Size, Value and Momentum in International Stock Returns

by

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy of Cardiff University

Department of Accounting and Finance of Cardiff Business School,

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Abstract

This thesis extends the empirical asset pricing literature by testing whether alternative specifications of Fama and French's (1993) three-factor and Carhart's (1997) four-factor models capture size, value and momentum anomalies. Specifically, the alternative models tested include the modified and index-based models of Cremers et al. (2013) and decomposed models of Fama and French (2012). This thesis investigates international stock returns and whether asset pricing models are integrated across four countries, namely the US, UK, Japan, and Canada. Finally, the information content of the empirically motivated size, value and momentum factors is tested using Petkova's (2006) ICAPM model. The models are tested using both time-series and cross-sectional regression approaches.

The results show that the factors constructed using different approaches have quite different average returns. In general, there is no size premium in average stock returns in any country. There is a value premium only for Japan and Canada that increases with size, while there is a momentum premium everywhere except Japan, which declines with size. Both time-series and cross-sectional results show that the alternative models significantly improve the pricing performance, and especially the index-based model successfully explains the size and B/M portfolio returns for the four countries. None of the models can explain the size and momentum portfolio returns except for Japan. Although the international index-based model receives some empirical support in a combined international sample, the US and Japan, generally, the international models fail badly, which indicates a lack of integration. When relating size, value and momentum factors with innovations to the state variables in an ICAPM specification, the results are discouraging and contradict Petkova's (2006) results for the US. The size, value and momentum factors remain important factors in explaining the cross-sectional returns for all countries, even in the presence of the state variable innovations.

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Chapter 01: Introduction

1.1 Background and Context

The Capital Asset Pricing Model (CAPM) is one of the central pillars of finance since the 1960s. Indeed, there has been a vast amount of research on the theoretical and empirical validity of the CAPM. The model was developed independently by Sharpe (1964) and Lintner (1965) and was later extended by Black (1972). CAPM describes the relationship between the systematic risk and return of an asset and states that the asset return is linearly related to the asset's market beta. Beta is a measure of systematic risk, a risky asset's or portfolio's sensitivity to the risk of the market as a whole.

However, CAPM has also attracted criticism on theoretical as well as empirical fronts. Specifically, empirical findings suggest return anomalies related to some accounting measures that do not result directly or convincingly from financial theories. These prominent anomalies include the size effect – small market capitalization stocks earn higher returns than big market capitalization stocks [Banz (1981)], the book-to-market (B/M) effect – high B/M ratio stocks earn higher returns than low B/M ratio stocks [Rosenberg et al. (1985)], and the momentum effect – positive (negative) stock returns tend to be followed by positive (negative) stock returns over a period of six to twelve months [Jegadeesh and Titman (1993)].

Fama and French (1992) review the empirical work on existing anomalies and in response proposed a three-factor (3F hereafter) model in Fama and French (1993). The 3F model augments CAPM with a size (*SMB*) factor for the comparative performance of small and big stock returns, and a value (*HML*) factor for the comparative performance of high and low B/M stock returns. Fama and French (1993, 1996) show that the 3F model satisfactorily explains portfolio returns sorted by various empirically observed anomalies, except for the momentum effect. Carhart (1997) suggest augmenting the 3F model with a momentum factor (referred to as the four-factor (4F) model) for the comparative performance of winner and loser stock returns.

Given the success of the 3F model and later the 4F model in explaining average stock returns, the models have now been widely used as benchmark models for the calculation of cost of capital [e.g. Fama and French (1997, 1999), Aboody et al. (2005) and Hann et al. (2013)], controlling for risk in a variety of different areas, including event studies [e.g., Barber and Lyon (1997), Fama (1998) and Kolari and Pynnonen (2011)], and for the performance evaluation of mutual funds [e.g., Carhart (1997), Bollen and Busse (2005) and Cremers et al. (2013)].

This thesis investigates the performance of the most popular and empirically successful asset pricing models on stock returns in the US, UK, Japanese, and Canadian stock markets[1]. The US and Japan are included in the sample because they are the two largest equity markets in the world and constitute more than 50% of market capitalization for developed countries' equity markets [Fama and French (2012)]. Fama and French (2012) also combine the Canadian and the US stock markets into one North American region on the assumption that the two stock markets are integrated. Therefore, Canada is included, although it is a much smaller market in terms of the market capitalization and the number of stocks compared to other three countries. Finally, the UK equity market is the largest in Europe but it is different from the US and Japanese markets in terms of market capitalization and trading activity [Griffin (2002) and Hou et al. (2011)]. Thus, the inclusion of the UK will give some insights regarding the performance of the asset pricing models at the international level.

This thesis examines portfolio returns sorted on the size, B/M ratio, and momentum variables using some alternative specifications of the 3F and 4F models, as the standard 3F and

[1] Griffin (2002) uses these four countries based on the evidence that they are most likely to be integrated with each other.

4F models fail empirically [see Fama and French (2008, 2012) and Gregory et al. (2013a) among others]. These alternative specifications include the decomposed models using the Fama and French (2012) factor decomposition, and the modified and index-based versions of the 3F and 4F models following Cremers et al. (2013). The aim is to investigate whether the use of the decomposed factors or constructing factors using the alternative methodology of Cremers et al. (2013) improve the model performance relative to the standard 3F and 4F models.

1.2 Motivation

This thesis is primarily motivated by the findings of two recent studies by Fama and French (2012) and Cremers et al. (2013). Using time-series regressions, Fama and French (2012) show that the 3F and 4F models fail to explain the returns on momentum portfolios and microcap portfolios of 23 developed stock markets divided into four regions. In particular, Fama and French (2012) show that both models result in large alphas for the microcap stocks of the size and B/M and size and momentum sorts indicating deficiencies in these models. On the other hand, Cremers et al. (2013) associate the resulting large alphas from the 3F and 4F models to the factor construction methodology. They argue that Fama and French's approach of equally weighting the *SMB* factor and the breakpoints used to construct *SMB* and *HML* factors create the problems for the 3F and 4F models. Cremers et al. (2013) report that even a passive benchmark index like the S&P500 has a positive and significant alpha for the 3F and 4F models. Therefore, they recommend the use of their modified and index-based models and show that these models perform better and have lower alphas compared to 3F and 4F models in their tests on US mutual fund returns.

This thesis follows Cremers et al. (2013) in constructing their modified and index-based models and test their performance against the traditional standard 3F and 4F models. The modified model uses the modified factors constructed using different breakpoints compared to the traditional Fama and French (1993) factors, while the index-based model uses index-based factors constructed following common industry practices and using country benchmark indices, such as the S&P500 and FTSE100. The purpose is to investigate whether the modified and index-based models are more powerful in explaining expected stock returns in the four countries examined in this thesis. The performance of the modified and index-based models has not yet been tested on stock returns in an international context. Cremers et al. (2013) test these models on US mutual fund returns, while Davies et al. (2014) test the index-based models using UK stock returns. Therefore, this is the first assessment of the modified and index-based models to explain international stock returns.

Fama and French (2012) highlight the significant differences in the value and momentum returns of small and big stocks, and Gregory et al. (2013a) argue that using separate factors for small and big stocks help explain returns on extremely small and large portfolio returns in the sorts of size and B/M and size and momentum. Therefore, decomposed value and momentum factors are constructed following Fama and French (2012) and are tested in asset pricing models by replacing the original factors with the decomposed factors. The decomposed factors are constructed by forming separate value and momentum factors for the small and big stocks using the construction methodology of Fama and French (2012). The decomposed models are expected to explain adequately the returns on microcap portfolios, which are known to be most problematic in the asset pricing literature [Fama and French (1993, 2008, 2012)]. As with the modified and index-based models, this is the first formal examination of the decomposed models using international stock returns.

Fama and French (2012) compare the performance of regional asset pricing models (models use the factors constructed from the data of a region that include one or more countries) and their global versions (factors constructed from combined data of all regions) to explain regional average returns for portfolios sorted on size and B/M, and size and momentum. They show that, in general, the regional models provide better descriptions of expected returns than global models. Their results provide evidence that asset pricing models are not integrated across regions, as the global models fail to explain the portfolio returns across the regions. Thus, given the evidence of Fama and French (2012) that the regional asset pricing models perform better than global models, we might expect country level asset pricing models to out-perform regional models. Griffin (2002) shows that the country (local) level 3F model performs better than its international version in explaining average stock returns for country portfolios sorted on size and B/M. However, there is little empirical work outside the US testing the performance of 3F or 4F models in explaining average stock returns. Therefore, in this thesis I use country-level data for the four major and developed equity markets to test the comparative performance of the local and international versions of the standard 3F and 4F models, and the decomposed, modified, and index-based models.

Given the discussion above, the primary aim of this thesis is to extend the search for a better and improved asset pricing model that adequately explains the average stock returns in the US, UK, Japan, and Canada. For that I construct and test models using alternative specifications of factors following Cremers et al. (2013) and Fama and French (2012). Noting the critique of Cremers et al. (2013), I construct the size and value factors using their modified and index-based factor construction methods. These factors are used to test the modified and index-based seven-factor (7F, hereafter) models of Cremers et al. (2013). I also construct models using decomposed factors, along the lines of Fama and French (2012).

In the time-series tests, I test these alternative factor models on 25 portfolios formed on independent sorts of size and B/M and 25 portfolios formed on independent sorts of size and momentum, as in Fama and French (2012). However, Lewellen et al. (2010) warn against testing the asset pricing models on portfolios formed using the same characteristics as the factors themselves in the cross-sectional tests. Lewellen et al. (2010) suggest, among other things, to use portfolios formed on industries in the tests of asset pricing models. I follow their suggestion and construct test portfolios based on industry classifications and use them together with size-B/M and size-momentum portfolios only in the cross-sectional asset pricing tests.

The second aim of this thesis is to investigate the performance of international models, in the spirit of Griffin (2002), Hou et al. (2011), and Fama and French (2012), and compare their performance with their counterpart local country models. For that, I construct and test the international versions of the models in which the factors are formed using the combined international sample of four countries, and the returns to be explained are both international and country level portfolios. I then compare the performance of these models with local models in which the factors and returns to be explained are all from the same country. The extent to which international models explain the international and country returns indicate the degree of asset pricing integration. The main question in this context is whether the asset pricing models are integrated across four countries? The adequacy of international models in explaining international and local returns is a direct test of the integration hypothesis.

I test asset pricing models in two stages. In the first stage, following Fama and French (1993, 1996, and 2012) I use the time-series regression framework along with the *F*-test of Gibbons et al. (1989), hereafter *GRS*, in Chapter 4. As pointed out by Fama (2015), the time-series approach use factor returns as independent variables and estimate coefficients to see whether the factors can explain the test portfolio returns. In the time-series approach, the factor risk premium is taken as given, which is equal to the average factor return. In the second stage, I extend Fama and French (2012) to run Fama and MacBeth (1973) type two-step cross-sectional regression tests in Chapter 5 to examine whether the factors are priced. The cross-sectional approach use the time-series factor coefficients as independent variables and estimate the factor premium to see which factors are priced. For the cross-sectional tests I use the empirical methodology recently developed by Kan et al. (2013), who derive potential model misspecification robust standard errors for cross-sectional risk premia as well as cross-sectional R^2, and develop model comparison tests for the cross-sectional R^2.

Even if the factors in the cross-sectional regressions are significantly priced by the test portfolios, these return based factors, i.e. size and value, and momentum, have been established empirically with little economic support. Therefore, the economic interpretation of such factors is debatable. In fact, connecting the size, value, and momentum factors to the macroeconomy is one of the most important issues in current research in asset pricing [Cochrane (2001)]. Therefore, the third aim of this thesis is to provide an economic explanation for the size, value and momentum factors in the context of Merton's (1993) intertemporal CAPM (ICAPM) in Chapter 6. Using the cross-sectional regression framework, Petkova (2006) shows that the *SMB* and *HML* factors proxy for the state variables innovations that describe investment opportunity sets and, in the presence of those innovations, the *SMB* and *HML* factors lose their explanatory power. The ICAPM model of Petkova (2006) is tested on US stock returns and found to perform better than the 3F model [see Kan et al. (2013) and Gospodinov et al. (2014)]. This thesis provides an out-of-sample test and evidence for Petkova's (2006) ICAPM model using data from four international equity markets. An attempt is made to provide some economic explanation for not only the standard size, value, and momentum factors, but also their decomposed, modified and index-based versions. The objective is to test whether the size, value and momentum factors proxy for the innovations in the state variables and to explore the impact of using decomposed, modified and index-based factors on their relation to the state variable innovations. To this end, this is the first study to test Petkova's (2006) ICAPM model in the international context and provide evidence on the relation of the size, value and momentum factors and state variable innovations in four international equity markets.

1.3 Structure and Contribution of the Thesis

Chapter 2 reviews the asset pricing literature and discusses the main theories of asset pricing. The literature is divided into two main parts based on the empirical investigations. First, I critically discuss the literature on time-series and cross-sectional tests of the 3F and 4F models, and second, I discuss the asset pricing literature motivated from economic theory. This second part discusses the literature on the relation between stock returns and macroeconomic variables. Campbell (2000) and Cochrane (2005) stress the importance of the link between macroeconomic factors and stock prices. In the words of Cochrane (2005), *"the program of understanding the real, macroeconomic risks that drive asset prices (or the proof that they do not do so at all) is not some weird branch of finance; it is the trunk of the tree. As frustratingly slow as progress is, this is the only way to answer the central questions of financial economics"*.

Chapter 3 provides an overview of the data used in this thesis and discusses the portfolio and factor construction. In particular, Chapter 3 explains the various screens used to correct biases in the Thomson Reuters DataStream data based on existing literature and discusses the construction of the standard, decomposed, modified and index-based factors. The chapter also provides summary statistics for the test portfolios and return based factors to analyse the pervasiveness of the size, value and momentum effects in the four equity markets and to study the impact of different factors construction methodologies on average factor returns. Finally, Chapter 3 provides a comparison of the test portfolios and the factors in my data sample with those provided by the Kenneth French website[2] and Gregory et al. (2013a)[3]. The comparison helps to assess the robustness of the portfolios and factors constructed in this thesis using data collected from DataStream. Consistent with the existing literature, there is a momentum

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[3] http://xfi.exeter.ac.uk/researchandpublications/portfoliosandfactors/index.php

premium in all equity markets except Japan, and there is a value premium in the combined international sample, Japanese and Canadian markets. Further, there is no size premium in equity returns of any of the markets analysed in this study. Interestingly, the size, value and momentum premiums do not change much across different methods of factor construction and decomposition.

Chapter 4 provides the empirical results of the time-series tests of asset pricing models. Specifically, it follows closely the approach of Fama and French (2012) to compare the performance of the 3F and 4F models with alternative models for the US, UK, Japan, Canada, and a combined international sample. Overall, the local country models perform better than international models. The empirical results show that the alternative models, and specifically the index-based 7F model of Cremers et al. (2013), adequately explain the microcap returns left unexplained by the 3F and 4F models. This model also shows some indications of asset pricing integration in the test of its international version on international, US, and Japanese portfolio returns. In all of the time-series tests, the local models have higher explanatory power compared to their international counterparts, showing that the local models explain the average returns better than the international models. Therefore, one of the main contributions of this thesis is to report the success of the index-based 7F model in explaining the returns of the size-B/M portfolios in the US, UK, Japan and Canada and size-momentum portfolio in Japan. These results have some important implications for the investors and practitioners as it shows that the local country models, and from the local models the index-based 7F model, should be used for the performance evaluation and risk control exercises. Chapter 4 also contributes to the international asset pricing literature by showing the relatively better performance of the international index-based 7F model in explaining international and country portfolio returns.

Chapter 5 reports the empirical results of the cross-sectional asset pricing tests. By comparing the models using cross-sectional tests, I provide one of the first international studies based on the cross-sectional regression framework. The cross-sectional results are consistent with the results obtained in the time-series tests. However, in the cross-sectional tests, the international models perform as well as the local models, and the factors that are priced are similar in both sets of models. The 3F model is outperformed by the alternative models for most of the equity markets. Contrary to the similar performance of the international and local models, the factor pricing results show that the country factors are more accurately and reliably priced, as their factor premiums are close to their time-series averages. According to Lewellen et al. (2010), one of the tests of the model performance is that the cross-sectional factor risk premia should be equal to the time-series average of the factor returns. The local factors that are reliably priced include the momentum factor for the US and the UK, the market premium for the UK and Canada, and the value premium for Japan. Overall, the decomposed 6F, modified 7F, and index-based 7F models perfrom better than the standard 3F and 4F model. Therefore, the investors should use these models to estimate firms' cost of equity.

Chapter 6 follows Petkova (2006) and tests for the ICAPM explanation of the size, value and momentum premiums. Using the cross-sectional regression framework, this chapter shows that the ICAPM models perform as well as the 3F and 4F models, a result consistent with the existing literature [see Petkova (2006), Kan et al. (2013), and Gospodinov et al. (2014)], but are dominated by most of the alternative models. The state variable innovations are not priced for most of the datasets and therefore, the size, value and momentum factors do not lose their explanatory power. Thus, contrary to Petkova (2006), there is no evidence of any association between the size, value and momentum factors and state variable innovations. These results may have arisen because the size and value factors are not priced in the US, UK, and international samples, or it may be because Petkova's (2006) findings are sample specific and cannot be extended to other equity markets and time-periods.

Finally, Chapter 7 concludes and summarizes the empirical findings, lists the limitations, and suggests interesting avenues for future research.

Chapter 02: Related Literature

2.1 Introduction

This chapter reviews the evidence in the relevant asset pricing literature. It briefly introduces some of the asset pricing theories that attempt to model the risk and return relation of stocks in Section 2.2. Section 2.3 presents the literature on tests of the 3F and 4F models for the time-series and cross-sectional regression approaches along with their implications for asset pricing, by focusing on the empirical results rather than econometric methodologies. The econometric methodologies are discussed in Chapters 4 and 5. This chapter also attempts to evaluate and discuss the vast literature related to economic explanations of stock returns and the asset pricing models in Section 2.4. Finally, Section 2.5 discusses the prospective of behavioural finance in asset pricing, specially in explaining size, value, and momentum anomalies. Section 2.6 concludes.

2.2 Development of the CAPM, 3F and 4F Models

Markowitz (1952) proposes the portfolio selection model in which an investor selects a portfolio at time t that generates an expected return at time $t+1$. The portfolio selection model assumes risk averse investors, and these investors care only about the mean and variance of stock returns. Thus, on the basis of mean and variance, investors can choose from a set of efficient portfolios. Markowitz (1952) suggests that the portfolio selection should be based on mean-variance efficiency; that is the investor should select the portfolio that maximises the expected return given a specific portfolio variance or equivalently minimises the portfolio variance given an expected return.

Based on Markowitz's seminal work, Sharpe (1964) and Lintner (1965) individually develop the Capital Asset Pricing Model (CAPM). CAPM is based on two key underlying assumptions; first, all investors have the same expectations about the state of the economy, and second, risk-free borrowing and lending is possible at the same interest rate.

The CAPM provides intuitive and easy to use predictions about the relationship between the systematic risk and expected return, and how to measure that systematic risk. According to CAPM, the combination of a risk-free asset and a single risky tangency portfolio (i.e. the market portfolio) results in the so-called efficient portfolio, so that all investors hold the same portfolio of risky assets and adjust the riskiness of their investment by investing more or less in the risk-free asset. Sharpe (1964) and Lintner (1965) assume that the market portfolio must lie on the minimum-variance frontier. For *N* number of assets, the minimum-variance condition is given by

$$E\left(R_{i,t}\right) = R_{f,t} + \left[E\left(R_{MKT,t}\right) - R_{f,t}\right]\beta_{i,MKT}\,, \qquad i = 1,2, \ldots\ldots, N \tag{2.1}$$

where $E\left(R_{i,t}\right)$ is the expected return on asset i, $R_{f,t}$ is the risk-free rate, $E\left(R_{MKT,t}\right)$ is the expected return on the market portfolio, and $\beta_{i,MKT}$ is the market beta of asset *i*. $\beta_{i,MKT}$ is the covariance of return on the i^{th} asset with the market return ($cov(R_{i,t}, R_{MKT,t})$) divided by the variance of the market return ($\sigma^2_{R_{MKT,t}}$). According to CAPM, the expected return on an asset is equal to the return on the risk-free asset plus a market risk premium.

Black (1972) develops a version of CAPM without risk-free borrowing and lending by allowing the unrestricted short sale of risky assets. He concludes that a portfolio made of efficient assets is also efficient, and, therefore, the market portfolio is efficient as well. The important implication of the Sharpe, Lintner and Black versions of CAPM is that only the market beta can explain the differences in the expected return of assets and portfolios. CAPM considers systematic risk, reflecting a reality in which most investors have diversified portfolios from which unsystematic risk has been essentially eliminated. Importantly, CAPM generates a theoretically derived relationship between expected return of a stock or portfolio and the systematic risk, which has been subject to frequent empirical research and testing. Moreover, since more than five decades CAPM is still considered a better model to measure cost of equity and discount rate for investment appraisal than dividend growth model and weighted average cost of capital methods.

However, the use of a single risk factor, the market portfolio, attracted criticism as researchers argue that a single risk factor is not enough to completely capture systematic risk [Merton (1973)]. Moreover, Fama and French (2004) argue that empirical failure of CAPM could arise from its theoretical basis, its overly simplifying assumptions, or its empirical implementation difficulties. They argue that the CAPM says that the risk of an asset should be measured relative to the market portfolios, which should include, theoretically, financial assets, human capital, real estate, and consumer durables. However, it is not possible to construct such a portfolio that include all categories of assets mentioned. Moreover, the second question about whether the market portfolio should be limited to one country or assets from all the countries around the world is still not clear. After identifying similar shortfalls of CAPM, Merton (1973) develops the intertemporal CAPM (ICAPM) and explained that the single-period CAPM is a special case of the ICAPM when the investment opportunities are assumed to be constant. However, he points out that the interest rate is stochastic, which is a component of investment opportunities. Hence the assumption of constant investment opportunities is implausible, and a single market portfolio is unable to capture systematic risk. Merton (1973) develops an equilibrium model in which the expected return is a function of exposure to market risk and other risks that arise from changes in the future investment opportunities. An important feature of ICAPM relative to CAPM is that an asset's expected excess return will not be zero if it has a zero market beta.

Early research testing the validity of standard CAPM by Jensen et al. (1972) and Fama and MacBeth (1973) concludes that the model is powerful in explaining cross-sectional stock returns and the market portfolio successfully captures the systematic risk. The two-step cross-sectional regression methodology proposed by Fama and MacBeth (1973) became the standard technique for testing the cross-section of stock returns because of its econometric appeal. However, researchers identified problems with CAPM by identifying different anomaly variables that CAPM cannot explain.

In this context, Banz (1981) report the so-called size effect in the presence of stock βs and report higher returns on stocks with small market capitalization as compared to stocks with large market capitalization. Similarly, Basu (1977, 1983) notes that the stocks with high earnings-to-price (E/P) ratios earn higher positive abnormal returns than those with low E/P ratios. Rosenberg et al. (1985) find similar results for the B/M ratio. Moreover, Bhandari (1988) argue that leverage, measured by the total book value of debt divided by the market value of equity, has a significant role in the explanation of the average stock returns, independent of the market beta and size. The dividend to price ratio, commonly referred to as dividend yield, also found to forecast expected stock returns [Rozeff (1984), Shiller et al. (1984), Flood et al. (1986), Campbell and Shiller (1988), and Fama and French (1988)]. Interestingly, all the ratios mentioned have stock's market price as a common variable in their calculation. Given that the stock's price is an expectation of its future cash flows, different prices may lead to differences in returns. Principally, CAPM should still explain these differences in average returns, its failure to do so shows that β alone is unable to capture the variations in average equity returns and only the one factor, market portfolio, fails to capture the systematic risk.

Although, researchers have not found much support for the dividend yield as a factor determining expected stock returns in the US, as B/M captures much of its information content [Fama and French (1992,1996)], the case is different for the UK. Morgan and Thomas (1998) found a positive relation between dividend yield and expected stock returns after controlling for seasonal effects, firm size, and market risk. Using UK stock data, they also show that this relation is independent of any tax effects. ap Gwilym et al. (2000) also show that the dividend yield, and stability of dividend policy, has an important role in explaining expected returns on the UK stock. Using UK stock returns data Dimson et al. (2003) found that the dividend yield, as a measure of value, produces similar results as the B/M ratio, and the time-series spreads obtained using the two measures are quite similar. However, in this thesis, I only focus on the primary measure of value, i.e. B/M ratio, for the sample of countries considered.

Fama and French (1992) comprehensively study all the prevailing firm-specific anomalies identified by previous studies and examine whether CAPM can explain the abnormal return on these anomalies. They conclude that the market β has no role in explaining average stock returns. Further, although size, B/M, E/P, and leverage have significant explanatory power when used alone, only size and B/M appear to have significant explanatory power in multivariate regressions to explain average stock returns in the cross-section. Thus, Fama and French (1992) float the multidimensional view of the risk-return relation in rational asset pricing. Extending their earlier work, Fama and French (1993) construct the *SMB* factor to capture the size anomaly and the *HML* factor to capture the B/M anomaly using 2x3 double sort portfolios based on size and B/M ratio. Using monthly time-series regressions, they show that the 3F model successfully explains average returns on 25 size-B/M sorted portfolios.

Fama and French (1996) use the 3F model to explain existing asset pricing anomalies. Using the time-series regression approach, they conclude that the 3F model successfully explains the variation in the average portfolio returns sorted on single sorts of B/M, E/P, cash flow-to-price (C/P), five-year sales growth, and the long-term past return variables and double sorts of sales growth and B/M, E/P, and C/P variables. However, the 3F model fails to explain the momentum returns documented by Jegadeesh and Titman (1993). Chan et al. (1996) and Jegadeesh and Titman (2001) also report that the 3F model is unable to explain the momentum returns.

As the 3F model cannot explain short-term momentum described by Jegadeesh and Titman (1993), Carhart (1997) introduces a fourth factor, called the momentum factor, to capture the momentum anomaly, and the model is referred as the 4F factor model. The momentum factor is based on the difference in the return between portfolios of winner stocks and portfolios of loser stocks. Many researchers examine the performance of both the models using the time-series regression tests in the spirit of Fama and French (1993, 1996) and also the cross-sectional regression tests using the two-step approach of Fama and MacBeth (1973). The next section discusses the literature related to the time-series and cross-sectional tests of the 3F and 4F models.

2.3 Time-Series and Cross-Sectional Asset Pricing Tests of the 3F and 4F models

Fama and French's (1993) 3F model uses an indirect approach of choosing factors that help to explain the expected return. They argue that market portfolio alone cannot capture the systematic risk, therefore, the size and B/M are needed and these variables are priced separately. Both variables reflect unknown state variables and produce non-diversifiable systematic risk in returns that are not captured by CAPM. Their model is given by

$$E(R_{i,t}) - R_{f,t} = \alpha_i + \beta_{i,MKT}\left[E(R_{MKT,t}) - R_{f,t}\right] + \beta_{i,SMB}E(R_{SMB,t}) + \beta_{i,HML}E(R_{HML,t}), \quad (2.2)$$

where $E(R_{SMB,t})$ (small-minus-big) is the difference between the expected return on diversified portfolios of small and big stocks, $E(R_{HML,t})$ (high-minus-low) is the difference between the expected return on diversified portfolios of high and low B/M stocks, and $\beta_{i,SMB}$ and $\beta_{i,HML}$ are the slopes of the multivariate regression of $E(R_{i,t}) - R_{f,t}$ on $R_{SMB,t}$ and $R_{HML,t}$.

As already mentioned, the 3F model is unable to explain momentum profits, so Carhart (1997) augments the model with Jegadeesh and Titman's (1993) one-year momentum factor to evaluate the performance of mutual funds. He reports that when used to explain average returns on 27 portfolios sorted on size, B/M and momentum, the 4F model has lower pricing errors in the time-series regression approach compared to both the CAPM and 3F models. The 4F model is given by

$$E(R_{i,t}) - R_{f,t} = \alpha_i + \beta_{i,MKT}[E(R_{MKT,t}) - R_{f,t}] + \beta_{i,SMB}E(R_{SMB,t}) + \beta_{i,HML}E(R_{HML,t}) + \beta_{i,WML}E(R_{WML,t}), \quad (2.3)$$

where $E(R_{WML,t})$ is the expected return on the zero-cost portfolio capturing the momentum anomaly and $\beta_{i,WML}$ is the time-series slope from the multivariate regression.

2.3.1 Time-series tests of 3F and 4F models

Fama and French (1993) construct the *SMB* and *HML* factor returns from the six portfolios sorted on two size groups and three B/M groups. They use the median size and the 30th and 70th percentiles of the B/M ratio of all NYSE stocks as the size and the B/M breakpoints, respectively. The *SMB* returns are then the equally-weighted average of the three small size portfolios minus the equally-weighted average of the three big size portfolios. The *HML* returns are the equally-weighted average of the two high B/M portfolios minus the equally-weighted average of the two low B/M portfolios. Fama and French (1993) use size and

B/M breakpoints based on NYSE stocks to avoid the sorts being dominated by a large number of small stocks on NASDAQ.

However, some distinct methods have emerged to construct the *SMB*, *HML*, and *WML* factors in the literature, especially for countries other than the US. The main reasons for the divergence from the Fama and French (1993) method are the unavailability of an NYSE equivalent proxy of stocks with big market capitalisation and the very low number of stocks in samples outside the US. Also, there are some differences in international studies regarding the definitions of size, B/M, and momentum factors and the date of sorting stocks into portfolios, depending on the accounting methods and the date of fiscal year end in different countries [see Liew and Vassalou (2000), Daniel et al. (2001), Griffin (2002), Aretz et al. (2010), and Hou et al. (2011)].

Following the factor construction approach of Fama and French (1993), Daniel and Titman (1997) challenge the initial results of Fama and French (1993, 1996) and show that average stock returns are better explained by firm characteristics, such as size and B/M ratio, rather than the factor mimicking risk factors *SMB* and *HML*. Using 45 portfolios sorted on three size, three B/M, and five pre-formation factor loading groups (either the *SMB* or *HML*), they show that returns are similar for the portfolios having similar characteristics but different *SMB* and *HML* factor loadings. Further, Daniel and Titman (1997) report that the expected returns and the factor loadings do not have any positive relation after controlling for the size and B/M characteristics. These results contradict the Fama and French (1993, 1996) argument that returns to the characteristics arise because they proxy for the non-diversifiable factor risk and indicate that it is the characteristics themselves that explain the cross-sectional variation in stock returns.

However, Davis et al. (2000) using monthly US data from 1929 to 1997, show that the 3F model is better at explaining the average stock returns compared to the characteristics-based model of Daniel and Titman (1997). They argue that the evidence of Daniel and Titman (1997) is sample-specific and arises largely from their short sample period. Lewellen (1999) also reports similar results using conditional models (conditional on the B/M ratio) and shows that the 3F model explains the time-varying average returns better than the B/M ratio.

2.3.2 Cross-sectional tests of 3F and 4F models

Despite the early success of the 3F and 4F models in explaining average stock returns in time-series tests, different researchers questioned their ability to explain stock returns in the cross-section. Jagannathan and Wang (1996) are the first to examine the performance of the 3F model using the cross-sectional regression approach of Fama and MacBeth (1973). Using non-financial stocks on NYSE and AMEX, they construct 100 portfolios sorted on size and pre-sorted beta and use them as test assets in their asset pricing tests. While comparing the performance of their conditional-CAPM with the 3F model, they show that both models have a significant zero-beta rate in excess of the T-bill rate. Thus, it is possible that the model is missing some important factor whose premium is reflected in the significant zero-beta rate. Further, Jagannathan and Wang (1996) show that the 3F model has similar explanatory power as of the conditional-CAPM model. In their cross-sectional regression tests, the market risk premium is negative, but not significantly different from zero, and the size and value factors have positive and insignificant risk premiums.

Brennan et al. (1998) test the performance of the 3F model against the characteristics based benchmark model and a model based on the principle component approach of Connor and Korajczyk (1988). Using individual stock data for US securities, they show that the size and B/M effects are reduced under the 3F model but remain significant. They also find strong evidence for the return momentum anomaly even after adjusting for the 3F model, endorsing the time-series findings of Fama and French (1996). Further, the 3F model also fails to explain the returns on the principle component based factors. Velu and Zhou (1999), using the

Generalised Method of Moments (GMM) test that allows for conditional heteroskedasticity, also reject the 3F model in the cross-section of returns.

Ferson and Harvey (1999) use conditional models to investigate the role of the 3F model in explaining average stock returns in time-series as well as cross-sectional dimensions. They use lagged values of five different state variables as conditioning variables, which include the difference in the One-month and three-month T-bill rates, the dividend yield of the S&P500 index, the difference between Moody's Baa and Aaa rated corporate bond yields, the difference between yields on a ten-year and a one-year Treasury bond, and the one-month T-bill rate. Ferson and Harvey (1999) report that the 3F model fails to explain the conditional expected returns using 25 size-B/M portfolios and 27 portfolios sorted on the size, B/M, and momentum.

Brennan et al. (2004) develop and test their ICAPM model, which includes the real interest rate and the maximum Sharpe ratio, against the standard CAPM and 3F models using 25 size-B/M and 30 industry portfolios. They report that both the CAPM and 3F models are rejected in cross-sectional tests, and only the excess market returns appear to have a positive and significant risk premium. Similarly, Dittmar (2002) tests nonlinear pricing kernels having endogenously generated risk factors, which include the return on aggregate wealth. He reports that the cross-sectional stock returns are better explained by these nonlinear pricing kernels compared to the 3F model. He also finds that the significance of the *SMB* and *HML* factors vanishes by introducing the cubic term of the pricing kernel.

Avramov and Chordia (2006) test the ability of various asset pricing models to explain stock market anomalies, such as size, B/M, turnover, and momentum. Using both conditional and unconditional asset pricing models, they show that the unconditional 3F model fails to explain these anomalies, while the conditional 3F model only explains the size and B/M effects. Avramov and Chordia (2006) also show that the momentum effect remains unexplained even by the conditional and unconditional versions of the 4F model. Using individual stock data, Chordia et al. (2015) also reject the CAPM and 3F models in cross-sectional tests. However, they conclude that both firm-specific characteristics and factor loadings are equally important and the choice of the factors and characteristics determines their relative importance.

Kan et al. (2013) use their newly developed misspecification robust cross-sectional regression tests to examine the CAPM and 3F models and compare their performance with various other models. The misspecification bias occurs when some relevant factors are omitted or the wrong factors are considered, and misspecification robust tests account for that bias. They show that the 3F model performed second best to Petkova's ICAPM model in explaining average returns on 25 size-B/M and five industry portfolios. However, the model fails the specification tests, whereas the size and value factors are still priced.

2.3.3 Tests of 3F and 4F models using international data

Using the time-series approach and data from 23 developed countries, Fama and French (2012) show that the regional 3F and 4F models are better at explaining average excess returns on regional size-B/M and size-momentum portfolios, compared to global versions of these models. They show that the regional 4F model successfully explains the average excess returns on the regional 25 size-B/M portfolios for Europe and Japan and 20 size-B/M portfolios, excluding microcaps, for Asia Pacific and North America. The regional 4F model also explains the average excess returns on 25 size-momentum portfolios in Japan and 20 size-momentum portfolios, excluding microcaps, for North America. However, both the global and regional models fail to explain the excess returns on size-momentum portfolios of Asia Pacific and Europe. Further, Fama and French (2012) illustrate that the average excess returns on global 25 size-B/M and 25 size-momentum portfolios, microcaps aside, are only explained by the global 4F model.

Fama and French's (2012) results of global models' failures to explain regional average returns show the lack of integration in asset pricing models across regions. This lack of integration can arise from a variety of reasons including, but not limited to, the differences in reporting standards of the accounting data between countries, the differences in rules and regulations governing the trading on equity exchanges resulting in different kinds of market structures, and differing levels of economic exposures. Based on Fama and French's (2012) results, one can argue that the asset pricing models may also not integrate at a regional level, given their inability to explain regional size-momentum portfolios and microcaps. In that case, country specific models may outperform the regional models.

In this context, Griffin (2002) tests the country specific and world versions of the 3F model to explain the average stock returns in the US, UK, Japan, and Canada. Griffin's (2002) world model factors are simply the weighted averages of country specific factors, weighted by total market capitalization. Griffin (2002) shows that the country specific 3F model does a better job in explaining average stock returns compared to the world model. However, Griffin (2002) does not examine the 4F model. Like Griffin (2002), Hou et al. (2011) investigate the performance of country specific and world models to explain the average stock returns in each country. They conclude that world factors have no role in explaining local average stock returns.

2.3.4 Tests of some alternative versions of 3F and 4F models

All the studies mentioned above use the standard versions of asset pricing models. That is the zero-cost characteristic based risk factors are constructed by equally weighting the individual component portfolios in the spirit of Fama and French (1993). However, Cremers et al. (2013) argue that equally weighting the *SMB* factor distorts the model alpha by disproportionately weighting the big-value stocks. Similarly, the equally weighted *HML* factor overweight's the small stocks. Hence, the higher *HML* returns are due to small-value stocks' better performance. Because of these distortions, Cremers et al. (2013) show that the 3F and

4F model leave large and significant alphas even for the passive benchmark indices like the S&P500 and Russell2000.

Cremers et al. (2013) propose two alternative approaches to construct the *SMB* and *HML* factors and recommend restricting the market portfolio to only domestic stocks traded on a country's domestic stock exchange. In their first recommendation, they suggest value-weighting the portfolios to construct the "modified" *SMB* factor instead of using Fama and French's equal-weighted *SMB* factor or constructing the "index-based" market, *SMB* and *HML* factors based on benchmark indices following common industry practices. They also point out that as in common industry practice, the benchmark indices rather than the Fama and French (1993) factor construction method should be used to construct the market portfolio and the *SMB* and *HML* factors. In their second recommendation, Cremers et al. (2013) propose the formation of three size and two B/M groups to construct two size and three value factors instead of single *SMB* and *HML* factors. They argue that single factors fail to capture the whole effect of size and value, and use of separate factors will result in fewer model rejections. Again, they suggest two size factors by value-weighting the characteristic portfolios, and constructing the index-based market, size, and value factors following benchmark indices.

Following Cremers et al. (2013), Gregory et al. (2013a) use the value-weighted *HML* and *WML* factors, together with a value-weighted *SMB* factor, to explain the cross-section of average stock returns in the UK. They also decompose the *HML* and *WML* factors by constructing separate factors for small and big stocks. Gregory et al. (2013a) find a modest improvement in the performance of value-weighted and decomposed models compared to standard asset pricing models.

2.4 Asset Pricing Literature based on Economic Theory

2.4.1 Literature based on Intertemporal CAPM (ICAPM) and Arbitrage Pricing Theory (APT)

Like Merton's (1973) ICAPM, Ross (1976) proposed an Arbitrage Pricing Theory (APT) model, explaining that additional risk factors need to be considered. He argues that the covariance of common risk factors with stock returns should be the only determinant of the average returns, as the higher level of co-movement shows that the factor represent the systematic risk. Macroeconomic variables can be used for both the ICAPM and APT, as they represent the underlying systematic risk factors. Moreover, Cochrane (2001) argues that the ICAPM and APT differ regarding their intuition for selecting the candidate risk factors. In particular, the ICAPM proposes state variables that define the conditional distribution of an asset's future returns, while the APT recommends a covariance analysis of returns and macro variables and extraction of factors characterizing the common variations in the average returns.

Roll and Ross (1980) demonstrate that the APT model can be tested empirically, as it does not need a market portfolio. Using individual equity data, Roll and Ross (1980) find four pricing factors in the return generating process using Principle Component Analysis (PCA). They show that as predicted by APT of Ross (1976), the expected returns depend on the estimated factor loadings. Burmeister and McElroy (1988) show that for APT the candidate risk factors can be both statistically motivated as well as driven by economic theory.

Chen et al. (1986) argue that any variables that affect the expected cash flows or the discount rates, and even if they do not directly affect the cash-flows and discount-rate, but describe the changes in the investor's opportunity set, can be candidate state variables in the context of ICAPM. They show that shocks to industrial production, term spread, default spread, and real interest rates are important in explaining expected stock returns. They do not claim that these factors exhaust the investor's opportunity set, but the market index becomes insignificant in the presence of these factors. As these factors do not exhaust the investor's opportunity set, any additional macroeconomic factors can be considered in the ICAPM framework.

Asprem (1989) finds some macro variables related to stock market returns and argues that these macro factors represent ICAPM state variables. More specifically, using data from different European countries, Asprem (1989) shows a negative reaction of stock prices to the news related to employment, interest rates, and inflation. Chen (1991) also reports an association among the predictability of expected stock returns and the macroeconomy using state variables. He points out that the dividend yield and the default spread track the current growth in the economy, which is negatively related to the expected returns. He further argues that future growth of the economy is positively related to the expected returns and it is tracked by the term structure, the T-bill rate, and the past growth of industrial production. These results show that economic variables are important determinants of expected stock returns.

Campbell (1996) proposes a model in which he describes the asset return as a function of innovations in the following factors: (1) market return, (2) predictors of future returns on the market, and (3) predictors of future human capital returns. He identifies the second set of factors (2 above) as the ICAPM state variables. He reported that the overriding pricing factor is the market risk and stated that the value of the intertemporal view of asset pricing theory comes from its ability to give an explanation of the importance of the market return as a risk factor in asset returns. He argues that this importance stems from the market return's association with other two factors (2 and 3 above) and not just being part of the investor's wealth.

Ferson and Harvey (1999) argue that the ICAPM is one of the likely successors to the empirically failed CAPM, although their empirical evidence is disappointing. They report that some lagged macro variables, including the dividend yield, term spread, default spread and short-term interest rate, capture the variations in expected stock returns. Vassalou (2003) finds that expected GDP news is important for pricing of stocks and captures the pricing power of the *HML* and *SMB* factors. She points out that a pricing model, which includes a proxy for expected GDP's news and market returns as risk factors, is consistent with the ICAPM in which investors are hedging against the state variable's risk. Liew and Vassalou (2000) also find that future GDP growth is related to the *SMB* and *HML* returns.

Brennan et al. (2004) argue that one of the key features of the ICAPM is its flexibility to use innovations in predictive factors of the investment opportunities as state variables. They develop a model that includes the Sharpe ratio and the real interest rate as state variables. Brennan et al. (2004) report that these state variables are priced, and their ICAPM model outperformed the 3F model and the CAPM in a number of exercises.

Petkova (2006) proposes an ICAPM model containing excess market returns and innovations to four state variables, namely the dividend yield, term spread, default spread and T-bill rate. She points out that these four potential state variables describe the conditional returns and the yield curve components of the investment set. She reports that her ICAPM model outperforms the 3F model, and the ICAPM specification succeeds as a conditional model whereas the 3F model fails conditionally.

2.4.2 Literature based on Consumption CAPM (CCAPM)

Recognizing the importance of the intertemporal aspect of ICAPM, Breeden (1979) argues that the model is not empirically testable because it uses multiple betas to measure the risk of state variables that are unknown. He proposes a consumption-based CAPM (CCAPM) and claims that CCAPM is empirically testable as it substitutes multiple betas of ICAPM with one consumption beta. However, Cochrane (2001) argue that although the CCAPM is theoretically well established, its failure on the empirical front stimulates the need for a better model.

Cochrane (1996) also reports the poor empirical performance of the CCAPM and indicates that problems with the reliability of consumption data can be a possible reason.

Lettau and Ludvigson (2001) use income, wealth, and consumption incorporated in a co-integration ratio and argue that the performance of the consumption-based CAPM, as well as the 3F model, improves drastically with the inclusion of this ratio. They report that the consumption-to-wealth ratio fluctuations are a strong predictor of average stock returns. Lettau and Ludvigson (2001) argue that the consumption-to-wealth ratio forecasts the short-term and intermediate-term returns better than most of the popular forecasting variables, including the dividend pay-out ratio and the dividend yield.

Supporting the importance of the macroeconomy for stock returns, Flannery and Protopapadakis (2002) argue that risk factors, in the context of Merton (1973), Ross (1976) and Breeden (1979), could be proxied by macro variables, although they do not receive the expected empirical support. They examine the importance of the announcements of 17 macroeconomic variables for the stock market. They find six variables are potentially important risk factors. More specifically, they report new evidence of the influential role of employment, housing starts and the balance of trade on the conditional variance of stock returns. They also report that the CPI and PPI influence the market return, and money supply influences the level and the conditional variance of returns, while industrial production and GNP are not relevant.

Parker and Julliard (2005) argue that the risk should be measured by the cumulative covariance of consumption growth and expected returns over a period of many quarters following the returns, rather than by their contemporaneous covariance. They show that their three-year ultimate consumption risk measure can explain a large proportion of the variation of 25 size-B/M portfolio returns compared to its contemporaneous measure.

Santos and Veronesi (2006) argue that dividends and wages are the two sources of investors' income. As both of these grow stochastically over time, economic conditions affect only the fraction of total income produced by wages. They show that the investors' required rate of return on stocks changes with these economic fluctuations. Santos and Veronesi (2006) find that the conditional CCAPM adjusted for these fluctuations explains cross-sectional returns quite well.

Based on consumption and dividend growth rates, Bansal and Yaron (2004) argue that if consumption news significantly affects economic uncertainty or expected growth rates in the long-run, consumption volatility news and expected growth rates in the short-run will influence the asset prices. To capture this intuition, they proposed a growth rates model. They argue that many asset pricing puzzles can be explained by their growth rates model together with the preferences of Weil (1989) and Epstein and Zin (1989). For a reasonable level of preference parameters, they show that the price-to-dividend and the wealth-to-consumption ratio increase as both better growth prospects in the long-run and economic uncertainty decline. They argue that the observable magnitudes and volatilities of the market premium and the risk-free rate, as well as the volatility of the dividend yield, are justifiable using their model. Bansal and Yaron (2004) also show that their model explains the volatility feedback effect very well, as measured by the negative correlation between return volatility news and return news. According to their model, expected growth rate fluctuations account for about half of the equity prices' variability, and the cost of capital fluctuations account for the remaining half.

Using Bansal and Yaron's (2004) model, Bansal et al. (2005), Hansen et al. (2008), Malloy et al. (2009), and Bansal et al. (2009) found results supporting the growth rates model. However, Constantinides and Ghosh (2011) raise some issues regarding the implications of the model. They argue that the latent state variable of Bansal and Yaron's (2004) model, make it empirically difficult to test. In Bansal and Yaron's (2004) model, the observable variables, the market-wide price-to-dividend ratio, and the risk-free rate, are functions of the model parameters and the latent state variables. By inverting these functions, the latent variables can be shown as known functions of the model parameters and observable variables. However, Constantinides and Ghosh (2011) argue that the process ignores the importance of the information set used by consumers to filter the state variables by bypassing the actual filtering of the state variables.

2.4.3 Literature based on beta decomposing and production-based asset pricing model

Campbell and Vuolteenaho (2004) decompose the market beta into the cash-flow beta and discount-rate beta based on the individual stock returns' covariance with market cash flows and discount rates, respectively. ICAPM suggests that the cash-flow beta should have a higher risk premia than the discount rate beta. Thus they classified them as "bad" beta and "good" beta. They find that the cash-flow betas are significantly higher for small stocks and value stocks compared to big stocks and growth stocks, which in part explain their higher average returns. Campbell and Vuolteenaho (2004) also point out that growth stocks and stocks with high betas in the past have mostly good betas with low risk premiums, which cause CAPM to perform poorly.

Extending the work of Campbell and Vuolteenaho (2004), Campbell et al. (2010) decompose the market beta into four parts based on the covariance of individual stock returns' with market cash flows and discount rates, with the objective of understanding equity prices' co-movements. Campbell et al. (2010) show that the growth stocks' cash-flows are predominantly sensitive to temporary aggregate stock price movements, and shocks to market discount rates drive these temporary movements. On the contrary, the value stocks' cash-flows are predominantly sensitive to permanent aggregate stock price movements, and shocks to aggregate cash flows drive these permanent movements. Therefore, fundamentals based on cash-flows for growth and value stocks determine their high betas for discount rates and cash flows, respectively. They argue that growth stocks are not merely "glamor stocks", and investor sentiment is not the sole determinant of their systematic risk. Rather, the systematic risks of their fundamentals primarily drive the systematic risks of individual stocks with similar accounting characteristics.

