	27	19	26	13	18	20	12	13	8	12	15
SM	22	18	15	21	14	13	15	16	14	18	21	15	10
SH	99	93	80	76	71	56	53	53	69	57	51	46	30
ML	59	50	38	39	36	24	26	26	28	21	22	19	20
MM	27	24	30	26	19	21	16	15	23	19	12	18	10
MH	33	40	38	35	39	24	30	34	31	35	35	25	17
BL	84	80	76	75	65	56	54	55	69	66	62	52	28
BM	35	34	25	19	29	13	17	20	17	14	12	9	11
BH	37	21	22	22	17	13	15	14	9	8	6	12	16
Total	422	384	351	332	316	233	244	253	272	251	229	208	157

<u>Note</u> Port X_1X_2 where X_1 represents size: S=Small, M= Moderate, B=Big

X_2 represents BM: L=Low, M=Medium, H=High

Panel A presents the average number of firms in each portfolio of the nine size-BM portfolios for the Thai market during 1993-2005. For instance, on average, there are 26 firms in the small and low-BM (SL) portfolio while the number of firms in the big and high-BE/ME (BH) portfolio is 37 for the year 2005. The total firms for the year 2005 are 422.

Panel B: The sixteen size-BM portfolios

Port	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
11	9	9	11	11	8	7	8	5	2	2	3	4	5
12	11	9	8	9	12	5	9	13	10	8	7	10	7
13	29	17	21	25	21	13	20	20	20	20	20	18	14
14	57	61	48	38	38	32	24	25	36	33	27	20	13
21	18	22	15	12	14	7	7	13	10	7	6	6	8
22	28	23	26	23	19	16	20	8	14	17	13	13	12
23	30	31	26	19	23	23	14	16	22	17	18	14	7
24	29	20	20	29	23	13	20	26	22	21	20	18	12
31	32	24	25	22	17	14	15	15	18	13	16	16	14
32	34	35	26	27	30	17	19	24	22	23	19	15	8
33	24	25	23	22	18	17	14	16	19	19	15	10	9
34	15	12	14	12	14	10	13	8	9	8	7	11	8
41	47	41	37	38	40	30	31	30	38	41	31	26	13
42	32	29	28	24	18	20	13	18	22	14	20	14	11
43	22	23	17	17	17	6	13	11	6	6	4	10	10
44	5	3	6	4	4	3	4	5	2	2	3	3	6
Total	422	384	351	332	316	233	244	253	272	251	229	208	157

Note Port Y_1Y_2 where Y_1 represents size: 1=firms of percentile 1-25, 2= firms of percentile 26-50
3= firms of percentile 51-75, 4= firms of percentile 76-100
Y_2 represents BM: 1=firms of percentile 1-25, 2= firms of percentile 26-50
3= firms of percentile 51-75, 4= firms of percentile 76-100

Panel B presents the average number of firms in each portfolio of the sixteen size-BM portfolios for the Thai market during 1993-2005. For instance, on average, there are 9 firms in the small and low-BM (11) portfolio while the number of firms in the big and high-BM (44) portfolio is 5 for the year 2005.

The distribution of firms in the firm size-BM portfolios
Singapore, 1993-2005

Panel C: The nine size-BM portfolios

Port	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
SL	52	58	51	49	46	29	23	26	28	27	18	17	9
SM	47	31	34	33	31	22	20	16	16	16	10	5	10
SH	96	80	72	73	58	39	42	42	35	27	19	17	19
ML	63	55	56	51	47	30	27	26	29	26	15	15	13
MM	34	32	25	27	25	11	17	14	14	11	4	5	4
MH	69	58	55	55	44	35	28	32	24	23	21	14	16
BL	107	81	73	77	62	44	47	44	33	27	21	13	22
BM	30	33	31	29	21	18	11	18	15	13	12	12	7
BH	58	56	54	49	52	28	27	22	31	30	14	14	9
Total	556	484	451	443	386	256	242	240	225	200	134	112	109

Note Port X_1X_2 where X_1 represents size : S=Small, M= Moderate, B=Big
X_2 represents BM : L=Low, M=Medium, H=High

Panel C presents the average number of firms in each portfolio of the nine size-BM portfolios for the Singaporean market during 1993-2005. For instance, on average, there are 52 firms in the small and low-BM (SL) portfolio while the number of firms in the big and high-BM (BH) portfolio is 58 for the year 2005. The total firms for the year 2005 are 556.

Panel D: The sixteen size-BM portfolios

port	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
11	23	24	23	22	17	4	11	11	12	12	5	3	1
12	29	19	27	27	25	22	14	14	14	13	11	7	5
13	47	41	39	33	28	22	15	17	17	13	9	9	9
14	40	37	24	29	27	16	21	18	13	12	9	9	12
21	31	24	21	21	18	14	8	12	9	14	10	9	5
22	34	36	26	28	27	16	15	16	20	15	8	8	7
23	34	32	32	28	31	14	18	18	12	9	4	3	8
24	40	29	33	33	20	20	19	14	15	12	11	8	7
31	33	35	34	26	28	21	22	13	20	8	9	9	11
32	44	31	28	26	21	13	12	13	7	13	5	4	5
33	24	24	19	27	16	16	16	15	15	12	11	9	7
34	38	31	32	32	31	14	10	19	14	17	8	6	4
41	52	38	36	42	34	25	20	24	16	16	10	7	11
42	33	35	30	29	23	13	19	17	14	9	9	9	9
43	33	24	23	23	21	12	11	10	13	16	9	7	4
44	21	24	24	17	19	14	11	9	14	9	6	5	4
Total	556	484	451	443	386	256	242	240	225	200	134	112	109

Note Port Y_1Y_2 where Y_1 represents size: 1=firms of percentile 1-25, 2= firms of percentile 26-50
3= firms of percentile 51-75, 4= firms of percentile 76-100
Y_2 represents BM: 1=firms of percentile 1-25, 2= firms of percentile 26-50
3= firms of percentile 51-75, 4= firms of percentile 76-100

Panel D presents the average number of firms in each portfolio of the sixteen size-BM portfolios for the Singaporean market during 1993-2005. For instance, on average, there are 23 firms in the small and low-BM (11) portfolio while the number of firms in the big and high-BM (44) portfolio is 21 for the year 2005.

Biography

Miss Nuntipa Sintaweewat was born on September 23, 1980 in Khon Kaen. At the undergraduate level, she graduated from the Faculty of Commerce and Accountancy, Thammasat University in February 2002 with a Bachelor of Business Administration degree (First Class Honors), majoring in Accounting. She joined the Master of Science in Finance program, Chulalongkorn University in June 2005. Before joining the program, she was working as a senior auditor at Ernst & Young Office Company Limited during April 2002 and May 2005.