Researchers have also considered a firm as having a pool of assets and some real growth options on those assets. Berk et al. (1999) show that firm's systematic risk and average returns can be predicted using its assets and growth options. Gomes et al. (2003), Carlson et al. (2004), Zhang (2005), and Cooper (2006) used the model of Berk et al. (1999) and found that the investment costs and investment irreversibility costs can explain the failure of CAPM. In a different direction, Bernardo et al. (2007) and Da et al. (2012) use the firm's growth options to explain their impact on the cost of capital.

Cochrane (1991) postulates an asset pricing model using q-theory, referred to as the production-based model. He argues that this model is analogous to the standard CCAPM. However, instead of the consumers and utility functions, the production-based model is based on the producers and production functions. The model tries to link average stock returns with returns on investment (i.e., marginal rates of transformation), measured using the production function and investment data. Cochrane (1991) argues that, theoretically, average stock returns should be equal to the investment returns. Based on this notion, Cochrane (1991) derives a partial equilibrium for average stock returns forecastability. Cochrane (1996) reports evidence in support of the production-based model.

Xing (2008) explains the value effect using q-theory and a production-based asset pricing model. He uses an investment growth factor, defined as the difference of returns between low and high investment stocks, and shows that this factor captures the same information as the *HML* factor. He finds that the stocks with low-investment growth earn higher expected returns compared to stocks with high investment growth. Xing (2008) reports that there is no value effect in the presence of an investment growth factor, and results do not change for the marginal product of capital.

Hou et al. (2015) also examine a model based on q-theory that contains the market, size, investment, and profitability factors. They show that the model adequately explains average stock returns in the cross-section. They comprehensively examine 80 prominent anomalies of the asset pricing literature and show that their model explains about half of these anomalies. More importantly, the performance of their model is similar to the 3F and 4F models in explaining returns on the remaining half of the anomalies. More recently, Fama and French (2015) propose a five-factor (5F) model motivated from the dividend discount valuation model. They show that the 3F model is dominated by their 5F model containing the market factor and factors capturing size, value, profitability, and investment patterns in average stock returns. They also report that the value factor becomes redundant for describing average returns in the presence of profitability and investment factors. The results of both Hou et al. (2015) and Fama and French (2015) show that instead of considering alternative versions of the 3F and 4F models in the form of decomposed, modified, and index-based factors, inclusion of additional factors capturing the investment and profitability effects may be one of the possible extension of the 3F model. However, as already mentioned, the purpose of this thesis is to explain size, value and momentum effects using variations of the 3F and 4F models, not the extension of the 3F model by adding additional risk factors.

2.4.4 Literature on explaining Size, Value, and Momentum factors using macroeconomic models

Among the studies mentioned, Petkova (2006) is the first of its kind linking size and value factors with innovations to state variables representing changes in an investor's opportunity set in the context of ICAPM. In addition to simple tests of the 3F model and her ICAPM model, she examines an extended model that includes the excess market returns and innovations to four state variables and the *SMB* and *HML* factors. She reports that in the presence of the state variable innovations, the risk premiums on the *SMB* and *HML* factors become insignificant. Based on these results, she concludes that the factors proxy for state variable innovations.

There are quite a few other studies that attempt to rationalize the size and value factors by linking them to the macroeconomy. Li et al. (2006) use sector investment growth to explain average stock returns. Their empirical model outperformed the CAPM and production-based model of Cochrane (1996) and had comparable performance with the 3F model in explaining average stock returns. Li et al. (2006) also report that the investment growth rates of individual sectors explain all the information captured by the *HML* factor.

Perez-Quiros and Timmermann (2000) show that the cyclical differences in risk and average returns are higher for small stocks compared to big stocks. They also find that tighter credit market conditions, measured by higher interest rates, higher default premium, and lower money supply growth, have a stronger effect on small stocks compared to the big stocks, which usually are better collateralized. Based on these results, Hahn and Lee (2006) investigate whether the *SMB* and *HML* factors represent business cycle risk. They report that changes in the default spread and term spread capture the systematic differences in the size and B/M sorted returns in the same way as captured by the *SMB* and *HML* factors. The default spread loadings are higher for small stocks compared to big stocks, and term spread loadings are higher for high B/M stocks compared to low B/M stocks. Moreover, the *SMB* and *HML* factors are redundant in the presence of default and term spread changes. The findings suggest that the premiums on the size and value factors are compensations for credit market risk.

Researchers also tried to link momentum profits with different variables including the macroeconomy. Using data from 40 international markets, Griffin et al. (2003) show that momentum profits cannot be explained using Chen et al.'s (1986) unconditional model nor a lagged instruments based conditional model. However, Liu and Zhang (2008) argue that about half of momentum profits are explained by industrial production growth and stress that the economy-wide risk drives the momentum profits. They show that the winner stocks have higher loadings on industrial production growth and consequent higher average future growth rates compared to loser stocks. They also report that the expected growth risk is a priced factor in cross-sectional tests, and it is directly related to expected growth.

2.5 Asset Pricing Literature based on Behavioral Finance

Being a relatively new field, behavioural finance offers an alternative to traditional finance. It attempts to study why people buy or sell financial assets based on the psychological principles of decisions making. Instead of completely replacing traditional finance, behavioural finance plays a complementary role in helping to understand the issues that traditional finance fails to provide satisfactory answers for, such as: (i) Why do individual investors trade? (ii) How do they perform? (iii) How do they choose their portfolios? (iv) Why do returns vary across stocks for reasons other than risk? Behavioural finance focuses on how investors interpret and act on information during their investment decision making. The standard assumption underlying traditional finance that investors always behave in a rational, predictable and an unbiased manner is relaxed in behavioural finance. Behavioural financial economists have documented plenty of evidence that investors' emotions and cognitive errors are associated with various financial market anomalies.

Lakonishok et al. (1994) argue that the value effect arises from errors in the expectations of investors regarding future earnings of value and growth stocks. They show that due to investors tendency to extrapolate past performance of stocks into the future, some investors overvalue stocks that performed well and overbuy them, which causes overpricing of growth stocks. Similarly, value stocks are underpriced because of investors overreaction to their past poor performance. Ultimately, the prices of stocks revert to their mean and value stocks outperform growth stocks. La Porta et al. (1997) and Skinner an Sloan (2002) also report evidence that investors overestimate future earnings of growth stocks and underestimate those of value stocks.

Daniel et al. (1998, 2001) propose a theory that uses investor overconfidence, including the precision of private information, its asymmetric shifts and self-attribution bias, to explain patterns in expected stock returns. They argue that there is overreaction to private information and underreaction to public information by the investors, which lead to anomalies such as the B/M effect. Moreover, contrary to the existing evidence, they show that the continuing overreaction can lead to positive return autocorrelation, hence the existence of the momentum effect. Along the same lines, Gervais and Odean (2001) model the role of self-attribution bias in the development of an investor's overconfidence. They argue that overconfidence changes with success and failure, and in cases of success the investor revises his/her beliefs about his/her ability upwards, attributing most of the success to his/her abilities. Asem and Tian (2010) report higher momentum profits in the case when the state of the market remains the same compared to the case when the market transitions to a different state. They argue that their findings support the overconfidence explanation of Daniel et al. (1998).

Barberis et al. (1998) propose a model of investor sentiment, explaining how investors form their beliefs. They argue that investors expect continuity of small sample patterns and extrapolate random sequences, which creates overreaction. Meanwhile underreaction is induced by investors' underweighting of new information relative to previous information (conservatism), which causes the momentum effect.

Hong and Stein (1999) propose a model based on positive feedback trading, in which interaction takes place between two groups of investors that are boundedly rational, but have the ability to process only a subset of information. They argue that there is a gradual diffusion of private information which generates momentum profits, because investors are only able to extract each others' private information according to this gradual diffusion. Hong et al. (2000) endorse the view of Hong and Stein (1999) that the momentum effect is caused by the slow diffusion of private information. They show that the momentum effect is prominent in the returns on stocks with small size and low analyst coverage, and it is caused by slow diffusion of information in these firms. Doukas and McKnight (2005) find similar results for a sample of 13 European stock markets.

Barberis and Shleifer (2003) provide a behavioral view for the comovement of stock returns. They argue that the investors have a tendency to group heuristically into different categories, such as large-cap stocks or growth stocks, and allocate their investments based on these different categories. Based on the assumption that these categories are also adopted by noise traders, they argue that price pressure induced by these noise traders cause common factors in the stock returns of these categories. Hence, any stock added to a particular category begins to comove with that category. Barberis et al. (2005) provide empirical evidence for the "Category" view of Barberis and Shleifer (2003). They show that when a stock is included in (excluded from) the S&P500 index, the beta of the stock with respect to the S&P500 goes up (down). According to Barberis et al. (2005), this happens because investors mentally classify stocks in the S&P500 as a single category.

Ali et al. (2003) argue that the value effect is higher for stocks that have arbitrage risk. They show that stocks with higher idiosyncratic return volatility, higher transaction costs, and lower ownership sophistication are difficult to arbitrage, and have a higher value effect. Baker and Wurgler (2006) also show that stocks having these characteristics are difficult to arbitrage, causing mispricing, and are closely related to investor sentiment.

2.6 Conclusion

This chapter provides a comprehensive and detailed review of the asset pricing literature. Being conscious of the vast amount of literature on asset pricing models, ranging from empirical tests of well-documented anomalies to investigations of their theoretical background in the context of the CAPM, ICAPM, APT, and CCAPM models, I focused only on directly relevant studies and discuss only empirical results. For that purpose, the literature review is divided into the time-series and cross-sectional literature on 3F and 4F models, and wider literature motivated from economic theory.

Given the results of Fama and French (2012) and recommendations of Cremers et al. (2013) described in subsections 2.3.3 and 2.3.4, there is a need for an improved and integrated asset pricing model that can price the cross-section of stock returns in an international sample of the US, UK, Japan, and Canada. To achieve this, I construct and test the modified 7F and index-based 7F models of Cremers et al. (2013), the two models that perform best in their tests. I also construct and test the decomposed versions of the 3F and 4F models, following the decomposition approach of Fama and French (2012). The purpose is to investigate whether the decomposition of the factors or switching to the other factor construction method improves the model performance in the sample of countries considered, as shown by Cremers et al. (2013) for US mutual fund returns.

Given the lack of cross-sectional tests in the international context, I also test the above mentioned models using the cross-sectional regression tests. The primary reason for a lack of cross-sectional studies in an international context is that the factors used in the models are returns based, and in such cases time-series and cross-sectional test results should be the same, at least in theory. However, Fama and French (2008) point out that the cross-sectional regression approach provides direct estimates of the marginal effects of the factors and show which factors have unique information about average returns. Therefore, I use both the time-series as well as cross-sectional regression approaches to test the performance of the asset pricing models and to examine which returns based factors have unique explanatory power.

Moreover, given the evidence in the subsection 2.4.3 that size, value, and momentum factors represent some unobservable macro phenomena, I attempt to link the *SMB*, *HML,* and *WML* factors to the macroeconomy following the approach of Petkova (2006) in Chapter 6. All of the studies mentioned above, including Petkova (2006), are based on US stock returns. I extend Petkova's (2006) work to an international context and investigate her ICAPM model along with 3F and 4F models and their alternative specifications. The main reason to focus only on Petkova's (2006) model is that different researchers have found that the model performs better than the 3F and 4F models [Kan et al. (2013) and Gospodinov et al. (2014)] and state variable innovations used in the model are found to proxy for the size and value factors [Perez-Quiros and Timmermann (2000), Petkova (2006) and Hahn and Lee (2006)].

Petkova (2006) uses a VAR model to obtain innovations to the four state variables, namely the dividend yield, term spread, default spread and T-bill rate, and uses these innovations along with the excess market returns as an ICAPM model. The VAR model also contains excess market returns and returns on *SMB* and *HML* factors. Replicating Petkova (2006) in application of a VAR model, I use these state variable together with return based factors to obtain innovations. As I test the 3F and 4F models together with decomposed, modified and index-based models, I incorporate the four state variables with factors from each separate returns based model into a VAR to obtain innovations. This results in six sets of innovations for each of the four state variables, each corresponding to separate return based model, I then test these innovations in six different ICAPM models.

Petkova's (2006) tests are based on the 25 size-B/M portfolios and assumed that the 3F and 4F models are correctly specified. Keeping in view the criticism of Lewellen et al. (2010), I use an industry augmented set of test portfolios, that is the 25 size-B/M and 25 size-momentum portfolios both augmented with 19 industry portfolios. Moreover, I test these models using model misspecification adjusted tests of Kan et al. (2013), who provide asymptotic results for the potential model misspecification. Despite the fact that the cross-sectional R^2 is an intuitive tool to test the overall fit of the model, Petkova (2006) suggests that one should interpret it with caution. Therefore, I use the asymptotic distribution of cross-sectional R^2 to test whether it is different from one and different from zero following Kan et al. (2013).

Chapter 03: Data Description, Factor Construction, and Formation of Test Portfolios

3.1 Introduction

This chapter presents and describes the dataset used in this thesis. Specifically, Section 3.2 describes the filters used to determine the sample for the empirical analysis. Section 3.3 explains the construction of monthly returns for explanatory factors. Section 3.4 reports descriptive statistics for the returns of the explanatory factors. Section 3.5 discusses the construction of the test portfolios to be used as dependent variables in the assets pricing tests and presents their descriptive statistics. The test portfolios include 25 size-B/M, 25 size-momentum, and 19 industry portfolios. Section 3.6 reports some robustness results for the monthly returns of the risk factors and the test portfolios for the US, and Japan by comparing them with their equivalents from Kenneth French's website[4] and for the UK by comparing them with the data from Gregory et al. (2013a)[5]. Finally, Section 3.7 concludes this chapter.

3.2 Data Filtering and Dataset Construction

The sample includes the stocks from the US, UK, Japan, and Canada. Initially, the G7 countries were considered, including France, Germany, and Italy. But due to the low number of stocks for these countries, it was not possible to construct well diversified test portfolios (discussed in section 3.5) for these individual countries. Fama and French (2012) stress on the importance of having well diversified portfolio in the asset pricing regressions, which are the focus of asset

[4] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html (accessed on 06/06/2014)
[5] http://business-school.exeter.ac.uk/research/areas/centres/xfi/research/famafrench/files/ (accessed on 26/08/2015)

pricing tests in this thesis. They argue that the diversification improves regression fit and increase the precision of intercepts, on which the asset pricing tests are based on. Therefore, there is a trade-off between wanting to look at the stock returns of individual countries and having well diversified portfolio to maintain the precision of the regression fit. In this thesis I opt to construct well diversified portfolios on country level stock returns data for the US, UK, Japan, and Canada, which gives a good coverage of markets on international level. There is still some possibility that the results may not be generalizable to the countries not considered in this thesis.

The dataset include all the listed and delisted firms from the sample countries that are covered by Thomson DataStream (TDS) for the period January 1986 to December 2013. I include delisted stocks to avoid survivorship bias[6]. According to Thomson Financial (2013), the accounting data on Thomson WorldScope (TWS), an integrated part of TDS, is more complete from 1985 onwards. Table A1 in the appendix presents the TDS mnemonics for the security constituent lists used to construct the dataset for each country. Following Ince and Porter (2006) and Hou et al. (2011), static filters, presented in Panel A of Table 3.1, are applied to get a comprehensive and high-quality sample.

The initial sample included all listed stocks from each of the four countries. To construct a representative sample for each country, I consider only those securities that are common equity listings, the purpose of which is to avoid duplicate listings. Then, I keep only domestic stocks that trade on each country's major stock exchange(s). Following Hou et al. (2011), the stock exchange(s) with the higher average trading volume during the period of this study is selected. One exchange is included for the UK and Canada, whereas multiple exchanges are combined for the US and Japan because a large number of domestic stocks trade

[6] Survivorship bias is the systematic error that is induced from excluding companies that no longer exist. Kothari et al. (1995) argue that survivorship bias is a serious problem for the asset pricing studies, because the exclusion of firms that didn't survive distress results in higher average returns than including the dead stocks. Further, the trading strategies with *ex post* selection bias in factors and portfolios construction are not replicable *ex ante*.

on these different stock exchanges and using firms listed on only one exchange will not allow me to construct an appropriate representative sample for the stock markets of these countries. Additionally, a stock is required to have at least 12 monthly returns for the last year to be part of the sample. Table A1 also shows the number of stocks included in each country, after applying the static filters. The sample includes a total of 29,520 stocks from all four countries. Monthly data for these stocks from January 1985 to December 2013 are collected from TDS. These include the Total Return Index (TDS mnemonic, RI), Adjusted Price (P), Unadjusted Price (UP), Dividend rate (DDE), Market Value (MV), Number of Shares (NOSH), and the annual price-to-book ratio[7] (WC09304), all these variables are denominated in US dollars.

The dollar denominated returns are used to make a cross-country comparison of the asset pricing models. It also allows the test of market integration across the four countries. However, there is a possibility that the use of returns denominated in US dollars may inadvertently include an exchange rate component, which motivates the robustness test presented in Section 3.6. The robustness test shows that dollar denominated and local currency returns have no significant differences. As a result, and consistent with Griffin (2002), Hou et al. (2011), and Fama and French (2012), the asset pricing tests in this thesis ignore the exchange rate risk. However, there is an implicit assumption in this thesis, and with the tests of Fama and French (2012), that either there is complete purchasing power parity (relative prices of goods are the same everywhere and an exchange rate the ratio of the nominal prices in two countries) or the exchange rate risk cannot be hedged using the assets considered [Fama and Farber (1979), Adler and Dumas (1983)].

[7] I use annual price-to-book ratio because the book value per share is an accounting item from the balance sheet, available annually for stocks from all countries.

Table 3.1 Static and Time-Series Filters

This table describes the filters and the Thomson Reuters DataStream (TDS) mnemonics of data items involved in the filtering process. Panel A reports the static filters applied to obtain a representative sample for the common equities in each country. Panel B reports the items for the time-series filters applied to correct any TDS data errors.

Panel A: Static Filters

Static filter ID	Filter description	TDS Mnemonic
S01	Drop all duplicate listings across different constituent lists for each country	DSCD
S02	Drop all non-equity constituents (i.e., TYPE= 'EQ')	TYPE
S03	Drop all non-major constituents and keep only major listings (i.e., MAJOR= 'Y')	MAJOR
S04	Drop all non-domestic stocks and keep only domestic listings (i.e., GEOGN= 'UNITED STATES', GEOGN= 'UNITED KINGDOM', GEOGN= 'JAPAN', and GEOGN= 'CANADA')	GEOGN
S05	Drop all stocks not listed on countries' major exchange(s), and keep only those stocks traded on NYSE, AMEX, and NASDAQ for the US, LSE for the UK, OSAKA and TOKYO for Japan, and TORONTO for Canada.	EXMNEM and EXNAME
S06	Drop all the stocks for which the company name contains any suspicious words indicating that the listing may not belong to equities, is a duplicate, or is an expired security.	NAME

Panel B: Time-Series Screens

Time-Series Filter ID	Filter Description	TDS Mnemonic
T01	Drop all the observations in the sample when the last month unadjusted price is less the $1.00.	UP
T02	When there are no observations in the total return index or the two methods of calculating returns yield different results, the return from the total return index is replaced with the one calculated from the adjusted price and dividend. As this is only valid in the absence of stock splits, the replacement is done in those months only when the adjusted price to unadjusted price ratio is the same as in the previous month.	RI, P, and DDE
T03	Drop all monthly observations from the end of the sample period back to the first non-zero return.	RI, P, and DDE
T04	Drop both the current month return (R_t) and previous month return (R_{t-1}), if R_t or R_{t-1} is greater than 300% and the cumulative return is less than 50%, i.e., $[(1+R_t)\times(1+R_{t-1})-1]<50\%$	RI, P, and DDE
T05	Drop all the returns that do not fall within the 0.1% to 99.9% percentile range in each market.	RI, P, and DDE
T06	When there are no observations of the market value (MV) or the two methods of calculating MV yield different results, the MV is replaced with the value calculated by multiplying the unadjusted price by number of shares.	MV, UP, and NOSH

Ince and Porter (2006) and Schmidt et al. (2014) stress that the monthly returns and market capitalization calculated from the raw TDS data are not error-free and can lead to wrong inferences regarding the performance of asset pricing models. To correct the TDS data, I apply several time-series filters following Ince and Porter (2006), Hou et al. (2011), and Schmidt et al. (2014), which are summarized in Panel B of Table 3.1. Filter T01 in Panel B of Table 3.1 drops all the monthly observations when the last month's unadjusted price is less the \$1.00. This filter deals with the non-trivial errors in the returns of stocks with very small prices that arise from TDS's practice to round prices to the nearest penny. It also ensures the exclusion of illiquid stocks and outliers to avoid sudden drastic change in the returns and market values [Ince and Porter (2006) and Hou et al. (2011)].

Monthly returns are calculated using the end of month total return index as well as using the month end adjusted prices and dividends (if at least the adjusted price is available). The return of the total return index is replaced with the return calculated from the adjusted price and dividends when there are no observations for the total return index or when the two methods of calculating returns yield different results (Filter T02). It is done for two reasons: first, to get return data when the total returns index is not available; and second, to deal with any errors in the return calculated from total return index. Filter T03 excludes all zero returns for dead firms from the end of the sample back to the non-zero return, this removes them from the sample considering TDS practice is to report the last valid data point for delisted stocks. Following Ince and Porter (2006) and Hou et al. (2011), any return above 300% that is reversedin one month is dropped (Filter T04). Filter T05 removes any remaining outliers by dropping all the returns that do not fall in the 0.1% to 99.9% percentile range. Finally, filter T06 is used to construct a single market value figure from the TDS market value (MV) and self-created market value (unadjusted price (UP) times the number of shares (NOSH)). The purpose is to get the market value figure in the case that the MV is not available.

3.3 Construction of the explanatory return based factors

Fama and French (1993) and Carhart (1997) thoroughly describe the approach for constructing the *SMB*, *HML*, and *WML* factor returns for their 3F and 4F models. Fama and French (1993) define the market value of equity as the stock price times the number of shares outstanding. They also define the book value of equity as the stockholders' common book equity, plus the balance sheet deferred taxes and investment tax credit, if available, minus the book value of the preferred stock. Size is then defined as the market value of equity at the end of June in year *t,* and the B/M ratio is the book equity at the end of fiscal year $t - 1$ divided by the market value of equity at the end of December $t - 1$. They then construct six portfolios by independently sorting stocks according to size and B/M in every June of year *t*. Value-weighted monthly returns are then calculated from July of year *t* to June of year $t + 1$.

Fama and French (1993) use the median size of all the NYSE listed stocks as the size breakpoint to divide stocks into small and big categories and the 30th and 70th B/M percentiles of all the NYSE listed stocks as the B/M breakpoints to categorize stocks as growth (i.e., the stocks in the bottom 30th percentile of the B/M ratio), neutral (i.e., the stocks in the middle 40th percentile of the B/M ratio), and value (i.e., stocks in the top 30th percentile of the B/M ratio). They then construct six portfolios from the intersection of two size and three B/M groups. *SMB* is the difference between the equal-weighted average of the value-weighted returns on the three small size portfolios and the equal-weighted average of the value-weighted returns on the three big size portfolios. Similarly, *HML* is the difference between the equal-weighted average of the value-weighted returns on the two high B/M portfolios and the equal-weighted average of the value-weighted returns on the two low B/M portfolios.

Carhart (1997) explains the construction of the *WML* factor (which he names *PR1YR*) as the value-weighted returns on a zero-investment portfolio, i.e., simultaneously taking a long position in the winner stocks and equivalent short position in loser stocks. *WML* is the equally-weighted average of the value-weighted returns on the stocks in the top 30th percentile of the 11-month past returns lagged by one month (named the momentum variable), minus the equally-weighted average of the value-weighted past returns on the stocks in the bottom 30th percentile of the 11-month returns lagged by one month. Following their earlier approach, Fama and French constructed the *WML* (initially referred to as *UMD*) factor from the six portfolios formed on independent sorts of size and momentum. The *UMD* factor returns are calculated as the difference between the equally-weighted average of the value-weighted returns on the two high return portfolios (i.e., up portfolios) and the equal-weighted average of the value-weighted returns on the two low return portfolios (i.e., down portfolios). Some examples of the studies that employed the *UMD* factor from Kenneth French's website are Eckbo and Norli (2001), Lamont (2002), Affleck-Graves and Miller (2003), Sapp and Tiwari (2004), and Lewellen (2011).

Fama and French (1993) use the intersection of independent sorts of size and B/M, instead of a single sort, to construct the *SMB* and *HML* factors so that the factors are free from each other's effect and any influence of the sorting order. Further, only two portfolios are formed by size as compared to the three B/M portfolios on the basis of evidence in Fama and French (1992) that size has comparatively little role in explaining the average stock returns compared to B/M. Both arguments also apply to the six size-momentum portfolios used to construct the *UMD* factor, given the evidence in Fama and French (2008, 2012) about the prevalence of the momentum effect in small stocks. Further, Fama and French (1993) use the NYSE breakpoints to avoid the domination of the resultant portfolio by large numbers of illiquid and small stocks from AMEX and NASDAQ [Fama and French (2008, 2012)]. The small stocks constitute a large part of the US equity market and certainly are not a significant part of institutional investors' investment universe. As a result, the portfolios and risk factors based on inappropriate breakpoints will be weighted heavily by illiquid and small stocks, and inevitably will lead to biased inferences.

In addition to the Fama and French's (1993) standard approach to construct the *SMB*, *HML*, and *UMD* factors, which focus exclusively on the US, there exist a number of modifications in the empirical literature. The main reasons for divergence from the Fama and Frenchs's (1993) approach for international studies are the low number of stocks and unavailability of an NYSE equivalent proxy for stocks with big market capitalization in the equity markets outside the US. Also, there are significant differences in the definitions of the size, B/M, and momentum variables and timing of sorting stocks. These differences are mainly due to different accounting standards and dates of the fiscal year in different countries. Recognizing these data limitations, Liew and Vassalou (2000) use sequential/dependent three-way sorts to construct the *SMB*, *HML*, and *UMD* factors. Daniel et al. (2001) construct portfolios at the end of every September for the Japanese stock market, because most of the stocks listed on Tokyo Stock Exchange have a March fiscal year end, and accounting data is available before September. Hou et al. (2011) use breakpoints based on all the stocks in their sample to construct the *SMB* and *HML* factors as the return spread between the upper 20% and lower 20% of stocks sorted by size and B/M, respectively. More recently, Gregory et al. (2013a) use size a, B/M, and momentum breakpoints based on the largest 350 stocks in terms of market capitalization to construct the UK versions of the size, value, and momentum factors.

Fama and French (2012) argue that factors formed using all stocks are likely to be dominated by small stocks. Fama and French (2008) find that because small stocks are more plentiful than big stocks, and that fundamentals of small stocks are typically more dispersed, the factors constructed using sorts on all stocks are dominated by small stocks. Recognizing the bias created in the construction of the factors, I follow Fama and French's (2012) methodology for constructing the risk factors and the size-B/M and size-momentum portfolios.

All the data and returns are denominated in US dollars to make the cross-market comparison and testing of the integrated international asset pricing models meaningful. Returns are discrete and include both the dividend and capital gains. Campbell et al. (1997) point out that discrete returns are commonly used in cross-sectional asset pricing tests.

Size-B/M portfolios for July of year j to June of $j + 1$ include all stocks with market equity data for June of year j and a B/M ratio for the end of year $j - 1$. Following Hou et al. (2011), B/M is calculated as the inverse of the price-to-book (P/B) ratio. TWS define the P/B ratio as *"the market price at year end divided by book value per share"*. The market price is defined as *"the closing price of the company's stock at December 31 for US Corporations, and the closing price of the company's stock at their fiscal year end for non-US corporations"*. The book value per share is defined as *"the proportioned common equity divided by outstanding shares at the company's fiscal year end for non-US corporations and at the end of the last calendar quarter for US corporations"*. According to TWS, preference stock has been included in equity and the calculation of the book value per share where it participates with the common shares in the profits of the company. Further, preference stock is excluded from the book value in all the other cases where it does not participate with the common shares in the profits of the company.

To construct the *SMB* and *HML* factors, I form six size-B/M portfolios[8]. I sort all stocks into two groups according to size and three groups according to B/M at the end of each June in year j. Following Fama and French (2012), small stocks (S) are those in the bottom 10% of the June market value, and big stocks (B) are those in the top 90% of the June market value. The B/M breakpoints are the 30th and 70th percentiles based on big stocks (i.e., top 90% of the market value), and are used to divide stocks into growth (G, bottom 30%), neutral (N, middle

[8] I mostly used STATA for the data screening and factor and portfolio construction in this chapter and for time-series tests in the chapter 4. MATLAB is used for the cross-sectional regression tests in chapter 5 and 6.

40%), and value (V, top 30%). As a result, the independent 2x3 sorts on the size and B/M produce the six portfolios, SG, SN, SV, BG, BN, and BV.

Six size-momentum portfolios are formed each month in the same manner to construct the *UMD* factor (denoted by *WML* hereafter). For portfolios formed at the end of month $t-1$, I define momentum to be the stock's cumulative returns for month $t-12$ to month $t-2$. The momentum breakpoints of the 30th and 70th percentiles of the big stocks are used to divide stocks into losers (L, bottom 30%), neutral (N, middle 40%), and winners (W, top 30%). The 2x3 sorts on the size and momentum produce the following six value-weighted portfolios, SL, SN, SW, BL, BN, and BW.

Following Cremers et al. (2013), I construct and test modified and index-based versions of size and value factors by closely following their approach. All the stocks in a market are divided into three size and two B/M groups to form six modified size-B/M portfolios, separate from the standard six size-B/M portfolios, used to construct modified factors, the modification comes in terms of breakpoints used. Size breakpoints are the stocks in the top 75%, stocks between the 75% to 90%, and the stock in the bottom 10% of the total market value at the end of each June in year *j*; these are labelled as small (S), medium (M), and big (B) groups, respectively. The B/M breakpoint is the 30th percentile of the B/M ratio based on stocks in the top 90% of the market value that result in two B/M groups with stocks in the bottom 30% as growth (G) and stocks in the top 70% as value (V). The independent 3x2 sorts on the size and B/M produce the following six value-weighted portfolios: SG, SV, MG, MV, BG, and BV. These portfolios are then used to form modified factors presented in Table 3.2.

Cremers et al. (2013) use the S&P500, Russell Midcap, and Russell2000 indices as proxies for the big, medium, and small indices, respectively. Davies et al. (2014) construct the index-based factors for the UK by forming three size indices as portfolios of stocks in the FTSE100 index as the big index, the portfolio of stocks ranked 101 to the largest 90% of the market value as the medium index, and the portfolio of stocks in the bottom 9% of the market value as the small index. The authors do not include the bottom 1% of the stocks with lowest market values to avoid liquidity issues. Following Davies et al. (2014), I construct size indices in every June of year *j*, using the market values at the end of June in year *j*. The big indices (B) are formed as the portfolio of the largest 500 stocks based on the S&P-00 index for the US, the portfolio of the largest 100 stocks based on the FTSE100 and TOPIX100 indices for the UK and Japan, respectively, and the portfolio of the largest 60 stocks based on the SPTSX60 index for Canada. The medium indices (M) are the portfolios of stocks ranked in between the big indices and top 90% of the market value for each country, and small indices (S) are the portfolios of stocks in the bottom 10% of the market value for each country, as the small and illiquid stocks have already been dropped using time-series filters in Section 3.2. Each size index is divided into two B/M groups using the 30^{th} percentile of the B/M ratio to create value and growth indices.

For the construction of all international portfolios, i.e., the portfolios constructed from combined data of four countries, the size breakpoints are based on all stocks of the international sample. Following Fama and French (2012) the B/M and momentum breakpoints of each country are used to allocate stocks to international portfolios, a practice that accounts for the differences in the reporting of accounting data across the different countries. However, because the construction of index-based factors is based on country indices and there is no proxy for these indices for the combined four countries, the index-based size factors for the international sample use the country breakpoints. Table 3.2 reports a summary of construction of all the factors.

Table 3.2 Factor Construction
This table gives details of how factors are constructed. The factors include the standard, decomposed, modified and index-based factors.

Factor	Name	Explanation	Construction
		Standard Factors	
$R_{MKT,t}$	Market Portfolio	It includes all the stocks in a market with a valid return for the month t and market value for the month $t-1$.	Value-weighted returns on the market portfolio minus one month US dollar T-bill rate.
$R_{SMB,t}$	Size Factor	Constructed from the 2x3 size-B/M portfolios.	$\frac{(R_{SG,t}+R_{SN,t}+R_{SV,t})}{3}-\frac{(R_{BG,t}+R_{BN,t}+R_{BV,t})}{3}$
$R_{HML,t}$	Value Factor	Constructed from the 2x3 size-B/M portfolios following Fama and French (2012).	$\frac{(R_{SV,t}+R_{BV,t})}{2}-\frac{(R_{SG,t}+R_{BG,t})}{2}$
$R_{WML,t}$	Momentum Factor	Constructed from the 2x3 size-momentum portfolios following Fama and French (2012).	$\frac{(R_{SW,t}+R_{BW,t})}{2}-\frac{(R_{SL,t}+R_{BL,t})}{2}$
		Decomposed Factors	
$R_{HML_s,t}$	Small Stock's Value Factor	Constructed from the 2x3 size-B/M portfolios following Fama and French (2012).	$R_{SV,t}-R_{SG,t}$
$R_{HML_b,t}$	Big Stock's Value Factor	Constructed from the 2x3 size-B/M portfolios following Fama and French (2012).	$R_{BV,t}-R_{BG,t}$
$R_{WML_s,t}$	Small Stock's Momentum Factor	Constructed from the 2x3 size-momentum portfolios following Fama and French (2012).	$R_{SW,t}-R_{SL,t}$
$R_{WML_b,t}$	Big Stock's Momentum Factor	Constructed from the 2x3 size-momentum portfolios following Fama and French (2012).	$R_{BW,t}-R_{BL,t}$
		Modified Factors	
$R_{SMM,t}$	Small-Minus-Medium Modified Size Factor	Value-weighted size factor for the relative performance of small and medium size stocks, constructed from the 3x2 size-B/M portfolios following Cremers et. al. (2013). 'V' indicates the market value of each portfolio in subscripts.	$\frac{\left(R_{SG,t}\times V_{SG,t-1}+R_{SV,t}\times V_{SV,t-1}\right)}{V_{SG,t-1}+V_{SV,t-1}}-\frac{(R_{MG,t}\times V_{MG,t}+R_{MV,t}\times V_{MV,t})}{V_{MG,t}+V_{MV,t-1}}$
$R_{MMB,t}$	Medium - Minus-Big Modified Size Factor	Value-weighted size factor for the relative performance of medium and big size stocks, constructed from the 3x2 size-B/M portfolios following Cremers et al. (2013).	$\frac{\left(R_{MG,t}\times V_{MG,t-1}+R_{MV,t}\times V_{MV,t-1}\right)}{V_{MG,t-1}+V_{MV,t-1}}-\frac{(R_{BG,t}\times V_{BG,t-1}+R_{BV,t}\times V_{BV,t-1})}{V_{BG,t-1}+V_{BV,t-1}}$

(Continued overleaf)

Table 3.2 (continued)			
Factor		**Explanation**	**Construction**
$R_{SHML,t}$	Small Stock's Value Factor	Constructed from the 3x2 size-B/M portfolios following Cremers et al. (2013).	$R_{SV,t} - R_{SG,t}$
$R_{BHML,t}$	Big Stock's Value Factor	Constructed from the 3x2 size-B/M portfolios following Cremers et al. (2013).	$R_{BV,t} - R_{BG,t}$
Index-based Factors			
$R_{INDMKT,t}$	Index-based Market Portfolio	Index-based excess market returns, constructed from the big index of each market following Cremers et al. (2013).	Value-weighted returns on the big index minus one month US dollar *T*-bill rate.
$R_{INDSMM,t}$	Small-Minus-Medium Index-based Size Factor	Index-based size factor for the relative performance of small and medium size stocks, constructed from the small index and medium index portfolios following Cremers et al. (2013).	$R_{S,t} - R_{M,t}$
$R_{INDMMB,t}$	Medium - Minus-Big Index-based Size Factor	Index-based size factor for the relative performance of medium and big size stocks, constructed from the medium index and big index portfolios following Cremers et al. (2013).	$R_{M,t} - R_{B,t}$
$R_{INDSHML,t}$	Small Stock's Index-based Value Factor	Constructed from small size index following Cremers et al. (2013).	$R_{SV,t} - R_{SG,t}$
$R_{INDMHML,t}$	Medium Stock's Index-based Value Factor	Constructed from medium size index following Cremers et al. (2013).	$R_{MV,t} - R_{MG,t}$
$R_{INDBHML,t}$	Big Stock's Index-based Value Factor	Constructed from big size index following Cremers et al. (2013).	$R_{BV,t} - R_{BG,t}$

3.4 Descriptive Statistics for the Risk Factors

Panel A of Table 3.3 reports the summary statistics for the monthly excess market returns and the monthly returns on the *SMB*, *HML*, and *WML* factors and the decomposed counterparts of the *HML* and *WML* factors following Fama and French (2012). Panel B of Table 3.3 reports descriptive statistics for the alternative risk factors following the approach of Cremers et al. (2013) (i.e., the modified and index-based versions of the decomposed factors). For the sake of completeness, the table also reports the Skewness, Kurtosis, and 25th, 50th, and 75th percentiles value along with mean and standard deviation.

The average market premiums for the period 1987-2013 are large for three out of four countries ranging from 0.33% per month for the UK to 0.64% per month for the US. For Japan, the market premium is -0.02% per month, similar to Fama and French (2012) who also report a very low and negative equity premium for Japan. Despite the large average, the equity premium estimates are imprecise, and are statistically significant only for US and Canada at the 5% and 10% levels of significance, respectively. Fama and French (2012) highlight a similar issue in the average equity returns of the four regions they studied. The return on the international market portfolio (0.36% per month) is also statistically indistinguishable from zero. There is no size (*SMB*) premium in any country or the international sample. Many recent studies report the absence of a size premium in equity returns. Fama and French (2012) report the absence of a size premium in the four regions they studied, and Gregory et al. (2013a) report a statistically insignificant and close to zero size premium for UK stock returns.

The value premium is strong and statistically significant for two out of four countries, and the international sample. The *HML* returns are 0.32%, 0.53%, and 0.44% per month, for the international sample, Japan, and Canada, respectively, and they are significant at the 5% or lower level of significance. The *HML* returns are statistically insignificant for the US and the UK. Fama and French (2012) also report a statistically insignificant value premium for the North American region, which is largely dominated by the US equity market. Gregory et al. (2013a) also report that the UK value premium has only marginal statistical significance at the 10% level. The value premium on small stocks is larger than the value premium on big stocks, except for Japan and Canada as shown by R_{HML_S} and R_{HML_B} columns in panel A.

Table 3.3 Summary statistics for the risk factors, April 1987 to December 2013

The table reports summary statistics for the factors constructed from the portfolios explained in section 3.3. Results are reported for the international sample and the US, UK, Japanese, and Canadian stock markets. All monthly returns are denominated in US dollars. R_{MKT} and R_{INDMKT} are the excess returns in excess of the one-month US *T*-bill rate. The mean value of the *T*-bill rate is 0.28% per month over the 321 months. Statistics reported are the mean, standard deviation (StDev), Skewness, maximum (max), minimum (min), 25th percentile (p25), median (p50), 75th percentile (p75), and kurtosis. '***', '**', '*' represent the level of significance for the *t*-statistics test that the mean value is equal to zero at the 1%, 5%, and 10%, respectively.

	R_{MKT}	R_{SMB}	R_{HML}	R_{HML_S}	R_{HML_B}	R_{WML}	R_{WML_S}	R_{WML_B}
International								
Mean (%)	0.36	0.14	0.32**	0.42**	0.23	0.50**	0.60***	0.40*
StDev (%)	4.14	2.32	2.53	2.94	2.7	3.77	3.81	4.37
Skewness	-0.60	0.07	0.59	0.55	0.56	-0.56	-0.71	-0.32
P(25) (%)	-2.01	-1.05	-0.79	-0.89	-1.31	-0.87	-0.93	-1.43
P(50) (%)	0.70	0.01	0.19	0.27	0.17	0.71	0.90	0.69
P(75) (%)	3.02	1.43	1.44	1.48	1.74	2.39	2.59	2.36
Kurtosis	4.28	7.06	8.44	10.01	5.66	8.61	9.44	6.57
United States (US)								
Mean (%)	0.64**	0.21	0.14	0.29	-0.01	0.47	0.60**	0.35
StDev (%)	4.46	2.84	3.56	4.42	3.29	4.7	4.74	5.05
Skewness	-0.98	0.76	0.27	0.01	0.34	-0.11	-0.13	-0.10
P(25) (%)	-1.94	-1.61	-1.49	-1.40	-1.95	-0.95	-0.80	-1.69
P(50) (%)	1.25	0.11	0.09	0.05	0.21	0.59	0.85	0.67
P(75) (%)	3.48	1.87	1.59	1.92	1.60	2.44	2.31	2.52
Kurtosis	5.79	10.35	8.23	10.19	5.76	11.66	13.18	9.13
United Kingdom (UK)								
Mean (%)	0.33	0.04	0.17	0.23	0.1	0.84***	1.07***	0.60***
StDev (%)	4.04	2.93	2.58	3.22	3.2	3.36	3.75	3.68
Skewness	-0.46	-0.09	-0.06	-0.43	0.14	-1.08	-1.08	-0.70
P(25) (%)	-2.05	-1.78	-1.13	-1.29	-1.69	-0.53	-0.43	-1.24
P(50) (%)	0.33	0.21	0.16	0.22	0.04	1.23	1.47	0.78
P(75) (%)	2.71	1.73	1.41	1.61	1.59	2.70	2.88	3.03
Kurtosis	5.19	5.03	8.12	9.40	5.08	7.03	8.10	5.19
Japan								
Mean (%)	-0.02	0.13	0.53***	0.39**	0.66	0.19***	0.2	0.17
StDev (%)	5.93	3.53	2.5	2.8	3.24	4.69	4.3	5.7
Skewness	0.37	0.03	-0.28	-0.58	-0.23	-0.47	-0.38	-0.34
P(25) (%)	-3.95	-1.85	-0.82	-0.96	-1.03	-1.90	-1.89	-2.36
P(50) (%)	0.00	0.16	0.57	0.58	0.66	0.45	0.37	0.47
P(75) (%)	3.48	2.07	2.04	1.98	2.60	2.68	2.53	3.09
Kurtosis	4.21	4.51	4.15	5.06	4.47	4.93	4.79	4.97
Canada								
Mean (%)	0.43*	0.01	0.44**	0.39*	0.50**	1.21***	1.48***	0.94***
StDev (%)	4.57	2.41	3.42	4.04	4.25	3.75	3.68	4.84
Skewness	-0.92	0.28	0.16	-0.73	1.28	-0.87	-0.64	-0.15
P(25) (%)	-1.94	-1.46	-1.33	-1.79	-1.48	-0.53	-0.62	-1.05
P(50) (%)	0.71	-0.03	0.31	0.43	0.49	1.52	1.79	1.05
P(75) (%)	3.16	1.57	2.27	2.66	2.19	3.51	3.70	3.51
Kurtosis	6.69	4.22	8.66	6.51	11.41	5.84	5.20	8.01

(Continued Overleaf)

	R_{SMM}	R_{MMB}	R_{SHML}	R_{MHML}	R_{BHML}	R_{INDMKT}	R_{INDSMM}	R_{INDMMB}	$R_{INDSHML}$	$R_{INDMHML}$	$R_{INDBHML}$
International											
Mean (%)	0.05	0.21**	0.34**	0.1	0.14	0.41*	0.29**	-0.04	0.2	0.16	0.1
StDev (%)	1.25	1.89	2.44	2.8	2.14	4.29	2.55	3.17	2.36	2.18	2.11
Skewness	-0.47	0.03	0.77	-1.00	0.30	-0.65	-0.78	0.41	0.02	0.10	0.32
P(25) (%)	-0.63	-0.86	-0.70	-0.95	-1.06	-2.01	-1.00	-1.53	-0.83	-0.79	-1.04
P(50) (%)	0.01	0.28	0.28	0.15	0.07	0.79	0.41	-0.20	0.16	0.34	0.08
P(75) (%)	0.71	1.35	1.15	1.04	1.37	3.09	1.71	1.51	1.19	1.10	1.30
Kurtosis	5.72	3.99	9.70	17.47	5.18	4.41	7.30	7.61	8.82	10.11	5.48
United States (US)											
Mean (%)	0.08	0.24**	0.23	-0.05	-0.09	0.60**	0.04	0.25**	0.21	-0.09	-0.1
StDev (%)	1.47	2.11	3.72	3.69	2.54	4.4	1.51	2.14	2.89	3.98	2.54
Skewness	-0.06	0.65	-0.02	-1.04	0.00	-0.88	-0.21	0.85	0.24	-0.92	-0.04
P(25) (%)	-0.78	-1.04	-1.12	-1.34	-1.53	-1.81	-0.89	-1.18	-0.99	-1.59	-1.55
P(50) (%)	0.06	0.17	0.12	-0.10	-0.06	1.05	-0.06	0.38	0.05	0.03	0.07
P(75) (%)	0.92	1.45	1.47	1.44	1.31	3.40	0.93	1.53	1.33	1.52	1.26
Kurtosis	5.20	6.40	10.95	16.14	5.54	5.40	6.27	8.95	7.56	18.26	5.99
United Kingdom (UK)											
Mean (%)	0.03	0.06	0.23	-0.02	0.1	0.51*	0.03	0.03	0.16	0.1	0.04
StDev (%)	1.99	2.28	2.61	2.98	2.71	4.87	2.01	2.37	2.47	3.42	2.62
Skewness	0.05	-0.15	-0.62	-0.43	-0.23	-0.40	-0.12	-0.17	-0.14	0.13	-0.09
P(25) (%)	-1.24	-1.31	-0.86	-1.59	-1.34	-2.23	-1.20	-1.45	-1.09	-1.59	-1.39
P(50) (%)	0.08	0.21	0.20	0.06	0.06	0.47	0.10	0.02	0.25	0.03	0.05
P(75) (%)	1.16	1.39	1.44	1.42	1.71	3.54	1.15	1.53	1.28	1.66	1.43
Kurtosis	4.32	3.36	10.49	11.64	4.77	4.91	5.11	3.32	9.81	8.57	4.34
Japan											
Mean (%)	0.15	0.13	0.32**	0.30**	0.51***	-0.04	0.14	0.16	0.28***	0.24**	0.51***
StDev (%)	1.87	2.75	2.52	2.63	2.6	6.21	2.39	2.65	1.94	2.2	3.12
Skewness	0.24	0.00	-0.54	-0.93	-0.10	0.27	0.12	0.14	-0.58	-0.54	-0.27
P(25) (%)	-0.87	-1.28	-0.99	-0.82	-0.85	-4.44	-1.33	-1.38	-0.81	-0.77	-1.21
P(50) (%)	0.02	0.04	0.44	0.55	0.40	0.11	0.10	0.06	0.38	0.47	0.48
P(75) (%)	1.26	1.66	1.60	1.74	2.05	4.03	1.62	1.67	1.56	1.46	2.56
Kurtosis	4.27	4.27	5.31	8.29	4.66	3.66	4.43	4.09	4.46	6.32	4.49
Canada											
Mean (%)	0.06	0	0.28	-0.29	0.55**	0.63**	0.04	0.02	0.27	-0.23	0.63**
StDev (%)	1.65	2.56	3.57	3.59	4.55	5.44	1.71	2.6	3.04	3.64	4.43
Skewness	0.20	-0.59	-0.52	-0.01	1.76	-0.75	0.18	-0.59	-0.63	-0.18	1.75
P(25) (%)	-1.01	-1.36	-1.72	-2.31	-1.78	-2.36	-1.09	-1.42	-1.53	-2.24	-1.67
P(50) (%)	0.11	0.01	0.44	-0.23	0.37	0.83	0.15	0.02	0.38	-0.23	0.38
P(75) (%)	1.05	1.30	2.34	1.80	2.07	3.97	1.01	1.48	2.39	1.90	2.07
Kurtosis	3.76	10.35	4.91	6.34	13.14	6.15	4.27	7.94	6.12	4.84	12.32

Qualitatively similar results are reported by Fama and French (2012) for the same four regions, and by Fama and French (1993), Kothari et al. (1995), Loughran (1997), and Cremers et al. (2013) for the US. HML returns on big stocks are higher than the small stocks for Japan and Canada. Fama and French (2012) also report similar findings for Japan. Except for the US and the UK, the value premiums on small stocks are statistically significant at the 10% level or less. For big stocks, only the value premiums for Japanese and Canadian stock markets are statistically significant.

The momentum premium is statistically significant in three out of the four countries and the international sample. There is no momentum premium for Japan, a result similar to Fama and French (2012). The average WML returns are 0.50%, 0.47%, 0.84% and 1.21% per month, for the international sample, US, UK and Canada. These are statistically significant for the UK and Canada at the 1% level, at the 5% level for international sample, and at the 10% level for the US. Chui et al. (2010), Fama and French (2012), and Asness et al. (2013) report similar findings. Like the value premium, the momentum premium is more pronounced in small stocks compared to big stocks as seen in columns R_{WML_S} and R_{WML_B} in panel A. The average WML returns on small stocks are statistically significant at the 5% level for US and at the 1% level for international sample and the UK, and Canada. For the big stocks, the WML factor is significantly different from zero at the 10% level for international sample and at the 1% level for UK and Canada.

Consistent with Fama and French (2012), I find significant differences in the value and momentum premiums on small and big stocks in my sample. Therefore, it will be interesting to test the performance of asset pricing models with decomposed value and momentum factors compared to the standard 3F and 4F models. Since Fama and French (2012) do not use the decomposed factors in their asset pricing models, this analysis presents an important contribution to the empirical asset pricing literature.

Panel B reports summary statistics for the modified and index-based factors. As explained in section 3.3, the modified factors are constructed following Cremers et al. (2013) from the six size-B/M portfolios, formed using three size groups and two B/M groups using modified breakpoints. Unlike the *SMB* factor returns, the decomposed *MMB* factor returns are statistically significant for the international sample and US, at the 5% level. However, the *SMM* factor returns are not statistically different from zero for any country and international sample. This shows that there is still some size premium in the US and international stock returns for the medium stocks compared to big stocks. The modified *SHML* premium is positive and statistically different from zero for the international sample and Japan at the 5% level of significance. The *MHML* factor returns are also statistically significant for Japan at the 5% level, and the *BHML* factor returns are statistically significant for Japan and Canada at the 1% and 5% levels, respectively. Note that the value premium does not change much between the decomposed factor and modified factors, which shows that the value premium is not sensitive to the factor construction methodology. However, the modified versions of two size factors and three value factors capture much more variation of the size and value effects compared to standard and decomposed factors. Therefore, they are expected to explain average stock returns more adequately.

Following Cremers et al. (2013), the index-based factors in Table 3.3 are constructed from three size indices and two B/M indices, using single sorts on both size and B/M. The large size index for each country is constructed by replicating the leading domestic stock market index. The index-based excess market returns (R_{INDMKT}) are the returns on the large size index minus the one month US T-bill rate. The R_{INDMKT} for the international sample and the US, UK, and Canada are statistically different from zero at the 10% level or lower, and ranges from 0.41% per month for the international sample to 0.63% per month for Canada. The index-based *SMM* factor returns are statistically significant at the 5% level for the international sample, while the index-based *MMB* factor returns are statistically different from zero for the US at the 5% level of significance. Like the case of the modified factors, there are some size premiums for the US and Japan resulted from decomposing the standard *SMB* factor. The index-based value premium for Japan is consistently significant for the three size categories, while only index-based *BHML* factor returns for Canada is statistically significant. Unlike standard, decomposed, and modified factors, the intentional index-based value premium is not significant for any of the size categories. However, similar to modified factors, the index-based factors capture more variation of the size and value factors. Moreover, as identified by Cremers et al. (2013) the index-based factors are expected to explain the average stock returns better because factor construction follows the common industry benchmarks.

3.5 Summary Statistics for Monthly Excess Returns on the Test Portfolios

Fama and French (1993) construct 25 size-B/M portfolios using independent sorts on five quintile breakpoints of size and B/M ratio. They then use these 25 portfolios as dependent variables in their asset pricing regression equations. Since then, the 25 size-B/M portfolios have been used extensively to test various asset pricing models. Fama and French (1993) form these portfolios using breakpoints based on NYSE stocks. Since, NYSE equivalent breakpoints are not available for other countries, Fama and French (2012) propose alternatives for sorting stocks. I follow Fama and French (2012) to select the size breakpoints as 3%, 7%, 13%, and 25% of the stock market's aggregate market value. Similar to Fama and French (1993), the B/M breakpoints are the 20^{th}, 40^{th}, 60^{th}, and 80^{th} percentiles of the B/M ratio for the big stocks (top 90% of the market value). According to Fama and French (2012), these size and B/M breakpoints roughly correspond to the NYSE quintile breakpoints. The size-momentum portfolios are constructed as 5x5 independent sorts on size and momentum. The size-momentum portfolios are formed each month and use the same breakpoint conventions as the size-B/M portfolios. For the size-momentum portfolios, size is the market value at the start of the month and momentum is the cumulative monthly returns for *t*–12 to *t*–2.

Panel A in Table 3.4 reports the excess returns and their standard deviations on the 25 size-B/M portfolios. The returns for all markets increase monotonically from left to right for every row, suggesting strong value effect. The spreads are larger between the extreme value (5^{th} column) and growth portfolios (1^{st} column) for the small stocks than big stocks for the international sample and the US and UK, and it is reverse for Japan and Canada. Fama and French (2012) also report similar results for their four regions. These discrepancies are important in the context of model tests, as Fama and French (2012) attribute the failure of their models for small stocks to these discrepancies. They also report the value premium left in the intercepts of small stocks, possibly resulting from large value-growth spreads on small size stocks. There is also a size effect in all of the markets other than the UK; the small portfolios have higher average returns than the big portfolios.

Fama and French (1993, 2012) point out that very low average returns on their small-growth portfolios are the major challenge for the asset pricing models they test. However, contradicting their findings, the small-growth portfolios presented in Panel A of Table 3.4 do not have low average returns. In fact, the small-growth portfolios have higher average returns than the big-growth portfolios for all of the markets, except the UK. This suggests that these small-growth portfolios should not be a problem for the asset pricing models to be investigated in this thesis. Possibly these higher returns on the small-growth portfolios are a result of excluding stocks with low returns (stock with a price of less than $1) and winsorizing the returns in the time-series screens.

Table 3.4 Summary statistics for size-B/M and size-momentum portfolios' excess returns
Results are reported for the international sample, US, UK, Japanese, and Canadian stock markets. The 25 size-B/M portfolios for each market are constructed at the end of June of each year. The size breakpoints are the 3%, 7%, 13%, and 25% of the aggregate market value at the end of June *j* for a stock market. The B/M quintile breakpoints are based on the big stocks (i.e., top 90% of market cap). The intersections of the 5x5 independent size and B/M sorts produce the 25 value-weighted size-B/M portfolios. The 5x5 sorts on the size and momentum use the same breakpoint conventions as the size and B/M sorts, except that the size-momentum portfolios are formed in each month. For portfolios formed at the end of month *t*, the size is the market value at the start of the month, and the momentum is a stock's cumulative monthly return from *t*-12 to *t*-2. The intersections of the independent 5x5 size and momentum sorts produce the 25 value-weighted portfolios. The international portfolios for the size-B/M and size-momentum sorts use the international size breakpoints, but the B/M and momentum breakpoints of each country are used to allocate their stocks to international portfolios. All returns are in US dollars and in excess of the one-month US T-bill rate. 'Mean' and 'StDev' are the mean and standard deviation of the monthly returns.

Panel A: Monthly excess returns for 25 size-B/M portfolios

	Low	2	3	4	High	Low	2	3	4	High
	Mean (%)					StDev (%)				
International										
Small	0.30	0.61	0.75	0.75	0.94	6.18	5.35	5.09	4.40	4.24
2	0.34	0.40	0.57	0.62	0.73	6.02	5.43	4.90	4.63	4.50
3	0.39	0.43	0.51	0.53	0.72	5.90	5.20	4.76	4.55	4.63
4	0.52	0.39	0.60	0.53	0.67	5.82	4.86	4.74	4.55	4.81
Big	0.18	0.42	0.39	0.47	0.48	4.90	4.50	4.26	4.35	4.91
United States (US)										
Small	0.83	0.90	0.96	0.96	1.19	7.97	6.86	6.06	5.31	5.25
2	0.60	0.65	0.90	0.76	0.97	7.46	6.41	5.93	4.91	5.19
3	0.88	0.68	0.69	0.79	0.95	7.29	5.71	5.05	4.67	5.03
4	0.86	0.69	0.77	0.69	0.89	6.57	5.36	5.07	4.89	5.16
Big	0.60	0.63	0.56	0.65	0.50	5.01	4.58	4.35	4.35	5.24
United Kingdom (UK)										
Small	0.32	0.31	0.58	0.61	0.68	6.25	5.34	5.55	5.45	5.04
2	0.51	0.57	0.56	0.66	0.78	6.21	6.15	5.69	5.92	5.52
3	0.40	0.41	0.64	0.51	0.50	6.23	5.93	6.13	5.65	5.46
4	0.57	0.59	0.60	0.40	0.54	6.01	5.57	5.78	5.93	5.84
Big	0.38	0.61	0.52	0.44	0.59	4.71	5.33	5.53	5.70	6.24
Japan										
Small	0.00	0.34	0.43	0.38	0.50	8.80	7.80	7.47	7.05	6.89
2	-0.04	0.11	0.20	0.17	0.34	8.15	7.77	7.23	6.90	6.87
3	-0.13	-0.01	0.07	0.26	0.38	7.63	7.06	6.80	6.51	6.54
4	-0.18	0.05	0.15	0.12	0.31	7.31	6.59	6.39	6.06	6.49
Big	-0.43	-0.02	0.14	0.21	0.41	6.99	6.38	6.03	6.01	6.23
Canada										
Small	0.61	0.86	0.95	1.09	0.87	9.53	7.26	6.27	6.37	5.49
2	0.10	0.36	0.43	0.53	0.95	8.06	6.99	6.40	6.07	6.18
3	0.43	0.64	0.78	0.54	0.63	8.11	6.74	5.95	5.56	5.59
4	0.98	0.57	0.52	0.62	0.53	7.57	7.45	6.10	5.26	5.73
Big	0.17	0.80	0.55	0.84	0.81	7.46	5.85	5.29	5.56	6.19

(Continued overleaf)

Panel B: Monthly excess returns on 25 size-momentum portfolios										
	Loser	2	3	4	Winner	Loser	2	3	4	Winner
	Mean (%)					StDev (%)				
International										
Small	0.28	0.28	0.30	0.71	1.33	5.53	3.09	2.93	3.56	4.95
2	0.35	0.35	0.34	0.66	0.96	6.00	3.70	3.43	3.94	5.38
3	0.34	0.36	0.34	0.55	0.86	5.97	4.02	3.67	4.15	5.46
4	0.33	0.36	0.41	0.47	0.79	5.99	4.28	3.96	4.08	5.33
Big	0.08	0.23	0.24	0.55	0.54	5.78	4.32	3.93	3.99	5.27
United States (US)										
Small	0.68	0.85	0.95	1.25	1.71	7.09	4.68	4.55	5.04	6.82
2	0.70	0.75	0.90	0.91	1.33	7.35	5.04	4.74	4.99	7.01
3	0.56	0.72	0.80	0.82	1.24	7.04	4.92	4.57	4.74	6.69
4	0.47	0.66	0.76	0.78	1.13	7.04	4.98	4.47	4.63	6.47
Big	0.41	0.56	0.43	0.72	0.83	6.15	4.53	4.13	4.29	5.91
United Kingdom (UK)										
Small	-0.38	-0.18	-0.15	0.55	1.29	5.06	3.11	3.25	3.92	4.67
2	-0.24	-0.02	-0.19	0.46	1.11	5.69	3.28	3.61	4.18	5.12
3	0.07	-0.05	-0.20	0.49	1.00	5.80	3.42	3.69	4.59	5.55
4	0.20	-0.01	-0.07	0.47	0.91	5.90	3.65	3.71	4.64	5.43
Big	0.14	-0.06	0.05	0.50	0.74	5.66	3.72	3.71	4.37	5.41
Japan										
Small	0.42	0.34	0.52	0.56	0.55	8.13	6.77	6.47	6.40	7.53
2	0.10	0.16	0.32	0.29	0.42	7.95	6.85	6.51	6.65	7.16
3	0.07	0.10	0.12	0.25	0.24	7.77	6.63	6.04	6.18	6.71
4	0.06	0.02	0.18	0.12	0.20	7.51	6.48	6.13	5.94	6.62
Big	-0.08	-0.16	-0.17	0.07	0.07	7.85	6.30	5.98	5.88	6.85
Canada										
Small	-0.47	-0.12	0.05	0.73	1.18	5.58	2.95	2.92	4.06	5.33
2	-0.58	-0.12	-0.06	0.60	1.46	6.22	3.14	3.12	4.53	6.33
3	-0.34	-0.09	0.01	0.52	1.14	6.32	3.31	3.49	4.68	6.27
4	-0.08	0.05	0.10	0.57	1.21	6.25	3.31	3.60	4.48	5.85
Big	0.02	0.09	0.23	0.63	0.97	6.28	3.79	3.79	4.68	6.72

The behaviour of portfolio returns volatility, measured by standard deviation of monthly excess returns, also gives some insights into the returns on the size-B/M portfolios. In general, the volatility decreases monotonically from low B/M portfolios to high B/M portfolios. This is apparent for small stocks with the extreme small-growth portfolio being the most volatile. The high standard deviation is expected given the small size and the high market values compared to the book values of the low-growth stocks. The high standard deviation of the low B/M portfolios results in the majority of the low B/M portfolios returns being statistically insignificant compared to the high B/M portfolios since they have high returns and lower volatility. Fama and French (1993 and 2012) report similar results for the US and their four regions.

Panel B of Table 3.4 reports the excess returns and their standard deviations for the 25 size-momentum portfolios. The momentum effect is very strong, and indeed stronger than the value effect, in all stock markets, except Japan. The monthly excess returns increase monotonically for every size quintile from left (losers) to right (winners), and the winner-loser spreads are higher for small stocks compared to the big stocks. Fama and French (2012) report similar monotonic momentum patterns for all size groups of their global and regional 25 size-momentum portfolios. Like the size-B/M portfolios, Fama and French (2012) report that because of the discrepancies in momentum profits on small and big stocks, their asset pricing models fail for small size portfolios and also leave momentum patterns in the intercepts. For Japan, there are no clear patterns in the returns across momentum portfolios, consistent with the empirical results for the Japanese stock market reported in the literature [see Griffin et al. (2003), Chui et al. (2010), Fama and French (2012), Asness et al. (2013), and Hanauer (2014)]. There is a size effect in the size-momentum returns for the international, US, and Japanese markets. However, the size effect is more pronounced in the last two columns of the size-momentum return matrix, particularly for the UK and Canada. The standard deviations of the size-momentum portfolios show that loser portfolios have higher volatility compared to the winner portfolios in all size groups. However, there are no monotonic patterns in the standard deviations across the different momentum groups.

Table 3.5: Summary statistics for the excess returns on the 19 industry portfolios

Results are reported for the international sample (INT) and the US, UK, Japanese (JP), and Canadian (CN) stock markets. The 19 industry portfolios are formed at the beginning of each month, and the monthly returns are calculated at end of each month. The stocks are grouped into industries using the level three grouping of the Industry Classification Benchmark (ICB). All returns are dominated in US dollars and in excess of the one-month US T-bill rate. 'Mean' and 'StDev' are the mean and standard deviation of the returns, respectively.

Monthly excess returns for the 19 industry portfolios										
	Mean (%)	StDev (%)	Mean (%)	StDev (%)	Mean (%)	StDev (%)	Mean (%)	StDev (%)	Mean (%)	StDev (%)
Industries	INT		US		UK		JP		CN	
Automobiles & Parts	0.16	5.29	0.70	7.83	-0.01	3.78	0.49	6.09	0.51	6.08
Banks	-0.09	5.33	0.63	6.41	0.69	6.45	-0.30	6.81	1.03	5.96
Basic Resources	0.04	6.20	0.57	7.41	0.77	7.50	0.06	7.69	0.18	6.04
Chemicals	0.09	5.11	0.72	5.93	0.29	4.64	0.11	7.03	0.75	6.37
Construction & Materials	-0.18	5.53	0.65	5.98	0.24	4.91	-0.08	7.20	0.21	5.36
Financial Services	0.03	6.28	0.84	6.43	0.46	4.57	-0.20	8.39	0.42	4.74
Food & Beverage	0.19	3.64	0.72	4.19	0.55	4.47	-0.02	5.71	0.22	3.67
Healthcare	0.31	3.95	0.79	4.54	0.45	4.51	0.15	5.74	0.79	6.98
Ind. Goods & Services	0.13	4.89	0.66	5.28	0.29	4.30	0.22	6.65	0.38	4.43
Insurance	0.18	4.54	0.65	5.16	0.40	4.89	0.01	7.29	0.84	6.18
Media	0.15	5.03	0.64	6.10	0.39	5.36	0.10	6.75	0.20	4.29
Oil & Gas	0.36	5.05	0.78	5.36	0.54	5.54	0.06	7.75	0.54	5.15
Personal & Household Goods	0.18	4.03	0.81	4.55	0.60	4.46	0.14	5.78	0.24	3.94
Real Estate	-0.02	4.87	0.56	5.29	0.26	4.83	0.15	8.29	0.15	4.23
Retail	0.22	4.27	0.77	5.20	0.31	4.45	0.27	6.89	0.53	4.55
Technology	0.37	7.10	0.82	7.67	0.41	6.94	0.26	7.48	0.58	9.74
Telecommunication	-0.06	4.66	0.51	5.40	0.45	5.12	0.01	8.96	0.74	4.93
Travel & Leisure	-0.01	4.68	0.77	5.78	0.33	4.92	-0.06	6.11	0.34	5.15
Utilities	-0.05	3.51	0.51	3.84	0.29	3.59	-0.09	6.83	0.47	3.76

As mentioned earlier, Lewellen et al. (2010) argue that testing any asset pricing model, in the cross-sectional tests, only on the characteristics based portfolios (such as size-B/M), is likely to yield misleading results, as any of the models containing variables loosely related to these characteristics will have higher explanatory power. Kan et al. (2013) use industry portfolios along with 25 size-B/M portfolios in their cross-sectional asset pricing tests, and report significant differences in their results. Therefore, I also construct 19 industry portfolios to expand the test assets beyond the size-B/M and size-momentum characteristic based portfolios. The industry portfolios are formed on the basis of the Industry Classification Benchmark (ICB) supersector categories.

Table 3.5 reports summary for the 19 industry portfolios. Industry portfolios produce lower return spreads compared to size-B/M and size-momentum portfolios, which means a lower hurdle for any asset pricing model. The return spreads between the most profitable and the least profitable industry are higher for Canada (Banking sector = 1.03% per month and the Real Estate sector = 0.15% per month), and lowest for the US (Financial Services = 0.84% per month and Telecommunication and Utilities each = 0.51% per month). There are no obvious trends regarding the performance of industries across the four countries.

3.6 Robustness Tests for Data

The factors and test portfolios in this thesis are constructed following the approach of Fama and French (2012). Also, all the data comes from TDS and TWS, and is further screened using static and time-series filters (described in section 3.2). Therefore, to assess the robustness of the construction of risk factors and test portfolios, this section compares the factor and test portfolio returns constructed using TDS data with the Fama and French data for the US and Japan and Gregory et al. (2013a) data for the UK. As Gregory et al.'s (2013a) UK data is denominated in sterling, I reconstructed the risk factors and test portfolios for the UK using sterling denominated data. The factors and test portfolios are reconstructed using the methodology of Fama and French (2012), as described in sections 3.3 and 3.5. The sterling denominated UK factors and test portfolios are constructed for comparison purposes only, all the empirical chapters use the dollar denominated data.

The dataset used in this thesis differ considerably from both Fama and French (1993, 2012) and Gregory et al. (2013a) data in terms of constituents. The Fama and French (1993) data for the US are based on the Centre of Research in Security Prices (CRSP) database, whilst the Gregory et al. (2013a) factors and portfolios for the UK are constructed using a broader data set that includes TDS, Thomson One Banker, Hemscott data from Gregory et al. (2013b), and hand collected data on bankrupt firms from Christidis and Gregory (2010) as sources. Moreover, screens applied in this thesis to smooth out the effects of the TDS data irregularities, and the presence of outliers have a considerable effect on the returns and especially the returns on small size portfolios. Ince and Porter (2006) raise similar issues; however the screens are essential to get error free data. The purpose of this section is to show that data is error free, and the factor and portfolios are comparable to other data sources and factor construction methods

Panel A of Table 3.6 compares the returns on the return based risk factors between two datasets for each country. For the US and Japan, the results are very similar for the TDS and Fama and French data, and for the UK between the TDS and Gregory et al. (2013a) data. The results for the factors show that factor returns constructed in this thesis are consistent with those obtained from other databases for the same time period. Moreover, use of the different breakpoints to classify small and big, value and growth, and winner and loser stocks have no significant effect on the actual factor returns calculated. The results for UK data also show that there is little impact of exchange rate on the factor returns.

Table 3.6: Comparison of Thomson DataStream data with FF's website data for the US and Japan, and with Gregory et al. (2013) data for the UK

The table presents a comparison of the excess market returns (MKT), *SMB*, *HML*, and *WML* factors, the six size-B/M portfolios, the 25 size-B/M portfolios, the six size-momentum portfolios, and the 25 size-momentum portfolios. 'Mean' and 'Diff.' are the mean and difference of a variable between two versions of data, and 'Corr.' is the correlation between the variable from the two data sets. 'TDS' and 'GTC' represent the data from the Thomson DataStream and Gregory et. al. (2013), respectively. '***', '**', '*' represent the level of significance for the *t*-statistics test that the mean value is equal to zero at the 1%, 5%, and 10%, respectively.

	US				UK				JP			
	Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.
	TDS	FF			TDS	GTC			TDS	FF		
Panel A: Explanatory Variables												
MKT	0.64**	0.59**	0.05***	0.99	0.82***	0.37	0.46***	0.99	-0.03	-0.03	0.00	0.99
HML	0.14	0.26	-0.11*	0.95	0.28*	0.24	0.04	0.81	0.43***	0.44***	-0.01	0.90
SMB	0.21	0.14	0.07	0.97	-0.01	0.11	-0.12	0.92	-0.09	-0.05	-0.04	0.98
WML	0.47*	0.57**	-0.09	0.94	1.02***	1.00***	0.02	0.95	0.24	0.13	0.11**	0.98
Panel B: Six size-B/M portfolios returns												
SG	0.98**	0.75**	0.23***	0.98	0.60*	0.79**	-0.19***	0.97	0.03	0.03	0.01	0.99
SN	1.12***	1.17***	-0.05	0.98	0.86***	0.98***	-0.12	0.96	0.22	0.23	-0.01	0.99
SV	1.28***	1.26***	0.02	0.98	1.01***	1.12***	-0.11	0.97	0.38	0.45	-0.08	0.99
BG	0.94***	0.92***	0.02	0.99	0.75***	0.81***	-0.06	0.93	0.02	0.08	-0.06	0.98
BN	0.88***	0.91***	-0.03	0.97	0.83***	0.79***	0.05	0.95	0.35	0.26	0.09	0.98
BV	0.93***	0.93***	0.00	0.97	0.90***	0.97***	-0.06	0.91	0.54	0.53	0.00	0.94
Panel C: Six size-momentum portfolios returns												
SL	0.96***	0.66	0.30***	0.98	0.18	0.37	-0.20***	0.98	0.18	0.31	-0.13*	0.99
SN	1.17***	1.09***	0.08	0.98	0.95***	0.99***	-0.04	0.98	0.26	0.35	-0.08	0.99
SW	1.56***	1.43***	0.13***	0.99	1.50***	1.60***	-0.10	0.97	0.46	0.38	0.09	0.99
BL	0.78***	0.73**	0.05	0.98	0.38	0.47	-0.09	0.95	0.14	0.16	-0.01	0.99
BN	0.84***	0.83***	0.01	0.98	0.93***	0.96***	-0.03	0.96	0.09	0.10	0.00	0.98
BW	1.13***	1.09***	0.04	0.98	1.09***	1.23***	-0.14	0.95	0.38	0.36	0.02	0.99

(Continued overleaf)

Table 3.6 (Continued)		Panel D: 25 size-B/M portfolios returns											
		US				UK				JP			
		Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.
		TDS	FF			TDS	GTC			TDS	FF		
Small	Low	1.12**	0.35	0.77***	0.96	0.26	0.73**	-0.46***	0.90	0.00	0.28	-0.28**	0.96
	2	1.19***	1.09***	0.10	0.95	0.56*	0.98***	-0.42**	0.85	0.23	0.24	-0.01	0.96
	3	1.25***	1.13***	0.12	0.95	0.95***	1.02***	-0.07	0.89	0.44	0.35	0.09	0.95
	4	1.26***	1.27***	-0.02	0.94	0.75***	1.11***	-0.35***	0.92	0.34	0.41	-0.08	0.98
	High	1.48***	1.36***	0.12	0.97	1.03***	1.19***	-0.16	0.94	0.45	0.58	-0.13**	0.99
2	Low	0.89**	0.79**	0.10	0.95	0.8**	0.69*	0.11	0.87	0.00	-0.06	0.06	0.97
	2	0.94***	0.99***	-0.05	0.93	0.70***	0.88**	-0.18	0.85	0.19	0.00	0.19	0.94
	3	1.19***	1.23***	-0.04	0.93	0.84***	0.97***	-0.13	0.80	0.23	0.20	0.03	0.97
	4	1.05***	1.14***	-0.09	0.95	1.12***	1.02***	0.10	0.86	0.21	0.34	-0.13	0.98
	High	1.26***	1.17***	0.10	0.95	1.09***	1.07***	0.02	0.84	0.32	0.39	-0.07	0.99
3	Low	1.17***	0.85**	0.32**	0.95	0.54	0.76**	-0.23	0.87	-0.02	0.02	-0.05	0.98
	2	0.97***	1.09***	-0.12	0.94	0.98***	0.72**	0.26	0.88	0.06	0.03	0.03	0.96
	3	0.98***	1.11***	-0.13	0.93	0.87***	0.94***	-0.07	0.87	0.12	0.13	-0.01	0.96
	4	1.08***	1.13***	-0.05	0.93	1.00***	0.92***	0.08	0.88	0.28	0.20	0.07	0.97
	High	1.24***	1.37***	-0.12	0.94	0.99***	1.29***	-0.30	0.86	0.41	0.46	-0.05	0.98
4	Low	1.16***	1.08***	0.08	0.97	0.76**	1.06***	-0.3*	0.88	-0.05	-0.10	0.05	0.98
	2	0.99***	1.03***	-0.04	0.91	0.80***	0.81**	-0.01	0.86	0.15	0.19	-0.03	0.97
	3	1.06***	1.00***	0.07	0.93	1.16***	1.14***	0.03	0.88	0.34	0.15	0.19***	0.98
	4	0.98***	1.14***	-0.17	0.93	0.82**	1.02***	-0.20	0.87	0.21	0.34	-0.13*	0.98
	High	1.18***	1.10***	0.09	0.95	0.90***	1.08***	-0.18	0.88	0.41	0.40	0.01	0.97
Big	Low	0.89***	0.92***	-0.03	0.98	0.66**	0.72***	-0.06	0.87	-0.09	0.04	-0.14	0.97
	2	0.92***	0.95***	-0.03	0.91	1.03***	0.77***	0.26	0.86	0.27	0.25	0.02	0.96
	3	0.85***	0.89***	-0.05	0.93	0.69**	0.84***	-0.15	0.81	0.43	0.21	0.22***	0.96
	4	0.94***	0.85***	0.09	0.91	0.90***	0.94***	-0.04	0.82	0.43	0.46	-0.03	0.90
	High	0.79***	0.95***	-0.16	0.89	1.07***	0.89***	0.17	0.72	0.59	0.69	-0.10	0.87

(Continued overleaf)

Table 3.6 (Continued)		Panel E: 25 size-momentum portfolios returns											
		US				UK				JP			
		Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.	Mean (%)	Mean (%)	Diff. (%)	Corr.
		TDS	FF			TDS	GTC			TDS	FF		
Small	Loser	0.97**	0.36	0.61***	0.96	-0.13	1.07***	-1.20***	0.92	0.38	0.54	-0.16*	0.99
	2	1.14***	0.88***	0.26***	0.96	0.36	0.97***	-0.62***	0.90	0.23	0.57	-0.35***	0.97
	3	1.24***	1.09***	0.16**	0.96	0.87***	1.15***	-0.28*	0.83	0.39	0.51	-0.12	0.98
	4	1.54***	1.34***	0.21**	0.96	1.12***	1.16***	-0.04	0.85	0.51	0.62	-0.10	0.98
	Winner	2.00***	1.68***	0.32***	0.95	1.79***	1.14***	0.66***	0.89	0.51	0.38	0.14	0.98
2	Loser	1.00**	0.65	0.35**	0.97	0.02	0.70	-0.68***	0.83	0.12	0.22	-0.10	0.99
	5	1.05***	1.00***	0.04	0.96	0.67**	1.00***	-0.34	0.79	0.12	0.28	-0.17	0.98
	6	1.19***	1.13***	0.06	0.96	1.04***	0.98***	0.06	0.83	0.34	0.31	0.03	0.97
	7	1.20***	1.24***	-0.04	0.96	1.24***	0.87***	0.37**	0.82	0.27	0.39	-0.12	0.97
	Winner	1.62***	1.48***	0.14	0.98	1.58***	0.84**	0.74***	0.77	0.52	0.32	0.20**	0.98
3	Loser	0.85**	0.78*	0.07	0.96	0.31	0.96**	-0.65**	0.81	0.10	0.25	-0.15*	0.98
	8	1.02***	0.98***	0.04	0.95	0.57*	1.13***	-0.55***	0.84	0.08	0.12	-0.04	0.97
	9	1.09***	1.05***	0.04	0.95	1.06***	1.07***	-0.01	0.85	0.16	0.25	-0.09	0.97
	10	1.11***	1.10***	0.01	0.97	1.09***	0.64*	0.44**	0.83	0.32	0.32	0.00	0.97
	Winner	1.54***	1.37***	0.16*	0.97	1.29***	0.82**	0.47*	0.79	0.41	0.35	0.06	0.98
4	Loser	0.76*	0.63	0.13	0.97	0.46	0.80**	-0.35	0.85	0.12	0.22	-0.09	0.99
	11	0.96***	1***	-0.04	0.96	0.79**	1.02***	-0.22	0.84	0.11	0.26	-0.16*	0.97
	12	1.06***	1.09***	-0.04	0.96	1.02***	1.06***	-0.04	0.85	0.26	0.18	0.08	0.97
	13	1.08***	1.12***	-0.05	0.95	1.09***	1.07***	0.02	0.82	0.21	0.21	0.00	0.96
	Winner	1.42***	1.26***	0.15	0.96	1.52***	1.24***	0.28	0.78	0.30	0.34	-0.03	0.98
Big	Loser	0.70**	0.57	0.13	0.94	0.25	0.59***	-0.34	0.75	0.18	0.18	0.00	0.99
	14	0.86***	0.91***	-0.05	0.93	0.87***	0.83***	0.04	0.76	0.03	0.07	-0.04	0.97
	15	0.72***	0.78***	-0.06	0.94	1.09***	0.76***	0.34**	0.80	0.07	0.05	0.01	0.97
	16	1.01***	0.98***	0.03	0.93	0.90***	0.86***	0.03	0.78	0.37	0.26	0.11	0.96
	Winner	1.12***	1.09***	0.03	0.95	1.12***	0.85**	0.27	0.69	0.38	0.33	0.04	0.99

The average market premiums for the US and Japan (0.64% and -0.03% per month, respectively) are very close to the Fama and French market premiums (0.59% and -0.03% per month, respectively), with a correlation coefficient of 0.99. However, the UK market premium (0.82% per month) differs significantly from that of Gregory et al. (2013a) (0.37% per month), but they have a correlation of 0.99. The difference of 0.05% and 0.46% per month for the US and UK market premiums, is significant at the 1% level. The *HML* factor returns for the US are not statistically different from zero for both datasets, but the TDS *HML* returns are significantly less than the Fama and French *HML* factor. Only the *HML* returns from TDS are significant at the 10% level for the UK, while both the HML returns are significant for Japan at the 1% level. The size premium is insignificant for the US, UK, and Japan using either of the datasets, while the momentum premium in the two datasets is significant for the US and UK and is insignificant for Japan. The correlation of the returns on the factors for the two datasets of each country is always 0.90 or above, except for the UK value premium. For the UK, the correlation between the TDS *HML* returns and Gregory et al. (2013a) *HML* factor premium is 0.81.

Panels B and C report the comparisons of the simple returns for the test portfolios between two datasets for each country. There are significantly higher average returns for the small-growth and small-loser portfolios for the US in the TDS data compared to Fama and Frenchs data, and there are significantly lower average returns for the small-growth and small-loser portfolios for the UK in the TDS data compared to Gregory et al. (2013a) data. For Japan, only small-loser portfolios for the TDS data have significantly lower returns than those of the Fama and Frenchs data. Thus, the higher returns on the small-growth and small-loser portfolios for the US in the TDS data lower the respective *HML* and *WML* factor returns. Similarly, the lower returns on the small-growth portfolios for the UK and smaller loser portfolios for the UK and Japan in the TDS data result in the higher and significant returns for the UK value premium and slightly higher returns for the momentum premium for the UK and Japan. Despite the difference in the returns of the small-growth and small-loser portfolios, the portfolios from the two datasets of each country have very high correlations, which are always above 0.90.

Ince and Porter (2006) also report higher average returns for the US small stocks' portfolio constructed from screened TDS data (2.69% per month) compared to CRSP data (1.33% per month)[9]. Ince and Porter (2006) argue that the CRSP and TDS returns cannot be identical because of differences in the coverage of the two datasets and the survivorship bias present in the TDS data. TDS reports the most recent exchange information available by reporting only those firms currently trading on an exchange, and they also exclude delisted firms. These firms may still be trading in the OTC market, so may not be included in dead lists as well. Hence, if included, they are most likely to fall into the small-growth and small-loser portfolios. Thus, as suggested by Ince and Porter (2006), this will raise the average returns on the remaining firms.

Panels D and E report the comparison of simple returns on the 25 size-B/M and 25 size-momentum portfolios, respectively. The results are qualitatively similar for the two datasets of each country, as the returns increase monotonically across the B/M and momentum quintiles and the correlation coefficients between the two datasets are always high, close to 0.90 for the US and Japan and in the range of 0.80 to 0.90 for the UK.

The differences in the US and UK data may have arisen from the fact that the Fama and French and Gregory et al. (2013a) portfolios and risk factors are constructed using breakpoints based on the NYSE stocks and largest 350 stocks in terms of market capitalisation, respectively, while this thesis follows the different methodology of Fama and French (2012). Despite the differences, the similar average returns on the portfolios and risk factors along, with high correlation coefficients between the two datasets of each country indicate that the

[9] Reported in Table 3 of Ince and Porter (2006).

exchange classification bias and the effect of a different methodology are not severe. In general, the filters applied in Section 3.2 understate the returns on the small stocks in my sample. As mentioned earlier, the purpose of most of the screens is to remove the outliers and to filter out illiquid and tiny stocks, which results in the larger differences for the small stocks when compared to the Fama and French and Gregory et al. (2013a) data. The comparison is presented for the US, UK, and Japan, as the country data for Canada is not available from a different source.

3.7 Conclusion

This chapter describes the sources of data, the sample selection criteria, and the filters applied to construct the factors and test portfolios to be used in the asset pricing tests, for the four countries and international sample covered in this thesis. It also reports the summary statistics for the simple excess market returns and returns on the size, value, and momentum factors, together with the modified and index-based versions of the *SMB* and *HML* factors. The value and momentum premiums are pervasive in most of the markets. There is no value premium for the US and UK, and the momentum premium is absent in Japan. The results are similar for the modified and index-based versions of the decomposed *HML* factors. However, as the additional components of the modified and index-based factors capture more variation in the size and value effect, the models using these variables are expected to perform better. Further, the value and momentum premiums on the small stocks are larger compared to big stocks, except for the value and momentum premiums in Japan and the value premium in Canada. The returns on the index-based market portfolios are statistically significant for the international sample and the US, UK, and Canada, compared to the simple excess market returns, which is only significant for the US and Canada.

The chapter also presents the summary statistics for the returns on the test portfolios I use as dependent assets in the asset pricing tests; these include 25 size-B/M, 25 size-momentum, and 19 industry portfolios. The results for the size-B/M and size-momentum portfolios are consistent with the existing literature [Fama and French (1993, 1996, and 2012)]. In the cross-sectional asset pricing tests, I use size-B/M and size-momentum portfolios each augmented with 19 industry portfolios. Finally, in order to assess the robustness and quality of the factor and portfolios returns, this chapter shows that the returns on factors and portfolios for the US, UK from TDS data are qualitatively similar to the returns on the corresponding factors and portfolios from the Fama and French website and Gregory et al. (2013a) website, respectively. This exercise mitigates any concerns regarding errors in the data from alternative sources.

Chapter 04: Time-Series Tests of the Asset Pricing Models

4.1 Introduction and Motivation

Fama and French (2012) test the ability of global and regional versions of the CAPM, 3F, and 4F models to explain the average returns on portfolios sorted by size and B/M and size and momentum in North America, Japan, Europe and the Asia Pacific regions. They show that the regional models outperform the global models in time-series asset pricing tests. For average returns on size-B/M portfolios from North America (excluding microcaps), Japan and Europe, the regional models pass the specification tests. The regional models also successfully explain the average returns of the size-momentum portfolios for Japan and North America (again excluding microcaps). However, the models perform poorly in their tests on size-momentum portfolios for Europe and Asia Pacific.

Fama and French's (2012) findings lead to two main conclusions. First, the asset pricing models do not integrate well across the four developed market regions and second, although the regional 3F and 4F models provide better descriptions of the average returns, they fail to provide a satisfactory explanation for the returns on the North American microcaps and size-momentum portfolios for Europe and Asia Pacific. These findings raise two concerns regarding Fama and French's (2012) regional asset pricing tests. First, there is the possibility that the 3F and 4F models are inadequate and, therefore, cannot provide a satisfactory explanation for the excess returns on the size-momentum portfolios for Europe and Asia Pacific and microcaps for North America. Second, it is possible that the asset pricing models tested by Fama and French (2012) do not integrate on a regional level. This chapter addresses both of these issues by testing some different specifications of the 3F and 4F models at a country level.

This chapter uses three different types of specifications of the 3F and 4F models to examine whether these models satisfactorily explain the expected stock returns. The specifications examined are the decomposed, modified, and index-based factor models. Fama and French (2012) decompose the *HML* and *WML* factor returns for small and big stocks and report statistically significant differences in returns of the two groups. However, they do not then use the decomposed factors in their asset pricing tests and do not mention any reason for not doing so. This chapter tests the decomposed models constructed following the decomposition method of Fama and French (2012), which follows the same methodology as the standard *HML* and *WML* factors but are constructed separately for small and big stocks. The models with decomposed value and momentum factors are expected to perform better, especially to explain the average portfolio returns on small stocks. Fama and French (2012) report that the 3F and 4F models fail to explain returns on small size stocks and leave value and momentum patterns in their intercepts; using decomposed factor models are expected to capture those patterns.

The alternative model specifications are proposed by Cremers et al. (2013). Cremers et al. (2013) criticise the use of an equal-weighted *SMB* factor and the construction of only one factor to capture each of the size and value effects. They argue that the standard 3F and 4F models leave abnormal returns (i.e. alphas) even for common benchmark indices like the S&P500 and Russel2000 indices. Therefore, as a remedy, Cremers et al. (2013) propose the modified and the index-based approaches to construct the size and value factors. As already been mentioned the modified model uses the modified factors constructed using different breakpoints than standard and decomposed models, while the index-based model uses factors constructed following common industry practices and using country benchmark indices, such as S&P500 and FTSE100. Cremers et al. (2013) show that their modified and the index-based models perform better than standard 3F and 4F models in explaining average mutual fund returns.

Following Cremers et al. (2013), this chapter uses the alternative models to explain average stock returns and compares their performance with the standard 3F and 4F models. In this regard, to the best of my knowledge, this is the first study to test the modified and index-based asset pricing models alongside the decomposed versions of the 3F and 4F models to explain excess stock returns. Gregory et al. (2013a) test a variation of modified models for UK stock returns and find that these models perform better than the standard 3F and 4F models. More recently, Davies et al. (2014) test only the index-based models for UK stock returns using a cross-sectional regression rather than a time-series regression approach. Davies et al. (2014) also find that the index-based models are more effective in explaining the UK cross-sectional returns than the standard 3F and 4F models.

Besides Fama and French (2012), quite a few studies attempt to investigate the integration of asset pricing models across different countries, i.e., whether a single international model constructed using international data can explain average stock returns across different countries. Fama and French (1998) examine the value premium in an international sample of 13 countries and show that a two-factor model, that includes an international market factor and a factor for relative distress (*HML*) of value and growth stocks, successfully captures international and individual country value returns. Griffin (2002) tests country specific (domestic) and international versions of the 3F model to explain average stock returns in the US, UK, Japan, and Canada. He shows that the domestic 3F models are better at explaining country stock returns compared to their international versions. Like Griffin (2002), Hou et al. (2011) investigate the ability of domestic and global versions of different factor models to explain average stock returns in 29 different countries, including countries studied in this thesis. They conclude that the global factors are less important than the domestic factors in explaining country average returns. However, Hou et al. (2011) show that global models successfully explain global portfolio returns.

Given the evidence of the failure of model integration on an international level, this study attempts to investigate the performance of asset pricing models at country level data for a sample of four countries. Based on the findings of Fama and French (2012) that their regional models outperform global models, the purpose is to investigate whether the local country models can explain average excess returns. Further, the degree of integration of asset pricing models is also examined by testing international versions of the models. Given the findings of Hou et al. (2011), the international models are expected to perform well in explaining international stock returns.

The standard, modified, and index-based factors and the size-B/M and size-momentum portfolios are formed for the US, UK, Japan, and Canada[10] and a combined international sample over the period April 1987 to December 2013, as described in chapter 3. This chapter reports the results of the standard 3F and 4F models and compare their performance to the performance of the decomposed, modified and index-based models with respect to how well they explain the average excess returns. Tests of these models are performed using a time-series regression approach and its related test statistics. Consistent with Carhart (1997) and Cremers et al. (2013), the purpose is to search for a model that provides an adequate explanation of average stock returns and to identify the best performing model, not to interpret the underlying risks of the factor models.

The rest of the chapter is organised as follows. Section 4.2 discusses and outlines the empirical framework. Sections 4.3 and 4.4 then present the empirical results for the size-B/M

[10] Initially, I also considered the stock markets from France, Germany, and Italy to conduct a G7 study. But I then decided to omit them because it was not possible to construct the risk factors and test portfolios for these countries due to low number of listed stocks.

and size-momentum portfolio returns, respectively. Section 4.5 discusses some further tests, and section 4.6 concludes.

4.2 Empirical Framework

There are two main approaches in the literature to test asset pricing models: the time-series regression approach and the cross-sectional regression approach. This chapter focuses on the time-series regression tests of asset pricing models, whilst the cross-sectional regression tests are discussed in the next chapter. The time-series approach, advanced by Jensen et al. (1972), involves regressing the excess returns on stocks or portfolios on explanatory variables (usually return based risk factors) across time to obtain the regression coefficients or factor loadings, which are interpreted as sensitivities of test portfolios to the risk factors. The unconditional form of a general time-series regression is given by

$$E(R_{i,t}) = \alpha_i + \beta_{i,F} E(R_{F,t}) + \varepsilon_{i,t}, \tag{4.1}$$

where $E(R_{i,t})$ is the excess return on portfolio *i* at time *t* in excess of the risk-free rate, α_i is the intercept term for portfolio *i*, $E(R_{F,t})$ is the return on the risk factor *F* at time *t*, $\beta_{i,F}$ is the sensitivity of portfolio *i* to risk factor *F*, and $\varepsilon_{i,t}$ is the error term, which is assumed to be independently and identically distributed (*i.i.d.*). The factor risk premium, γ_F, in the case of a time-series regression is assumed to be simply the time series average of the factor return, given as

$$\gamma_K = \frac{1}{T} \sum_{t=1}^{T} R_{F,t}, \forall_i, \tag{4.2}$$

Jensen et al. (1972) propose the first order condition for the mean-variance efficient risk factor to minimise the variance for the given level of portfolio expected returns.

$$\partial R_{i,t} = \beta_F \partial R_{F,t}, \tag{4.3}$$

Combining this first order condition with the distributional assumptions given in (4.1) results in the following parameter restriction

$$H_0: \quad \alpha_i = 0 \text{ , } \forall_i, \tag{4.4}$$

meaning that the intercept terms of the regression should be statistically indistinguishable from zero. This is because the intercepts of the time-series regression in (4.1) are interpreted as pricing errors. For the individual portfolios, the null hypothesis in (4.4) can be tested using the calculated coefficient's *t*-statistic. So, if the null is rejected, the portfolio has extra return unexplained by the risk factors in the model, which in turn indicates model misspecification.

Gibbons et al. (1989), *GRS* henceforth, construct a test statistic for testing the joint restriction of $\alpha_i = 0$ for multiple portfolios. The *GRS* test is given by

$$GRS = \frac{T-N-K}{N}(1 + \hat{\mu}_K' \hat{\sum}_K^{-1} \hat{\mu}_K)^{-1} \hat{\alpha}' \hat{\sum}_\varepsilon^{-1} \hat{\alpha} \ \sim F(N, T-N-K), \tag{4.5}$$

where *T*, *N*, and *K* are the total number of observations, the number of portfolios, and the number of risk factors in the model, respectively. $\hat{\alpha}$ is the $N\times1$ vector of portfolio intercepts, $\hat{\mu}_K$ is the $K\times1$ vector of the factors' means, $\hat{\sum}_K$ is the $K\times K$ variance-covariance matrix for the factors, and $\hat{\sum}_\varepsilon$ is the $N\times N$ residual covariance matrix. The *GRS F*-test has a simple finite sample F distribution, in addition to its interesting economic interpretations. The *F* distribution recognizes sampling variation in $\widehat{\sum}_{\varepsilon}$, and requires that the errors ε are normal as well as uncorrelated and homoskedastic. With normal errors, the $\hat{\alpha}$ are normal and $\widehat{\sum}_{\varepsilon}$ is an independent Wishart (the multivariate version of a χ^2). This distribution is exact in a finite sample. Gibbons et al. (1989) also show that

$$\hat{\alpha}'\widehat{\sum}_{\varepsilon}^{-1}\hat{\alpha} = SR(\alpha) = sr_q^2 - sr_K^2, \tag{4.6}$$

where sr_q is the maximum *ex-post* tangency Sharpe ratio that can be constructed from the *N* assets and *K* factors in a time-series regression test, and sr_F is the maximum *ex-post* tangency Sharpe ratio that can be constructed only from *K* factors. Fama and French (2012) refer to *SR(α)* as the Sharpe ratio of unexplained returns of a model. Thus, a lower value for *SR(α)* provides strong evidence in support of the asset pricing model under consideration, and vice versa. This chapter uses the *SR(α)* to assess the model performance alongside the *GRS* test.

The time-series regression models tested in this chapter include the standard 3F and 4F models tested by Fama and French (2012). In addition, I extend the asset pricing literature by testing two decomposed and two modified and index-based specifications of the 3F and 4F models. The decomposed specifications include a four-factor (4F) model and a six-factor (6F) model, which use the decomposed factors following Fama and French (2012). Further, I test a modified seven-factor (7F) model and an index-based seven-factor (7F) model, which use the modified and index-based factors constructed following Cremers et al. (2013). The first model I test is the standard 3F model of Fama and French (1993):

$$R_{i,t} = \alpha_i + \beta_{i,MKT}R_{MKT,t} + \beta_{i,SMB}R_{SMB,t} + \beta_{i,HML}R_{HML,t} + \varepsilon_{i,t}\ , \tag{4.7}$$

where $R_{MKT,t}$, $R_{SMB,t}$ and $R_{HML,t}$ are the vectors of the monthly excess market returns, and returns on the zero-cost size and value factors, respectively. As explained in section 3.3, the size and value factors are constructed using the six intersecting portfolios formed using two size and three B/M groups, which aim to capture the size and B/M anomalies. Both factors are constructed using an equally-weighted scheme as in Fama and French (1993), although the returns on the six portfolios, and hence the factors, are value-weighted. Next, I test the standard 4F model, which augments the 3F model with a momentum (*WML*) factor as follows

$$R_{i,t} = \alpha_i + \beta_{i,MKT} R_{MKT,t} + \beta_{i,SMB} R_{SMB,t} + \beta_{i,HML} R_{HML,t} + \beta_{i,WML} R_{WML,t} + \varepsilon_{i,t}, \tag{4.8}$$

where $R_{WML,t}$ is the vector of momentum factor returns. As explained in section 3.3, the *WML* factor is constructed using returns on the six intersecting portfolios formed from two size and three momentum groups, which aim to capture the momentum anomaly.

The first decomposed specification uses the decomposition of the *HML* factor in the 3F model. The model, labelled as the decomposed 4F model, is then given by:

$$R_{i,t} = \alpha_i + \beta_{i,MKT} R_{MKT,t} + \beta_{i,SMB} R_{SMB,t} + \beta_{i,HML_s} R_{HML_s,t} + \beta_{i,HML_b} R_{HML_b,t} + \varepsilon_{i,t}, \tag{4.9}$$

The subscripts *s* and *b* for *HML* indicate returns on small stocks' and big stocks' *HML* factors. The second decomposed specification decomposes both *HML* and *WML* factors and replaces the *HML* and *WML* factor returns of the standard 4F model. The decomposed version of the 4F model, labelled as the decomposed six-factor (6F) model, is then given by:

$$\begin{aligned} R_{i,t} = {} & \alpha_i + \beta_{i,MKT} R_{MKT,t} + \beta_{i,SMB} R_{SMB,t} + \beta_{i,HML_s} R_{HML_s,t} + \beta_{i,HML_b} R_{HML_b,t} + \\ & \beta_{i,WML_s} R_{WML_s,t} + \beta_{i,WML_b} R_{WML_b,t} + \varepsilon_{i,t}, \end{aligned} \tag{4.10}$$

where the subscripts *s* and *b* for *WML* indicate returns on small and big stocks' *WML* factors.

I test two models following Cremers et al. (2013), which are different from the decomposed models. For testing the modified 7F and index-based 7F models, I replace the *SMB* and *HML* factor returns in equation (4.8) with the returns on modified and index-based versions of the *SMB* and *HML* factors. The modified *SMB* and *HML* factors are constructed using the six size-B/M portfolios formed from the intersection of the three size and two B/M groups and use modified breakpoints as explained in section 3.3. The modified 7F model is:

$$R_{i,t} = \alpha_i + \beta_{i,MKT}R_{MKT,t} + \beta_{i,SMM}R_{SMM,t} + \beta_{i,MMB}R_{MMB,t} + \beta_{i,SHML}R_{SHML,t} + \beta_{i,MHML}R_{MHML,t} + \beta_{i,BHML}R_{BHML,t} + \beta_{i,WML}R_{WML,t} + \varepsilon_{i,t}, \quad (4.11)$$

where the subscripts *SMM* (i.e. small-minus-medium) and *MMB* (i.e. medium-minus-big) are the modified components of the *SMB* factor, and the subscripts *SHML*, *MHML*, and *BHML* indicate *HML* factors for small, medium, and big stocks, respectively.

For the index-based 7F model, I replace the excess market returns in equation (4.11) with the index-based excess market returns (*INDMKT*), and replace modified versions of the size and value factors with their index-based versions. The index 7F model is then given by:

$$R_{i,t} = \alpha_i + \beta_{i,INDMKT}R_{INDMKT,t} + \beta_{i,INDSMM}R_{INDSMM,t} + \beta_{i,INDMMB}R_{INDMMB,t} + \beta_{i,INDSHML}R_{INDSHML,t} + \beta_{i,INDMHML}R_{INDMHML,t} + \beta_{i,INDBHML}R_{INDBHML,t} + \beta_{i,WML}R_{WML,t} + \varepsilon_{i,t}\ , \quad (4.12)$$

where the prefix *IND* on the subscripts indicates that the factor is constructed following the index-based approach. The index-based factors are constructed from three size and two B/M indices following Cremers et al. (2013) as explained in section 3.3.

4.3 Results for Size-B/M Portfolio Returns

This section presents the empirical results of the asset pricing models specified above for the 25 size-B/M portfolios. For all models, the *GRS* statistics and the associated summary statistics of the time-series regression intercepts are reported in Table 4.1. Summary statistics include the average absolute value of the 25 intercepts, the average adjusted R^2 of the 25 regressions, the average standard errors of intercepts ($SE(\alpha)$), and the Sharpe ratio of intercepts ($SR(\alpha)$), defined in equation 4.6. The results are presented separately for the international models and local models, depending on whether the factors used in the models are international or country specific. Table 4.2 reports the regression intercepts and the associated *t*-statistics for the regressions of the international size-B/M portfolio returns on international models and the local size-B/M portfolio returns on local models. For the sake of brevity, the intercepts, and *t*-statistics for the regressions of the local size-B/M portfolio returns on the international models are given in the Appendix Table A2. The *t*-statistics are corrected for autocorrelation and heteroskedasticity[11] using the Newey-West estimator with five lags[12].

The Next subsection discusses the results of the international models' abilities to explain international size-B/M portfolio returns. It is worth noting that these tests are a direct examination of the integration hypothesis, assuming the correct specification of the asset pricing model is used. Under the integration hypothesis, I expect that the international models can adequately explain average returns on the international as well as country portfolios.

[11] In the presence of autocorrelation or heteroskedasticity the regression estimates are inefficient and the resulting standard errors are incorrect, which may lead to biased inferences on the basis of *t*-statistics. This effect is mitigated by using Newey-West (1987) standard errors.
[12] I also estimate the Newey-West (1987) standard errors using 1, 2, 3, and 4 lags, and 5 lags are selected using the Akaike information criterion (AIC). Nevertheless, the choice of lag lengths has little effect on findings.

4.3.1 International Models for the International Size-B/M Portfolio Returns

The results in Table 4.1 reveal that the *GRS* test rejects the 3F and 4F models at the 1% level of significance. The portfolio intercepts in Panel A of Table 4.2 show that the models leave a value pattern in the intercepts of the international microcaps (i.e. a positive intercept for the extreme value and a negative intercept for the extreme growth portfolios), and a reverse value pattern for the megacaps (i.e. a positive intercept for the extreme growth and a negative intercept for the extreme value portfolios). The explanation follows from the wider value-growth spread of international small stocks, especially microcaps (Panel A of Table 3.4), and lower spreads of model's *HML* slopes for microcaps (not shown for the sake of brevity). As a result, the models underestimate the value-growth spread for microcaps and overestimate the spread for megacaps.

For both standard models, the majority of statistically significant intercepts belong to microcap portfolios, which implies that the models fail to explain the microcap returns. In short, the 3F and 4F models fail the integration test for the international size-B/M portfolios, a result similar to that of Fama and French (2012). Using decomposed value and momentum factors improve the *GRS* test statistics of the models, especially for the 6F model that decomposes both the *HML* and *WML* factors. Despite this, the two decomposed models are rejected by the *GRS* test, meaning that they cannot adequately explain the average size-B/M portfolio returns. They also fail to explain returns on microcaps and leave value patterns in the intercepts of the microcaps (Panel A in Table 4.2). Again, the value patterns for the microcap intercepts arise as a result of low spreads in the HML_S slopes for microcaps (not shown for the sake of brevity). However, spreads for the HML_B slopes (also not reported) for megacaps are wide enough to eliminate the reverse value patterns for the decomposed models.

Table 4.1: Summary statistics for tests of 25 size-B/M portfolio returns

The regressions use the international and local models to explain the excess returns on the 25 size-B/M portfolios for the international sample, US, UK, Japan, and Canada. The models include the standard 3F and 4F models (equations 4.7 and 4.8), the decomposed 4F and 6F models (equations 4.9 and 4.10), the modified 7F model (equations 4.11), and the index-based 7F model (equations 4.12). The *GRS F*-test is the test statistics of the null hypotheses that all intercepts in a set of 25 regressions are zero; |α| is the average absolute intercept for a set of regressions; R^2 is the average adjusted-R^2; *SE(α)* is the average standard error of the intercepts; and *SR(α)* is the Sharpe ratio for the intercepts. '***', '**', and '*' represents the level of statistical significance at the 1%, 5%, and 10% levels, respectively.

	International Models					**Local Models**				
	GRS	**|*α*|**	**R^2**	***SE(α)***	***SR(α)***	***GRS***	**|*α*|**	**R^2**	***SE(α)***	***SR(α)***
International										
Standard 3F	2.57***	0.00	0.93	0.07	0.48	N/A	N/A	N/A	N/A	N/A
Standard 4F	2.33***	0.02	0.94	0.07	0.46	N/A	N/A	N/A	N/A	N/A
Decomposed 4F	2.15***	0.02	0.94	0.07	0.45	N/A	N/A	N/A	N/A	N/A
Decomposed 6F	2.03***	0.05	0.94	0.07	0.44	N/A	N/A	N/A	N/A	N/A
Modified 7F	2.04***	0.04	0.96	0.06	0.44	N/A	N/A	N/A	N/A	N/A
Index 7F	2.19***	0.01	0.93	0.07	0.45	N/A	N/A	N/A	N/A	N/A
United States (US)										
Standard 3F	2.28***	0.30	0.68	0.18	0.45	2.01***	0.00	0.92	0.09	0.42
Standard 4F	1.93***	0.32	0.68	0.19	0.42	1.83**	0.02	0.92	0.09	0.40
Decomposed 4F	2.07***	0.41	0.69	0.18	0.44	1.41*	0.02	0.92	0.09	0.36
Decomposed 6F	1.80**	0.44	0.70	0.19	0.41	1.40*	0.04	0.93	0.09	0.36
Modified 7F	1.64**	0.31	0.72	0.18	0.39	1.30	0.02	0.94	0.08	0.35
Index 7F	1.57**	0.16	0.87	0.13	0.39	1.17	0.01	0.93	0.09	0.33
United Kingdom (UK)										
Standard 3F	0.98	0.01	0.54	0.23	0.30	1.23	0.11	0.83	0.14	0.32
Standard 4F	0.84	0.02	0.54	0.24	0.28	1.57**	0.15	0.83	0.14	0.37
Decomposed 4F	1.12	0.15	0.56	0.23	0.32	1.18	0.12	0.84	0.14	0.32
Decomposed 6F	1.02	0.13	0.56	0.24	0.32	1.84***	0.16	0.84	0.14	0.41
Modified 7F	0.81	0.12	0.56	0.24	0.28	1.41*	0.16	0.86	0.13	0.36
Index 7F	0.80	0.01	0.54	0.24	0.26	0.87	0.00	0.87	0.13	0.28
Japan										
Standard 3F	1.51*	0.40	0.47	0.31	0.36	1.14	0.01	0.93	0.11	0.32
Standard 4F	1.27	0.30	0.47	0.30	0.35	1.13	0.01	0.93	0.11	0.32
Decomposed 4F	1.65**	0.67	0.52	0.31	0.39	1.15	0.00	0.93	0.11	0.32
Decomposed 6F	1.35	0.58	0.53	0.30	0.36	1.14	0.00	0.94	0.10	0.32
Modified 7F	1.45*	0.35	0.56	0.29	0.37	1.05	0.04	0.94	0.09	0.30
Index 7F	1.32	0.02	0.79	0.17	0.35	1.04	0.00	0.95	0.09	0.30
Canada										
Standard 3F	1.51*	0.11	0.46	0.29	0.36	1.75**	0.12	0.76	0.19	0.39
Standard 4F	1.45*	0.07	0.47	0.28	0.36	1.83**	0.16	0.76	0.19	0.42
Decomposed 4F	1.63**	0.22	0.47	0.29	0.39	1.78**	0.12	0.77	0.19	0.40
Decomposed 6F	1.63**	0.21	0.48	0.28	0.39	1.92***	0.15	0.77	0.20	0.45
Modified 7F	1.48*	0.12	0.49	0.28	0.37	2.83***	0.19	0.79	0.18	0.52
Index 7F	1.49*	0.03	0.51	0.28	0.37	1.16	0.01	0.79	0.18	0.35

Table 4.2: Regression intercepts for tests of 25 size-B/M portfolio returns

The regressions use international models to explain international size-B/M returns and local models to explain the excess returns on the 25 size-B/M portfolios for the US, UK, Japan, and Canada. The models include the standard 3F and 4F models, the decomposed 4F and 6F models, the modified 7F model, and the index-based 7F model. Panels A to E report intercepts, α, and *t*-statistics for the intercepts, *t*(α). The *t*-statistics are corrected for autocorrelation and heteroskedasticity using the Newey-West estimator with five lags. With 321 monthly observations, the critical values of the *t*-statistics are 1.65, 1.96, 2.25, and 2.58 for the 10%, 5%, 2.5%, and 1% significance level, respectively.

Panel A: International size-B/M returns regressed on international factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.19	0.10	0.25	0.18	0.30	-1.93	1.06	2.42	2.60	3.60
2	-0.08	-0.10	-0.03	-0.03	0.02	-1.30	-1.30	-0.43	-0.56	0.39
3	0.00	-0.10	-0.08	-0.12	0.00	-0.01	-1.28	-1.03	-1.56	0.04
4	0.20	-0.12	0.01	-0.08	-0.04	1.83	-1.78	0.20	-1.18	-0.60
Big	0.05	0.10	-0.04	-0.02	-0.16	0.74	1.79	-0.80	-0.36	-2.00
Standard 4F										
Small	-0.20	0.11	0.22	0.18	0.30	-1.92	1.07	2.22	2.50	3.51
2	-0.05	-0.06	0.02	0.00	0.04	-0.78	-0.75	0.24	-0.06	0.72
3	0.01	-0.07	-0.02	-0.06	0.03	0.14	-0.87	-0.25	-0.90	0.42
4	0.16	-0.08	0.04	-0.03	0.01	1.78	-1.10	0.58	-0.44	0.16
Big	0.08	0.12	-0.03	0.01	-0.11	1.11	2.00	-0.52	0.17	-1.27
Decomposed 4F										
Small	-0.09	0.17	0.31	0.17	0.21	-0.98	1.95	2.80	2.36	2.62
2	0.03	0.00	-0.02	-0.06	-0.06	0.41	-0.05	-0.33	-0.97	-1.35
3	0.11	-0.04	-0.06	-0.14	-0.05	1.66	-0.57	-0.80	-1.90	-0.72
4	0.29	-0.13	0.00	-0.09	0.00	2.63	-1.82	-0.05	-1.25	0.04
Big	-0.06	0.09	-0.02	0.06	0.00	-0.89	1.51	-0.40	0.86	-0.06
Decomposed 6F										
Small	-0.09	0.19	0.28	0.19	0.23	-0.94	2.00	2.85	2.50	2.69
2	0.04	0.04	0.03	-0.05	-0.04	0.62	0.56	0.37	-0.70	-0.79
3	0.12	-0.03	-0.01	-0.10	-0.03	1.67	-0.35	-0.09	-1.52	-0.39
4	0.24	-0.09	0.02	-0.05	0.04	2.58	-1.36	0.28	-0.71	0.50
Big	-0.03	0.10	-0.01	0.09	0.04	-0.43	1.58	-0.14	1.33	0.62
Modified 7F										
Small	-0.10	0.14	0.19	0.16	0.26	-1.16	1.86	2.33	2.72	3.99
2	0.09	-0.02	-0.01	-0.01	0.01	1.40	-0.34	-0.08	-0.14	0.17
3	0.06	-0.04	0.00	-0.03	0.04	1.14	-0.62	0.00	-0.62	0.62
4	0.10	-0.08	0.05	0.01	0.08	2.78	-1.46	1.19	0.15	1.26
Big	-0.02	0.11	0.01	0.10	0.00	-0.53	1.78	0.11	1.67	-0.04
Index 7F										
Small	-0.21	0.11	0.21	0.18	0.30	-1.61	0.92	1.90	1.96	2.51
2	-0.07	-0.08	0.01	-0.03	0.01	-0.81	-0.98	0.07	-0.52	0.24
3	0.01	-0.06	-0.02	-0.08	0.02	0.19	-0.74	-0.33	-1.57	0.24
4	0.17	-0.05	0.08	-0.01	0.02	2.48	-0.83	1.41	-0.17	0.37
Big	-0.13	0.08	-0.02	0.01	-0.08	-2.68	1.24	-0.47	0.18	-0.86

(Continued overleaf)

Table 4.2 (Continued)

Panel B: United States (US) size-B/M returns regressed on local factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.05	0.00	0.10	0.13	0.30	-0.42	0.02	1.11	1.85	4.20
2	-0.20	-0.21	0.01	-0.05	0.06	-1.75	-3.02	0.08	-0.80	1.08
3	0.08	-0.13	-0.10	0.02	0.09	0.62	-1.26	-0.93	0.23	1.13
4	0.17	-0.05	-0.02	-0.10	0.04	1.46	-0.51	-0.17	-1.18	0.37
Big	0.13	0.05	-0.05	0.03	-0.31	1.69	0.70	-0.70	0.42	-2.85
Standard 4F										
Small	-0.07	0.04	0.11	0.13	0.27	-0.52	0.34	1.29	1.86	3.74
2	-0.11	-0.16	0.02	-0.04	0.08	-0.99	-2.38	0.22	-0.55	1.27
3	0.02	-0.11	-0.04	0.07	0.08	0.18	-1.13	-0.44	0.72	1.03
4	0.15	-0.02	-0.01	-0.06	0.07	1.43	-0.24	-0.06	-0.77	0.73
Big	0.14	0.07	-0.04	0.06	-0.25	1.91	0.84	-0.52	0.68	-2.29
Decomposed 4F										
Small	0.03	0.11	0.11	0.07	0.19	0.26	0.99	1.30	1.05	2.86
2	0.01	-0.17	0.02	-0.09	-0.02	0.06	-2.24	0.20	-1.33	-0.36
3	0.23	-0.08	-0.14	-0.04	0.05	1.97	-0.77	-1.31	-0.41	0.68
4	0.23	-0.04	-0.01	-0.08	0.08	2.02	-0.39	-0.12	-0.88	0.75
Big	0.01	-0.01	0.01	0.18	-0.12	0.09	-0.16	0.07	2.29	-1.07
Decomposed 6F										
Small	0.01	0.14	0.12	0.08	0.17	0.09	1.27	1.37	1.14	2.37
2	0.09	-0.12	0.03	-0.06	0.00	0.86	-1.71	0.32	-0.91	0.03
3	0.15	-0.08	-0.11	0.01	0.05	1.50	-0.77	-1.05	0.08	0.56
4	0.21	-0.01	0.02	-0.05	0.11	2.03	-0.13	0.19	-0.64	1.02
Big	0.04	0.00	0.01	0.19	-0.09	0.53	0.01	0.14	2.40	-0.91
Modified 7F										
Small	-0.04	0.06	0.08	0.06	0.18	-0.27	0.64	0.92	0.89	2.47
2	0.07	-0.15	-0.01	-0.07	0.02	0.66	-2.04	-0.07	-1.05	0.25
3	0.08	-0.09	-0.09	0.01	0.07	0.98	-0.98	-0.97	0.19	0.85
4	0.07	-0.06	0.02	-0.03	0.10	1.27	-0.73	0.26	-0.47	0.98
Big	0.03	0.03	0.05	0.18	-0.16	0.51	0.39	0.74	2.19	-1.17
Index 7F										
Small	-0.03	0.08	0.12	0.05	0.12	-0.19	0.84	1.35	0.63	1.77
2	0.04	-0.14	0.05	-0.09	-0.04	0.30	-1.77	0.45	-1.47	-0.78
3	0.03	-0.09	-0.07	-0.02	0.00	0.39	-1.08	-0.75	-0.27	-0.01
4	0.12	-0.04	0.02	-0.06	0.03	1.09	-0.48	0.31	-0.76	0.28
Big	-0.03	0.08	0.06	0.18	-0.20	-0.81	0.95	0.91	2.10	-1.51

(Continued overleaf)

Table 4.2 (Continued)										
Panel C: United Kingdom (UK) size-B/M returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.07	-0.07	0.19	0.17	0.23	-0.51	-0.70	1.45	1.59	2.16
2	0.13	0.17	0.16	0.16	0.27	1.03	1.09	1.19	1.05	2.39
3	0.03	0.01	0.15	0.03	0.00	0.20	0.06	0.88	0.25	-0.02
4	0.22	0.18	0.16	-0.10	0.02	1.70	1.18	0.90	-0.67	0.12
Big	0.16	0.27	0.10	-0.01	0.08	1.36	1.94	0.71	-0.05	0.50
Standard 4F										
Small	-0.02	-0.09	0.20	0.20	0.25	-0.11	-0.89	1.78	2.00	2.69
2	0.21	0.25	0.15	0.22	0.30	1.54	1.59	1.06	1.46	2.69
3	0.12	0.07	0.23	0.08	0.05	0.71	0.47	1.27	0.59	0.43
4	0.21	0.24	0.26	-0.09	0.04	1.66	1.54	1.41	-0.56	0.25
Big	0.16	0.32	0.22	-0.05	0.15	1.42	2.39	1.63	-0.30	0.82
Decomposed 4F										
Small	0.00	-0.05	0.24	0.18	0.20	0.03	-0.45	1.90	1.65	1.96
2	0.20	0.24	0.17	0.13	0.21	1.76	1.72	1.29	0.89	1.99
3	0.11	0.03	0.13	0.00	-0.05	0.86	0.22	0.73	0.02	-0.37
4	0.26	0.18	0.13	-0.09	0.02	2.00	1.12	0.76	-0.63	0.13
Big	0.09	0.26	0.11	0.05	0.19	0.82	1.94	0.72	0.32	1.23
Decomposed 6F										
Small	0.07	-0.09	0.24	0.25	0.25	0.54	-0.83	2.19	2.64	2.86
2	0.31	0.29	0.17	0.22	0.26	2.49	2.03	1.13	1.46	2.44
3	0.21	0.05	0.14	0.04	0.00	1.40	0.38	0.81	0.30	0.01
4	0.27	0.21	0.22	-0.11	0.04	2.17	1.28	1.25	-0.70	0.24
Big	0.07	0.36	0.28	-0.01	0.28	0.62	2.59	2.16	-0.04	1.88
Modified 7F										
Small	0.05	-0.10	0.18	0.18	0.23	0.41	-0.88	1.58	1.73	2.32
2	0.27	0.31	0.12	0.20	0.25	2.00	2.08	0.87	1.39	2.09
3	0.22	0.06	0.21	0.07	0.05	1.54	0.46	1.24	0.53	0.47
4	0.16	0.24	0.28	0.03	0.16	2.17	1.89	1.89	0.29	1.30
Big	0.13	0.29	0.21	-0.01	0.29	1.34	2.17	1.66	-0.05	1.46
Index 7F										
Small	-0.14	-0.23	0.06	0.04	0.10	-1.02	-2.25	0.52	0.37	0.96
2	0.07	0.14	-0.03	0.02	0.12	0.60	0.92	-0.20	0.16	1.16
3	0.02	-0.07	0.06	-0.08	-0.08	0.17	-0.58	0.37	-0.66	-0.70
4	0.04	0.10	0.09	-0.17	-0.05	0.37	0.76	0.61	-1.24	-0.39
Big	-0.08	0.11	0.04	-0.13	0.12	-0.92	0.85	0.32	-0.93	0.59

(Continued overleaf)

Table 4.2 (Continued)										
Panel D: Japanese size-B/M returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
			α					t(α)		
Standard 3F										
Small	0.04	0.20	0.26	0.13	0.13	0.17	1.34	2.51	1.75	1.52
2	0.04	-0.01	-0.01	-0.12	-0.09	0.28	-0.04	-0.14	-1.30	-1.24
3	-0.09	-0.06	-0.19	-0.06	-0.02	-0.69	-0.59	-1.56	-0.48	-0.24
4	-0.04	0.00	0.02	-0.17	-0.08	-0.38	-0.02	0.19	-1.28	-0.71
Big	-0.10	0.13	0.10	0.03	0.07	-1.13	1.40	0.98	0.26	0.57
Standard 4F										
Small	0.04	0.21	0.27	0.14	0.14	0.21	1.51	2.78	1.78	1.76
2	0.04	0.00	0.00	-0.10	-0.08	0.26	0.01	0.03	-1.35	-1.24
3	-0.09	-0.05	-0.17	-0.05	-0.02	-0.69	-0.48	-1.53	-0.45	-0.22
4	-0.04	0.01	0.04	-0.15	-0.07	-0.39	0.13	0.34	-1.38	-0.67
Big	-0.09	0.13	0.11	0.04	0.07	-1.13	1.58	1.11	0.34	0.57
Decomposed 4F										
Small	0.00	0.20	0.26	0.14	0.15	-0.02	1.27	2.51	1.96	2.04
2	0.00	-0.02	0.00	-0.11	-0.07	0.02	-0.15	-0.04	-1.26	-1.19
3	-0.12	-0.07	-0.19	-0.05	-0.01	-1.03	-0.73	-1.55	-0.45	-0.12
4	-0.07	0.00	0.02	-0.17	-0.08	-0.64	0.03	0.20	-1.29	-0.73
Big	-0.08	0.14	0.10	0.01	0.02	-1.04	1.58	0.97	0.09	0.22
Decomposed 6F										
Small	0.00	0.20	0.26	0.15	0.15	-0.03	1.41	2.76	2.03	2.18
2	-0.01	-0.02	0.00	-0.10	-0.07	-0.07	-0.21	0.03	-1.32	-1.25
3	-0.12	-0.06	-0.16	-0.05	-0.01	-1.05	-0.60	-1.48	-0.45	-0.16
4	-0.06	0.02	0.04	-0.15	-0.08	-0.60	0.21	0.37	-1.47	-0.83
Big	-0.08	0.14	0.10	0.02	0.02	-1.14	1.71	1.04	0.20	0.29
Modified 7F										
Small	-0.01	0.17	0.24	0.12	0.15	-0.09	1.28	2.62	1.51	2.37
2	0.04	-0.01	0.03	-0.06	-0.03	0.34	-0.12	0.35	-0.82	-0.54
3	-0.10	-0.03	-0.11	0.03	0.07	-0.86	-0.27	-1.16	0.38	1.16
4	0.01	0.10	0.13	-0.04	0.07	0.19	1.08	1.58	-0.61	0.83
Big	-0.05	0.10	0.02	0.01	0.09	-0.68	1.20	0.23	0.06	0.84
Index 7F										
Small	-0.02	0.15	0.23	0.12	0.12	-0.12	1.22	2.50	1.31	2.41
2	0.01	-0.01	0.02	-0.08	-0.06	0.11	-0.08	0.28	-1.36	-1.50
3	-0.12	-0.06	-0.17	-0.01	0.03	-1.13	-0.61	-1.85	-0.18	0.43
4	-0.10	-0.01	0.03	-0.10	0.00	-1.20	-0.15	0.41	-1.61	0.02
Big	-0.11	0.00	0.01	0.01	0.13	-2.17	0.05	0.17	0.08	1.05

(Continued overleaf)

Table 4.2 (Continued)										
Panel E: Canadian size-B/M returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	0.4	0.38	0.45	0.49	0.21	1.29	1.91	2.33	2.61	1.81
2	-0.28	-0.2	-0.01	-0.06	0.18	-0.99	-0.99	-0.08	-0.4	1.16
3	0.13	0.21	0.16	-0.12	-0.08	0.65	1.15	0.82	-0.69	-0.55
4	0.64	0.25	-0.05	0.01	-0.16	2.75	0.81	-0.24	0.07	-0.9
Big	0.02	0.34	-0.08	0.13	-0.01	0.09	2	-0.63	0.95	-0.08
Standard 4F										
Small	0.34	0.37	0.45	0.48	0.23	1.16	1.85	2.41	2.63	2.16
2	-0.26	-0.12	-0.2	0	0.28	-0.98	-0.54	-1.08	0.03	1.82
3	0.05	0.27	0.24	0.02	0.01	0.25	1.47	1.15	0.12	0.06
4	0.69	0.07	0.14	0.14	0	2.9	0.25	0.65	0.96	0.02
Big	0.02	0.34	0.1	0.12	0.25	0.1	2.13	0.62	0.82	1.54
Decomposed 4F										
Small	0.42	0.38	0.44	0.47	0.19	1.42	1.92	2.31	2.63	1.79
2	-0.26	-0.19	-0.02	-0.07	0.16	-0.9	-0.96	-0.09	-0.47	1.14
3	0.14	0.21	0.17	-0.13	-0.09	0.7	1.15	0.84	-0.75	-0.61
4	0.64	0.26	-0.05	0.02	-0.16	2.74	0.81	-0.25	0.11	-0.88
Big	-0.01	0.35	-0.07	0.15	0.01	-0.08	1.98	-0.57	1.11	0.03
Decomposed 6F										
Small	0.33	0.38	0.29	0.44	0.2	1.11	1.78	1.53	2.26	1.97
2	-0.31	-0.24	-0.19	-0.01	0.32	-1.14	-1.08	-1.06	-0.06	2.09
3	0.15	0.26	0.29	0.04	0	0.64	1.35	1.25	0.23	0.02
4	0.68	0.14	0.11	0.05	0.06	2.73	0.48	0.5	0.39	0.27
Big	-0.12	0.55	0.06	0.09	0.2	-0.62	2.71	0.41	0.54	1.34
Modified 7F										
Small	0.14	0.35	0.5	0.47	0.29	0.51	1.71	3	2.59	2.69
2	-0.24	-0.07	-0.27	0.03	0.39	-0.88	-0.34	-1.46	0.16	2.92
3	-0.12	0.24	0.34	0.1	0.15	-0.57	1.33	1.62	0.58	0.99
4	0.44	-0.04	0.34	0.34	0.24	2.89	-0.16	1.6	2.61	1.38
Big	0.05	0.23	0.14	0.2	0.45	0.41	1.65	0.98	1.42	2.52
Index 7F										
Small	0.05	0.34	0.33	0.27	0.04	0.17	1.71	1.95	1.52	0.4
2	-0.42	-0.17	-0.35	-0.18	0.15	-1.44	-0.79	-1.84	-1.19	1.31
3	-0.33	0.11	0.19	-0.13	-0.07	-1.54	0.59	0.96	-0.76	-0.54
4	0.3	-0.14	0.13	0.14	-0.01	1.74	-0.49	0.62	1.06	-0.04
Big	-0.02	0.03	-0.08	0.01	0.15	-0.22	0.24	-0.55	0.08	0.94

The modified and index-based *SMB* and *HML* factors further improve the pricing performance of the modified and index 7F models. Specifically, the modified 7F model has the lowest *GRS* statistics and Sharpe ratio of intercepts, and the highest average adjusted R^2 among all models. Nevertheless, the model still produces a value pattern in the intercepts of microcaps. For the two 7F models, the statistically significant intercepts are also concentrated in microcaps, which show that even these models are unable to explain the microcap returns.

Overall, the international models fail to explain the returns on the international size-B/M portfolio returns, which shows the lack of integration of these asset pricing models. Fama and French (2012) also report the failure of their global 3F and 4F models to explain global size-B/M returns, despite their high explanatory power indicated by their adjusted R^2. The results show that the performance of the modified and index-based 7F models is not significantly better than the decomposed 4F and 6F models in terms of specification tests, according to the *GRS* statistics and the $SR(\alpha)$. However, the decomposed, modified, and index-based models perform slightly better than the standard models. The modified 7F model is found to have the highest explanatory power among all the international models. Similar to Fama and French (2012), the integration of the international models does not extend to microcaps as the models in Panel A in Table 4.2 leave large unexplained returns for these portfolios. Fama and French (2012) show that their models successfully explain the international size-B/M portfolio returns excluding microcaps. However, they warn that omitting these problematic portfolios creates a bias in favour of the models in question, as the models are expected to perform well excluding the microcaps.

Failure of the international models to explain the returns on international size-B/M returns, specifically the microcaps, motivates the test of their ability to explain returns on country size-B/M portfolios. The purpose is to identify the specific countries or country portfolios that are creating problems for international models and to investigate whether mixing stocks from different countries to form international test portfolios conceals the asset pricing problems.

4.3.2 International Models for Country Size-B/M Portfolio Returns

The *GRS* statistics clearly reject the international standard and decomposed models for the US size-B/M portfolio at the 1% level of significance (Table 4.1). The explanatory power of the models is deemed to be quite low, given that the models leave a large amount of returns unexplained (i.e. 0.30%-0.44% per month) and create reverse value patterns in the intercepts of megacaps (Panel A of Table A2). Moreover, the intercepts are systematically large and positive for all size groups. The large and positive intercepts indicate that the average returns for the US size-B/M portfolios are higher than predicted by these international models, which follows from the high average returns on the 25 US size-B/M portfolios seen in Panel A of Table 3.4. The models also have large $SE(\alpha)$ and $SR(\alpha)$, which show that the models are not estimated precisely. Adding the momentum factor or its decomposed elements improves the *GRS* statistics of models. However, the *GRS* test rejects these models.

The two 7F models perform better than the standard and decomposed models for the US size-B/M portfolios. This supports the asset pricing integration as it shows that using different breakpoints and more factors to capture size and value effect improve the performance of international models. The *GRS* test (Table 4.1) barely rejects the modified and the index-based 7F models at the 5% level of significance. These models also have the lowest $SR(\alpha)$ values. Specifically, the index-based 7F model has the lowest average absolute intercept and $SE(\alpha)$ together with the highest average R^2 among tests of all international models for the US, which shows that the model is precisely estimated. As a result, the intercept estimates do not reflect the large and positive abnormal returns (Panel A in Table A2). However, the low B/M portfolios remain the toughest for the index-based 7F model to explain as can be seen from their positive and significance intercepts.

Consistent with the US, the explanatory power of the international models is quite low for the size-B/M portfolio returns of the three other countries. For the 25 size-B/M portfolio returns in Japan and the UK, the *GRS* test cannot reject any of the models, except for the standard 3F and decomposed 4F models in Japan. The average adjusted R^2 values of the models remain quite low, and models have quite high average *SE(α)* values. The regression intercepts for the case of Japanese size-B/M portfolio returns in Panel C of Table A2 are systematically negative and large; as a result the average absolute intercepts are enormous, ranging from 0.30% to 0.67% per month. The systematically large and negative intercepts are consistent with the lower average returns on the Japanese size-B/M portfolios in Panel A in Table 3.4. Fama and French (2012) also report similar findings in their tests of global models for the Japanese size-B/M portfolio returns. The index-based 7F model stands out as the best among all international models. This model has the highest average adjusted R^2 of 0.79 and lowest average absolute intercept, and *SE(α)* of 0.02% and 0.17% per month. The large and negative estimated intercepts also disappear for the index-based 7F model.

The UK size-B/M portfolios appear to be easily explained by the international standard 3F and 4F models as shown in 4.1, because of the lowest variation of their excess returns (Panel A in Table 3.4). For the UK, the international models have much lower average absolute intercept and *SR(α)* values in Table 4.1. Consistent with the lower *GRS* statistics, only the decomposed 4F model has one significant intercept term in Panel B of Table A2. Despite the fact that the international models perform adequately according to the *GRS* test, the models fail badly in terms of explanatory power as can be seen from the low average values of the adjusted R^2. The maximum value of the average adjusted R^2 for the international models is 0.56, which means the models explain at most 56% of the variation in the excess returns of UK size-B/M portfolios.

The *GRS* test barely rejects the international standard 3F and 4F, modified 7F, and index-based 7F models, at the 10% level of significance, in their tests to explain 25 Canadian size-B/M portfolio returns, which shows support for these international models. However, the models have low explanatory power and precision, shown by low values of average adjusted R^2 and high values of average $SE(\alpha)$. The decomposition of international value and momentum factors worsen the model performance. In particular, the *GRS* test rejects the decomposed models at the 5% level of significance, and the models have higher average absolute intercepts and $SR(\alpha)$ values compared to other models. Given the poor explanatory power, the international models are not suitable for the UK and Canadian size-B/M portfolio returns. These findings are inconsistent with the integration of the asset pricing models.

The results of international standard 3F and 4F models for the country portfolio returns are generally in line with the existing literature. Both models are rejected with high regression intercepts for the US size-B/M portfolios, which show the failure of the models. Fama and French (2012) also reject the two versions of their models for North America and report large intercepts. Both models are rejected for Canadian size-B/M portfolios as well. Griffin (2002) rejects the international 3F model in tests to explain the US and Canadian size-B/M portfolio returns, which further highlights the rather weak explanatory power of this model. The results for the UK size-B/M portfolio returns are also broadly consistent with those of Fama and French's (2012) global 3F and 4F models for the European region. Although Fama and French (2012) cannot reject the two models for the Japanese size-B/M portfolios, they declare them failures on the basis of their large estimated intercepts and low average adjusted R^2 values. Griffin (2002) reports similar results for the test of the international 3F model on the Japanese size-B/M portfolio returns. However, Griffin (2002) reports the failure of the international 3F model to explain size-B/M portfolio returns for the UK. My different findings for the UK may be due to the differences in the sample period and sample of stocks[13], as well as, the method used to construct the *SMB* and *HML* risk factors[14].

The persistent pattern of the extreme positive and negative intercepts for the US and Japanese size-B/M portfolios show that the regional differences in the levels of average returns create problems for international models. Despite models' success under the *GRS* test for the UK and Japan, they have very low explanatory power and estimation precision shown by small values of average adjusted R^2 and large values of $SE(\alpha)$. The index-based 7F model performs better in US and Japan, the two countries for which the other models produce a persistent pattern of large abnormal returns. The lower average absolute intercepts of the model in the US and Japanese equity markets endorse the findings of Cremers et al. (2013) that the model produces lowest model alphas. The model has quite high average R^2 of 0.87 and 0.79 for the US and Japan, respectively. Overall, the poor performance of international models in explaining country size-B/M portfolio returns motivates further tests of local models to examine if the local versions of these models can provide some adequate explanation of average size-B/M portfolio returns. Studies such as Fama and French (1993, 1996, and 2012), Griffin (2002), and Gregory et al. (2013a) document the success of local standard models to explain size-B/M portfolio returns for different countries. Moreover, it will be interesting to see how the local versions of the decomposed and alternative models perform. If these models perform better than the standard models, this will be one of the first international evidence supporting the Cremers et al. (2013) methodological changes in the construction of return based factors and use of factors based on common benchmark indices.

[13] The sample in this study includes financial stocks while Griffin (2002) excludes them, and in addition this study applies several static and times-series screenings to clean TDS data.
[14] Griffin (2002) construct *SMB* and *HML* factors using break-point based on all the stocks, whereas this study follows Fama and French (2012) in the choice of break-points for constructing these factors.

4.3.3 Local Models for Country Size-B/M Portfolio Returns

In general, the local models in Table 4.1 have higher explanatory power and lower average *SE(α)* values compared to the international models in their tests to explain country specific size-B/M portfolio returns. Also, the local models do not leave large unexplained returns for US and Japanese size-B/M portfolio returns as shown in Panels B and D of Table 4.2. However, the *GRS* test rejects the standard 3F and 4F models for 25 US size-B/M portfolio returns at the 1% level of significance (Table 4.1). The decomposed models are barely rejected at the 10% level, while the modified and index-based models successfully pass the *GRS* test. The two 7F models also have higher average adjusted R^2 and lower average *SR(α)* values compared to other local models.

The regression intercepts in Panel B of Table 4.2 do not show any pervasive patterns. The standard models still create a value pattern in the estimated intercepts of microcaps and produce a reverse value pattern in the intercepts of megacaps. Fama and French (2012) identify similar patterns for the tests of their regional 3F and 4F models for the North American size-B/M portfolio returns. The two 7F models do not create any reverse value patterns in the intercepts of megacaps, and the value patterns for microcaps shrink in magnitude. In short, the modified 7F and index-based 7F models provide an adequate explanation for the US size-B/M portfolio returns. Therefore, they should be used instead of standard 3F and 4F models for performance evaluation and risk adjustment. This is the first empirical evidence in support of the modified and index-based models of Cremers et al. (2013) for the US size-B/M portfolio returns.

For the 25 UK size-B/M portfolio returns, the *GRS* test cannot reject the standard 3F, decomposed 4F, and index-based 7F models (Table 4.1), and barely rejects the modified 7F model at the 10% level of significance. The momentum factor appears to distort the model performance and models that include a *WML* factor or its decomposed components fail the *GRS* test, except the index-based 7F model. Gregory et al. (2013a) report the success of the standard 3F and 4F models to explain the 25 size-B/M portfolio returns for the UK. Although the standard 4F model is rejected in my tests, the *GRS* test barely rejects it at the 5% level of significance. The index-based 7F model performs best and has the lowest average absolute intercept and *SR(α)* values and highest average adjusted R^2. Therefore, the index-based 7F model should be preferred over the standard 3F model for the applications in the UK.

For 25 Japanese size-B/M portfolio returns, the *GRS* test cannot reject any of the models (Table 4.1). The models, on average, capture 93% of the variation in the returns. The average absolute intercepts are very close to zero, and there are no patterns in their estimates (Panel D of Table 4.2). Contrary to the results of the international models, the significant positive intercepts for microcaps show that the Japanese microcaps have extra returns than the local models predict. However, because the abnormal returns for microcaps are small in magnitude, they do not affect the *GRS* results in Table 4.1. All models provide an adequate explanation of average Japanese size-B/M portfolios, and for the index-based 7F model the explanation is relatively better.

The *GRS* test rejects all models, except the index-based 7F models, for their tests to explain the 25 Canadian size-B/M portfolios (Table 4.1). The models are rejected with higher *GRS* statistics compared to their international counterparts, even after their improved explanatory power. Panel E in Table 4.2 shows that all models have on average 6 to 8 significant intercept terms, and for each model the majority of the statistically significant intercepts are related to the case of the microcaps. Again, the index-based 7F model is an exception. The model has the highest average adjusted R^2 and the lowest *SR(α)* values among local models and produces only one significant portfolio intercept. Clearly the index-based 7F model appears to be the better choice, and it should be used for the applications of performance evaluation and risk control in Canada.

In summary, the local models provide an adequate explanation for Japanese size-B/M portfolio returns. The modified and index-based models significantly improve the performance of local models for the US. In the UK, the standard 3F, decomposed 4F, index-based 7F models perform quite well. However, the index-based 7F model is the only model that provides an adequate description of the size-B/M portfolio returns in all four countries. For all the countries, this model has the highest R^2 together with the lowest values of average absolute intercepts and associated *SR(α)*. Further, the performance of the modified 7F model is comparable to the index-based 7F model in the US and Japan. For both of these countries, the 7F models perform equally well with similar average adjusted R^2 and *SR(α)* values.

This should be a good news for those interested in pricing of value and growth effects in extreme small portfolios, which the standard 3F and 4F models fail to capture. The local version of index-based 7F model successfully explain these effects in average stock returns. Therefore, the investors should use index-based 7F model as benchmark model for the performance evaluation of value and growth portfolios, regardless of their size. Moreover, the model should also replace the the standard models in the academic research involving event studies and risk control.

Still, there is question why index-based model perform better? Cremers et al. (2013) argue that if co-movements in stocks within a given size or value category are partly produced by changes in investors' appetites for stocks of a given style, and if these appetites get expressed via investment vehicles that track benchmark indices, then the indices themselves should track the resulting asset price changes more precisely than academic factors that approximate them [Roll (1992) and Stutzer (2003)]. Moreover, investors may also prefer to trade common indices due to lower transaction costs, especially when shorting stocks.

For the international models, the results reject the integration hypothesis as none of the models can provide an adequate explaination of the international or country specific size-B/M portfolio returns. Nevertheless, the index-based 7F model is relatively more integrated based on its performance for the international sample and the US and Japan. Additionally, the better performance of local models for country size-B/M portfolio returns indicates that the asset pricing is purely a local issue, not an international one.

Next section discusses the results of asset pricing tests for the size-momentum portfolio returns. These results are very important, as very few studies looked at the momentum effect in the international stock returns. In fact, only other study that examined momentum effect in the international asset pricing context is the Fama and French (2012). Further, as shown in chapter 3, the momentum effect is most pronounced across small and big stocks in the US, UK, and Canada.

4.4 Results for the Size-Momentum Portfolio Returns

Table 4.3 presents the summary statistics of regressions to explain excess returns on 25 size-momentum portfolio returns. The models used are those specified in section 4.2, from equation (4.7) to (4.12). Further details of the intercepts and corresponding *t*-statistics are shown in Table 4.4. These include the international models used to explain international size-momentum portfolio returns and local models used to explain local size-momentum portfolio returns. To save space, the intercepts of the local size-momentum portfolio returns' regressions on international models are presented in the appendix (Table A3).

4.4.1 International Models for International Size-Momentum Portfolio Returns

The *GRS* test rejects the international models for the 25 international size-momentum portfolios (Table 4.3). Panel A in Table 4.4 shows that the standard 3F and decomposed 4F models, the models with no momentum factor, leave strong momentum patterns for all size groups. The models with momentum and its components, the standard 4F, decomposed 6F, modified 7F, and index-based 7F models, leave a momentum pattern in microcaps only. The significant intercepts are not concentrated in microcaps, rather they are scattered randomly over all the size groups. The standard 3F and decomposed 4F models also have the lowest average adjusted R^2, and largest *SE(α)* and *SR(α)* values. Apparently, adding a momentum factor improves the performance of the models. Nevertheless, none of the models provide an adequate explanation for international size-momentum returns.

Fama and French (2012) is the only other study that examines the international size-momentum portfolio returns. They also show that both the standard 3F and 4F models cannot explain the size-momentum portfolio returns, even excluding microcaps. Importantly, the models are rejected at the higher levels of significance and have lower R^2 compared to the 25 international size-B/M portfolios. The inability of the asset pricing models to explain the international size-momentum portfolio returns along with size-B/M portfolios returns is a clear indication that these models do not integrate sufficiently across the four countries. The factor construction method and use of the decomposed factors have little impact on the model performance. Given this disappointing situation, the international models are next tested to find out if they explain returns on country size-momentum portfolios, and to trace the causes of their inferior performance.

4.4.2 International Models for Country Size-Momentum Portfolio Returns

The remaining results in Table 4.3 for international models to explain country size-momentum portfolios are similar to those of international size-momentum portfolios. The *GRS* test rejects all the models for the US, UK, and Canada. For these countries, the models have very low average adjusted R^2 and large average *SE(α)* and *SR(α)* values. For Japan, although the international models pass the *GRS* test, they also exhibit low explanatory power as shown by the small average adjusted R^2 and large average *SE(α)* values.

Table 4.3: Summary statistics for tests of 25 size-momentum portfolio returns

The regressions use the international and local models to explain the excess returns on the 25 size-momentum portfolios for the international sample, US, UK, Japan, and Canada. The models include the standard 3F and 4F models (equations 4.7 and 4.8), the decomposed 4F and 6F models (equations 4.9 and 4.10), the modified 7F model (equations 4.11), and the index-based 7F model (equations 4.12). The *GRS F*-test is the test statistics of the null hypotheses that all intercepts in a set of 25 regressions are zero; |α| is the average absolute intercept for a set of regressions; R^2 is the average adjusted-R^2; *SE(α)* is the average standard error of the intercepts; and *SR(α)* is the Sharpe ratio for the intercepts. '***', '**', and '*' represents the level of statistical significance at the 1%, 5%, and 10% levels, respectively.

	International Models					Local Models				
	GRS	*|α|*	R^2	*SE(α)*	*SR(α)*	*GRS*	*|α|*	R^2	*SE(α)*	*SR(α)*
International										
Standard 3F	3.62***	0.00	0.82	0.12	0.57	N/A	N/A	N/A	N/A	N/A
Standard 4F	3.20***	0.04	0.89	0.09	0.54	N/A	N/A	N/A	N/A	N/A
Decomposed 4F	3.52***	0.00	0.82	0.13	0.57	N/A	N/A	N/A	N/A	N/A
Decomposed 6F	3.09***	0.04	0.91	0.08	0.54	N/A	N/A	N/A	N/A	N/A
Modified 7F	3.22***	0.06	0.91	0.08	0.55	N/A	N/A	N/A	N/A	N/A
Index 7F	3.01***	0.03	0.89	0.09	0.53	N/A	N/A	N/A	N/A	N/A
United States (US)										
Standard 3F	2.16***	0.33	0.61	0.20	0.44	2.83***	0.06	0.84	0.13	0.50
Standard 4F	1.88***	0.36	0.68	0.19	0.41	2.57***	0.08	0.91	0.09	0.48
Decomposed 4F	2.11***	0.41	0.62	0.21	0.44	2.42***	0.05	0.84	0.14	0.47
Decomposed 6F	1.85***	0.46	0.69	0.19	0.41	2.08***	0.08	0.92	0.09	0.44
Modified 7F	1.84***	0.35	0.72	0.18	0.41	2.03***	0.07	0.93	0.09	0.44
Index 7F	1.89***	0.20	0.85	0.14	0.42	1.84***	0.05	0.92	0.09	0.41
United Kingdom (UK)										
Standard 3F	7.08***	0.10	0.37	0.22	0.79	7.62***	0.07	0.70	0.15	0.81
Standard 4F	6.58***	0.12	0.40	0.22	0.77	6.42***	0.04	0.77	0.12	0.77
Decomposed 4F	7.25***	0.01	0.38	0.22	0.81	7.75***	0.07	0.71	0.15	0.81
Decomposed 6F	6.77***	0.03	0.41	0.21	0.79	6.57***	0.06	0.79	0.13	0.78
Modified 7F	7.04***	0.01	0.41	0.22	0.81	6.36***	0.05	0.79	0.12	0.77
Index 7F	6.84***	0.09	0.39	0.22	0.80	6.56***	0.15	0.74	0.13	0.77
Japan										
Standard 3F	1.01	0.32	0.42	0.33	0.30	0.99	0.02	0.85	0.17	0.30
Standard 4F	1.04	0.23	0.45	0.31	0.30	0.98	0.03	0.91	0.12	0.30
Decomposed 4F	1.04	0.60	0.47	0.30	0.30	1.03	0.02	0.86	0.16	0.30
Decomposed 6F	1.00	0.51	0.50	0.31	0.30	1.00	0.03	0.92	0.11	0.30
Modified 7F	1.05	0.28	0.54	0.30	0.32	1.10	0.06	0.92	0.11	0.32
Index 7F	0.90	0.03	0.77	0.20	0.28	1.02	0.02	0.92	0.11	0.30
Canada										
Standard 3F	4.64***	0.10	0.42	0.22	0.64	5.30***	0.12	0.73	0.15	0.69
Standard 4F	4.27***	0.12	0.45	0.21	0.62	3.78***	0.07	0.79	0.14	0.60
Decomposed 4F	4.37***	0.02	0.43	0.22	0.63	5.36***	0.13	0.73	0.15	0.69
Decomposed 6F	4.04***	0.02	0.46	0.21	0.62	2.85***	0.13	0.81	0.13	0.54
Modified 7F	4.45***	0.07	0.47	0.21	0.65	3.69***	0.04	0.80	0.14	0.60
Index 7F	4.21***	0.14	0.49	0.21	0.62	4.21***	0.18	0.78	0.14	0.65

Table 4.4: Regression intercepts for tests of 25 size-momentum portfolio returns
The regressions use international models to explain international size-momentum returns and local models to explain the excess returns on the 25 size-momentum portfolios for the US, UK, Japan, and Canada. The models include the standard 3F and 4F models, the decomposed 4F and 6F models, the modified 7F model, and the index-based 7F model. Panels A to E report intercepts, α, and *t*-statistics for the intercepts, *t*(α). The *t*-statistics are corrected for autocorrelation and heteroskedasticity using the Newey-West estimator with five lags. With 321 monthly observations, the critical values of the *t*-statistics are 1.65, 1.96, 2.25, and 2.58 for the 10%, 5%, 2.5%, and 1% significance level, respectively.

Panel A: International size-momentum returns regressed on international factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.31	-0.12	-0.08	0.27	0.84	-1.82	-1.15	-0.69	2.58	5.61
2	-0.32	-0.15	-0.12	0.17	0.45	-1.86	-1.62	-1.43	1.99	3.62
3	-0.32	-0.17	-0.14	0.02	0.37	-1.96	-1.84	-1.63	0.26	2.90
4	-0.30	-0.17	-0.10	-0.01	0.37	-1.62	-1.75	-1.31	-0.12	2.39
Big	-0.34	-0.15	-0.12	0.20	0.27	-1.74	-1.73	-1.54	2.24	1.87
Standard 4F										
Small	0.07	-0.04	-0.09	0.17	0.63	0.52	-0.38	-0.78	1.59	4.87
2	0.12	-0.01	-0.13	0.08	0.19	1.45	-0.14	-1.52	0.91	2.56
3	0.12	0.00	-0.12	-0.08	0.08	1.40	0.03	-1.41	-0.90	1.18
4	0.16	0.00	-0.08	-0.12	0.06	1.85	0.04	-0.98	-1.72	0.69
Big	0.10	0.02	-0.12	0.04	-0.11	1.00	0.32	-1.47	0.62	-1.20
Decomposed 4F										
Small	-0.25	-0.15	-0.09	0.23	0.83	-1.25	-1.37	-0.78	2.30	5.80
2	-0.24	-0.17	-0.15	0.12	0.46	-1.18	-1.72	-1.72	1.53	3.49
3	-0.24	-0.19	-0.16	0.00	0.38	-1.27	-1.89	-1.84	-0.02	2.76
4	-0.20	-0.18	-0.12	-0.04	0.40	-0.96	-1.76	-1.60	-0.57	2.29
Big	-0.31	-0.16	-0.14	0.18	0.28	-1.44	-1.61	-1.70	1.89	1.70
Decomposed 6F										
Small	0.20	-0.04	-0.11	0.10	0.60	1.84	-0.37	-0.87	1.04	5.05
2	0.26	-0.01	-0.16	0.00	0.17	4.25	-0.15	-1.87	0.02	2.68
3	0.22	-0.01	-0.16	-0.13	0.07	2.82	-0.12	-1.93	-1.76	1.13
4	0.23	-0.02	-0.11	-0.16	0.08	2.63	-0.33	-1.50	-2.45	0.87
Big	0.02	-0.05	-0.15	0.06	0.01	0.30	-1.09	-1.72	0.99	0.08
Modified 7F										
Small	0.11	-0.04	-0.05	0.20	0.66	0.88	-0.37	-0.46	2.05	5.60
2	0.15	-0.02	-0.09	0.11	0.19	1.75	-0.18	-1.16	1.44	2.61
3	0.15	0.00	-0.08	-0.03	0.09	1.87	-0.05	-1.08	-0.49	1.36
4	0.20	0.03	-0.04	-0.11	0.07	2.40	0.44	-0.60	-2.27	0.87
Big	0.09	0.02	-0.10	0.06	-0.13	0.88	0.29	-1.25	0.97	-1.50
Index 7F										
Small	0.03	-0.01	-0.05	0.20	0.63	0.21	-0.08	-0.38	1.61	4.76
2	0.09	0.00	-0.11	0.07	0.17	0.96	0.00	-1.29	0.94	2.34
3	0.10	0.01	-0.12	-0.06	0.06	1.15	0.10	-1.52	-0.78	0.94
4	0.18	0.01	-0.06	-0.12	0.05	2.19	0.16	-0.78	-1.91	0.61
Big	0.05	-0.02	-0.14	0.01	-0.17	0.47	-0.33	-1.67	0.21	-1.87

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Table 4.4 (Continued)										
Panel B: United States (US) size-momentum returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.35	0.07	0.20	0.48	0.83	-2.17	0.85	2.21	4.38	5.04
2	-0.36	-0.07	0.11	0.12	0.43	-2.03	-0.79	1.45	1.26	2.93
3	-0.43	-0.06	0.06	0.07	0.42	-2.13	-0.57	0.72	0.73	2.86
4	-0.50	-0.11	0.06	0.09	0.40	-2.39	-1.00	0.76	1.01	1.99
Big	-0.33	-0.04	-0.11	0.18	0.24	-1.61	-0.41	-1.20	2.12	1.54
Standard 4F										
Small	0.02	0.18	0.20	0.39	0.59	0.22	2.20	2.00	3.89	4.74
2	0.06	0.07	0.13	0.02	0.15	0.71	0.84	1.49	0.23	1.53
3	0.01	0.09	0.08	-0.03	0.11	0.09	0.95	0.90	-0.27	1.05
4	-0.06	0.03	0.09	-0.01	0.04	-0.67	0.31	1.05	-0.16	0.31
Big	0.09	0.11	-0.12	0.03	-0.14	0.61	1.77	-1.35	0.45	-1.53
Decomposed 4F										
Small	-0.29	0.04	0.14	0.39	0.72	-1.44	0.41	1.42	3.46	4.52
2	-0.27	-0.13	0.04	0.02	0.39	-1.33	-1.25	0.53	0.19	2.45
3	-0.31	-0.06	0.00	0.01	0.42	-1.38	-0.52	0.06	0.14	2.59
4	-0.37	-0.10	0.09	0.03	0.42	-1.66	-0.84	0.97	0.39	1.86
Big	-0.18	0.00	-0.11	0.13	0.20	-0.77	-0.05	-1.13	1.30	1.17
Decomposed 6F										
Small	0.12	0.18	0.16	0.31	0.45	1.25	2.14	1.46	3.00	3.63
2	0.18	0.02	0.09	-0.07	0.08	2.50	0.27	0.98	-0.81	1.03
3	0.10	0.08	0.04	-0.07	0.08	1.21	0.78	0.42	-0.65	0.76
4	-0.02	0.02	0.11	-0.05	0.12	-0.20	0.16	1.24	-0.58	0.85
Big	0.02	0.02	-0.13	0.06	0.00	0.20	0.28	-1.30	0.91	0.03
Modified 7F										
Small	-0.03	0.10	0.11	0.29	0.48	-0.23	1.12	1.12	3.08	4.03
2	0.02	-0.03	0.04	-0.04	0.11	0.18	-0.42	0.55	-0.43	1.30
3	0.01	0.04	0.00	-0.05	0.16	0.15	0.55	0.06	-0.60	1.41
4	-0.03	0.00	0.09	-0.04	0.04	-0.35	-0.03	1.04	-0.46	0.31
Big	0.08	0.11	-0.11	0.01	-0.16	0.59	1.80	-1.11	0.19	-1.70
Index 7F										
Small	-0.02	0.14	0.16	0.32	0.48	-0.15	1.69	1.65	3.33	4.06
2	0.05	0.00	0.09	-0.02	0.12	0.59	0.04	1.08	-0.20	1.43
3	0.01	0.06	0.06	-0.03	0.13	0.09	0.77	0.71	-0.41	1.20
4	-0.05	0.01	0.11	-0.03	0.03	-0.57	0.12	1.53	-0.45	0.25
Big	0.09	0.11	-0.10	0.05	-0.13	0.64	1.73	-1.04	0.76	-1.42

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Table 4.4 (Continued)										
Panel C: United Kingdom (UK) size-momentum returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.74	-0.40	-0.39	0.24	0.95	-3.42	-3.36	-2.98	1.74	8.24
2	-0.66	-0.26	-0.45	0.14	0.75	-2.89	-2.04	-3.27	1.14	6.13
3	-0.34	-0.31	-0.48	0.13	0.59	-1.48	-2.53	-3.28	0.89	5.08
4	-0.22	-0.28	-0.34	0.11	0.53	-0.98	-2.14	-2.57	0.77	4.15
Big	-0.27	-0.33	-0.21	0.19	0.40	-1.50	-2.73	-1.60	1.64	3.23
Standard 4F										
Small	-0.18	-0.31	-0.49	0.02	0.75	-1.24	-2.33	-3.89	0.15	6.84
2	0.03	-0.11	-0.60	-0.11	0.53	0.19	-0.78	-4.74	-1.03	4.65
3	0.43	-0.14	-0.65	-0.16	0.26	3.07	-0.99	-4.82	-1.42	2.68
4	0.52	-0.10	-0.52	-0.20	0.19	3.75	-0.63	-4.62	-1.52	1.71
Big	0.35	-0.10	-0.36	-0.08	0.00	2.98	-0.66	-3.11	-0.99	-0.01
Decomposed 4F										
Small	-0.71	-0.42	-0.41	0.23	0.95	-3.26	-3.53	-3.21	1.62	8.19
2	-0.64	-0.28	-0.48	0.12	0.76	-2.80	-2.21	-3.50	0.97	6.15
3	-0.32	-0.34	-0.51	0.11	0.61	-1.43	-2.72	-3.50	0.75	5.15
4	-0.19	-0.31	-0.37	0.10	0.55	-0.88	-2.31	-2.83	0.66	4.39
Big	-0.25	-0.35	-0.24	0.18	0.40	-1.42	-2.92	-1.87	1.58	3.24
Decomposed 6F										
Small	0.00	-0.28	-0.56	-0.07	0.72	0.03	-2.05	-4.37	-0.54	6.57
2	0.16	-0.08	-0.69	-0.22	0.46	1.17	-0.51	-5.33	-2.48	4.72
3	0.50	-0.13	-0.75	-0.27	0.25	3.28	-0.78	-5.25	-2.77	2.45
4	0.52	-0.10	-0.60	-0.28	0.22	3.40	-0.54	-5.23	-2.40	2.07
Big	0.23	-0.13	-0.43	-0.09	0.16	1.78	-0.85	-3.73	-1.14	1.88
Modified 7F										
Small	-0.17	-0.33	-0.52	-0.01	0.72	-1.24	-2.55	-4.23	-0.10	6.42
2	0.02	-0.13	-0.62	-0.12	0.51	0.18	-0.95	-5.04	-1.15	4.11
3	0.43	-0.17	-0.67	-0.17	0.26	3.13	-1.18	-5.10	-1.55	2.54
4	0.55	-0.12	-0.53	-0.18	0.22	3.82	-0.81	-4.68	-1.49	2.13
Big	0.35	-0.10	-0.38	-0.07	0.00	2.98	-0.72	-3.32	-0.93	-0.02
Index 7F										
Small	-0.30	-0.38	-0.56	-0.07	0.64	-1.99	-2.53	-3.90	-0.48	5.31
2	-0.12	-0.20	-0.68	-0.21	0.40	-0.95	-1.25	-4.74	-1.82	3.20
3	0.28	-0.24	-0.74	-0.26	0.13	2.03	-1.45	-4.90	-2.25	1.41
4	0.40	-0.20	-0.60	-0.28	0.07	2.84	-1.11	-4.56	-2.28	0.66
Big	0.19	-0.20	-0.46	-0.21	-0.17	1.71	-1.24	-3.45	-2.31	-1.71

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Table 4.4 (Continued)										
Panel D: Japanese size-momentum returns regressed on local factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	0.25	0.08	0.21	0.23	0.28	1.09	0.53	1.90	1.84	1.32
2	-0.06	-0.11	0.04	-0.04	0.24	-0.30	-0.76	0.29	-0.40	1.27
3	-0.08	-0.17	-0.12	-0.02	0.09	-0.37	-1.08	-0.91	-0.21	0.55
4	-0.03	-0.13	0.00	-0.06	0.05	-0.10	-0.74	0.01	-0.50	0.28
Big	0.03	-0.09	-0.19	-0.04	0.08	0.11	-0.51	-1.58	-0.28	0.34
Standard 4F										
Small	0.31	0.11	0.22	0.20	0.24	2.22	0.95	2.01	1.67	1.16
2	0.01	-0.08	0.05	-0.07	0.19	0.06	-0.76	0.37	-0.58	1.32
3	-0.01	-0.13	-0.12	-0.05	0.04	-0.05	-1.23	-0.92	-0.46	0.35
4	0.06	-0.08	0.01	-0.09	0.00	0.46	-0.85	0.11	-0.78	-0.03
Big	0.13	-0.04	-0.17	-0.08	0.01	0.85	-0.37	-1.45	-0.73	0.07
Decomposed 4F										
Small	0.26	0.09	0.23	0.24	0.28	1.16	0.73	2.27	1.95	1.34
2	-0.06	-0.09	0.05	-0.04	0.23	-0.29	-0.70	0.44	-0.33	1.26
3	-0.07	-0.15	-0.11	-0.02	0.08	-0.33	-1.09	-0.89	-0.19	0.48
4	-0.02	-0.11	0.00	-0.07	0.03	-0.09	-0.72	0.03	-0.53	0.17
Big	0.04	-0.09	-0.19	-0.05	0.06	0.15	-0.49	-1.56	-0.33	0.27
Decomposed 6F										
Small	0.35	0.14	0.23	0.20	0.20	2.59	1.38	2.33	1.84	1.18
2	0.03	-0.05	0.06	-0.08	0.14	0.34	-0.55	0.48	-0.80	1.30
3	0.02	-0.11	-0.11	-0.06	0.00	0.15	-1.09	-0.86	-0.58	0.03
4	0.05	-0.07	0.01	-0.10	-0.02	0.42	-0.74	0.09	-0.84	-0.20
Big	0.07	-0.06	-0.18	-0.06	0.03	0.61	-0.59	-1.47	-0.60	0.39
Modified 7F										
Small	0.31	0.13	0.25	0.24	0.22	2.17	1.18	2.60	2.12	1.10
2	0.02	-0.02	0.11	-0.01	0.20	0.20	-0.22	1.10	-0.05	1.51
3	0.04	-0.05	-0.03	0.03	0.07	0.35	-0.62	-0.34	0.34	0.71
4	0.12	0.01	0.13	0.00	0.07	0.99	0.12	1.45	0.03	0.59
Big	0.11	-0.08	-0.19	-0.06	-0.03	0.74	-0.62	-1.57	-0.52	-0.28
Index 7F										
Small	0.28	0.09	0.23	0.20	0.22	1.95	0.83	2.31	1.80	1.20
2	-0.01	-0.07	0.06	-0.04	0.18	-0.07	-0.64	0.61	-0.39	1.40
3	-0.03	-0.12	-0.09	-0.02	0.03	-0.29	-1.18	-0.90	-0.19	0.29
4	0.03	-0.06	0.05	-0.06	0.01	0.33	-0.66	0.49	-0.67	0.12
Big	0.09	-0.09	-0.19	-0.09	-0.04	0.67	-0.76	-1.47	-0.81	-0.36

(Continued overleaf)

Table 4.4 (Continued)										
Panel E: Canadian size-momentum returns regressed on local standard factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.98	-0.45	-0.26	0.33	0.69	-5.75	-4.64	-2.39	2.48	3.82
2	-1.16	-0.45	-0.41	0.15	1.01	-5.83	-4.51	-3.58	1.05	5.57
3	-0.89	-0.43	-0.31	0.03	0.66	-4.04	-3.80	-2.65	0.21	3.03
4	-0.64	-0.30	-0.27	0.10	0.75	-2.65	-2.42	-2.02	0.83	5.75
Big	-0.40	-0.29	-0.14	0.16	0.46	-1.69	-1.97	-1.11	1.57	2.54
Standard 4F										
Small	-0.48	-0.27	-0.27	0.19	0.33	-3.16	-2.75	-2.12	1.39	2.03
2	-0.44	-0.24	-0.42	-0.06	0.46	-3.33	-2.42	-3.21	-0.38	3.06
3	-0.17	-0.19	-0.39	-0.18	0.14	-1.00	-1.85	-2.91	-0.98	0.81
4	0.12	-0.05	-0.36	-0.03	0.26	0.69	-0.39	-2.27	-0.24	2.10
Big	0.59	0.03	-0.13	-0.04	-0.23	3.28	0.23	-0.94	-0.34	-1.41
Decomposed 4F										
Small	-0.99	-0.45	-0.26	0.32	0.68	-5.75	-4.67	-2.41	2.44	3.82
2	-1.16	-0.45	-0.41	0.14	1.00	-5.86	-4.51	-3.65	1.01	5.54
3	-0.89	-0.44	-0.32	0.03	0.65	-4.03	-3.80	-2.68	0.17	3.00
4	-0.65	-0.30	-0.28	0.10	0.75	-2.65	-2.40	-2.04	0.78	5.77
Big	-0.40	-0.29	-0.14	0.17	0.46	-1.68	-1.95	-1.10	1.61	2.52
Decomposed 6F										
Small	-0.23	-0.23	-0.35	-0.01	0.14	-1.72	-2.11	-2.79	-0.12	0.93
2	-0.22	-0.18	-0.49	-0.28	0.18	-1.60	-1.82	-3.86	-2.17	1.49
3	0.04	-0.08	-0.52	-0.44	-0.16	0.26	-0.74	-4.32	-2.89	-0.94
4	0.18	0.01	-0.45	-0.20	0.17	1.09	0.05	-2.88	-1.59	1.43
Big	0.12	0.06	-0.30	-0.08	0.15	0.85	0.46	-2.30	-0.67	1.08
Modified 7F										
Small	-0.50	-0.24	-0.24	0.22	0.34	-3.32	-2.48	-1.89	1.67	2.25
2	-0.45	-0.23	-0.38	0.01	0.42	-3.38	-2.26	-2.99	0.03	3.02
3	-0.17	-0.17	-0.35	-0.11	0.15	-1.01	-1.66	-2.67	-0.60	0.92
4	0.18	-0.01	-0.31	0.05	0.28	1.17	-0.05	-2.08	0.41	2.61
Big	0.62	0.05	-0.08	0.04	-0.26	3.74	0.42	-0.58	0.34	-1.72
Index 7F										
Small	-0.65	-0.34	-0.32	0.07	0.21	-4.22	-3.07	-2.25	0.52	1.34
2	-0.61	-0.32	-0.49	-0.13	0.27	-4.56	-2.97	-3.46	-0.80	1.83
3	-0.34	-0.28	-0.47	-0.26	-0.02	-2.05	-2.50	-3.25	-1.33	-0.12
4	-0.01	-0.10	-0.44	-0.15	0.15	-0.08	-0.79	-2.75	-1.11	1.48
Big	0.44	-0.06	-0.18	-0.10	-0.47	2.61	-0.44	-1.25	-0.82	-3.12

For all four countries, including the momentum factor or its decomposed components in the model improves the model performance, as it is expected that including the factor constructed using the same characteristic as the test portfolios will explain better those portfolios. The models with the momentum factor have lower *GRS* statistics, higher average adjusted R^2, and lower $SR(\alpha)$ values. Again, the international index-based 7F model performs better for the US and Japan, with an average adjusted R^2 of 0.85 and 0.77, and $SE(\alpha)$ values of 0.14% and 0.20% per month, respectively. As for the size-B/M portfolio returns for the US and Japan, the international index-based model continues to show better performance for the size-momentum portfolio returns. Thus, the index-based 7F model integrates better compared to any other model, which offers some evidence in support of the integration hypothesis.

The international models leave strong momentum patterns for all of the size quintiles in Canadian size-momentum portfolio returns (Panel D of Table A3). This is because the size-momentum portfolio returns have large variations for Canada (Panel B in Table 3.4), while the momentum factors do not produce large enough coefficients (not shown for the sake of brevity) to explain the large variations in the returns. There are also strong momentum patterns in the intercepts of US microcaps and the three lower size groups of UK size-momentum portfolio returns (Panels A and B of Table A3). The significant intercepts for the size-momentum portfolio returns are not concentrated in the microcaps in any country, but instead are scattered over all size groups. For the US, UK, and Canada, the winner-loser spreads are lower for the two 7F models. Similar to the 25 size-B/M portfolios, there are positive and large abnormal returns for the US size-momentum portfolio returns, and almost equal but opposite abnormal returns for the Japanese size-momentum portfolio returns. This indicates that the US size-momentum portfolios have higher, and the Japanese size-momentum portfolios have lower average returns than predicted by the international models. However, the extreme intercepts almost disappear for the two 7F models, which show that the two 7F models perform relatively better than other models.

In summary, the international models do not give an adequate explanation of the country size-momentum portfolio returns. Fama and French (2012) also show that the global versions of the standard 3F and 4F models fail to explain the regional size-momentum portfolio returns. Fama and French (2012) also report that in Japan the models are not rejected by the *GRS* test, but have very low explanatory power. Despite this, there is some evidence of asset pricing integration for the index-based 7F model in my results. For all countries, the winner-loser spreads in the regression intercepts are the lowest for the index-based 7F model. Additionally, the model does not leave extreme abnormal returns for the US and Japan. Similar to the size-B/M portfolio returns, the index-based 7F model has the highest explanatory power for the US and Japanese size-momentum portfolio returns. The next subsection discusses the results on the ability of the local factor models to explain country size-momentum portfolio returns. Given the empirical results of the size-B/M portfolio returns in the previous section, the local models are also expected to perform better than international models for the country size-momentum portfolio returns.

4.4.3 Local Models for Country Size-Momentum Portfolio Returns

Consistent with the results of international models, the *GRS* test rejects all the local models for the size-momentum portfolio returns of the US, UK, and Canada (Table 4.3). Nevertheless, the local models exhibit high explanatory power in terms of higher average adjusted R^2 and better estimation precision as shown by lower average $SE(\alpha)$ values. As noted in the case of international models, the performance of local models also improves by the inclusion of the momentum factors. The performance enhancement is reflected in the lower *GRS* statistics for these models, as well as models' improved average adjusted R^2, average $SE(\alpha)$, and $SR(\alpha)$

values. Again, the index-based 7F model for the US has the lowest *GRS* statistics and *SR(α)* and highest average adjusted R^2 among all the models. For the UK and Canada, the modified 7F model performs relatively better than the index-based 7F model. Fama and French (2012) also reject the regional versions of the standard 3F and 4F models' ability to explain the regional size-momentum portfolio returns for North America, Europe, and Asia Pacific. For the UK, Gregory et al. (2013a) report the failure of the standard 3F and 4F models for the 27 size-B/M-momentum portfolios.

For the Japanese size-momentum portfolio returns, the *GRS* test cannot reject any of the models. The models also have quite high explanatory power as the average R^2 values are 85% or above. The models that include momentum factors exhibit the lower average *SE(α)* and better average adjusted R^2 values, especially the decomposed 6F, modified 7F, and the index-based 7F models. The adequate explanation of the Japanese size-momentum portfolio returns by the local models emerges largely from the absence of a momentum premium in Japan and the low variation in the returns as shown in Panel B in Table 3.4. Fama and French (2012) also report similar results for the 3F and 4F models for the Japanese size-momentum portfolios. They report even higher values of average adjusted R^2 and show significant abnormal returns concentrated in the microcaps.

The results in Panel D of Table 4.4 for Japan shows that the standard 3F and 4F models have significant intercept terms in microcaps only. For the other three countries, the standard 3F and decomposed 4F models leave strong momentum patterns in all size groups of the size-momentum portfolio returns (Panels B, C, and E of Table 4.4). Other models leave strong momentum patterns in intercepts of microcaps only. The standard 4F, modified 7F, and index-based 7F models in the UK and Canada create a strong reverse momentum pattern in the megacaps as well. For the US size-momentum portfolio returns, the significant intercepts are concentrated in microcaps. For the case of the UK and Canada, the significant intercept terms are dispersed over all the size groups.

To summarise, the local models provide an adequate description of the size-momentum portfolio returns only in Japan. For the case of the US, the microcaps appear to be important for the rejection of the local models. For the UK and Canadian size-momentum portfolio returns, the local models perform poorly and leave large momentum spreads in the microcap intercepts. For all the countries, using models with momentum factors improves the *GRS* statistics and explanatory power of the models. Including the momentum factor also reduces the spreads between the extreme winner and loser portfolios. Thus, the use of momentum factors is recommended for evaluation of the portfolios with momentum tilts. Consistent with the asset pricing literature, the size-momentum portfolios have higher returns spreads (Panel B Table 3.4) that are left unexplained by the asset pricing models.

4.5 Some further Asset Pricing Tests

In this section, I provide some additional results for the performance of international and local asset pricing models. Specifically, I discuss the ability of international models to explain excess returns on the market portfolios of the four countries, as studies such as Solink (1974), Harvey (1991) and Fama and French (1998) use country market portfolios to test the performance of international models and report some evidence in support of asset pricing integration.

Moreover, in addition to the tests of the six factor models specified in section 4.2, six alternative versions of the decomposed, modified, and index-based models are also applied to explain the excess returns on the size-B/M and size-momentum portfolios. These other versions are tested for completeness since they represent all remaining representations of decomposed, modified, and index-based factors. However, the results of these models are not reported as none of them perform better than the standard 3F and 4F models. I tested two decomposed models; the first includes only decomposed value factors while the market, size, and momentum factors are the same as in the standard 4F model. This model is the same as the one examined by Gregory et al. (2013a). The second decomposed model uses only the decomposed momentum factors while the market, size, and value factors are the same as in the standard 4F model. I also test two modified and two index-based versions of the asset pricing models proposed by Cremers et al. (2013). These index-based 3F and 4F models that have the same factors as the standard 3F and 4F models, except the index-based factors are constructed from three size and two B/M indices explained in section 3.3. Similarly, the modified versions of the 3F and 4F models include factors constructed using six modified size-B/M portfolios using three size and two B/M groups, as discussed in section 3.3. The poor performance of these models and relatively better performance of the modified and index-based 7F models show that the modified and index-based factor construction methodology is only effective when it is used for the construction of decomposed size and value factors. The modified and index-based version of the 3F and 4F models perform as well as the standard versions of the 3F and 4F models.

4.5.1 International Models for the Country Market Portfolios Returns

The persistent pattern of the extreme intercepts in the estimates of the international models for the size-B/M and size-momentum portfolio returns of the US and Japan suggest that the country differences in the level of average returns are a problem for the international models. To investigate whether these problems persist when there are small number of test portfolios, the international models are asked to explain the excess returns on the market portfolios of four individual countries. Table 4.5 reports the results of the time-series regression of the excess returns on the simple market portfolios and index-based market portfolios as dependent variables on the international factors as explanatory variables.

For both the simple and the index-based market portfolio returns, the *GRS* test cannot reject the standard, modified, and index-based models, while the decomposed 4F and 6F models are rejected at the 5% level of significance. Despite the inferences that international models pass the *GRS* test, these models exhibit poor regression fit in terms of the lower values of average adjusted R^2. The index-based 7F model is an exception with the highest average R^2 of 0.79 and 0.80, and the lowest average $SE(\alpha)$ values of 0.12% and 0.13% per month, for simple market returns and index-based market returns. For the index-based 7F model, only the US intercepts (Panel B of Table 4.5) are positive and significant. For other models, the intercepts are significant for the US and Japanese market portfolio returns. Echoing the results of size-B/M and size-momentum portfolio, the intercepts for the US market portfolio returns are large and positive and for the Japanese market portfolio returns are large and negative.

Fama and French (2012) reject the global 3F and 4F models for the four regional market portfolios and term the enhanced model power as one of the possible reasons. Solink (1974), Harvey (1991), and Fama and French (1998) used market portfolios for many countries as test portfolios and cannot reject the global CAPM, which is evidence supporting the international model integration. However, in multiple comparison tests such as *GRS*, more test portfolios imply less power. Using four country market portfolios, I find that the international 3F and 4F models provide adequate descriptions for their returns, and these asset pricing models are integrated quite well. The relatively superior performance of the international 3F and 4F models for the country market portfolio returns raise the main issue with Fama and French's (2012) regional results: do asset pricing tests even integrate at the regional level? and indicate that the asset pricing tests should be conducted at the country level rather than regional level.

Table 4.5: Regression intercepts for tests of simple and index-based country market portfolio returns

Panel A reports the *GRS F*-test for the null hypotheses that all the intercepts in a set of four regressions are zero; |*α*| is the average absolute intercept for a set of regressions; R^2 is the average adjusted-R^2; *SE(α)* is the average standard error of the intercepts; and *SR(α)* is the Sharpe ratio for the intercepts. Panels B reports intercepts, *α*. '***', '**', and '*' represents the level of statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Model Summary					
	GRS	**|*α*|**	R^2	***SE(α)***	***SR(α)***
Simple Market returns					
Standard 3F	1.37	0.02	0.63	0.17	0.13
Standard 4F	1.55	0.04	0.63	0.17	0.14
Decomposed 4F	2.22*	0.01	0.65	0.17	0.17
Decomposed 6F	2.20*	0.02	0.65	0.17	0.18
Modified 7F	1.59	0.03	0.68	0.17	0.15
Index 7F	1.35	0.02	0.79	0.12	0.13
Index-based Market returns					
Standard 3F	1.3	0.03	0.65	0.18	0.13
Standard 4F	1.37	0.02	0.65	0.18	0.14
Decomposed 4F	2.29*	0.06	0.67	0.18	0.18
Decomposed 6F	2.26*	0.06	0.67	0.18	0.18
Modified 7F	1.76	0.04	0.69	0.17	0.16
Index 7F	1.41	0.03	0.8	0.13	0.14

Panel B: Model intercepts				
	United States (US)	**United Kingdom (UK)**	**Japan**	**Canada**
Simple Market returns				
Standard 3F	0.29**	-0.04	-0.40*	0.06
Standard 4F	0.30**	-0.08	-0.39*	0.01
Decomposed 4F	0.36***	0.06	-0.62***	0.16
Decomposed 6F	0.37***	0.01	-0.59**	0.13
Modified 7F	0.28**	0.01	-0.45**	0.04
Index 7F	0.13**	-0.07	-0.1	-0.03
Index-based Market returns				
Standard 3F	0.29**	0.05	-0.42*	0.22
Standard 4F	0.31**	0.02	-0.42*	0.18
Decomposed 4F	0.35***	0.17	-0.61***	0.33*
Decomposed 6F	0.38***	0.14	-0.59***	0.32*
Modified 7F	0.30***	0.13	-0.49**	0.2
Index 7F	0.14**	0.02	-0.14	0.11

4.6 Conclusion

In this chapter, I use time-series regression tests to examine whether the empirical asset pricing models employed in this thesis adequately capture the value and momentum patterns in average excess returns in the US, UK, Japan and Canada. The chapter also investigates whether the asset pricing models are integrated across these four countries by testing international models. The extent to which international models capture the variation in average returns for international portfolios and for country portfolios determines the degree of asset pricing integration.

In the tests of the international versions of the standard 3F and 4F models on international size-B/M and size-momentum portfolio returns, the *GRS* test rejects the null hypothesis that the estimated intercepts are equal to zero. Although the models' performances are rather weak in the case of the microcaps of the size-B/M portfolios, this is not the case for the size-momentum portfolios. For the size-momentum portfolio returns, the problematic portfolios are the extreme winners and extreme losers. Therefore, unlike Fama and French (2012), removing the microcaps will not substantially affect the results in favour of the international standard 3F and 4F models. The results are the same for the decomposed 4F and 6F models. Despite the rejection of models by *GRS* test, the models have high explanatory power for the international portfolios. Unfortunately, the results of tests for the international models for explaining country portfolio returns are worse. Rejections of the models based on the *GRS* test, the large average absolute intercepts, and the very low explanatory power make the international standard models extremely unattractive in their application to country portfolio returns. In short, the use of the Fama and French (2012) type international models is not recommended in applications to explain international or local portfolio returns.

The international versions of the two 7F models, specifically the index-based 7F model, show a significant performance improvement. For the international portfolio returns, although the *GRS* test rejects the international versions of both models, they still have comparatively higher explanatory power and lower *GRS* statistics. For the country portfolios of the US and Japan, the international versions of the index-based 7F model appear to provide adequate descriptions of average returns. For both of these countries, the model has very high explanatory power and lower *GRS* statistics compared to other international models. The problem of large estimated intercepts in the US and Japanese portfolio returns vanish for the index-based 7F model. Therefore, the international version of the index-based 7F model can be used for the international portfolios consisting of stocks from the US and Japan. For instance, the index-based 7F model can be used for the performance evaluation of mutual funds that hold stocks from the US and Japan.

The failure of the standard 3F and 4F models and their decomposed specifications for the country portfolio returns motivates the use of local models. There are some common results for the local models. First, the decomposed models always perform better than the standard 3F and 4F models in terms of lower *GRS* statistics and higher explanatory power. Second, the decomposed models that perform the best vary with the test portfolios employed. That is, for the size-B/M portfolios, the 4F model with decomposed value factors performs better and for the size-momentum portfolio, the decomposed 6F model with both decomposed value and momentum factors performs better. The portfolios that are successfully explained by these models include the size-B/M portfolios of the US, UK, and Japan, and the size-momentum portfolios of Japan. The models fail to explain the Canadian portfolio returns and the size-momentum returns of the US and UK. However, the models fail mainly for the portfolios with extreme tilts to winners or losers, which are very rare in practical applications [Fama and French (2012)]. Thus, the decomposed 4F and 6F models can be used for applications to explain country portfolio returns in the US, UK, and Japan that do not have momentum tilts.

The results of time-series asset pricing tests confirm and extend the findings of Cremers et al (2013) by applying their models to a wider set of stock portfolios and to stock markets outside US. For the tests of 7F models on the country portfolio returns, the index-based 7F model performs better than any other model. The returns successfully explained by the index-based 7F model include the size-B/M portfolio returns of all four countries, and the size-momentum portfolio returns of Japan. The index-based 7F model also has a small number of failures and comparatively higher explanatory power than the decomposed models. Therefore, the index-based 7F model should be preferred over decomposed models in applications explaining country portfolio returns.

The results presented in this chapter have important implications for investors, fund managers, regulators, and academics. These implications directly arise from the finding that an index-based 7F model, that uses factors based on benchmark indices, best explains the average returns on stocks compared to traditional 3F and 4F models. In particular, these results can be used in any application that requires estimates of expected returns. These results can be interpreted as good news for those interested in long run event studies or portfolio performance evaluation in large as well as small firms, though clearly those interested in researching momentum effects in such firms will take little comfort from this. The solution may lie in the use of control portfolios in such studies. However, Fama and French (2012) argue that the extreme momentum tilts are very rare in practical applications, therefore, that will not be a problem for the index-based 7F model in the practical applications of performance evaluation and risk control.

The investors and fund managers are more interested in significant risk factors and the way they affect their portfolio selection and portfolio performance evaluation than in the explanatory power or the pricing errors of the model. Hence, they can estimate the exposures of a candidate portfolio to the risk factors in the index-based 7F model by the regression of the portfolio past excess returns on the explanatory returns. Next, the regression slopes and historical average factors' premium can then be used to estimate the portfolio expected returns.

The results of this chapter are also important for evaluating the performance of a managed portfolio. Jensen (1968) suggests the use of the intercept (Jensen's alpha) from the time-series regression of the managed portfolio's excess returns on the excess return of the market portfolio to judge the performance of the fund manager. However, my results suggest that the average abnormal returns needed to judge the performance of a fund manager should be extracted instead from the intercept in the time-series regression of the managed portfolio's excess returns on the explanatory returns of the index-based 7F model.

Finally, academics and regulators are more interested in the explanatory power and the pricing errors of the model as a whole. My results show that the index-based 7F model has more explanatory power and less pricing errors than the standard 3F and 4F models. Therefore, the index-based 7F model should be used for measuring the abnormal returns in the event studies not the standard 3F and 4F models. However, given the absence of 'industry standards' for construction of index-based factors outside US, and the evidence provided in this chapter of a real difference between the outcomes of applying different sets of factors, caution needs to be taken in factor construction.

Chapter 05: Cross-Sectional Tests of Asset Pricing Models

5.1 Introduction and motivation

Economic theory suggests that an asset's expected return should be high if it has large exposure to the systematic risk factors that carry high risk premia. Further, if the systematic risk is sufficiently represented by a few economy-wide variables, then an asset's expected return is a linear function of its factor(s) loadings [Ross (1976), Connor (1984)]. Traditionally, the two-stage cross-sectional regression methodology developed by Fama and MacBeth (1973) is used to test the performance of linear beta pricing models. Unlike the time-series regression approach in Chapter 4, the cross-sectional approach does not assume the factor risk premia as the time-series average of the factor(s), rather it estimates the risk premium in a cross-sectional regression. The time-series approach fits the cross section of returns by a simple line that joins the origin and the factor(s). The deviations from this line represent the pricing errors for all the other assets; the factors themselves have no pricing error. In contrast, for the cross-sectional approach, we try to fit the cross section of all asset returns including the factors. The regression picks the slope (the factor risk premium) and the intercept (zero-beta rate in excess of risk-free rate) that best fits all the points. Lewellen et al. (2010) emphasise that one of the diagnostic tests for the performance of an asset pricing model with traded factors is that the risk premia estimates from the cross-sectional and the time-series regressions should be statistically indistinguishable.

This chapter examines the cross-sectional performance of the beta pricing models using the two-stage cross-sectional regression methodology of Fama and MacBeth (1973) and following the statistical tests of Kan et al. (2013). The cross-sectional regression approach illustrates which model has more power in explaining the cross-sectional variation of average portfolio returns and, at the same time, shows which factors are priced. This is in contrast to the time-series regression approach that only shows whether models successfully explain average portfolio returns. Moreover, given the evidence in the literature that the size, value and momentum factors are priced, it is important to find out whether decomposed, modified, and index-based versions of these factors are priced.

Despite the good performance of the 3F and 4F models in time-series studies, researchers have raised doubts about their cross-sectional performance. For example, in cross-sectional tests for the US stock returns, Daniel and Titman (1997) reject the 3F model, and Brennan et al. (1998) report a significant premium for the size and B/M characteristics even in the presence of size and value factors. Fama and French (2008) report the persistence of other anomaly variables, such as accruals, investment, and profitability, in the tests of the 3F model. More recently, Chordia et al. (2015) also reject the 3F model using individual stock data for the US. On the other hand, Wang (2003) and Avramov and Chordia (2006) find some support for the 3F model. Researchers have also considered the momentum factor in cross-sectional tests. In this regard, Avramov and Chordia (2006) rejected the 4F model in their tests. Although Kan et al. (2013) reject the 3F model, the model performed second best to Petkova's (2006) ICAPM in their tests.

A number of different researchers have tested the cross-sectional performance of the 3F model and 4F model using US stock data as well as data from other countries. However, no study to date has examined the cross-sectional performance in an international context. The international investigations of asset pricing models, such as Fama and French (1998), Griffin (2002), Hou et al. (2011) and Fama and French (2012), focused primarily on the time-series tests. The main reason for this is that when using returns based risk factors, the time-series tests yield the same results as cross-sectional tests, and the factor risk premium is just the time-series average of the risk factor. However, there is contradictory evidence in the literature that the performance of the 3F and 4F models differs in the time-series and cross-sectional tests, and also the cross-sectional risk premia on the factor loadings differ from their time-series average [Shanken and Zhou (2007), Lewellen et al. (2010), Gregory et al. (2013a)]. These findings indicate that the empirical performance of factor models is not consistent across two methodologies, and their cross-sectional performance should always be tested to see if they provide an adequate explanation of expected returns. Therefore, it is worth examining the performance of asset pricing models using the cross-sectional regression approach in an international context. The primary aim of this chapter is to contribute to the international asset pricing literature by testing the 3F and 4F models and their alternative specifications using the cross-sectional tests of Kan et al. (2013). Ideally, I expect the cross-sectional results to be consistent with the time-series results, and the cross-sectional factor risk premia to be close to their time-series factor average. Moreover, if the size, value and momentum factors are priced, that is if they are important in explaining cross-sectional returns, the pricing results should be consistent across standard, decomposed, modified, and index-based factors. Any differences in pricing of the factors across different factor constructions will indicate the sensitivity of the asset pricing models towards different methods of factor constructions.

Along with the standard versions of the 3F and 4F models, the cross-sectional performance of the decomposed, modified and index-based models is also tested, similar to the time-series tests in Chapter 4. These models are examined to investigate whether the factor decomposition and use of modified and index-based factors improve the model performance in the cross-sectional tests, especially as this was the case in the time-series tests. I also test the international versions of these factor models to investigate their degree of integration, that is how well these international factor models explain the international and country portfolio returns in the cross-sectional tests and whether international factors are priced compared to local factors. The cross-sectional tests of the international factor models give a novel opportunity to look at the integration of asset pricing models, given the absence of evidence of integration using the time-series tests in the chapter 4 and in the empirical asset pricing literature [Griffin (2002), Hou et al. (2011) and Fama and French (2012)].

This chapter uses the recent statistical tests proposed by Kan et al. (2013) for the two-stage cross-sectional regression methodology of Fama and MacBeth (1973). Kan et al. (2013) extend the work of Shanken (1992) and Jagannathan and Wang (1998) and derive the asymptotic properties of the cross-sectional regression methodology. Jagannathan and Wang (1998) emphasised the importance of model misspecification bias in interpreting cross-sectional results. The misspecification bias occurs when some relevant explanatory factors are omitted, or the wrong explanatory factors are considered. Thus, when comparing the performance of different competing models, some, if not all, of the models are bound to be misspecified. In this regard, Kan et al. (2013) derive the asymptotic properties of the two-stage methodology that allows for model misspecification and doesn't assume normal (*i.i.d)* errors. Thus, the potential model misspecification robust standard errors allow for more reliable inference for the cross-sectional risk premiums.

Lewellen et al. (2010) criticise the use of the cross-sectional R^2 for assessing the performance of asset pricing models. They argue that the high cross-sectional R^2 is a low hurdle to meet for an asset pricing model that is explaining test portfolios sorted on characteristics common with the factors (such as size and B/M). Responding to the critique of Lewellen et al. (2010), Kan et al. (2013) derive the asymptotic distribution of the cross-sectional R^2. This is an important step beyond the descriptive interpretation of the cross-sectional R^2 towards its use in the hypothesis testing. Using the asymptotic distribution of the cross-sectional R^2, the hypothesis of whether the R^2 is equal to zero or one can be tested. Going one step further, Kan et al. (2013) also derive the asymptotic tests for the pair-wise and multiple model comparison of the cross-sectional R^2. The model comparison tests allow researchers to compare directly the explanatory power of the competing models and identify the best performing model.

The main empirical analysis in this chapter is based on the two sets of the 44 portfolios constructed in Chapter 3. The first set includes the 25 size-B/M and the 19 industry portfolios (referred to as size-B/M-industry hereafter), and the second set includes the 25 size-momentum and the 19 industry portfolios (referred to as size-momentum-industry hereafter). As discussed in Chapter 3, Lewellen et al. (2010) recommend the use of test portfolios constructed using some criteria other than the characteristics used to construct the risk factors. They argue that using only characteristics based portfolios yield misleading results, therefore the characteristics based portfolios are augmented with the industry portfolios in the cross-sectional asset pricing tests in this chapter and Chapter 6. Kan et al. (2013) also show a significant role of using industry portfolios as test assets along with size-B/M portfolios in the cross-sectional asset pricing tests. The models are also tested using the 25 size-B/M and size-momentum portfolios for robustness and to examine the effect of industry portfolios on model performance.

The remainder of the chapter is organised as follows. Section 5.2 outlines the empirical framework, Section 5.3 discusses the main results of the cross-sectional tests, Section 5.4 discusses some further results, and section 5.5 concludes.

5.2 Empirical framework

The cross-sectional regression approach involves a second-stage regression of the monthly excess portfolio returns on the estimated time-series factor loading for each time period. The cross-sectional regression is given by,

$$\mu_R = X\gamma + e, \tag{5.1}$$

where μ_R is the vector of mean excess returns for the *N*-assets vector R, $X=[1_N, \beta]$, where 1_N is an *N*-vector of ones and β is the $N \times K$ multiple regression beta matrix of the *N*-assets with respect to K factors, $\gamma = [\gamma_0, \gamma_1']'$ comprises the vector of the excess zero-beta rate in excess of the risk-free rate (γ_0) and the vector of risk premiums on *K* factors (γ_1), and e is the vector of pricing errors for *N*-assets. However, since the loadings used to estimate the factor risk premium in the cross-sectional regressions are pre-estimated from the time-series regressions, there exists an errors-in-variables (EIV) problem in the estimates of the factor risk premium. Chen and Kan (2005) identify two main consequences associated with the EIV problem. First, the estimated zero-beta rate and risk premiums are biased, and second, the standard errors of the estimated coefficients are inconsistent.

Shanken (1992) studies both of the consequences that the cross-sectional regression approach faces with respect to the EIV problem. First, he shows that when the length of the time-series used to estimate the loadings increases to infinity, the estimation errors of the time-series loadings approach zero. Therefore, the estimated zero-beta rate and risk premiums from the second-stage cross-sectional regressions are still consistent for a long time-series. Second, he proposes an asymptotically valid EIV adjustment for standard errors. The adjustment assumes that the risk factors are generated by a stationary process and the errors from the time-series regressions are *i.i.d.* over time. Jagannathan and Wang (1998) extend the work of Shanken (1992) and provide the asymptotic theory for the estimation of cross-sectional regression standard errors that account for both heteroscedastic and autocorrelated errors.

Kan et al. (2013) argue that the pricing error vector $e = \mu_R - X\gamma$ will be non-zero for all values of γ in the presence of potential model misspecification. Therefore, it will be optimal to choose γ that minimizes aggregate pricing errors. Kan et al. (2013) propose the following specification for the estimation of the γ that minimizes the quadratic form of pricing errors,

$$\hat{\gamma} = \left(\hat{X}'W\hat{X}\right)^{-1}\hat{X}'W\hat{\mu}_R, \tag{5.2}$$

where W is an $N \times N$ symmetric positive-definite weighting matrix. The most popular choice of W in the literature is $W = I_N$ for the case of OLS cross-sectional regressions [see for example Shanken (1992), Jagannathan and Wang (1998), Shanken and Zhou (2007), and Kan et al. (2013)].

Kandel and Stambaugh (1995) develop an R^2 measure to assess the goodness-of-fit of the cross-sectional regression models, which is given by

$$\hat{\rho}^2 = 1 - \frac{\hat{Q}}{\hat{Q}_0}, \tag{5.3}$$

where $\hat{Q} = \hat{e}'W\hat{e}$ and $\hat{Q}_0 = \hat{e}_0'W\hat{e}_0$ and $\hat{e}_0 = [I_N - 1_N(1_N'W1_N)^{-1}1_N'W]\hat{\mu}_R$ being the deviations of mean returns from their cross-sectional average. The $\hat{\rho}^2$ is considered a natural measure of goodness-of-fit in the cross-sectional regressions as it is a decreasing function of the aggregate pricing errors. However, Lewellen et al. (2010) criticise the practice of relying on the point estimation of the cross-sectional R^2 for assessing the performance of asset pricing model. In response to that criticism, Kan et al. (2013) provide formal statistical analysis of $\hat{\rho}^2$ by deriving its asymptotic distribution, which allows for hypothesis testing as well as comparison of the cross-sectional R^2 across different competing models.

In this chapter, I evaluate and compare the performance of asset pricing models using this recent empirical framework of Kan et al. (2013). They derive the misspecification robust asymptotic distribution of γ, under general distributional assumptions, which control for the estimation error of beta. I use their distribution theory to examine whether there are significant factor risk premia ($\gamma_K \neq 0$). I also use the asymptotic distribution of the OLS R^2, derived by Kan et al. (2013). Their asymptotic distribution theory gives two important tests of the cross-sectional R^2, first the test of whether the model is correctly specified by testing the hypothesis $H_0: \hat{\rho}^2 = 1$, and second the test of whether the model has any explanatory power by testing the hypothesis $H_0: \hat{\rho}^2 = 0$.

As has already been discussed, Kan et al. (2013) develop a pair-wise model comparison test for the difference between the R^2 values of two competing models under the null hypothesis that the two models have the same cross-sectional R^2. The model comparison test depends on whether the two models being compared are nested or non-nested. I use the χ^2 test statistic of Kan et al. (2013) for the nested model comparisons and their normal test statistic for the comparison of the non-nested models.

Given the various specifications of asset pricing models, which are further divided into international and local versions, the main purpose is to test whether the *benchmark* model (the chosen model under investigation) has the highest R^2 among all the models. For that purpose, I perform the multiple model comparison using the multivariate inequality test developed by Kan et al. (2013). The test is based on the likelihood ratio (LR) test of Wolak (1987) and Wolak (1989) for the case of non-nested models. For the nested models, Kan et al. (2013) show that the pair-wise nested model comparison framework can be easily adapted for the multiple nested model comparison tests.

Six asset pricing models are analysed in the cross-sectional regression tests, analogous to their time-series specifications, starting with the standard 3F and 4F models. The cross-sectional specifications of these models are given by

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{SMB,t}\hat{\beta}_{i,SMB} + \gamma_{HML,t}\hat{\beta}_{i,HML} + e_{i,t}\ , \tag{5.4}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{SMB,t}\hat{\beta}_{i,SMB} + \gamma_{HML,t}\hat{\beta}_{i,HML} + \gamma_{WML,t}\hat{\beta}_{i,WML} + e_{i,t}, \tag{5.5}$$

where $\hat{\beta}$'s in both models represent the time-series factor loadings of each test portfolio on the factors in the subscript, that is the excess market return (*MKT*), *SMB*, *HML*, and *WML*[15]. The γ_0 is the zero-beta rate in excess of risk-free rate and the remaining γ's represent the cross-sectional factor risk premia. The next cross-sectional specifications are the decomposed versions of the 3F and 4F models, following the technique of Fama and French (2012) to decompose the *HML* and *WML* factors. The resultant decomposed 4F and 6F models are given by

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{SMB,t}\hat{\beta}_{i,SMB} + \gamma_{HML_s,t}\hat{\beta}_{i,HML_s} + \gamma_{HML_b,t}\hat{\beta}_{i,HML_b} + e_{i,t}, \quad (5.6)$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{SMB,t}\hat{\beta}_{i,SMB} + \gamma_{HML_s,t}\hat{\beta}_{i,HML_s} + \gamma_{HML_b,t}\hat{\beta}_{i,HML_b} + \gamma_{WML_s,t}\hat{\beta}_{i,WML_s} + \gamma_{WML_b,t}\hat{\beta}_{i,WML_b} + e_{i,t} \ , \quad (5.7)$$

where HML_s and HML_b indicate returns on small stocks' and big stocks' value factors. Similarly, *WML*s and WML_b indicate the returns on small stocks' and big stocks' momentum factors. Finally, cross-sectional specifications of modified 7F and index-based 7F models are examined following Cremers et al. (2013). The models are given by

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{SMM,t}\hat{\beta}_{i,SMM} + \gamma_{MMB,t}\hat{\beta}_{i,MMB} + \gamma_{SHML,t}\hat{\beta}_{i,SHML} + \gamma_{MHML,t}\hat{\beta}_{i,MHML} + \gamma_{BHML,t}\hat{\beta}_{i,BHML} + \gamma_{WML,t}\hat{\beta}_{i,WML} + e_{i,t}, \quad (5.8)$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{INDMKT,t}\hat{\beta}_{i,INDMKT} + \gamma_{INDSMM,t}\hat{\beta}_{i,INDSMM} + \gamma_{INDMMB,t}\hat{\beta}_{i,INDMMB} + \gamma_{INDSHML,t}\hat{\beta}_{i,INDSHML} + \gamma_{INDMHML,t}\hat{\beta}_{i,INDMHML} + \gamma_{INDBHML,t}\hat{\beta}_{i,INDBHML} + \gamma_{WML,t}\hat{\beta}_{i,WML} + e_{i,t}, \quad (5.9)$$

[15] The construction of these factors, and those to follow, has been discussed in the section 3.3.

In specification (5.8), *SMM* is the return difference between the portfolio of small market capitalization stocks and the portfolio of medium market capitalization stocks, *MMB* is the return difference between the portfolio of medium market capitalization stocks and the portfolio of large market capitalization stocks. *SHML*, *MHML*, and *BHML* are the returns on the small stocks', medium stocks', and big stocks' value factors respectively. Similarly, in the specification (5.9) the prefix *IND* indicates the factors are constructed using the index-based approach of Cremers et al. (2013), while the factor definitions remain the same as in (5.8). The $\hat{\beta}$'s and γ's in eqatuins (5.6), (5.7), (5.8), and (5.9) represnet the time-series loadings of the factors in subscipt and their respective cross-sectional risk premia.

5.3 Empirical results

There are some prior studies examining the cross-sectional performance of standard factor models in individual markets, especially the US and the UK. The literature suggest that although the standard 3F and 4F models have high explanatory power for portfolio returns, the models usually fail the specification tests [see Petkova (2006), Shanken and Zhou (2007) and Kan et al. (2013) for US evidence and Gregory et al. (2013a) for UK evidence]. The US evidence shows that the equity premium is negatively priced, and size, value and momentum premia are positively priced. However, the zero-beta rate in excess of the risk-free rate is also reported to be significant, which is difficult to reconcile. For the UK, Gregory et al. (2013a) report a positive and significant risk premium for the value factor. The excess zero-beta rate is high and insignificant, while no other factors are priced. None of these studies examine the cross-sectional performance of decomposed, modified and index-based models. Based on time-series results, these models are expected to perform better than standard 3F and 4F models.

As in chapter 4, I focus on testing the integration of international models. Therefore, I analyse the performance of international models at each stage of analysis. This section starts with an analysis of the cross-sectional R^2s of the models described above, followed by pair-wise and multiple comparisons tests of cross-sectional R^2s for different benchmark models. Finally, factor risks premia (γ) are presented along with Shanken (1992) *t*-statistics (SH *t*-stats) and potential misspecification robust *t*-statistics (PM *t*-stats).

5.3.1 Cross-sectional R²s of the models

Tables 5.1 and 5.2 report the $\hat{\rho}^2$s and specification tests of the six asset pricing models tested on 44 size-B/M-industry and 44 size-momentum-industry portfolios. Each table presents results for the international sample, US, UK, Japan and Canada. The *p*-value for the test H_0: $\hat{\rho}^2$ = 0 is given by $p(\hat{\rho}^2 = 0)$, and the asterisks for the $\hat{\rho}^2$ indicate the level of significance for the specification test of H_0: $\hat{\rho}^2 = 1$. $se(\hat{\rho}^2)$ is the standard error of $\hat{\rho}^2$. The tests of H_0: $\hat{\rho}^2 = 0$, H_0: $\hat{\rho}^2 = 1$, and standard errors of $\hat{\rho}^2$ are based on the asymptotic results of Kan et al. (2013). The hypothesis H_0: $\hat{\rho}^2 = 0$ tests whether the $\hat{\rho}^2$ of the models is equal to zero, while hypothesis H_0: $\hat{\rho}^2 = 1$ tests whether the $\hat{\rho}^2$ of is equal to one. Kan et al. (2013) argue that the H_0: $\hat{\rho}^2 = 1$ is an alternative test for the specification of the model. The Q_c is the generalised version of the Cross-Sectional Regression Test (*CSRT*) of Shanken (1985), and the asterisks indicate the level of significance for the approximate *F*-test of $H_0 : Qc = 0$.

The *F*-test for *Qc* rejects all the models for the international size-B/M-industry portfolio in Table 5.1. For the R^2 test, the index-based 7F model cannot be rejected, while the standard 4F model is rejected at the 10% level of significance; the remaining four models are rejected at the 5% level. The index-based 7F model has the highest R^2 of 69% (the $\hat{\rho}^2$ column). The index-based 7F model also has the highest R^2 for international size-momentum-industry portfolios (the $\hat{\rho}^2$ column in Table 5.2) along with the decomposed 6F model, and the modified 7F model is the second best.

Table 5.1: Cross-Sectional R^2 and Specification Tests for 25 Size-B/M and 19 Industry Portfolios

This table presents the sample cross-sectional R^2 ($\hat{\rho}^2$) and the generalised *CSRT* (Q_c) of six beta pricing models. The models include the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-B/M and 19 industry portfolios. $p(\hat{\rho}^2=0)$ is the *p*-value for the test of $H_0 : \hat{\rho}^2 = 0$; and $se(\hat{\rho}^2)$ is the standard error of $\hat{\rho}^2$ under the assumption that $0 < \hat{\rho}^2 < 1$. '***', '**', '*' represent the level of statistical significance at the 1%, 5%, and 10%, respectively. For the $\hat{\rho}^2$, the significance level is for the test of $H_0 : \hat{\rho}^2 = 0$, and for the Q_c, it is for the approximate *F*-test of $H_0 : Qc = 0$.

	International Models				Local Models			
	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	*Qc*	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	*Qc*
International								
Standard 3F	0.41***	0.06	0.19	1.09***	N/A	N/A	N/A	N/A
Standard 4F	0.51**	0.05	0.20	0.63***	N/A	N/A	N/A	N/A
Decomposed 4F	0.43***	0.06	0.18	1.09***	N/A	N/A	N/A	N/A
Decomposed 6F	0.51**	0.07	0.19	0.62***	N/A	N/A	N/A	N/A
Modified 7F	0.61**	0.02	0.15	0.55***	N/A	N/A	N/A	N/A
Index 7F	0.69	0.01	0.14	0.48***	N/A	N/A	N/A	N/A
United States (US)								
Standard 3F	0.35	0.70	0.41	0.18	0.34	0.70	0.42	0.18
Standard 4F	0.39	0.74	0.41	0.16	0.43	0.69	0.40	0.15
Decomposed 4F	0.41	0.69	0.39	0.15	0.42	0.69	0.39	0.16
Decomposed 6F	0.50	0.73	0.36	0.13	0.52	0.71	0.36	0.14
Modified 7F	0.58	0.70	0.31	0.13	0.62	0.65	0.27	0.13
Index 7F	0.56	0.71	0.33	0.13	0.57	0.71	0.31	0.13
United Kingdom (UK)								
Standard 3F	0.38	0.50	0.29	0.19	0.36	0.51	0.29	0.19
Standard 4F	0.42	0.54	0.29	0.18	0.36	0.58	0.29	0.19
Decomposed 4F	0.46	0.47	0.28	0.15	0.38	0.57	0.29	0.18
Decomposed 6F	0.57	0.46	0.24	0.14	0.54	0.49	0.24	0.16
Modified 7F	0.56	0.51	0.25	0.12	0.53	0.53	0.22	0.15
Index 7F	0.59	0.49	0.21	0.13	0.52	0.54	0.23	0.15
Japan								
Standard 3F	0.32	0.46	0.39	0.15	0.40	0.32	0.34	0.15
Standard 4F	0.60	0.24	0.24	0.12	0.46	0.35	0.29	0.15
Decomposed 4F	0.53	0.32	0.25	0.14	0.47	0.30	0.28	0.15
Decomposed 6F	0.64	0.30	0.20	0.11	0.61	0.30	0.21	0.13
Modified 7F	0.63	0.36	0.21	0.10	0.69	0.25	0.16	0.12
Index 7F	0.69	0.27	0.22	0.10	0.69	0.26	0.17	0.13
Canada								
Standard 3F	0.22**	0.43	0.18	0.24**	0.25**	0.36	0.17	0.24**
Standard 4F	0.28*	0.36	0.19	0.22**	0.32	0.31	0.18	0.21**
Decomposed 4F	0.26**	0.44	0.17	0.24**	0.26**	0.41	0.18	0.23**
Decomposed 6F	0.30**	0.49	0.19	0.21**	0.33	0.42	0.18	0.20**
Modified 7F	0.30**	0.55	0.17	0.24***	0.45	0.24	0.17	0.18*
Index 7F	0.25**	0.70	0.19	0.21**	0.42	0.27	0.17	0.20**

Table 5.2: Cross-Sectional R^2 and Specification Tests for 25 Size-Momentum and 19 Industry Portfolios

This table presents the sample cross-sectional R^2 ($\hat{\rho}^2$) and the generalized *CSRT* (Q_c) of six beta pricing models. The models include the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-momentum and 19 industry portfolios. $p(\hat{\rho}^2=0)$ is the *p*-value for the test of $H_0 : \hat{\rho}^2 = 0$; and $se(\hat{\rho}^2)$ is the standard error of $\hat{\rho}^2$ under the assumption that $0 < \rho 2 < 1$. '***', '**', '*' represent the level of statistical significance at the 1%, 5%, and 10%, respectively. For the $\hat{\rho}^2$, the significance level is for the test of $H_0 : \hat{\rho}^2 = 0$, and for the Q_c, it is for the approximate *F*-test of $H_0 : Qc = 0$.

	International Models				Local Models			
	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	*Qc*	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	*Qc*
International								
Standard 3F	0.59**	0.00	0.15	0.85***	N/A	N/A	N/A	N/A
Standard 4F	0.66***	0.00	0.14	0.82***	N/A	N/A	N/A	N/A
Decomposed 4F	0.59***	0.00	0.15	0.84***	N/A	N/A	N/A	N/A
Decomposed 6F	0.74**	0.00	0.12	0.74***	N/A	N/A	N/A	N/A
Modified 7F	0.72***	0.00	0.13	0.80***	N/A	N/A	N/A	N/A
Index 7F	0.74***	0.00	0.11	0.74***	N/A	N/A	N/A	N/A
United States (US)								
Standard 3F	0.66	0.07	0.21	0.27***	0.64	0.08	0.22	0.27***
Standard 4F	0.76	0.07	0.18	0.26***	0.76	0.07	0.17	0.26***
Decomposed 4F	0.69	0.08	0.21	0.25**	0.66	0.09	0.21	0.26***
Decomposed 6F	0.83	0.06	0.14	0.21**	0.82	0.06	0.14	0.21**
Modified 7F	0.81	0.08	0.14	0.25***	0.82	0.07	0.13	0.23**
Index 7F	0.79	0.09	0.15	0.24***	0.81	0.08	0.14	0.23**
United Kingdom (UK)								
Standard 3F	0.28***	0.04	0.18	0.83***	0.35***	0.01	0.19	0.82***
Standard 4F	0.67**	0.00	0.12	0.65***	0.64***	0.00	0.12	0.70***
Decomposed 4F	0.42**	0.01	0.21	0.45***	0.45***	0.00	0.16	0.69***
Decomposed 6F	0.69**	0.00	0.12	0.53***	0.64***	0.00	0.12	0.65***
Modified 7F	0.74*	0.00	0.11	0.42***	0.67***	0.00	0.10	0.62***
Index 7F	0.72**	0.00	0.10	0.51***	0.71*	0.00	0.09	0.44***
Japan								
Standard 3F	0.52	0.29	0.32	0.13	0.42	0.33	0.35	0.14
Standard 4F	0.59	0.31	0.26	0.13	0.53	0.37	0.30	0.14
Decomposed 4F	0.58	0.31	0.27	0.13	0.61	0.23	0.23	0.15
Decomposed 6F	0.68	0.33	0.20	0.12	0.63	0.37	0.24	0.14
Modified 7F	0.69	0.37	0.20	0.13	0.75	0.30	0.19	0.13
Index 7F	0.73	0.32	0.20	0.10	0.72	0.33	0.20	0.13
Canada								
Standard 3F	0.09***	0.41	0.09	0.50***	0.16***	0.13	0.12	0.51***
Standard 4F	0.74**	0.00	0.08	0.32***	0.74**	0.00	0.08	0.40***
Decomposed 4F	0.12***	0.57	0.16	0.43***	0.16***	0.46	0.12	0.51***
Decomposed 6F	0.81	0.00	0.07	0.25***	0.82**	0.00	0.07	0.34***
Modified 7F	0.77**	0.00	0.08	0.31***	0.75**	0.00	0.08	0.34***
Index 7F	0.79	0.00	0.08	0.27***	0.74***	0.00	0.08	0.36***

However, for international size-momentum-industry portfolios, all the models are rejected by the F-test for Qc as well as the R^2 test. For the test of $\hat{\rho}^2 = 0$, the null hypothesis for all the models is rejected at the 10% or lower level of significance for size-B/M-industry portfolios, and at the 1% level for size-momentum-industry portfolios. Consistent with the time-series results, the cross-sectional results show that none of the models can provide adequate explanation of the expected returns, hence the asset pricing models are not integrated.

Both the F-test for Q_c and R^2 test fail to reject any of the international or local models for size-B/M-industry portfolio returns of the US, UK and Japan in Table 5.1 and size-momentum-industry portfolios returns of only Japan in Table 5.2. In general, for these portfolios, the $\hat{\rho}^2$ columns show that the international and local versions of each factor models have similar cross-sectional R^2, and the larger factor models, i.e. decomposed 6F, modified 7F, and index-based 7F models, have higher explanatory power. The $p(\hat{\rho}^2 = 0)$, for the test that the model has a zero R^2, cannot be rejected for any of the international or local models. These results are contrary to the existing literature for the US. The cross-sectional literature for the US report that the 3F and 4F models have much higher R^2 values and both models are frequently rejected by the specification tests. However, those studies test models only on 25 size-B/M portfolios, and as pointed out earlier, inclusion of the industry portfolios relaxes the tight factor structure of the characteristics based portfolios with factors and result in lower R^2 values. Lewellen et al. (2010) also report a substantial drop in the cross-sectional R^2 when industry portfolios are included with 25 size-B/M portfolios to test the standard 3F model.

All of the international and local models for the size-B/M-industry portfolio return for Canada in Table 5.1 and the size-momentum-industry portfolio returns for the US, UK, and Canada in Table 5.2 are rejected by both the F-test for Q_c and the R^2 test. The $\hat{\rho}^2$ of international and local versions of each factor model are still quite similar, and larger factor models have higher R^2 values. For these portfolios, the hypothesis of the zero model R^2 based on $p(\rho^2 = 0)$

is also rejected for all the models. The models have higher explanatory power for size-momentum-industry portfolio returns in Table 5.2 compared to size-B/M-industry portfolio returns of Table 5.1. Unlike the size-B/M portfolios, inclusion of industry portfolios does not result in lower pricing errors for most of the size-momentum portfolios in my sample. As a result, the models fail to explain most of the size-momentum-industry portfolio returns. Gregory et al. (2013a) report similar results for the UK size-B/M-momentum portfolios. As noticed, the performance of international models appears to be as good as local models for both size-B/M-industry and size-momentum-industry portfolios. Compared to time-series tests, the international models, and especially the larger factor models, show more integration in the cross-sectional tests on the country portfolio returns. However, the factor risk premia still needed to be considered before giving a verdict on the integration hypothesis.

In some cases a model with high R^2 (for example the local decomposed 6F model for the Canadian size-momentum portfolios) is rejected by both the F-test and the R^2 test, whereas a model with a lower R^2 (for example the local decomposed 4F model) for the same set of test portfolios is also rejected by both specification tests. Thus, it is not possible to identify the better performing model from these statistics. Further, it is quite possible that the rejection of a high R^2 model may be driven by small but precisely estimated errors, which will make any specification test unsuitable for the model comparison. Therefore, as suggested by Kan et al. (2013), an alternative test is needed to determine whether a model with high R^2 significantly outperforms other competing models.

The other relevant issue is the number of factors in the model, which means the 7F models will have an advantage in any given sample. However, the formal model comparison tests of Kan et al. (2013), to be discussed in the following subsection 5.3.2, controls for the sampling variation related to the number of factors. As noted in Tables 5.1 and 5.2, there is little sampling variability in R^2, especially among the larger factor models, and therefore, it is hard to identify a model that truly outperforms other models in any given sample.

5.3.2 Pair-Wise Model Comparison Tests of Cross-Sectional R^2

Pair-wise tests of R^2 equality are presented in Tables 5.3 and 5.4 for the size-B/M-industry portfolios and size-momentum-industry portfolios. Both tables report the difference between the cross-sectional R^2 for each pair of models and ***, **, and * indicate cases in which the R^2 difference is statistically significant at the 1%, 5%, and 10% levels, respectively.

For the international size-B/M-industry portfolios in Table 5.3, the index-based 7F model outperforms the standard 3F and decomposed 4F models at the 10% level. For Japanese size-B/M-industry portfolios, the standard 4F model dominates the standard 3F model at the 10% level. None of the models significantly dominates the other models for the US, UK and Canadian size-B/M-industry portfolios in Table 5.3.

For the international size-momentum-industry portfolios in Table 5.4, only the decomposed 6F model outperforms the decomposed 4F model. For the size-momentum-industry portfolios of the UK, the international standard 3F model is dominated by all the international and local models that contain a momentum factor or its decomposed factors. The local standard 3F model is also outperformed by the international and local modified 7F and index-based 7F models, and by the local standard 4F model. Similarly, the international decomposed 4F model is dominated by the international decomposed 6F model, and the local decomposed 4F model is dominated by the international modified 7F and index-based 7F models and local standard 4F and decomposed 6F models. In short, the models without a momentum factor appear to be unattractive for the UK size-momentum-industry portfolios as they are significantly outperformed by the models with a momentum factor. Therefore, neither the international nor local versions of the standard 3F nor decomposed 4F models are suitable for explaining cross-sectional returns on the UK size-momentum-industry portfolios.

Table 5.3: Tests of Equality of Cross-Sectional R^2 of the Beta Pricing Models for 25 Size-B/M and 19 Industry Portfolios

This table presents pair-wise tests of equality of the OLS cross-sectional R^2s of six beta pricing models. The models include the international and local versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-B/M and 19 industry portfolios. Each panel reports the difference between the sample cross-sectional R^2s of the models in row i and column j, $\hat{\rho}_i^2 - \hat{\rho}_j^2$, and ***, **, and * indicate cases in which the R^2 difference is statistically significant at 1%, 5%, and 10% levels, respectively, for the test of $H_0 : \hat{\rho}_i^2 - \hat{\rho}_j^2$. The p-values are computed under the assumption that the models are potentially misspecified.

		International Models						Local Models				
	Model	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F	Index 7F	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F
International												
International Models	Standard 4F	0.10										
	Decomposed 4F	0.03	-0.07									
	Decomposed 6F	0.11	0.00	0.08								
	Modified 7F	0.20	0.10	0.17	0.10							
	Index 7F	0.29*	0.19	0.26*	0.18	0.09						
United States (US)												
International Models	Standard 4F	0.04										
	Decomposed 4F	0.07	0.03									
	Decomposed 6F	0.15	0.11	0.09								
	Modified 7F	0.23	0.20	0.17	0.08							
	Index 7F	0.21	0.17	0.15	0.06	-0.02						
Local Models	Standard 3F	0.00	-0.04	-0.07	-0.16	-0.24	-0.22					
	Standard 4F	0.08	0.04	0.02	-0.07	-0.15	-0.13	0.09				
	Decomposed 4F	0.07	0.03	0.00	-0.08	-0.17	-0.14	0.07	-0.01			
	Decomposed 6F	0.17	0.13	0.11	0.02	-0.06	-0.04	0.18	0.09	0.10		
	Modified 7F	0.27	0.23	0.21	0.12	0.04	0.06	0.28	0.19	0.21	0.10	
	Index 7F	0.23	0.19	0.16	0.07	-0.01	0.01	0.23	0.14	0.16	0.05	-0.05

(Continued overleaf)

		International Models						Local Models				
	Model	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F	Index 7F	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F
United Kingdom (UK)												
International Models	Standard 4F	0.03										
	Decomposed 4F	0.07	0.04									
	Decomposed 6F	0.19	0.15	0.11								
	Modified 7F	0.18	0.14	0.10	-0.01							
	Index 7F	0.21	0.18	0.14	0.02	0.03						
Local Models	Standard 3F	-0.02	-0.05	-0.10	-0.21	-0.20	-0.23					
	Standard 4F	-0.02	-0.05	-0.10	-0.21	-0.20	-0.23	0.00				
	Decomposed 4F	0.00	-0.04	-0.08	-0.19	-0.18	-0.21	0.02	0.02			
	Decomposed 6F	0.15	0.12	0.08	-0.03	-0.02	-0.06	0.17	0.17	0.16		
	Modified 7F	0.15	0.12	0.08	-0.04	-0.03	-0.06	0.17	0.17	0.15	0.00	
	Index 7F	0.14	0.11	0.06	-0.05	-0.04	-0.07	0.16	0.16	0.14	-0.01	-0.01
Japan												
International Models	Standard 4F	0.28*										
	Decomposed 4F	0.21	-0.07									
	Decomposed 6F	0.32	0.05	0.11								
	Modified 7F	0.31	0.03	0.10	-0.01							
	Index 7F	0.37	0.09	0.15	0.04	0.06						
Local Models	Standard 3F	0.08	-0.20	-0.13	-0.25	-0.23	-0.29					
	Standard 4F	0.14	-0.14	-0.07	-0.18	-0.17	-0.23	0.06				
	Decomposed 4F	0.16	-0.12	-0.06	-0.17	-0.15	-0.21	0.08	0.02			
	Decomposed 6F	0.29	0.01	0.08	-0.03	-0.02	-0.08	0.21	0.15	0.13		
	Modified 7F	0.37	0.09	0.16	0.05	0.06	0.00	0.29	0.23	0.22	0.08	
	Index 7F	0.37	0.09	0.16	0.05	0.06	0.01	0.29	0.23	0.22	0.08	0.00
Canada												
International Models	Standard 4F	0.06										
	Decomposed 4F	0.03	-0.03									
	Decomposed 6F	0.08	0.02	0.04								
	Modified 7F	0.08	0.02	0.04	0.00							
	Index 7F	0.02	-0.04	-0.01	-0.05	-0.05						
Local Models	Standard 3F	0.03	-0.03	0.00	-0.05	-0.05	0.01					
	Standard 4F	0.10	0.04	0.07	0.03	0.02	0.08	0.07				
	Decomposed 4F	0.03	-0.03	0.00	-0.04	-0.04	0.01	0.00	-0.07			
	Decomposed 6F	0.10	0.04	0.07	0.03	0.03	0.08	0.07	0.00	0.07		
	Modified 7F	0.22	0.16	0.19	0.15	0.15	0.20	0.19	0.12	0.19	0.12	
	Index 7F	0.19	0.13	0.16	0.12	0.11	0.17	0.16	0.09	0.16	0.09	-0.03

Table 5.4: Tests of Equality of Cross-Sectional R^2 of the Beta Pricing Models for 25 Size-Momentum and 19 Industry Portfolios

This table presents pair-wise tests of equality of the OLS cross-sectional R^2s of six beta pricing models. The models include the international and local versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-momentum and 19 industry portfolios. Each panel reports the difference between the sample cross-sectional R^2s of the models in row i and column j, $\hat{\rho}_i^2 - \hat{\rho}_j^2$, and ***, **, and * indicate cases in which the R^2 difference is statistical significant at 1%, 5%, and 10% levels, respectively, for the test of $H_0 : \hat{\rho}_i^2 - \hat{\rho}_j^2$. The p-values are computed under the assumption that the models are potentially misspecified.

		International Models						Local Models				
	Model	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F	Index 7F	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F
International												
International Models	Standard 4F	0.07										
	Decomposed 4F	0.00	-0.07									
	Decomposed 6F	0.16	0.08	0.15*								
	Modified 7F	0.13	0.05	0.13	-0.03							
	Index 7F	0.16	0.08	0.15	0.00	0.03						
United States (US)												
International Models	Standard 4F	0.09										
	Decomposed 4F	0.03	-0.06									
	Decomposed 6F	0.17	0.08	0.14								
	Modified 7F	0.14	0.05	0.12	-0.02							
	Index 7F	0.12	0.03	0.10	-0.04	-0.02						
Local Models	Standard 3F	-0.02	-0.11	-0.05	-0.19	-0.16	-0.14					
	Standard 4F	0.10	0.01	0.07	-0.07	-0.05	-0.03	0.12				
	Decomposed 4F	0.00	-0.09	-0.03	-0.17	-0.15	-0.13	0.02	-0.10			
	Decomposed 6F	0.15	0.06	0.13	-0.02	0.01	0.03	0.17	0.05	0.16		
	Modified 7F	0.15	0.06	0.13	-0.01	0.01	0.03	0.18	0.06	0.16	0.00	
	Index 7F	0.14	0.05	0.11	-0.03	0.00	0.02	0.16	0.04	0.14	-0.01	-0.01

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		International Models						Local Models				
	Model	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F	Index 7F	Standard 3F	Standard 4F	Decomposed 4F	Decomposed 6F	Modified 7F
United Kingdom (UK)												
International Models	Standard 4F	0.39**										
	Decomposed 4F	0.14	-0.24									
	Decomposed 6F	0.41*	0.02	0.26**								
	Modified 7F	0.46**	0.07	0.31	0.05							
	Index 7F	0.44**	0.05	0.29	0.03	-0.02						
Local Models	Standard 3F	0.07	-0.31	-0.07	-0.33	-0.38*	-0.36*					
	Standard 4F	0.36*	-0.03	0.21	-0.05	-0.10	-0.08	0.28**				
	Decomposed 4F	0.17	-0.22	0.02	-0.24	-0.29*	-0.27*	0.09	-0.19			
	Decomposed 6F	0.36*	-0.03	0.21	-0.05	-0.10	-0.08	0.28	0.00	0.19**		
	Modified 7F	0.39**	0.00	0.25	-0.01	-0.06	-0.04	0.32*	0.04	0.22	0.04	
	Index 7F	0.43**	0.04	0.29	0.03	-0.03	0.00	0.36**	0.08	0.26*	0.08	0.04
Japan												
International Models	Standard 4F	0.07										
	Decomposed 4F	0.06	-0.01									
	Decomposed 6F	0.16	0.09	0.10								
	Modified 7F	0.17	0.10	0.11	0.01							
	Index 7F	0.21	0.14	0.15	0.05	0.04						
Local Models	Standard 3F	-0.10	-0.17	-0.16	-0.26	-0.26	-0.31					
	Standard 4F	0.01	-0.07	-0.05	-0.16	-0.16	-0.21	0.10				
	Decomposed 4F	0.09	0.02	0.03	-0.07	-0.07	-0.12	0.19	0.09			
	Decomposed 6F	0.11	0.04	0.05	-0.05	-0.06	-0.11	0.20	0.10	0.01		
	Modified 7F	0.23	0.16	0.17	0.07	0.06	0.02	0.32	0.22	0.13	0.12	
	Index 7F	0.20	0.13	0.14	0.04	0.03	-0.02	0.29	0.19	0.10	0.09	-0.03
Canada												
International Models	Standard 4F	0.65***										
	Decomposed 4F	0.04	-0.62***									
	Decomposed 6F	0.73***	0.07	0.69***								
	Modified 7F	0.68***	0.03	0.65***	-0.04							
	Index 7F	0.70***	0.05	0.67***	-0.02	0.02						
Local Models	Standard 3F	0.07	-0.58***	0.04	-0.65***	-0.61***	-0.63***					
	Standard 4F	0.65***	0.00	0.61***	-0.08	-0.04	-0.05	0.58***				
	Decomposed 4F	0.07	-0.58***	0.04	-0.65***	-0.61***	-0.63***	0.00	-0.57***			
	Decomposed 6F	0.73***	0.08	0.69***	0.01	0.05	0.03	0.66***	0.08*	0.66***		
	Modified 7F	0.66***	0.01	0.62***	-0.07	-0.02	-0.04	0.59***	0.01	0.59***	-0.07	
	Index 7F	0.66***	0.00	0.62***	-0.07	-0.03	-0.04	0.58***	0.01	0.58***	-0.07	0.00

For the US and Japanese size-momentum portfolios, neither of the international or local models are significantly outperformed by the other models. For the Canadian size-momentum-industry portfolios in Table 5.4, the local and international versions of the standard 3F and decomposed 4F models are dominated by each of the local and international models. Given the very low R^2 values of both of the models for their international as well as local versions in Table 5.2, all the models dominate them at the 1% level of significance. Moreover, the local decomposed 6F model also outperforms the local standard 4F model at the 10% significance level. The model with the highest R^2 in Table 5.2 for Canada is the local decomposed 6F model, and it appears to perform better than all the other models. The local decomposed 6F model outperforms not only international versions of the standard 3F and decomposed 4F models, but also the local versions of the standard 3F and 4F and decomposed 4F models. Thus, both the international and local versions of the standard 3F and 4F models or decomposed 4F model are not adequate for the Canadian size-momentum-industry portfolio returns, while the decomposed 6F model is a better choice.

Due to the limited precision of the R^2 estimates, there are many instances of large differences in R^2 that are not statistically significant. For example, the standard errors of the international and local versions of the 3F models for the US size-B/M-industry portfolios are large in Table 5.1. As a result, despite being dominated by the local modified 7F model by 27% and 28% for the international and local versions, respectively, the R^2 difference is not significant even at the 10% level. Therefore, as argued by Kan et al. (2013), comparison of point estimates of the sample R^2s is not particularly helpful in identifying superior models. As noted earlier, the explanatory power of the international and local versions of the models are quite similar, as a result the international (local) versions of the models are not dominated by their local (international) versions. This supports the integration hypothesis, as is shows that the international models perform as well as the local models in explaining expected stock returns on the country portfolios. Moreover, the standard 3F and 4F models and the decomposed 4F model are outperformed in the UK and Canadian size-momentum-industry portfolios, while none of the remaining larger factor models appear to outperform one another, which shows that these models are statistically indistinguishable using pair-wise comparison tests. Thus, to investigate whether all the models dominate the standard 3F and 4F models and the decomposed 4F model, and to identify the best performing models, the next subsection discusses the multiple model comparison tests.

5.3.3 Multiple model comparison

Following Kan et al. (2013), the tests are conducted using the *LR* test for the non-nested models and the R^2 equality test for the nested models. As in Kan et al. (2013), for each of the multiple model comparison, all the alternative models are removed if they are nested within the model in question (the benchmark model), since the benchmark model will always have the highest R^2. For the same reason, only the largest model from the remaining alternative models is kept, and any other models nesting within the largest model are dropped. Moreover, if the benchmark model nests in any other model then those other models are also removed as including these will violate the normality assumption for the R^2 comparisons as pointed out by Kan et al. (2013). For this case, following Kan et al. (2013), the test of R^2 equality that was used in the previous subsection is adapted, and a single expanded model is considered containing all variables that are included in those other models in which the benchmark model nests.

Tables 5.5 and 5.6 report the benchmark models in column 1 and their sample R^2s in column 2; *r* in column 3 is the number of alternative models in each multiple non-nested model comparison; LR in column 4 is the value of the likelihood ratio test statistic with p-value in column 5; and s in column 6 denotes the number of models that nest the benchmark model. Finally, $\hat{\rho}_M^2 - \hat{\rho}_i^2$ in column 7 is the difference between the sample R^2 of expanded model (M) and the sample R^2 of the benchmark model (i) with the p-value given in column 8.

Table 5.5: Multiple Model Comparison Tests of Beta Pricing Models for 25 Size-B/M and 19 Industry Portfolios

This table presents multiple model comparison tests of the OLS cross-sectional R^2s of beta pricing models. . The models include the international and local versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-B/M and 19 industry portfolios. Each panel reports the benchmark models in column 1 and their sample R^2s in column 2; r in column 3 denotes the number of alternative models in each multiple non-nested model comparison; LR in column 4 is the value of the likelihood ratio statistic with p-value given in column 5; and s in column 6 denotes the number of models that nest the benchmark model. Finally, $\hat{\rho}_M^2 - \hat{\rho}_i^2$ in column 7 denotes the difference between the sample R^2 of the expanded model (M) and the sample R^2 of the benchmark model with p-value given in column 8.

	Model	$\hat{\rho}^2$	r	LR	p-value	s	$\hat{\rho}_M^2 - \hat{\rho}_i^2$	p-value
International								
International Models	Standard 3F	0.41	3	3.30	0.08	1	0.10	0.18
	Standard 4F	0.51	3	1.51	0.22			
	Decomposed 4F	0.43	3	3.28	0.08	1	0.08	0.47
	Decomposed 6F	0.51	3	1.95	0.26			
	Modified 7F	0.61	3	0.96	0.35			
	Index 7F	0.69	3	0.00	0.64			
United States (US)								
International Models	Standard 3F	0.27	7	1.10	0.42	1	0.02	0.71
	Standard 4F	0.30	7	0.96	0.46			
	Decomposed 4F	0.33	7	0.78	0.50	1	0.11	0.67
	Decomposed 6F	0.44	7	0.21	0.66			
	Modified 7F	0.49	7	0.35	0.70			
	Index 7F	0.46	7	0.33	0.66			
Local Models	Standard 3F	0.27	7	1.11	0.41	1	0.07	0.49
	Standard 4F	0.34	7	0.59	0.59			
	Decomposed 4F	0.33	7	0.66	0.48	1	0.11	0.66
	Decomposed 6F	0.43	7	0.30	0.71			
	Modified 7F	0.56	7	0.00	0.87			
	Index 7F	0.49	7	0.55	0.65			
United Kingdom (UK)								
International Models	Standard 3F	0.38	7	2.02	0.36	1	0.03	0.54
	Standard 4F	0.42	7	1.35	0.41			
	Decomposed 4F	0.46	7	0.73	0.59	1	0.11	0.42
	Decomposed 6F	0.57	7	0.03	0.84			
	Modified 7F	0.56	7	0.02	0.73			
	Index 7F	0.59	7	0.00	0.87			
Local Models	Standard 3F	0.36	7	2.44	0.29	1	0.00	0.99
	Standard 4F	0.36	7	2.45	0.29			
	Decomposed 4F	0.38	7	1.81	0.38	1	0.16	0.24
	Decomposed 6F	0.54	7	0.14	0.75			
	Modified 7F	0.53	7	0.15	0.79			
	Index 7F	0.52	7	0.22	0.77			

(Continued overleaf)

Table 5.5 (Continued)

		Model	$\hat{\rho}^2$	r	LR	p-value	s	$\hat{\rho}_M^2 - \hat{\rho}_i^2$	p-value
Japan									
	International Models	Standard 3F	0.32	7	1.37	0.27	1	0.28	0.07
		Standard 4F	0.60	7	0.78	0.58			
		Decomposed 4F	0.53	7	0.83	0.47	1	0.11	0.37
		Decomposed 6F	0.64	7	0.19	0.82			
		Modified 7F	0.63	7	0.41	0.70			
		Index 7F	0.69	7	0.00	0.86			
	Local Models	Standard 3F	0.40	7	1.08	0.30	1	0.06	0.39
		Standard 4F	0.46	7	0.93	0.35			
		Decomposed 4F	0.47	7	0.99	0.43	1	0.13	0.39
		Decomposed 6F	0.61	7	0.19	0.65			
		Modified 7F	0.69	7	0.00	0.92			
		Index 7F	0.69	7	0.00	0.90			
Canada									
	International Models	Standard 3F	0.22	7	1.46	0.33	1	0.06	0.18
		Standard 4F	0.28	7	1.07	0.55			
		Decomposed 4F	0.26	7	1.17	0.37	1	0.04	0.58
		Decomposed 6F	0.30	7	0.86	0.53			
		Modified 7F	0.30	7	0.94	0.46			
		Index 7F	0.25	7	1.51	0.35			
	Local Models	Standard 3F	0.25	7	1.72	0.32	1	0.07	0.21
		Standard 4F	0.32	7	1.38	0.47			
		Decomposed 4F	0.26	7	1.59	0.33	1	0.07	0.43
		Decomposed 6F	0.33	7	1.15	0.47			
		Modified 7F	0.45	7	0.00	0.78			
		Index 7F	0.42	7	0.14	0.77			

Table 5.6: Multiple Model Comparison Tests of Beta Pricing Models for 25 Size-momentum and 19 Industry Portfolios

This table presents multiple model comparison tests of the OLS cross-sectional R^2s of beta pricing models. The models include the international and local versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-momentum and 19 industry portfolios. Each panel reports the benchmark models in column 1 and their sample R^2s in column 2; r in column 3 denotes the number of alternative models in each multiple non-nested model comparison; LR in column 4 is the value of the likelihood ratio statistic with p-value given in column 5; and s in column 6 denotes the number of models that nest the benchmark model. Finally, $\hat{\rho}_M^2 - \hat{\rho}_i^2$ in column 7 denotes the difference between the sample R^2 of the expanded model (M) and the sample R^2 of the benchmark model with p-value given in column 8.

	Model	$\hat{\rho}^2$	r	LR	p-value	s	$\hat{\rho}_M^2 - \hat{\rho}_i^2$	p-value
International								
International Models	Standard 3F	0.59	3	2.39	0.11	1	0.08	0.17
	Standard 4F	0.66	3	1.89	0.19			
	Decomposed 4F	0.59	3	2.14	0.13	1	0.15	0.05
	Decomposed 6F	0.74	3	0.00	0.73			
	Modified 7F	0.72	3	0.35	0.52			
	Index 7F	0.74	3	0.00	0.78			
United States (US)								
International Models	Standard 3F	0.66	7	1.18	0.25	1	0.09	0.26
	Standard 4F	0.76	7	0.98	0.41			
	Decomposed 4F	0.69	7	0.78	0.32	1	0.14	0.24
	Decomposed 6F	0.83	7	0.00	0.80			
	Modified 7F	0.81	7	0.18	0.79			
	Index 7F	0.79	7	0.46	0.65			
Local Models	Standard 3F	0.64	7	1.41	0.22	1	0.12	0.18
	Standard 4F	0.76	7	0.92	0.58			
	Decomposed 4F	0.66	7	1.32	0.23	1	0.16	0.15
	Decomposed 6F	0.82	7	0.11	0.82			
	Modified 7F	0.82	7	0.02	0.78			
	Index 7F	0.81	7	0.27	0.75			
United Kingdom (UK)								
International Models	Standard 3F	0.28	7	6.03	0.01	1	0.39	0.01
	Standard 4F	0.67	7	1.87	0.42			
	Decomposed 4F	0.42	7	1.99	0.12	1	0.26	0.04
	Decomposed 6F	0.69	7	0.98	0.46			
	Modified 7F	0.74	7	0.00	0.81			
	Index 7F	0.72	7	0.11	0.77			
Local Models	Standard 3F	0.35	7	4.13	0.04	1	0.28	0.02
	Standard 4F	0.64	7	3.34	0.27			
	Decomposed 4F	0.45	7	3.65	0.06	1	0.19	0.03
	Decomposed 6F	0.64	7	2.76	0.25			
	Modified 7F	0.67	7	1.26	0.44			
	Index 7F	0.71	7	0.08	0.64			

(Continued overleaf)

Table 5.6 (Continued)

	Model	$\hat{\rho}^2$	r	LR	p-value	s	$\hat{\rho}_M^2 - \hat{\rho}_i^2$	p-value
Japan								
International Models	Standard 3F	0.52	7	0.87	0.39	1	0.07	0.41
	Standard 4F	0.59	7	0.90	0.50			
	Decomposed 4F	0.58	7	0.66	0.45	1	0.10	0.45
	Decomposed 6F	0.68	7	0.28	0.73			
	Modified 7F	0.69	7	0.42	0.69			
	Index 7F	0.73	7	0.02	0.82			
Local Models	Standard 3F	0.42	7	1.03	0.27	1	0.10	0.41
	Standard 4F	0.53	7	0.83	0.35			
	Decomposed 4F	0.61	7	0.70	0.55	1	0.01	0.90
	Decomposed 6F	0.63	7	0.62	0.63			
	Modified 7F	0.75	7	0.00	0.91			
	Index 7F	0.72	7	0.36	0.76			
Canada								
International Models	Standard 3F	0.09	7	46.09	0.00	1	0.66	0.00
	Standard 4F	0.74	7	1.74	0.34			
	Decomposed 4F	0.12	7	16.94	0.00	1	0.69	0.00
	Decomposed 6F	0.81	7	0.01	0.82			
	Modified 7F	0.77	7	0.67	0.56			
	Index 7F	0.79	7	0.19	0.66			
Local Models	Standard 3F	0.16	7	24.99	0.00	1	0.58	0.00
	Standard 4F	0.74	7	2.85	0.26			
	Decomposed 4F	0.16	7	25.63	0.00	1	0.66	0.00
	Decomposed 6F	0.82	7	0.00	0.85			
	Modified 7F	0.75	7	1.62	0.38			
	Index 7F	0.74	7	2.11	0.40			

The size-B/M-industry portfolio results are presented in Table 5.5. The results reveal that none of the models are rejected by the *LR* test based on the *p*-values for the international sample, US, UK, Japan, and Canada. Only the international 3F model for Japan is rejected in the case of nested model comparisons based on the *p*-value in column 8. It is important to note that the model rejected by this test is the same as the one rejected in the pair-wise comparison in Table 5.3 for Japan. As the benchmark models only nest one other model for the nested model comparison, the results are exactly the same as in the pair-wise comparison. In summary, none of the models can be rejected in the multiple model comparisons for the size-B/M-industry portfolios, which means no model statistically outperforms any of the others. Consistent the pair-wise comparison tests, the multiple model comparison test results for the size-B/M-industry portfolios support the integration hypothesis, as none of the international models can be rejected in comparison to all the remaining local and international models. Similar to pair-wise comparison tests, none of the factor models are rejected by any other models, which shows that no model can be preferred over any other on the basis of their explanatory power for the size-B/M-industry portfolio returns.

The standard 3F and decomposed 4F models for the international size-momentum-industry portfolios in Table 5.6, barely miss the rejection at the 10% level by the *p*-value of the *LR* test. However, the decomposed model is rejected in the nested model comparisons at the 10% level of significance. For the UK size-momentum-industry portfolios, both the international and local standard 3F models are rejected by the *LR* test as well as by the nested model comparison *p*-value in column 8. For the UK, the local decomposed 4F model is also rejected in both the *LR* test and the nested model comparisons, while the international decomposed 4F model barely misses rejection by the *LR* test, but it is rejected at the 5% level in the nested model comparisons.

For the Canadian size-momentum-industry portfolios in Table 5.6, both the international and local versions of the standard 3F and decomposed 4F models are rejected by the *LR* test as well as the nested model comparisons at the 1% level of significance. Similar to the size-B/M-industry portfolios, the results in Table 5.6 for the size-momentum-industry portfolios support the integration of the asset pricing models in the cross-sectional tests. Moreover, similar to the pair-wise comparison tests, the standard 3F and decomposed 4F models for the UK and the standard 3F and 4F models and the decomposed 4F model for Canada are clearly rejected, and there are better alternatives available for these models.

In summary, the multiple model comparison test results give further insights into the identification of the best performing models, or alternatively, into the identification of the model(s) for which a better alternative is available. Based on the results in Tables 5.1 to 5.6, the standard 3F and decomposed 4F models in the UK and Canada and the standard 4F model for Canada are clearly outperformed by the other models. There is always a better performing model than the standard 3F and 4F models and decomposed 4F model, has higher explanatory power. However, none of the decomposed 6F, modified 7F or index-based 7F models, or their different international and local versions, dominate each the other in statistical terms for any of the samples examined. The results clearly show that the international models are not dominated by the local models, which is an evidence in support of the integration hypothesis in the cross-sectional tests. The next subsection discusses the factor pricing results in an attempt to offer further insights into the models' performances.

5.3.4 Factor Risk Premia under Potentially Misspecified Models

This subsection reports the factor pricing results for the six beta pricing models. Kan et al. (2013) demonstrate that the pricing inferences are affected a great deal depending on whether one uses standard errors based on a correctly specified model or standard errors that are robust to model misspecification. Therefore, as outlined in Section 5.2, Tables 5.7, 5.8, and A4 in the

Appendix report the risk premia (γ) estimates and their associated *t*-statistics. Following Shanken (1992) EIV adjustment labelled as SH *t*-stats and *t*-statistics under potential model misspecification following Kan et al. (2013) labelled as PM *t*-statistics. Given the encouraging results for the international models in previous subsections, the main analysis is based on risk premia of international factors for the international and country portfolio returns followed by the discussion of the country factor premia for the country portfolios.

5.3.4.1 Pricing Results for International Portfolio Returns

Table 5.7 reports the factor pricing results for the international sample. The γ estimates show that the market risk premium is not significant in any of the models for both sets of test portfolio returns, except for the index-based 7F model (*INDMKT* for the size-B/M-industry portfolios using the SH *t*-statistics. However, the *SMB* and *INDSMM* factors are consistently positively priced for both size-B/M-industry and size-momentum-industry portfolio returns. Moreover, the *MMB* premium for the size-B/M-industry portfolio returns and both *SMM* and *MMB* premiums for size-momentum-industry are significant for the modified 7F model.

However, the implied factor prices for the size factors are always greater than their mean values as reported in Table 3.4, as argued by Lewellen et al. (2010) these should be equal to the size factors' time-series mean. The higher cross-sectional risk-premium is evidence against the asset pricing model in question, as the factor loadings are not reasonably priced by the test portfolios rather they indicate that the factor loadings are capturing an additional premium for some missing factors. For the size-B/M-industry portfolio returns, the big stocks value premium is also positively priced in the decomposed models and the modified 7F model. Moreover, on a few occasions, the momentum premiums for size-B/M-industry returns are only priced for the SH *t*-statistics, and the factor premiums are implausible as they are much higher than the time-series averages of the momentum factors.

Table 5.7: Risk Premia (γ) Estimates of International Models for International Portfolios

This table presents the estimation results of six beta pricing models. The models include the international versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on international 25 size-B/M and 25 size-momentum plus 19 industry portfolios. Table reports parameter estimates γ, Shanken (1992) *t*-statistics (SH *t*-stats) and model misspecification-robust *t*-statistics (PM *t*-stats).

Size-B/M and Industry Portfolios

Standard 3F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML}				
Estimate	0.36	-0.15	0.37	0.14				
SH *t*-stats	1.75	-0.50	2.76	0.92				
PM *t*-stats	1.51	-0.49	2.65	0.91				
Standard 4F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML}	γ_{WML}			
Estimate	-0.09	0.37	0.30	0.24	2.10			
SH *t*-stats	-0.33	1.04	2.24	1.45	3.04			
PM *t*-stats	-0.23	0.78	2.03	1.38	1.48			
Decomposed 4F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML_s}	γ_{HML_b}			
Estimate	0.44	-0.23	0.35	-0.02	0.40			
SH *t*-stats	2.00	-0.74	2.64	-0.10	2.34			
PM *t*-stats	1.73	-0.71	2.55	-0.10	2.24			
Decomposed 6F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML_s}	γ_{HML_b}	γ_{WML_s}	γ_{WML_b}	
Estimate	-0.01	0.29	0.30	0.11	0.39	1.73	2.13	
SH *t*-stats	-0.05	0.81	2.22	0.60	2.21	2.74	2.93	
PM *t*-stats	-0.03	0.50	2.05	0.50	2.02	1.03	1.28	
Modified 7F	γ_0	γ_{MKT}	γ_{SMM}	γ_{MMB}	γ_{SHML}	γ_{MHML}	γ_{BHML}	γ_{WML}
Estimate	0.00	0.28	0.13	0.27	0.37	-0.25	0.36	1.48
SH *t*-stats	0.00	0.74	1.57	2.25	2.45	-1.41	2.25	2.21
PM *t*-stats	0.00	0.54	1.40	2.03	2.07	-1.39	1.96	1.15
Index 7F	γ_0	γ_{INDMKT}	γ_{INDSMM}	γ_{INDMMB}	$\gamma_{INDSHML}$	$\gamma_{INDMHML}$	$\gamma_{INDBHML}$	γ_{WML}
Estimate	-0.46	0.76	0.72	-0.31	0.07	0.28	0.15	1.91
SH *t*-stats	-1.49	1.91	3.74	-1.51	0.41	1.20	0.92	2.99
PM *t*-stats	-1.03	1.35	2.99	-1.36	0.35	0.90	0.86	1.73

Size-Momentum and Industry Portfolios

Standard 3F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML}				
Estimate	0.48	-0.24	0.54	-0.26				
SH *t*-stats	2.37	-0.78	3.78	-1.29				
PM *t*-stats	2.21	-0.79	3.71	-1.27				
Standard 4F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML}	γ_{WML}			
Estimate	0.28	-0.04	0.50	-0.14	0.52			
SH *t*-stats	1.69	-0.14	3.54	-0.71	2.44			
PM *t*-stats	1.51	-0.14	3.45	-0.73	2.44			
Decomposed 4F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML_s}	γ_{HML_b}			
Estimate	0.51	-0.28	0.53	-0.40	-0.07			
SH *t*-stats	2.77	-0.94	3.72	-1.68	-0.24			
PM *t*-stats	2.41	-0.91	3.63	-1.61	-0.21			
Decomposed 6F	γ_0	γ_{MKT}	γ_{SMB}	γ_{HML_s}	γ_{HML_b}	γ_{WML_s}	γ_{WML_b}	
Estimate	0.32	-0.09	0.48	-0.44	0.39	0.59	0.32	
SH *t*-stats	1.81	-0.32	3.45	-1.82	1.50	2.76	1.26	
PM *t*-stats	1.63	-0.31	3.38	-1.94	1.32	2.67	1.26	
Modified 7F	γ_0	γ_{MKT}	γ_{SMM}	γ_{MMB}	γ_{SHML}	γ_{MHML}	γ_{BHML}	γ_{WML}
Estimate	0.37	-0.12	0.20	0.31	0.02	-0.40	0.35	0.52
SH *t*-stats	1.81	-0.41	2.19	2.33	0.10	-1.90	1.60	2.42
PM *t*-stats	1.45	-0.37	1.82	1.92	0.08	-1.71	1.25	2.45
Index 7F	γ_0	γ_{INDMKT}	γ_{INDSMM}	γ_{INDMMB}	$\gamma_{INDSHML}$	$\gamma_{INDMHML}$	$\gamma_{INDBHML}$	γ_{WML}
Estimate	0.15	0.06	0.62	-0.14	-0.27	0.14	0.12	0.52
SH *t*-stats	0.90	0.20	3.13	-0.67	-1.29	0.64	0.57	2.45
PM *t*-stats	0.73	0.18	2.69	-0.60	-1.17	0.57	0.51	2.45

The momentum premium is consistently priced for size-momentum-industry portfolio returns. The models in which it is priced include the standard 3F, modified 7F and index-based 7F models, along with the WML_s premium in the decomposed 6F. Moreover, momentum is the only factor for the size-momentum-industry portfolios for which the cross-sectional premiums are equal to their time-series averages, showing the relatively better performance of the models that include the momentum factor. Overall, most of the factors are not priced and factor risk premiums for the priced factors are unreasonable, which show that the performance of the models is questionable, and they do not provide a complete description of the expected returns. The mispricing of the international factors indicate the inadequacy of the international models, and it is consistent with the failure of the international models in the time-series tests (Chapter 4) and their rejection by the cross-sectional specification tests reported in Tables 5.1 and 5.2.

Lewellen et al. (2010) and Shanken and Zhou (2007) not only identify the need for the factor risk premia to be equal to the average factor returns, but also argue that the zero-beta rate should be equal to the risk-free rate. However, the zero-beta rate is in excess of the risk-free rate in the standard 3F and decomposed 4F models for size-momentum-industry portfolios,. Meanwhile, only the decomposed 4F model for size-B/M-industry portfolios shows an excess zero-beta rate that is significant at the 5% level. These high zero-beta rates are difficult to reconcile, and are strong evidence against these models. This evidence is consistent with the results of R^2 and R^2 comparison tests in the previous subsections, which show that the standard 3F and decomposed 4F models are the worst performing models for both sets of test portfolios. Therefore, these models should not be used for the applications involving international portfolios, rather their better alternatives should be employed.

The positive and significant risk premium for the size and momentum factors and the factor premiums being close to their time-series averages show that these factors integrate quite well across the four countries. The size factor shows more signs of integration as it is priced for both sets of test portfolios. The pricing of momentum premia for size-momentum-industry portfolio returns supports the evidence in the literature that factors are more accurately priced when test portfolios are sorted by the same characteristic as the factors [Shanken and Zhou (2007) and Gregory et al. (2013a)]. However, it is important to examine specific country portfolios that create problems for pricing of international factors and whether the results of international portfolios extend to the country portfolios. Therefore, the next subsection discusses pricing results of international factors for country portfolios along with local factors.

5.3.4.2 Pricing Results for Country Portfolio Returns

Panels A to D in Table 5.8 report the factor pricing results for international models on the size-B/M-industry and the size-momentum-industry portfolios of the countries covered in this thesis. For brevity and to focus on the integration of the factor pricing, the corresponding results for the local models are reported in Table A4. In general, the local factor premiums are similar to the international premiums reported in Table 5.8. The factors that are priced are about exactly the same, with very few exceptions. Therefore, the international factor pricing results are discussed in detail, and local model results are referred to only when they give different results. The similar trend in the pricing of the factors for the international and local models shows that the international factors are relatively more integrated in their cross-sectional tests compared to the time-series tests in chapter 4. Moreover, as pointed out by Shanken and Zhou (2007) and Gregory et al. (2013a), the factors are more accurately priced by the test portfolios constructed using the same characteristics as the factors. It is quite possible that what matters most for the cross-sectional pricing is which characteristics are used to construct these factors rather than their international or local versions.

Panel A in Table 5.8 for the US shows that the international size premium, which is consistently priced in the international sample, is only priced in the standard and decomposed models for the size-momentum-industry portfolio returns, together with the *SMM* factor in the modified 7F model. The momentum premium in the standard 4F, modified 7F and index-based 7F models for the size-momentum-industry portfolio returns is significant at the 10% level, and the WML_s factor in the decomposed 6F model is priced at the 5% level. None of the other factors are priced. The results are exactly the same for the local models in Panel A of Table A4, except that the *SMM* factor in the modified 7F model is not using PM *t*-statistics for the size-momentum-industry portfolio returns.

However, there are significant excess zero-beta rates in all the international models, except the index-based 7F model for both sets of portfolios, and the decomposed 6F model for the size-B/M-industry portfolios. For the local models in Panel A of Table A4, only the index-based 7F and decomposed 6F models for size-B/M-industry portfolios do not have significant intercepts. Moreover, only the premiums for momentum factors (both international and local) are consistent with their time-series average returns in Table 3.4, which are very similar for the international sample.

In line with the tests on the international portfolios, the international factors continue to show the signs of integration for the country portfolios of the US, as the pricing results for the factors are similar to those of local factors and the international models perform equally as well as the local models. Consistent with the time series results, the index-based 7F model is a better alternative as it does not have a significant zero-beta rate for both sets of portfolios, and it also performs better in terms of explanatory power and model specification tests in Tables 5.1 and 5.2. Contrary to the literature, the market and value premiums are not priced for US portfolio returns, while the size premium is priced. As identified earlier, this may have resulted from the fact that the industry augmented sets of test portfolios are used compared to the previous literature.

Table 5.8: Risk Premium (γ) Estimates for International Models on Country Portfolios

This table presents the estimation results of six beta pricing models. The models include the international versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on international 25 size-B/M and 25 size-momentum plus 19 industry portfolios of individual countries. Table reports parameter estimates *γ*, Shanken (1992) SH *t*-statistics and model misspecification-robust PM *t*-statistics.

Panel A: United States (US)

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.75	-0.09	0.22	0.05				
SH *t*-stats	2.74	-0.22	1.29	0.33				
PM *t*-stats	2.69	-0.22	1.27	0.33				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	0.62	0.08	0.16	0.07	0.45			
SH *t*-stats	2.09	0.18	0.91	0.42	0.80			
PM *t*-stats	1.94	0.17	0.86	0.42	0.66			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.67	0.07	0.24	0.11	-0.06			
SH *t*-stats	2.32	0.16	1.41	0.56	-0.29			
PM *t*-stats	2.22	0.15	1.39	0.55	-0.27			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.39	0.46	0.20	0.15	-0.09	0.72	0.07	
SH *t*-stats	1.29	1.03	1.08	0.75	-0.40	1.28	0.09	
PM *t*-stats	1.17	0.92	1.05	0.74	-0.37	0.93	0.08	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.62	0.01	0.09	0.07	0.21	-0.10	0.02	0.47
SH *t*-stats	1.90	0.02	0.75	0.42	1.22	-0.56	0.11	0.82
PM *t*-stats	1.77	0.02	0.75	0.40	1.15	-0.61	0.11	0.67
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.46	0.19	0.25	-0.05	0.13	-0.05	-0.09	0.85
SH *t*-stats	1.25	0.31	0.54	-0.08	0.78	-0.22	-0.49	1.60
PM *t*-stats	1.20	0.30	0.50	-0.08	0.75	-0.19	-0.42	1.30

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.98	-0.30	0.49	-0.11				
SH *t*-stats	3.27	-0.72	2.60	-0.65				
PM *t*-stats	3.25	-0.72	2.75	-0.65				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	0.71	-0.01	0.37	-0.04	0.42			
SH *t*-stats	2.78	-0.02	2.07	-0.23	1.78			
PM *t*-stats	2.65	-0.02	2.08	-0.23	1.81			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.83	-0.07	0.48	-0.04	-0.21			
SH *t*-stats	2.93	-0.15	2.54	-0.17	-0.80			
PM *t*-stats	2.43	-0.13	2.62	-0.15	-0.69			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.51	0.33	0.42	-0.05	-0.06	0.72	-0.08	
SH *t*-stats	1.88	0.77	2.27	-0.23	-0.24	2.64	-0.25	
PM *t*-stats	1.79	0.71	2.34	-0.24	-0.21	2.51	-0.24	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.75	-0.19	0.25	0.14	0.05	-0.23	0.12	0.43
SH *t*-stats	2.27	-0.36	1.89	0.85	0.22	-1.04	0.43	1.79
PM *t*-stats	2.04	-0.33	1.98	0.83	0.20	-1.07	0.36	1.83
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.52	-0.09	0.50	-0.23	-0.12	0.07	0.00	0.49
SH *t*-stats	1.62	-0.17	1.04	-0.37	-0.60	0.32	-0.02	1.91
PM *t*-stats	1.33	-0.13	0.82	-0.29	-0.51	0.29	-0.01	1.90

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Table 5.8 (Continued) **Panel B: United Kingdom (UK)**

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.02	0.54	-0.03	0.02				
SH *t*-stats	-0.08	1.57	-0.15	0.10				
PM *t*-stats	-0.08	1.55	-0.15	0.09				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.13	0.62	-0.03	0.07	0.46			
SH *t*-stats	-0.51	1.74	-0.12	0.35	0.77			
PM *t*-stats	-0.46	1.64	-0.12	0.34	0.53			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.13	0.86	0.03	-0.03	-0.26			
SH *t*-stats	-0.57	2.23	0.15	-0.14	-0.90			
PM *t*-stats	-0.53	2.00	0.14	-0.13	-0.82			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.04	0.74	0.07	0.08	-0.18	-0.33	0.53	
SH *t*-stats	-0.15	1.80	0.31	0.34	-0.59	-0.48	0.75	
PM *t*-stats	-0.14	1.61	0.29	0.32	-0.56	-0.38	0.63	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.21	1.04	-0.03	0.04	0.01	-0.22	-0.44	0.21
SH *t*-stats	-0.78	2.67	-0.15	0.17	0.07	-0.96	-1.28	0.32
PM *t*-stats	-0.72	2.51	-0.12	0.16	0.06	-0.89	-1.13	0.24
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.39	1.09	-0.73	0.72	0.23	-0.24	-0.25	0.40
SH *t*-stats	-1.14	2.46	-1.25	1.17	0.89	-1.05	-0.89	0.63
PM *t*-stats	-1.07	2.27	-1.11	1.06	0.84	-0.94	-0.79	0.54

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.24	0.77	0.32	-0.18				
SH *t*-stats	-1.15	2.29	1.34	-0.88				
PM *t*-stats	-0.90	1.99	1.10	-0.69				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.47	1.02	0.06	-0.03	1.07			
SH *t*-stats	-2.21	3.01	0.25	-0.14	3.45			
PM *t*-stats	-2.10	2.94	0.24	-0.14	2.69			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.34	1.57	0.53	-0.21	-1.22			
SH *t*-stats	-1.27	3.80	1.83	-0.80	-2.81			
PM *t*-stats	-1.06	2.58	1.57	-0.66	-1.78			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.49	1.31	0.17	-0.12	-0.40	1.08	1.05	
SH *t*-stats	-2.20	3.49	0.66	-0.48	-1.11	2.92	2.24	
PM *t*-stats	-2.05	2.95	0.61	-0.45	-0.89	2.34	1.95	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.50	1.11	0.55	-0.36	0.16	-0.22	-0.29	0.99
SH *t*-stats	-1.85	2.53	1.94	-1.17	0.57	-0.79	-0.77	2.88
PM *t*-stats	-1.55	2.30	1.57	-1.05	0.37	-0.69	-0.72	2.11
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.69	1.40	-0.36	0.43	0.30	-0.27	-0.22	1.10
SH *t*-stats	-2.01	2.92	-0.44	0.52	0.97	-1.00	-0.75	3.34
PM *t*-stats	-1.54	2.24	-0.32	0.39	0.80	-0.81	-0.59	2.73

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Table 5.8 (Continued) **Panel C: Japan**

Size-B/M and Industry Portfolios

Standard 3F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.10	-0.11	0.15	0.34				
SH *t*-stats	0.23	-0.25	0.74	1.28				
PM *t*-stats	0.21	-0.24	0.73	1.11				
Standard 4F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.01	0.07	0.29	0.59	1.28			
SH *t*-stats	-0.03	0.15	1.39	2.20	1.88			
PM *t*-stats	-0.02	0.14	1.36	1.95	1.74			
Decomposed 4F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.51	-0.23	0.19	0.28	0.86			
SH *t*-stats	1.18	-0.53	0.93	1.02	2.41			
PM *t*-stats	1.09	-0.50	0.94	0.95	2.21			
Decomposed 6F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.08	0.09	0.27	0.46	0.88	1.00	0.87	
SH *t*-stats	0.16	0.19	1.31	1.65	2.49	1.41	1.21	
PM *t*-stats	0.14	0.16	1.29	1.50	2.29	1.21	1.02	
Modified 7F	Υ_{0}	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.21	-0.05	0.11	0.42	0.37	0.38	0.80	1.07
SH *t*-stats	0.48	-0.11	0.73	2.00	1.58	1.31	2.47	1.63
PM *t*-stats	0.36	-0.09	0.56	1.70	1.44	1.20	2.27	1.14
Index 7F	Υ_{0}	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.25	0.07	0.36	0.09	0.50	0.32	0.64	1.25
SH *t*-stats	0.47	0.14	1.07	0.25	1.56	1.73	2.18	1.86
PM *t*-stats	0.41	0.13	0.91	0.23	1.11	1.57	1.76	1.54

Size-Momentum and Industry Portfolios

Standard 3F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.18	-0.22	0.36	0.06				
SH *t*-stats	0.39	-0.48	1.77	0.20				
PM *t*-stats	0.38	-0.49	1.76	0.18				
Standard 4F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.01	-0.02	0.37	0.23	0.33			
SH *t*-stats	-0.03	-0.05	1.81	0.72	1.04			
PM *t*-stats	-0.03	-0.05	1.79	0.70	1.02			
Decomposed 4F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.45	-0.33	0.38	0.00	0.40			
SH *t*-stats	1.06	-0.74	1.82	-0.01	0.98			
PM *t*-stats	1.02	-0.72	1.83	-0.01	0.94			
Decomposed 6F	Υ_{0}	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.05	0.05	0.38	0.14	0.65	0.43	0.08	
SH *t*-stats	0.12	0.12	1.77	0.41	1.67	1.13	0.20	
PM *t*-stats	0.12	0.11	1.77	0.41	1.55	1.08	0.18	
Modified 7F	Υ_{0}	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.37	-0.20	0.19	0.32	0.04	0.23	0.64	0.19
SH *t*-stats	0.85	-0.45	1.29	1.29	0.12	0.79	1.72	0.58
PM *t*-stats	0.82	-0.44	1.15	1.24	0.11	0.84	1.58	0.57
Index 7F	Υ_{0}	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.39	-0.11	0.34	0.06	0.46	0.07	0.49	0.21
SH *t*-stats	0.79	-0.21	1.01	0.15	1.21	0.32	1.29	0.64
PM *t*-stats	0.77	-0.18	0.89	0.15	0.91	0.30	1.07	0.64

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Table 5.8 (Continued) **Panel D: Canada**

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.12	0.79	-0.11	0.10				
SH *t*-stats	-0.58	2.19	-0.46	0.51				
PM *t*-stats	-0.56	2.04	-0.43	0.48				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.28	0.99	-0.25	0.14	0.66			
SH *t*-stats	-1.26	2.59	-1.02	0.67	1.16			
PM *t*-stats	-1.21	2.35	-1.00	0.68	1.02			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.13	0.71	-0.16	-0.08	0.37			
SH *t*-stats	-0.65	1.89	-0.67	-0.35	1.30			
PM *t*-stats	-0.63	1.75	-0.64	-0.32	1.08			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.25	0.86	-0.26	-0.01	0.30	0.35	0.64	
SH *t*-stats	-1.12	2.09	-1.08	-0.05	1.06	0.55	0.97	
PM *t*-stats	-1.09	1.76	-1.05	-0.05	0.88	0.42	0.78	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.31	0.87	-0.09	-0.03	0.22	0.01	0.17	0.41
SH *t*-stats	-1.40	2.07	-0.54	-0.12	0.97	0.06	0.67	0.74
PM *t*-stats	-1.27	1.76	-0.44	-0.10	0.74	0.06	0.53	0.58
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.15	0.88	-0.19	0.14	0.14	-0.05	0.14	0.43
SH *t*-stats	-0.68	1.98	-0.47	0.26	0.70	-0.20	0.54	0.76
PM *t*-stats	-0.52	1.58	-0.35	0.21	0.63	-0.13	0.38	0.54

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.09	0.60	0.10	-0.09				
SH *t*-stats	-0.58	1.83	0.39	-0.41				
PM *t*-stats	-0.30	1.39	0.27	-0.32				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.46	1.21	-0.36	0.07	1.54			
SH *t*-stats	-2.76	3.42	-1.31	0.27	4.97			
PM *t*-stats	-2.32	3.15	-1.23	0.29	4.33			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.11	0.91	0.15	0.28	-0.52			
SH *t*-stats	-0.67	2.44	0.55	0.97	-1.44			
PM *t*-stats	-0.38	1.32	0.39	0.37	-0.58			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.59	1.66	-0.40	0.34	0.21	2.20	0.39	
SH *t*-stats	-3.07	3.83	-1.32	1.04	0.53	4.94	0.72	
PM *t*-stats	-2.73	3.41	-1.30	0.96	0.49	4.40	0.67	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{W}
Estimate	-0.53	1.10	0.09	-0.51	0.09	0.14	0.04	1.
SH *t*-stats	-2.97	2.68	0.45	-1.73	0.30	0.52	0.12	4.
PM *t*-stats	-2.63	2.18	0.33	-1.55	0.25	0.45	0.08	3.
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{W}
Estimate	-0.57	0.91	0.62	-0.99	-0.36	0.71	0.05	1.
SH *t*-stats	-3.11	1.90	1.10	-1.40	-1.24	2.22	0.15	4.
PM *t*-stats	-2.63	1.64	0.92	-1.26	-0.81	1.64	0.10	3.

The results for the UK in Panel B of Table 5.8 show that the market premium for both sets of test portfolios and the momentum premium for size-momentum-industry portfolios are consistently priced. The size, value, and momentum factors for size-B/M-industry portfolios, and size and value factors for size-momentum-industry portfolios are not priced, except for the HML_b factor in the decomposed 4F model, which has a significant negative premium at the 10% significance level. The local factor results in Panel B of Table A4 are generally consistent. The risk premiums for the market and the momentum factors are not consistent with the average factor returns for the international sample in Table 3.4. Only the UK *WML* and WML_b premiums are close to their time-series averages. Moreover, the excess zero-beta rate is significantly different from zero in the international standard 4F and decomposed 6F models and all the local models, except the standard 3F model for size-momentum-industry portfolios.

The findings suggest that UK size-momentum-industry portfolios have lower average returns than these models predict. The UK results also support the integration hypothesis. Although the factor premiums for the international market and momentum factors are far from the time-series averages, the fewer number of significant excess zero-beta rates make the international models preferable to the local models. Moreover, contrary to the findings of Gregory et al. (2013a) the UK value premium is not priced while the market and momentum premiums are significantly priced.

For the tests of the international models in Japan in Panel C of Table 5.8, only the value premium is consistently priced for the size-B/M-industry portfolio returns, and for the size-momentum-industry portfolio returns, the *SMB* factor is priced in standard and decomposed models. The results are the same for the local models (Panel C of Table A4), except for the *SMB* premium in standard models for size-momentum-industry portfolio returns, which is not significant and the *SMM* factor in modified and index-based models, which is consistently priced. However, the average premiums for the local value factors are closer to their time-series averages compared to their international counterparts. The literature also reports that the value factor is significantly priced in the Japan. Moreover, similar factor pricing results together with R^2s in Tables 5.1 and 5.2 show that the international models perform as well as the local models for the Japanese portfolio returns.

For the Canadian results in Panel D of Table 5.8, the market premium is priced for both sets of test portfolios, while the momentum premium is only priced for the size-momentum-industry portfolio returns. The results are the same for the local models (Panel D of Table A4). For the international and local models, the excess zero-beta rate is negative and significant in the standard 4F, decomposed 6F, modified 7F, and index-based 7F models for size-momentum-industry portfolios. Interestingly, the zero-beta rate is lower than the risk-free rate only in the models with a momentum factor, and in each case the negative zero-beta rate is off-set by unusually higher and significant market premiums. Although, the market risk premium is higher than its sample average in Canada (Table 3.4) for almost all models, there are irreconcilable negative values for γ_0 even when it is not significant. Shanken and Zhou (2007) point out that in most cases the large negative (positive) zero-beta rates in excess of the risk-free rates are offset by the opposite value of the market risk premiums.

The pricing results of international and local models tested on international and country portfolios reveal that none of the factors are consistently priced. In fact, the factors that are priced not only change with the type of test portfolios, but also differ a great deal across different countries. Gregory et al. (2013a) also report that the factors are not reliably priced while switching portfolios within their UK dataset. Nevertheless, in most of the cases when the value or momentum factors are priced, they are priced for their respective test portfolios and they often have premiums close to their local time-series averages.

On the contrary, the market risk premium and size premium are rarely close to their international or local sample averages. In this regard, the factor prices are closer to their country sample averages than the international average values, even in tests of international models. This indicates that although the international factors that are priced are same as the local factors, which supports the integration of those factors, the local rather than international factors should be used for the pricing of country portfolio returns as they are better priced by these portfolios.

5.4 Some further Cross-Sectional Tests

So far, the cross-sectional analysis presented in this chapter has addressed all the major critiques of Lewellen et al. (2010) regarding the R^2 of the models. The augmentation of characteristic based portfolios with industry portfolios is one crucial step. However, following standard practice in the literature [Jagannathan and Wang (1998) and Shanken and Zhou (2007) among others], this section provides some basic cross-sectional results for the 25 size-B/M and the 25 size-momentum portfolios to highlight the effects of including industry portfolios. Additionally, the cross-sectional analysis of section 5.3 is also performed for the six additional models as described in section 4.5. However, consistent with the time-series tests, the models do not perform any better than the standard 3F and 4F models. Therefore, the results are not reported for the sake of brevity.

Panels A and B of Table 5.9 reproduce the results of Table 5.1 and Table 5.2 for the 25 size-B/M and the 25 size-momentum portfolios. In general, the R^2s of the models are higher for the size-B/M and size-momentum portfolios, compared to industry augmented sets of portfolios. However, the size-B/M portfolios for the UK and Canada have lower R^2 values for most of the models. Most importantly, the $\hat{Q}_c$ statistics has lower values for all the models across all samples and as a result there are fewer model rejections on the basis of the generalised $CSRT$ test compared to Tables 5.1 and 5.2. Lewellen et al. (2010) report similar differences in the $\hat{Q}_c$ statistics for the models tested only on size-B/M portfolios.

Table 5.9: Cross-Sectional R^2 and Specification Tests for the Models on 25 Size-B/M Portfolios and 25 Size-momentum Portfolios

This table presents the sample cross-sectional R^2 ($\hat{\rho}^2$) and the generalised *CSRT* (Q_c) of six beta pricing models. The models include the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on 25 size-B/M portfolios. *p*($\hat{\rho}^2$=0) is the *p*-value for the test of $H_0 : \hat{\rho}^2 = 0$; and *se*($\hat{\rho}^2$) is the standard error of $\hat{\rho}^2$ under the assumption that 0 < ρ2 < 1. '***', '**', '*' represent the level of statistical significance at the 1%, 5%, and 10%, respectively. For the $\hat{\rho}^2$, the significance level is for the test of $H_0 : \hat{\rho}^2 = 0$, and for the Q_c, it is for the approximate *F*-test of $H_0 : Qc = 0$.

Panel A	**International Factors**				**Local Factors**			
	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c
International								
Standard 3F	0.78*	0.08	0.14	0.12**	N/A	N/A	N/A	N/A
Standard 4F	0.85	0.07	0.12	0.07	N/A	N/A	N/A	N/A
Decomposed 4F	0.78**	0.09	0.14	0.11**	N/A	N/A	N/A	N/A
Decomposed 6F	0.86	0.08	0.10	0.07	N/A	N/A	N/A	N/A
Modified 7F	0.89	0.07	0.08	0.07	N/A	N/A	N/A	N/A
Index 7F	0.83	0.09	0.11	0.08	N/A	N/A	N/A	N/A
United States (US)								
Standard 3F	0.62	0.34	0.27	0.09	0.60	0.35	0.27	0.10
Standard 4F	0.79	0.26	0.16	0.06	0.80	0.25	0.14	0.07
Decomposed 4F	0.67	0.33	0.24	0.07	0.65	0.33	0.23	0.09
Decomposed 6F	0.81	0.27	0.14	0.05	0.82	0.27	0.13	0.05
Modified 7F	0.86	0.26	0.11	0.05	0.83	0.27	0.13	0.05
Index 7F	0.85	0.26	0.12	0.04	0.84	0.27	0.12	0.06
United Kingdom (UK)								
Standard 3F	0.19	0.86	0.38	0.07	0.19	0.86	0.37	0.07
Standard 4F	0.21	0.91	0.38	0.06	0.25	0.87	0.38	0.07
Decomposed 4F	0.21	0.91	0.39	0.07	0.26	0.89	0.41	0.07
Decomposed 6F	0.26	0.96	0.37	0.06	0.38	0.90	0.40	0.05
Modified 7F	0.44	0.87	0.36	0.05	0.55	0.81	0.32	0.05
Index 7F	0.31	0.96	0.36	0.05	0.53	0.82	0.33	0.04
Japan								
Standard 3F	0.77	0.06	0.15	0.07	0.80	0.06	0.14	0.06
Standard 4F	0.84	0.05	0.11	0.05	0.87	0.05	0.10	0.04
Decomposed 4F	0.79	0.06	0.14	0.06	0.81	0.06	0.13	0.06
Decomposed 6F	0.84	0.06	0.11	0.05	0.87	0.06	0.10	0.04
Modified 7F	0.87	0.06	0.09	0.05	0.89	0.05	0.09	0.04
Index 7F	0.91	0.05	0.07	0.04	0.90	0.05	0.08	0.05
Canada								
Standard 3F	0.10**	0.76	0.20	0.12**	0.19*	0.51	0.25	0.11*
Standard 4F	0.16**	0.75	0.23	0.11*	0.26	0.46	0.24	0.10*
Decomposed 4F	0.12**	0.83	0.20	0.11*	0.21*	0.57	0.26	0.11*
Decomposed 6F	0.38	0.47	0.28	0.06	0.29	0.63	0.24	0.09*
Modified 7F	0.23**	0.87	0.24	0.10**	0.52	0.26	0.20	0.07
Index 7F	0.46	0.43	0.32	0.04	0.40	0.44	0.22	0.09*

(Continued overleaf)

Panel A	International Factors				Local Factors			
	$\widehat{\rho}^2$	$p(\widehat{\rho}^2=0)$	$se(\widehat{\rho}^2)$	Q_c	$\widehat{\rho}^2$	$p(\widehat{\rho}^2=0)$	$se(\widehat{\rho}^2)$	Q_c
International								
Standard 3F	0.65**	0.01	0.16	0.25***	N/A	N/A	N/A	N/A
Standard 4F	0.78***	0.01	0.12	0.24***	N/A	N/A	N/A	N/A
Decomposed 4F	0.77*	0.01	0.14	0.15***	N/A	N/A	N/A	N/A
Decomposed 6F	0.83***	0.01	0.11	0.21***	N/A	N/A	N/A	N/A
Modified 7F	0.83**	0.01	0.12	0.15***	N/A	N/A	N/A	N/A
Index 7F	0.81***	0.02	0.11	0.18***	N/A	N/A	N/A	N/A
United States (US)								
Standard 3F	0.85*	0.02	0.10	0.17***	0.85**	0.02	0.10	0.17***
Standard 4F	0.87**	0.02	0.10	0.16***	0.86**	0.02	0.10	0.16***
Decomposed 4F	0.89	0.02	0.09	0.10	0.87**	0.02	0.10	0.13**
Decomposed 6F	0.92**	0.02	0.07	0.11**	0.92**	0.02	0.07	0.11**
Modified 7F	0.92	0.02	0.08	0.07	0.92	0.02	0.07	0.09**
Index 7F	0.89*	0.03	0.10	0.07	0.91	0.02	0.07	0.09
United Kingdom (UK)								
Standard 3F	0.59***	0.00	0.16	0.39***	0.70**	0.00	0.12	0.32***
Standard 4F	0.78***	0.00	0.07	0.37***	0.77***	0.00	0.07	0.42***
Decomposed 4F	0.67*	0.00	0.20	0.16***	0.74**	0.00	0.09	0.28***
Decomposed 6F	0.84**	0.00	0.06	0.23***	0.83***	0.00	0.06	0.30***
Modified 7F	0.85	0.00	0.06	0.13**	0.82***	0.00	0.08	0.13***
Index 7F	0.81***	0.00	0.08	0.17***	0.80***	0.00	0.07	0.21***
Japan								
Standard 3F	0.82	0.15	0.15	0.05	0.67	0.16	0.33	0.05
Standard 4F	0.82	0.17	0.15	0.05	0.84	0.16	0.14	0.05
Decomposed 4F	0.83	0.16	0.14	0.05	0.76	0.19	0.20	0.05
Decomposed 6F	0.83	0.20	0.14	0.05	0.87	0.18	0.13	0.04
Modified 7F	0.85	0.19	0.12	0.05	0.88	0.18	0.12	0.04
Index 7F	0.86	0.19	0.12	0.04	0.88	0.18	0.11	0.04
Canada								
Standard 3F	0.36***	0.02	0.19	0.18***	0.30***	0.19	0.29	0.20***
Standard 4F	0.80***	0.00	0.07	0.19***	0.83***	0.00	0.06	0.26***
Decomposed 4F	0.67	0.00	0.24	0.05	0.31**	0.63	0.37	0.19***
Decomposed 6F	0.89***	0.00	0.05	0.10*	0.92**	0.00	0.03	0.13***
Modified 7F	0.89	0.00	0.06	0.07	0.87**	0.00	0.06	0.16***
Index 7F	0.85***	0.00	0.06	0.14***	0.87**	0.00	0.06	0.18***

In short, augmenting the characteristics based portfolios with industry portfolios in the main analysis yields the desired results as outlined by Lewellen et al. (2010). The inclusion of industry portfolios relaxes the tight factor structure of the size-B/M and size-momentum portfolios. As a result, the model R^2 and specification test results are more realistic, as they are no longer driven by only size, value, and momentum characteristics. Moreover, the evidence of the higher R^2 and better specification test results in Table 5.9, result in the consistent and reliable pricing of the size, value and momentum factors for the size-B/M and size-momentum portfolios. However, for the sake of brevity the factor pricing results for the size-B/M and size-momentum portfolios are not reported.

5.5 Conclusion

In this chapter, I analyse the cross-sectional performance of six asset pricing models. The models include standard versions of the 3F and 4F models, decomposed versions of 3F and 4F models using Fama and French (2012) type decomposition, and modified 7F and index-based 7F models of Cremers et al. (2013). The other main contribution of this chapter is to examine the cross-sectional performance of the international factor models, which has not yet been examined. Tests of the international models provide an opportunity to test their level of integration. Further, one of the empirical contributions of this chapter is that the chapter applies recently developed cross-sectional regression tests developed by Kan et al. (2013) and presents asymptotically robust tests for the R^2. The standard errors used are also adjusted for the potential model misspecification.

The main analysis is based on two sets of 44 portfolios, each including 19 industry portfolios and 25 size-B/M or 25 size-momentum portfolios. The industry augmented portfolios are used because of the recommendation Lewellen et al. (2010) that besides testing models using characteristics based portfolios (such as size-B/M), the test portfolios should also include some assets that are not sorted by the same factor characteristics. Keeping in view the sceptical approach of Lewellen et al. (2010) regarding cross-sectional tests, I adopt the following remedies to resolve their criticisms. First, along with point estimates of the R^2, *p*-values for the null hypotheses whether R^2 is equal to zero and one are examined. Second, while analysing the model performance, the cross-sectional intercepts should be zero. Third, the implied risk premium on any factor should have economic meaning, that is, it should be close to its time-series sample mean.

The results show that the international factor models do not perform well for the international portfolios, a result consistent with the time-series tests. However, the size factor and its modifications are priced consistently by both the size-B/M-industry and size-momentum-industry portfolios, and momentum is priced for size-momentum-industry portfolios. For the country portfolios, the international factor models perform almost as well as the local models, which indicates that the international models show evidence of integration across the four countries in cross-sectional tests. However, the country factors are priced more accurately and reliably than the international factors. The local factors that are reliably priced include the momentum factor for US size-momentum-industry portfolios, the market and momentum premiums for the UK, the value premium for the Japanese size-B/M-industry portfolios, and the market premium for Canada.

There are some changes in the results with alternative sets of tests assets, namely 25 size-B/M and size-momentum portfolios. As expected, the explanatory power of the models increases significantly, and there are fewer model rejections. Thus, the selection of test portfolios matters quite a lot in assessing cross-sectional model performance, as argued by Lewellen et al. (2010).

For individual models, the standard 3F and decomposed 4F models are the worst performers. These two models omit the momentum factor and they are dominated by other models. Therefore, the standard 3F and decomposed 4F models should not be used as there are better alternatives available for these models. Although, the standard 4F model is not significantly dominated by other models, the model has lower explanatory power compared to the decomposed 6F, modified 7F, and index-based 7F models. Therefore, these models should be preferred over the standard 4F model. However, the decomposed 6F, modified 7F, and index-based 7F models are indistinguishable from each other in terms of R^2.

The results presented have wider implications for a variety of users. The investors, fund managers, and regulators as well as researchers are always interested in which factors carry the risk premia in the cross-section of stock returns, and whether the alternative pricing models tested here really outperform the standard 3F and 4F models. The results show that the risk premia estimation is not consistent across the models. However, the alternative models, i.e. decomposed 6F, modified 7F, and index-based 7F models, significantly outperform the standard 3F and 4F models. Therefore, these models should be used for the estimation of expected stock returns and other practical applications instead of standard 3F and 4F models.

The factor risk premia studied in this chapter are also used to calculate the cost of equity for the firms. Therefore, it is important to identify a relatively better model for the calculation of cost of equity. Using cross-sectional asset pricing methodology, I show that alternative models are better than the standard 3F and 4F model for that purpose. For these models, if any factor is priced in a sample, it is priced consistently for these three models. Therefore, what matters most is that the decomposed factors should be used, regardless of their decomposition method. Moreover, it is important to to calculate the cost of equity using local country factors, rather than regional or interntional factors. Thus, practitioners should use these higher factor models to calculate the cost of equity for the firms.

Chapter 06: Innovations in State Variables and Size, Value, and Momentum Factors

6.1 Introduction and motivation

"Theorists develop models with testable predictions; empirical researchers document "puzzles" – stylized facts that fail to fit established theories – and this stimulates the development of new theories." Campbell (2000, p. 1515)

This chapter builds on the results of Chapters 4 and 5. Chapter 4 tests alternative asset pricing models using time-series methodology, along the lines of Fama and French (1993, 1996, 2012), and show that these alternative models outperform traditional 3F and 4F models. The time-series approach is used to show whether the asset pricing models considered can explain average portfolio returns. Chapter 5 uses the cross-sectional methodology of Fama and Macbeth (1973) to examine the factors that are priced by the test portfolios and to compare directly the pricing power of competing models. However, similar to Fama and French (1993, 1996), the alternative size, value, and momentum factors used are empirically motivated and lack economic justification. This chapter attempts to fill that gap by examining the relation between macroeconomic state variables and empirically motivated return based factors. Specifically, this chapter examines the extent to which stock returns are explained by financial economic theory in light of the recent developments in asset pricing. The chapter also aims to investigate the reliability of prior empirical findings and to study whether common anomalous puzzles remain unexplained. Finally, the chapter analysis how much support can be offered to the current empirical literature from the financial economic theory. The relation between stock returns and risk is of particular interest not only for researchers but also because it is at the very heart of all investment decisions as asset pricing models are used for risk adjustment and to compare the performance of different investment strategies. Thus, this chapter examines whether trading strategies based on size, B/M and momentum have any economic explanations.

Even though the asset pricing models of Sharpe (1964), Ross (1976) and Breeden (1979) make significant contributions to the asset pricing literature, Schwert (2003) notes that: "Researchers have developed extensions of the asset-pricing models that include multiple factors, although none of these models match closely with the empirical 3F model" Schwert (2003, p. 964). Although Schwert's (2003) statement appears to support the Fama and French (1993) 3F model, such empirically motivated asset pricing models face challenges in terms of their economic interpretations. However, despite the fact that the 3F model and its 4F extension have been found to be empirically satisfactory, the factors in these model are selected based on empirical results, and there is a lack of economic theory to support them [Fama and French (1993), Carhart (1997)]. Fama and French (1995) attempt to provide this economic interperation by arguing that these factors are related to firm profitability. Fama and French (1993) and Fama and French (1996) argue that the 3F model is an ICAPM model but that the state variables for the size and value factors still need to be established.

The link between the macroeconomic variables and size, value and momentum factors can be examined under both ICAPM and APT. Both models admit macroeconomic state variables as candidate factors, but they differ in inspiration about which variables to include [Cochrane (2001)]. The APT suggests that one start with a statistical analysis of the covariance matrix of returns and stresses the pervasive factors in random returns as the key determinants, whereas the ICAPM suggests that one start by thinking about state variables that describe the conditional distribution of future asset returns and non-asset income. Nevertheless, these two categories of variables are not always distinct: the set of state variables of the ICAPM can be identical to the set of pervasive factors of the APT.

In empirical terms, the ICAPM has one fixed risk factor, the market portfolio. In the APT the market portfolio is not necessarily a risk factor as APT assumes that an investor is perfectly well diversified and hence the only sources of risk are common factors. In the ICAPM, portfolios do not have to be perfectly diversified, nor does the market portfolio or the portfolios having the highest correlation with the state variables, hence we could interpret the risk from the market portfolio as arising from imperfect diversification. If all portfolios are perfectly diversified and the state variables equal the common factors, the ICAPM collapses to the APT [Fama (1996)]. Therefore, the APT and ICAPM are often treated alike, despite their different economic foundations [Constantinides and Malliaris (1995)].

As the Fama and French (1993) size and value factors and Carhart's (1997) momentum factor are empirically motivated, Campbell (2000) and Cochrane (2001) highlight the need to examine the association between macroeconomic variables and these return based factors. They also argue that the economic models motivated from ICAPM are a possible way to proceed. A vast literature has since emerged examining the relationship between size and value factors and shocks to some macroeconomic state variables, which measure the changes in the investment opportunity set [for future GDP growth see Lettau and Ludvigson (2001) and for default risk and the term structure see Hahn and Lee (2006) and Petkova (2006)]. The *HML* factor is shown to capture distress risk as it is related to the shocks in the term structure and future economic growth [Liew and Vassalou (2000) and Petkova (2006)], and the *SMB* factor is shown to capture shocks in default spreads [Petkova (2006)]. Researchers have also linked the *WML* factor with industry effects, market dynamics, and industrial production growth [Moskowitz and Grinblatt (1999), Cooper et al. (2004), Asem and Tian (2010) and Liu and Zhang (2008)].

Petkova (2006) argues that news about future GDP growth is not a sole measure of changes in financial investment opportunities. In this regard, Campbell (1996) comments that empirical implementations of the ICAPM model should not rely on choosing key macroeconomic variables. Instead, the factors in the model should be related to innovations in state variables that forecast future investment opportunities.

Petkova (2006) suggests a model that includes excess market return and innovations to the dividend yield, term spread, default spread and the one-month T-bill rate and reports that these state variables capture Fama and French's (1993) *SMB* and *HML* factor returns in the context of the ICAPM. She obtains the innovations to state variables from a VAR model. Campbell (1991) argues that a VAR model structure can be used to study the empirical implications of the ICAPM, and the factors used in the ICAPM should be shocks to state variables that predict future returns and not just any set of factors that are correlated with returns. Petkova (2006) shows that the ICAPM model outperforms the 3F model in cross-sectional tests and the influence of *SMB* and *HML* on stock returns disappears in the presence of state variable innovations. It shows that the Fama and French factors proxy for the state variable innovations and the innovations based ICAPM model can replace the 3F model.

The asset pricing literature reports that the dividend yield, term spread, default spread and the one-month T-bill rate forecast future investment opportunities and are related to expected stock returns [Chen et al. (1986), Fama and French (1993), Campbell (1996), and Ferson and Harvey (1999) among others]. Moreover, Petkova (2006) argues that these variables model two important aspects of the investment opportunity set, the yield curve and the conditional distribution of asset returns. She also points out that the T-bill rate and term spread capture the level and slope of the yield curve, which are the two most important factors driving the term structure of interest rates [Litterman and Scheinkman (1991)]. In asset pricing literature, the dividend yield is shown to be related to the expected future returns of the stock [Chen et al. (1986), Fama and French (1988)]. Moreover, Chen et al. (1986) argue that the default spread measures the business conditions, which is the spread is likely to be high when conditions are poor and low when they are strong. Additionally, Keim and Stambaugh (1986) find that a default spread indeed forecasts returns on bonds as well as stocks. Therefore, this chapter uses innovations to these four state variables obtained using a VAR model as proxies for future investment opportunities to explain the size, value, and momentum factor returns.

Moreover, this chapter provides an out-of-sample test for Petkova's (2006) results and responds to the critique of Lewellen et al. (2010) regarding the use of characteristics based test portfolios, and point estimates of cross-sectional R^2 to assess model performance. This chapter extends Petkova's (2006) work using the US, UK, Japanese, and Canadian stock market data, industry augmented test portfolios, and newly developed statistical tests of Kan et al. (2013), which are robust to model misspecification and allow hypothesis testing of the cross-sectional R^2.

The remainder of this chapter is structured as follows: Section 6.2 describes the data, the sample selection, and methodology. Section 6.3 reports the empirical results for cross-sectional pricing tests. Finally, Section 6.4 summarizes and concludes.

6.2 Empirical Framework

6.2.1 Data

The data for the test asset portfolios and risk-based factors are the same as in previous chapters and discussed in detail in chapter 3. Following Petkova (2006), the four state variables used are the market dividend yield (DY_t), the difference between the yields on a 10-year government bond and three-month T-bill (term spread, $TERM_t$), the difference between the yields on a long-term corporate bond and long-term government bond (default spread, DEF_t), and the three-month T-bill yield (RF_t). Dividend yield, DY_t, is computed as the dividend yield of the value-weighted portfolio of all the stocks in a market, computed following Petkova (2006) as the sum of dividends over the last 12 months divided by the level of the index. US bond data is obtained from the FRED® database of the Federal Reserve Bank of St. Louis. Bond data for other countries is obtained from DataStream. The corporate bond yield of the UK, Japan, and Canada is provided by the Economist magazine until September 2011[16]. For the UK

[16] The series was discontinued in September 2011, data last accessed on 13/01/2015.

and Japan, the BBB rated corporate bond yield provided by DataStream is used for the post September 2011 period, whilst for Canada, the US BBB rated corporate bond yield is used[17] as the DataStream BBB rated bond yield is not available for Canada.

6.2.2 Econometric Approach

To proxy for changes in the investors' investment opportunities, I define the time series dynamics of state variables for each market and then jointly estimate an unexpected component (innovation) for each variable. Following Petkova (2006), I specify a VAR model for the state variables. The vector of state variables is augmented with the factor returns that comprise each of the six models tested in Chapters 4 and 5. It enables a joint specification of the time-series dynamics of all variables with respect to each model. The first element of the vector is the simple market excess returns, $R_{MKT,t}$, or the index-based excess market returns, $R_{INDMKT,t}$, depending on the model, followed by dividend yield (DY_t), term spread ($TERM_t$), default spread (DEF_t), and risk-free rate (RF_t), in this order. A first-order VAR model is used based on the Akaike Information Criterion (AIC). The VAR (1) model can be written as follows:

$$\left\{\begin{matrix} R_{MKT,t}\ (R_{INDMKT,t}) \\ DY_t \\ TERM_t \\ DEF_t \\ RF_t \\ R_{RBF,t} \end{matrix}\right\} = \left\{\begin{matrix} R_{MKT,t-1}\ (R_{INDMKT,t-1}) \\ DY_{t-1} \\ TERM_{t-1} \\ DEF_{t-1} \\ RF_{t-1} \\ R_{RBF,t-1} \end{matrix}\right\} + \mu_t \quad , \tag{6.1}$$

where $R_{RBF,t}$ represents the vector of return based factors from each of the six models, which are specified in Chapter 4 equations (4.7) to (4.12). μ_t is a residual vector that contains the innovation series for each element of the VAR (1) model with respect to the information set at time t – 1.

[17] The correlation between the yield on US BBB rate bond and corporate bond yield for Canada provide by the Economist magazine is above 0.90 until September 2011.

These time-series of innovations represent the shocks to state variables and returns based factors and are denoted by μ_t^{DY}, μ_t^{TERM}, μ_t^{DEF}, μ_t^{RF}, and μ_t^{RBF}.

Similar to Campbell (1996), the VAR system is triangularized with respect to the excess market returns, so that innovations in $R_{MKT,t}$ ($R_{INDMKT,t}$) are unaffected, the orthogonalised innovations in DY_t are the component of original DY_t innovations orthogonal to $R_{MKT,t}$ $(R_{INDMKT,t})$, and so on for each of the state variable innovations. The orthogonalisation removes the high correlation between the dividend yield and market excess returns and allows the interpretation of the innovation series as shocks to the state variables which are independent of the excess market returns. Petkova (2006) also argues that after the orthogonalisation, the market beta in the multiple time-series regressions will be equal to the market beta estimated in an univariate regression. This allows direct observation of whether the state variable innovations have explanatory power incremental to the market return. Following Campbell (1996) and Petkova (2006), all the innovations are scaled to have the same variance as $R_{MKT,t}$ $(R_{INDMKT,t})$. To test whether an asset's exposure to state variable innovations are important determinants of average stock returns as suggested by the ICAPM, the cross-sectional regression methodology of Kan et al. (2013) is used to estimate the prices of risk.

6.3 Empirical Results

Petkova (2006) and Kan et al. (2013) report that the innovations based model (hereafter the ICAPM model) performs better than the standard 3F model in the cross-sectional asset pricing tests for the US. The main purpose of this section is to compare the performance of a range of factor models with ICAPM models using international data. Moreover, Petkova (2006) argues that the size and value factors are correlated with the innovations in the state variables. Chordia and Shivakumar (2002) also associate momentum profits with the state variable innovations and report that these vanish after adjusting for the innovations. However, most of these studies are based on US data. This chapter extends to the international dataset and attempts to identify any association between the standard, decomposed, modified and index-based versions of the size, value, and momentum factors and innovations to variables that describe the investment opportunity set. These factor models perform quite well in explaining the average portfolio returns as seen in Chapter 5.

6.3.1 Relation between Return Based Factors and the State Variable Innovations

Following Petkova (2006), this subsection examines the joint distribution of size, value, and momentum factors and the innovations to DY_t, $TERM_t$, DEF_t, and RF_t. To test whether standard, decomposed, modified and index-based factors proxy for state variable innovations, each innovation obtained from the VAR model, i.e. $\hat{\mu}_t^{DY}$, $\hat{\mu}_t^{TERM}$, $\hat{\mu}_t^{DEF}$, and $\hat{\mu}_t^{RF}$, is regressed on the six factor models which are nested in following general equation for a time-series regression:

$$\hat{\mu}_t = c_0 + c_{MKT} R_{MKT,t} \left(R_{INDMKT,t}\right) + \sum_{k=1}^{K} c_k R_{RBF,t}^{k}, \tag{6.2}$$

where $k = 1 \ldots K$ represents the number of factors in a returns based model. The results for these time-series regressions are presented in Table 6.1.

Focussing first on the US market, replicating the study of Petkova (2006), $\hat{\mu}_t^{DY}$ has a significant negative relationship with the WML_b and WML returns for the decomposed 6F and modified 7F models, respectively. This contrasts with Petkova (2006) who found that $\hat{\mu}_t^{DY}$ covaries with HML returns, though she did not study the momentum premium. Further, $\hat{\mu}_t^{RF}$ is significantly negatively related to size factor returns for all models except the modified 7F model. Petkova (2006) and Hahn and Lee (2006) report that size factor is related to changes in the default spread not the risk-free rate. $\hat{\mu}_t^{RF}$ is also related to value factor returns in the different models, but the relationship is not stable as the sign of the coefficients is not consistent.

Table 6.1: Innovation in state variables regressed on return based risk factors

This table presents time-series regressions of innovations in dividend yield ($\hat{\mu}_t^{DY}$), term spread ($\hat{\mu}_t^{TERM}$), default spread ($\hat{\mu}_t^{DEF}$), and 3-month T-bill yield ($\hat{\mu}_t^{RF}$) on the Standard 3F and 4F models, Decomposed 4F and 6F models, modified 7F model, and index-based 7F model. The innovations to the state variables are computed by the VAR system in equation (6.1). '***', '**', '*' are level of statistical significance for the *t*-statistics that the coefficient is zero at the 1%, 5%, and 10% level. The *t*-statistics are corrected for heteroskedasticity and autocorrelation using the Newey–West estimator with 5 lags, selected using the Akaike information criterion.

		International				United States (US)			
	Dep Var	μ^{DIV}	μ^{TERM}	μ^{DEF}	μ^{RF}	μ^{DIV}	μ^{TERM}	μ^{DEF}	μ^{RF}
Standard 3F	c_0	0.04	-0.08	0.06	0.04	0.00	-0.01	0.02	0.08
	c_{MKT}	-0.01	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	c_{SMB}	-0.19*	0.29**	-0.27*	-0.08	0.05	0.07	-0.05	-0.21
	c_{HML}	-0.05	0.10	-0.06	-0.08	-0.02	0.00	-0.06	-0.20**
Standard 4F	c_0	0.02	-0.05	0.09	0.04	0.05	0.02	0.06	0.05
	c_{MKT}	0.00	0.01	-0.02	-0.01	-0.03	-0.02	-0.02	-0.01
	c_{SMB}	-0.19*	0.29**	-0.24*	-0.07	0.07	0.07	-0.02	-0.20**
	c_{HML}	-0.03	0.07	-0.06	-0.07	-0.06	-0.02	-0.09	-0.16*
	c_{WML}	0.03	-0.04	-0.06	0.00	-0.08	-0.03	-0.07	0.04
Decom 4F	c_0	0.02	-0.01	-0.08	0.19	-0.02	0.01	0.03	0.14
	c_{MKT}	0.01	-0.02	0.07	-0.10	-0.01	-0.02	-0.01	-0.04
	c_{SMB}	-0.14	0.18	-0.08	-0.29**	0.08	0.04	-0.05	-0.26**
	c_{HML_s}	0.06	-0.16	0.38**	-0.45***	0.02	-0.04	-0.05	-0.22**
	c_{HML_b}	-0.11	0.25*	-0.39**	0.36***	-0.05	0.05	-0.02	0.02
Decom 6F	c_0	-0.01	-0.05	-0.01	0.23	0.08	0.00	0.08	0.13
	c_{MKT}	0.01	-0.03	0.07	-0.09	-0.03	-0.02	-0.03	-0.04
	c_{SMB}	-0.12	0.22*	-0.07	-0.31***	0.14*	0.09	-0.04	-0.27
	c_{HML_s}	0.07	-0.17	0.38***	-0.42***	0.04	-0.01	-0.06	-0.23
	c_{HML_b}	-0.10	0.24*	-0.40***	0.34**	-0.11	-0.01	-0.03	0.07
	c_{WML_s}	0.05	0.22**	-0.18*	-0.24**	-0.26***	0.02	-0.07	0.00
	c_{WML_b}	-0.02	-0.22***	0.09	0.23**	0.15	-0.07	0.00	0.04
Modified 7F	c_0	0.00	-0.02	0.01	0.16	0.03	-0.03	0.10	0.17
	c_{MKT}	0.01	0.01	0.03	-0.06	-0.03	0.01	0.00	-0.04
	c_{SMM}	-0.13	0.29	-0.05	-0.28	-0.06	0.08	0.34*	-0.13
	c_{MMB}	-0.10	0.11	-0.15	-0.33*	0.05	-0.05	-0.30	-0.21
	c_{SHML}	0.14	-0.11	0.21	-0.30*	0.09	0.23	-0.08	-0.46***
	c_{MHML}	-0.04	-0.08	0.07	-0.11	-0.20	-0.36**	0.00	0.38
	c_{BHML}	-0.16	0.30	-0.33*	0.49***	0.01	0.14	0.10	-0.03
	c_{WML}	0.01	-0.04	-0.04	-0.03	-0.10*	-0.07	-0.06	0.07
Index-based 7F	c_0	-0.04	-0.06	0.10	0.11	0.03	0.03	0.14	0.10
	c_{INDMKT}	0.01	0.01	-0.01	-0.04	-0.02	-0.02	-0.03	-0.02
	c_{INDSMM}	0.08	0.23	-0.25	-0.17	-0.18	-0.08	0.28	0.00
	c_{INDMMB}	-0.22**	0.18*	-0.09	-0.28**	0.06	0.11	-0.39*	-0.28*
	$c_{INDSHML}$	0.41*	-0.03	-0.15	-0.34*	0.01	-0.13	-0.01	-0.20
	$c_{INDMHML}$	-0.37*	-0.15	0.36**	0.11	-0.02	0.04	-0.14	0.07
	$c_{INDBHML}$	-0.10	0.24	-0.25	0.25*	-0.06	0.05	0.17	0.00
	c_{WML}	-0.01	-0.01	-0.05	-0.06	-0.09	-0.02	-0.05	0.07

(Continued overleaf)

		United Kingdom (UK)				**Japan**				**Canada**			
	Dep Var	μ^{DIV}	μ^{TERM}	μ^{DEF}	μ^{RF}	μ^{DIV}	μ^{TERM}	μ^{DEF}	μ^{RF}	μ^{DIV}	μ^{TERM}	μ^{DEF}	μ^{RF}
Standard	c_0	0.00	0.00	0.00	0.01	0.00	-0.05	-0.18	-0.07	-0.06	-0.03	-0.01	0.05
	c_{MKT}	0.00	0.00	-0.01	0.02	0.01	0.01	0.06	0.02	0.03	0.02	-0.01	-0.02
	c_{SMB}	-0.02	0.08	0.02	-0.03	-0.17*	0.24*	-0.08	0.05	0.12	-0.12	0.24*	0.09
	c_{HML}	-0.02	0.00	0.01	-0.06	0.04	0.04	0.37*	0.13	0.11	0.06	0.04	-0.08
Standard 4F	c_0	-0.01	0.01	-0.08	0.00	0.01	-0.05	-0.16	-0.07	-0.26	0.05	0.03	-0.05
	c_{MKT}	0.00	0.00	-0.02	0.02	0.01	0.01	0.05	0.02	0.01	0.03	-0.01	-0.03
	c_{SMB}	-0.02	0.08	0.01	-0.03	-0.19*	0.23*	-0.11	0.05	0.12	-0.12	0.24*	0.08
	c_{HML}	-0.02	0.00	0.03	-0.06	0.05	0.04	0.40**	0.12	0.12*	0.06	0.03	-0.08
	c_{WML}	0.01	-0.02	0.10	0.01	-0.09	-0.01	-0.18*	0.02	0.16**	-0.07	-0.03	0.08
Decom 4F	c_0	0.00	0.00	0.00	0.02	0.03	-0.10	-0.15	-0.08	-0.06	-0.03	-0.02	0.04
	c_{MKT}	0.00	-0.01	-0.01	0.00	0.01	0.02	0.06	0.02	0.03	0.02	-0.01	-0.01
	c_{SMB}	-0.02	0.07	0.02	-0.06	-0.09	0.12	0.00	0.03	0.16	-0.11	0.26*	0.12
	c_{HML_s}	0.00	-0.03	0.00	-0.11	0.28	-0.39**	0.43**	-0.02	0.10*	0.04	0.04	0.01
	c_{HML_b}	-0.03	0.03	0.00	0.05	-0.19**	0.37	-0.02	0.13	0.01	0.01	0.00	-0.09
Decom 6F	c_0	-0.02	-0.04	-0.18	0.05	0.05	-0.12	-0.14	-0.05	-0.24	0.05	0.11	-0.05
	c_{MKT}	0.00	-0.01	-0.02	0.00	0.00	0.02	0.05	0.01	0.02	0.03	-0.02	-0.02
	c_{SMB}	-0.02	0.05	-0.04	-0.04	-0.11	0.10	-0.04	0.03	0.15	-0.11	0.27**	0.12
	c_{HML_s}	0.01	-0.04	0.00	-0.10	0.27**	-0.39**	0.41**	-0.03	0.12**	0.04	0.05	0.02
	c_{HML_b}	-0.02	0.02	0.01	0.05	-0.18*	0.38	0.02	0.11	0.01	0.02	-0.02	-0.09
	c_{WML_s}	0.02	0.12	0.27**	-0.06	-0.09	0.18	-0.08	-0.24**	0.06	-0.03	-0.12	0.05
	c_{WML_b}	-0.01	-0.13	-0.17**	0.07	0.01	-0.16	-0.08	0.19**	0.09	-0.04	0.06	0.03
Modified 7F	c_0	-0.02	0.03	-0.11	0.06	-0.05	-0.14	-0.12	-0.17	-0.18	0.06	-0.02	-0.08
	c_{MKT}	0.01	0.00	-0.03	-0.01	0.02	0.00	0.07	0.02	0.07	0.05	-0.03	-0.03
	c_{SMM}	-0.05	0.16	-0.10	-0.11	0.19	0.21	0.16	0.53**	-0.17	-0.24	0.32**	0.18
	c_{MMB}	0.01	0.00	0.10	-0.02	-0.37**	0.07	-0.20	-0.30**	0.20**	-0.04	0.12	0.04
	c_{SHML}	0.06	-0.09	0.09	-0.24**	0.14	-0.10	-0.12	0.02	0.09	0.07	0.04	0.02
	c_{MHML}	-0.07	0.08	-0.09	0.15*	0.17	-0.46***	0.88***	0.00	0.18**	0.02	-0.12	-0.07
	c_{BHML}	-0.04	0.03	0.07	-0.01	-0.02	0.55*	-0.18	0.24**	-0.01	0.02	0.03	-0.06
	c_{WML}	0.00	-0.02	0.11	0.01	-0.08	-0.08	-0.09	-0.03	0.16**	-0.07	-0.04	0.08
Index-based 7F	c_0	-0.01	0.02	-0.08	0.02	-0.01	-0.04	-0.16	-0.05	-0.18	0.15	-0.08	-0.13
	c_{INDMKT}	0.01	0.01	-0.03	-0.02	-0.04	0.02	0.05	-0.01	0.05	0.04	-0.01	-0.03
	c_{INDSMM}	-0.07	0.23	-0.08	-0.19	0.06	0.17	0.17	0.28	-0.28	-0.35	0.35*	0.20
	c_{INDMMB}	-0.02	0.01	-0.01	-0.01	-0.72***	0.12	-0.25	-0.33**	-0.02	-0.03	0.12	0.03
	$c_{INDSHML}$	0.10	-0.06	-0.01	-0.19*	0.27	-0.26	0.02	-0.13	0.09	-0.04	0.14	0.05
	$c_{INDMHML}$	-0.09*	0.05	-0.10	0.05	0.05	-0.32*	0.97***	0.09	0.17*	0.15	-0.22*	-0.15
	$c_{INDBHML}$	-0.07	0.05	0.09	0.07	0.11	0.30*	-0.06	0.15	0.00	-0.01	0.05	-0.03
	c_{WML}	0.01	-0.04	0.12	0.02	-0.14	-0.02	-0.14*	-0.01	0.14	-0.09	-0.04	0.09

Moreover, $\hat{\mu}_t^{TERM}$ is significantly negatively related only to *MHML* returns for the modified 7F model, while $\hat{\mu}_t^{DEF}$ is related positively to *SMM* returns and negatively to *MMB* returns for the modified 7F and index-based 7F models, respectively. The results for the international sample, UK, Japan, and Canada are more mixed and unclear compared to the US. There are very few innovations that are related to the same risk factor across different models, which shows that the relation between return based factors and state variable innovations is not consistent across different construction methods. Hence, it is not possible to conclude that any individual return based factor proxies for some specific state variable innovation. Nevertheless, $\hat{\mu}_t^{DY}$ is significantly positively related to the returns on the size factors for the international sample and Japan and the value factors for Canada, across the different models. For the international sample, $\hat{\mu}_t^{TERM}$ and $\hat{\mu}_t^{DEF}$ are significantly positively and negatively related to size factor returns, respectively. For Canada, $\hat{\mu}_t^{DEF}$ is significantly positively related to the size factor returns as well. For all other innovations in all markets, the sign of the relationship is not consistent across different models even if there are significant coefficients. These results show that the innovations to state variable are related to both the *SMB* and *HML* factor returns and the returns on their alternative components. However, in most cases, the direction of the relationship is not consistent across different models. On the other hand, there is not enough statistical evidence to support a relation between the state variable innovations and momentum factor returns. The results remain unchanged if the innovations to returns based factors obtained from the VAR systems are used as independent variables instead of the factors themselves.

The empirical literature on the size and value premiums states that small stocks and value stocks are inclined to be more distressed because of their high leverage and cash-flow uncertainty [Fama and French (1996), Petkova (2006), and Hahn and Lee (2006)]. Petkova (2006) shows that asset duration risk, measure by the term spread, might be related to the value premium, while distress risk, measured by the default spread, might be represented by the size factor. I find that the size factor is related to both the term spread and default spread for the international sample. At the country level, the default spread is related to the size factor for Canada only. For the remaining countries, although both the term and default spreads are related to size and value factors, the direction of the relation is not consistent. The possible reason for this might be that the relation does not sustain to the different factor construction approaches and the innovations obtained with respect to those factors.

It is important to test whether the significant association between the state variable innovations and the return based factors give rise to the significant explanatory power for the returns based factors in the cross section of returns. In the next subsection, I examine two separate groups from the set of factors. The first group contains only the return based risk factors, while the second contains only innovations in the variables associated with time-series predictability. Then, the findings are compared as a test of the relation between the return based factors and state variable innovations.

6.3.2 Cross-sectional regressions

This subsection presents the cross-sectional results of two separate sets of models. The first set contains models based on only return based factors, which is replicating some results of Section 5.3. The results are repeated to provide a comparative analysis of these models with ICAPM models. The models are the standard 3F and 4F models, the decomposed 4F and 6F models, the modified 7F model, and the index-based 7F model all given in equations (5.4) to (5.9). The second set of models comprises local versions of excess simple market returns (or excess index-based market returns), and innovations to the dividend yield ($\hat{\mu}_t^{DY}$), term spread ($\hat{\mu}_t^{TERM}$), default spread ($\hat{\mu}_t^{DEF}$), and 3-month T-bill yield ($\hat{\mu}_t^{RF}$), named as ICAPM models. The factors and innovations are computed from data for each market. For the ICAPM models, the six innovation sets are obtained from the VAR model that also contains each of the six factor models, then the time-series loadings are computed for the market returns and each set of innovations. These loadings are then used as independent variables in the cross-sectional regressions. The cross-sectional specification for the ICAPM model is

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.3}$$

The objective of testing two sets of specifications is to compare the pricing performance of the factors and state variable innovations in the cross-sectional tests following Petkova (2006).

6.3.2.1 Cross-sectional R^2 of models

Panels A and B of Table 6.2 present results for the factor models and the ICAPM models for 44 size-B/M-industry and 44 size-momentum-industry portfolio returns. Only the local factor models are used for the country portfolio returns, based on the findings in Chapter 5 that the local factors are more accurately and reliably priced. The summary statistics presented are the same as in Chapter 5, and are explained in table note.

For the US, UK, and Japanese size-B/M-industry portfolios, the factor models and the ICAPM models are not rejected using both the Q_c and R^2 tests, apart from the standard 4F model for the UK, which is rejected at the 10% level by the Q_c test. Non-rejection of the models indicates that the models provide an adequate explanation of average size-B/M-industry portfolio returns. The ICAPM models have the comparable explanatory power to the standard 3F and 4F, and decomposed 4F models, endorsing the findings of Petkova (2006) and Kan et al. (2013) that the ICAPM model performs equally as well as the standard 3F model. Turning to the test of H_0: $\hat{\rho}^2 = 0$, the null hypothesis is not rejected for any of the factor models and ICAPM models, which is a bad news for these models. Non-rejection of the hypothesis H_0 : $\hat{\rho}^2 = 0$ mainly arises from the low R^2 values and the imprecise estimates of $\hat{\rho}^2$ shown by large standard errors of $\hat{\rho}^2$.

Table 6.2: Cross-Sectional R^2 and Specification Tests

This table presents the sample cross-sectional R^2 ($\hat{\rho}^2$) and the generalized *CSRT* (Q_c) of six factor models, along with ICAPM models based on macroeconomic innovations. The innovations are obtained from the VAR model with respect to return based factor model in column 1 of the table, as explain in section 6.2. The models are estimated using monthly returns on 25 size-B/M and 19 industry portfolios and 25 size-momentum and 19 industry portfolios. $p(\hat{\rho}^2=0)$ is the p-value for the test of $H_0 : \hat{\rho}^2 = 0$; and $se(\hat{\rho}^2)$ is the standard error of $\hat{\rho}^2$ under the assumption that $0 < \hat{\rho}^2 < 1$. '***', '**', '*' represent the level of statistical significance at the 1%, 5%, and 10%, respectively. For the $\hat{\rho}^2$, the significance level is for the test of $H_0 : \hat{\rho}^2 = 0$, and for the Q_c, it is for the approximate F-test of null $H_0 : Qc = 0$.

Panel A: 25 Size-B/M portfolios and 19 Industry Portfolios								
	Factor Models				ICAPM Models			
	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c
United States (US)								
Standard 3F	0.34	0.70	0.42	0.18	0.37	0.75	0.32	0.15
Standard 4F	0.43	0.69	0.40	0.15	0.35	0.79	0.33	0.15
Decomposed 4F	0.42	0.69	0.39	0.16	0.33	0.81	0.32	0.16
Decomposed 6F	0.52	0.71	0.36	0.14	0.32	0.83	0.33	0.15
Modified 7F	0.62	0.65	0.27	0.13	0.32	0.82	0.32	0.16
Index 7F	0.57	0.71	0.31	0.13	0.25	0.90	0.29	0.16
International								
Standard 3F	0.41***	0.06	0.19	1.09***	0.39***	0.10	0.17	0.79***
Standard 4F	0.51**	0.05	0.20	0.64***	0.38***	0.11	0.17	0.80***
Decomposed 4F	0.43***	0.06	0.18	1.09***	0.39**	0.09	0.17	0.76***
Decomposed 6F	0.51**	0.07	0.19	0.62***	0.40**	0.09	0.16	0.80***
Modified 7F	0.61**	0.03	0.15	0.56***	0.39**	0.10	0.17	0.80***
Index 7F	0.69	0.01	0.14	0.48***	0.40**	0.10	0.17	0.80***
United Kingdom (UK)								
Standard 3F	0.36	0.51	0.29	0.19	0.43	0.31	0.25	0.16
Standard 4F	0.36	0.58	0.29	0.19*	0.42	0.32	0.25	0.17
Decomposed 4F	0.38	0.57	0.29	0.18	0.43	0.31	0.25	0.16
Decomposed 6F	0.54	0.49	0.24	0.16	0.42	0.32	0.25	0.17
Modified 7F	0.53	0.53	0.22	0.15	0.43	0.32	0.25	0.16
Index 7F	0.52	0.54	0.23	0.15	0.40	0.37	0.26	0.17
Japan								
Standard 3F	0.40	0.32	0.34	0.15	0.63	0.18	0.16	0.15
Standard 4F	0.46	0.35	0.29	0.15	0.63	0.19	0.16	0.15
Decomposed 4F	0.47	0.30	0.28	0.15	0.63	0.18	0.16	0.15
Decomposed 6F	0.61	0.30	0.21	0.13	0.63	0.19	0.16	0.15
Modified 7F	0.69	0.25	0.16	0.12	0.64	0.18	0.16	0.15
Index 7F	0.69	0.26	0.17	0.13	0.64	0.21	0.17	0.16
Canada								
Standard 3F	0.25**	0.36	0.17	0.24**	0.17*	0.69	0.18	0.22**
Standard 4F	0.32	0.31	0.18	0.21**	0.19*	0.65	0.17	0.22**
Decomposed 4F	0.26**	0.41	0.18	0.23**	0.17**	0.71	0.18	0.22**
Decomposed 6F	0.33	0.42	0.18	0.20**	0.18*	0.68	0.17	0.22**
Modified 7F	0.45	0.24	0.17	0.18*	0.18*	0.66	0.18	0.21**
Index 7F	0.42	0.27	0.17	0.20**	0.18*	0.69	0.18	0.21**

(Continued overleaf)

Table 6.2 (continued)

Panel B: 25 Size-Momentum portfolios and 19 Industry Portfolios

	Factor Models				**ICAPM Models**			
	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c	$\hat{\rho}^2$	$p(\hat{\rho}^2=0)$	$se(\hat{\rho}^2)$	Q_c
United States (US)								
Standard 3F	0.64	0.08	0.22	0.27***	0.23	0.86	0.33	0.22**
Standard 4F	0.76	0.07	0.17	0.26***	0.21	0.89	0.32	0.22**
Decomposed 4F	0.66	0.09	0.21	0.26***	0.17	0.92	0.29	0.22**
Decomposed 6F	0.82	0.06	0.14	0.21**	0.16	0.93	0.28	0.22**
Modified 7F	0.82	0.07	0.13	0.23**	0.19	0.91	0.31	0.22**
Index 7F	0.81	0.08	0.14	0.23**	0.27	0.76	0.32	0.20*
International								
Standard 3F	0.59**	0.00	0.15	0.85***	0.53	0.03	0.21	0.45***
Standard 4F	0.66***	0.00	0.14	0.82***	0.56	0.01	0.21	0.41***
Decomposed 4F	0.59***	0.00	0.15	0.84***	0.52	0.03	0.21	0.46***
Decomposed 6F	0.74**	0.00	0.12	0.73***	0.55	0.01	0.20	0.44***
Modified 7F	0.71***	0.00	0.13	0.80***	0.55	0.02	0.21	0.43***
Index 7F	0.74***	0.00	0.11	0.74***	0.53	0.03	0.20	0.49***
United Kingdom (UK)								
Standard 3F	0.35***	0.01	0.19	0.82***	0.37***	0.22	0.16	0.72***
Standard 4F	0.64***	0.00	0.12	0.70***	0.36***	0.21	0.16	0.76***
Decomposed 4F	0.45***	0.00	0.16	0.69***	0.37***	0.22	0.16	0.72***
Decomposed 6F	0.64***	0.00	0.12	0.65***	0.36***	0.21	0.16	0.77***
Modified 7F	0.67***	0.00	0.10	0.62***	0.37***	0.18	0.15	0.76***
Index 7F	0.71*	0.00	0.09	0.44***	0.32***	0.25	0.16	0.73***
Japan								
Standard 3F	0.42	0.33	0.35	0.14	0.58	0.27	0.24	0.13
Standard 4F	0.53	0.37	0.30	0.14	0.58	0.27	0.24	0.12
Decomposed 4F	0.61	0.23	0.23	0.15	0.58	0.27	0.24	0.13
Decomposed 6F	0.63	0.37	0.24	0.14	0.58	0.27	0.24	0.12
Modified 7F	0.75	0.30	0.19	0.13	0.59	0.26	0.24	0.12
Index 7F	0.72	0.33	0.20	0.13	0.65	0.23	0.23	0.13
Canada								
Standard 3F	0.16***	0.13	0.12	0.51***	0.60	0.01	0.29	0.08
Standard 4F	0.74**	0.00	0.08	0.40***	0.58	0.01	0.31	0.08
Decomposed 4F	0.16***	0.46	0.12	0.51***	0.61	0.01	0.30	0.07
Decomposed 6F	0.82**	0.00	0.07	0.34***	0.59	0.01	0.31	0.07
Modified 7F	0.75**	0.00	0.08	0.34***	0.58	0.01	0.32	0.07
Index 7F	0.74***	0.00	0.08	0.36***	0.62	0.01	0.33	0.06

In short, for the size-B/M-industry portfolios of the US, UK, and Japan, the ICAPM models perform as well as standard 3F, standard 4F and decomposed 4F models, a result similar to Petkova (2006). However, the larger factor models have higher explanatory power than the ICAPM models. Moreover, the ICAPM model that includes the innovations with respect to the standard 3F model, proposed by Petkova (2006), performs as well as the ICAPM models that include the innovations obtained from any other model. Thus, the factors used to measure state variable innovations in the VAR model do not have any effect on the models' performances. Therefore, the innovations obtained with respect to the standard 3F model will be suffice to capture the time-series dynamics of these state variables.

For the Japanese size-momentum-industry portfolios, the factor models and the ICAPM models are not rejected, whereas they are rejected by the Q_c test for the US and by both the Q_c and R^2 tests for the UK. Moreover, the explanatory power of all the factor models is significantly higher than their corresponding ICAPM models[18] for the US and UK size-momentum-industry portfolio returns, except for the standard 3F model for the UK. The null hypothesis of $H_0 : \hat{\rho}^2 = 0$ is not rejected for any of the ICAPM models for the US, UK and Japan and factor models of the Japan. However, it is rejected for the factor models of both the US and UK. In summary, the ICAPM models have comparable performance to the factor models for the Japanese size-momentum industry portfolio returns. For the US and UK, the explanatory power of the ICAPM models is quite low in comparison to the factor models, for these test portfolios.

For the international and Canadian size-B/M-industry portfolio returns, the Q_c and R^2 tests reject the factor and ICAPM models, except for the standard 4F, decomposed 6F, modified 7F and index-based 7F models that are not rejected by the R^2 test for Canada. The factor models

[18] The pair-wise comparison of R^2s is not presented for the sake of brevity, as it does not add much to the explanation of Table 6.2.

are also rejected for the international and Canadian size-momentum-industry portfolio returns by both of the tests. The ICAPM models for the international size-momentum-industry portfolio returns are only rejected by the Q_c test, while none of the Q_c or R^2 tests reject them for the Canadian size-momentum-industry portfolio returns. However, the factor models have higher explanatory power than the ICAPM models for the international sample and Canada, except for the standard 3F and decomposed 4F models. Clearly, the ICAPM models are a better choice for the Canadian size-momentum-industry portfolios, as they pass the specification tests. For the international portfolios, the ICAPM models are comparable only to the standard 3F and decomposed 4F models. The international results also show that the factor models are better integrated across four countries when compared to the ICAPM models.

This subsection shows that the ICAPM models perform as well as the standard 3F and decomposed 4F models for size-B/M-industry portfolio, a result similar to that of Petkova (2006). Also, the results are similar for the size-momentum-industry portfolios, except for the US. The ICAPM models performed as well as any of the six factor models for Japan. Importantly, the results show that the ICAPM models are preferable to the factor models as they are rejected less frequently for all the markets. Comparable performance of ICAPM models with the standard 3F and decomposed 4F models in the international sample shows that ICAPM models integrate at least as much as these factor models. Moreover, there are no significant differences in the performance of the ICAPM models obtained from VAR models with respect to different factor models. Thus, the ICAPM model that includes the innovations with respect to the standard 3F model, following Petkova (2006), should only be used. However, the cross-sectional premiums on these innovations should be examined to see if the innovations obtained on different factors models are priced differently. This is done in the following subsection.

6.3.2.2 Factor risk premiums

Table 6.3 and Table 6.4 report the factor pricing results for the size-B/M-industry and size-momentum-industry portfolios. The tables report risk premiums for the factor and ICAPM models. However, the focus of discussion will be on ICAPM models and their comparison with factor models. Recognizing the critique of Lewellen et al. (2010), the cross-sectional intercepts should be zero, and the risk premiums should be reasonable in economic terms. The US risk premiums are presented in Panel A of Tables 6.3 and 6.4 to first provide the direct comparison with Petkova (2006). In both tables, none of the state variable innovations are significantly priced. For size-B/M-industry portfolio returns, there are no significant premiums for factor models either. However, for size-momentum-industry portfolio returns, the size and momentum premiums are consistently priced across different models. Although the state variable innovations are not priced, the ICAPM models do not have significant excess zero-beta rates, while all the factor models have a significant zero-beta rate, except the index-based 7F model for size-B/M-industry portfolios. This clearly indicates that the ICAPM do not leave any information unexplained, and thus outperform the factor models.

Petkova (2006) also reported a significant excess zero-beta rate for the standard 3F model. These significant zero-beta rates for the factor models together with the comparable performance of ICAPM models for the US size-B/M-industry portfolio returns in Panel A of Table 6.2, suggest that the ICAPM models provide a better description of US size-B/M-industry portfolios than standard 3F and 4F models and decomposed 4F model. The significant zero-beta rates indicate that the factor models provide an incomplete description of the US portfolio returns. Moreover, unlike the findings of Shanken and Zhou (2007), the high zero-beta rates do not offset the low market premiums.

Table 6.3: Risk Premia (γ) Estimates of 25 size-B/M and 19 Industry Portfolios

This table presents the risk premiums for six return based factor models, along with ICAPM models based on macroeconomic innovations of each sample. The local innovations are obtained from the VAR model with respect to return based factor model in column 1 of the table, as explain in section 6.2. The models are estimated using monthly returns on 25 size-B/M and 19 industry portfolios. Table reports parameter estimates *γ*, Shanken (1992) *t*-statistics (SH *t*-stats) and model misspecification-robust *t*-statistics (PM *t*-stats).

Panel A: United States (US) size-B/M-industry portfolio returns

	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.75	-0.07	0.18	0.05					0.71	-0.02	0.11	0.45	0.65	-1.94
SH t-stats	2.78	-0.19	1.13	0.23					2.03	-0.06	0.10	0.50	0.64	-1.57
PM t-stats	2.76	-0.19	1.12	0.23					1.63	-0.05	0.09	0.42	0.45	-1.27
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.54	0.16	0.17	0.06	0.71				0.72	-0.04	-0.02	0.61	0.42	-2.01
SH t-stats	1.96	0.44	1.04	0.30	1.22				1.99	-0.08	-0.02	0.67	0.40	-1.46
PM t-stats	1.80	0.41	1.04	0.30	0.99				1.57	-0.07	-0.02	0.55	0.28	-1.19
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.70	-0.01	0.18	0.10	-0.04				0.70	-0.01	0.19	0.44	0.67	-1.77
SH t-stats	2.51	-0.03	1.14	0.36	-0.22				2.04	-0.03	0.16	0.50	0.67	-1.42
PM t-stats	2.47	-0.03	1.11	0.37	-0.21				1.59	-0.02	0.15	0.41	0.45	-1.14
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.45	0.26	0.18	0.11	-0.04	0.84	0.63		0.73	-0.04	0.13	0.65	0.46	-1.84
SH t-stats	1.60	0.68	1.11	0.41	-0.20	1.50	0.90		2.08	-0.10	0.11	0.73	0.44	-1.33
PM t-stats	1.50	0.63	1.10	0.42	-0.20	1.21	0.74		1.64	-0.08	0.10	0.57	0.30	-1.08
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.52	0.21	0.09	0.11	0.20	-0.18	-0.04	0.87	0.68	0.00	-0.08	0.40	0.58	-1.81
SH t-stats	1.83	0.56	0.93	0.82	0.91	-0.81	-0.22	1.51	1.86	0.01	-0.07	0.44	0.57	-1.38
PM t-stats	1.74	0.54	0.92	0.79	0.87	-0.85	-0.21	1.34	1.50	0.01	-0.06	0.34	0.39	-1.18
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.47	0.22	0.06	0.13	0.13	-0.20	-0.07	0.91	0.60	0.07	-0.63	0.75	-0.15	-1.24
SH t-stats	1.50	0.55	0.56	0.88	0.72	-0.70	-0.43	1.56	1.54	0.15	-0.55	0.85	-0.14	-0.84
PM t-stats	1.47	0.54	0.53	0.85	0.68	-0.73	-0.41	1.31	1.34	0.13	-0.45	0.62	-0.09	-0.72

(Continued overleaf)

Table 6.3 (Continued)	Panel B: International size-B/M-industry portfolio returns													
	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.35	-0.14	0.37	0.14					0.54	-0.29	-1.71	1.64	-0.75	0.55
SH t-stats	1.70	-0.45	2.76	0.92					1.61	-0.74	-0.94	1.84	-0.99	0.47
PM t-stats	1.47	-0.45	2.65	0.91					1.49	-0.73	-0.60	1.38	-0.66	0.33
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.09	0.41	0.30	0.24	2.07				0.57	-0.31	-1.60	1.70	-0.87	0.48
SH t-stats	-0.34	1.11	2.23	1.45	2.96				1.72	-0.81	-0.89	1.90	-1.09	0.41
PM t-stats	-0.25	0.83	2.01	1.39	1.49				1.58	-0.79	-0.56	1.44	-0.73	0.29
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.44	-0.22	0.35	-0.02	0.40				0.51	-0.26	-1.94	1.61	-0.74	0.62
SH t-stats	1.98	-0.70	2.64	-0.10	2.35				1.43	-0.64	-1.18	1.81	-0.92	0.57
PM t-stats	1.71	-0.68	2.55	-0.10	2.24				1.33	-0.64	-0.70	1.36	-0.66	0.40
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.02	0.32	0.29	0.11	0.39	1.70	2.10		0.56	-0.30	-1.35	1.84	-0.95	0.37
SH t-stats	-0.07	0.89	2.21	0.60	2.21	2.67	2.87		1.67	-0.77	-0.82	2.11	-1.13	0.35
PM t-stats	-0.04	0.55	2.03	0.50	2.01	1.02	1.26		1.53	-0.76	-0.43	1.58	-0.78	0.22
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.01	0.34	0.13	0.26	0.36	-0.25	0.36	1.45	0.49	-0.24	-1.55	1.70	-1.01	0.38
SH t-stats	-0.02	0.88	1.58	2.24	2.43	-1.40	2.23	2.12	1.45	-0.60	-0.85	2.17	-1.28	0.34
PM t-stats	-0.01	0.64	1.40	2.00	2.06	-1.37	1.92	1.11	1.28	-0.57	-0.50	1.73	-0.90	0.24
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.46	0.76	0.72	-0.31	0.07	0.28	0.15	1.91	0.60	-0.39	-1.35	1.90	-0.79	0.55
SH t-stats	-1.49	1.91	3.74	-1.51	0.41	1.20	0.92	2.99	1.82	-0.96	-0.72	2.44	-0.98	0.43
PM t-stats	-1.03	1.35	2.99	-1.36	0.35	0.90	0.86	1.73	1.65	-0.94	-0.41	1.80	-0.64	0.26

(Continued overleaf)

Table 6.3 (Continued)	Panel C: United Kingdom (UK) size-B/M-industry portfolio returns													
	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.13	0.56	-0.02	0.10					-0.19	0.63	0.04	-0.80	-0.45	0.55
SH t-stats	-0.48	1.55	-0.14	0.62					-0.62	1.64	0.04	-0.91	-0.67	0.76
PM t-stats	-0.46	1.52	-0.14	0.61					-0.56	1.51	0.03	-0.73	-0.55	0.66
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.14	0.56	-0.02	0.10	0.03				-0.18	0.62	0.11	-0.66	-0.47	0.42
SH t-stats	-0.45	1.48	-0.14	0.62	0.06				-0.58	1.61	0.10	-0.76	-0.70	0.58
PM t-stats	-0.42	1.37	-0.14	0.61	0.05				-0.52	1.48	0.08	-0.61	-0.58	0.50
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.21	0.63	-0.02	0.08	0.07				-0.20	0.63	0.03	-0.80	-0.45	0.55
SH t-stats	-0.70	1.69	-0.10	0.38	0.34				-0.63	1.65	0.03	-0.92	-0.68	0.76
PM t-stats	-0.67	1.65	-0.10	0.38	0.33				-0.56	1.52	0.02	-0.73	-0.55	0.65
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.20	0.62	-0.01	0.09	-0.01	-0.33	0.53		-0.18	0.61	0.10	-0.67	-0.49	0.43
SH t-stats	-0.60	1.55	-0.04	0.45	-0.07	-0.59	0.86		-0.57	1.61	0.09	-0.74	-0.74	0.60
PM t-stats	-0.54	1.43	-0.04	0.45	-0.07	-0.51	0.77		-0.52	1.47	0.07	-0.59	-0.61	0.50
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.42	0.86	0.06	-0.09	0.19	-0.04	0.04	0.06	-0.22	0.66	-0.08	-0.83	-0.41	0.55
SH t-stats	-1.37	2.24	0.46	-0.70	1.15	-0.23	0.22	0.11	-0.68	1.67	-0.07	-0.82	-0.59	0.72
PM t-stats	-1.26	2.08	0.45	-0.68	1.12	-0.23	0.21	0.09	-0.61	1.54	-0.06	-0.68	-0.49	0.61
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.30	0.89	0.12	-0.16	0.17	-0.03	0.00	0.12	-0.13	0.71	-0.25	-0.70	-0.51	0.50
SH t-stats	-1.13	2.29	0.80	-0.97	1.08	-0.10	-0.03	0.21	-0.42	1.77	-0.18	-0.58	-0.58	0.55
PM t-stats	-1.05	2.19	0.77	-0.96	1.01	-0.09	-0.03	0.19	-0.38	1.66	-0.14	-0.46	-0.50	0.45

(Continued overleaf)

Table 6.3 (Continued)									Panel D: Japanese size-B/M-industry portfolio returns					
	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.14	-0.14	0.14	0.35					1.04	-1.00	-0.24	0.90	0.63	1.64
SH t-stats	0.30	-0.24	0.68	2.02					2.25	-1.80	-0.17	0.81	0.63	1.33
PM t-stats	0.25	-0.21	0.67	1.77					2.06	-1.68	-0.18	0.81	0.64	1.34
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.01	0.02	0.14	0.43	0.64				1.03	-0.99	-0.25	0.93	0.65	1.60
SH t-stats	0.03	0.04	0.71	2.83	1.05				2.24	-1.78	-0.18	0.84	0.66	1.30
PM t-stats	0.02	0.03	0.70	2.45	0.94				2.06	-1.67	-0.18	0.84	0.67	1.32
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.05	-0.06	0.13	0.16	0.65				1.04	-1.00	-0.24	0.89	0.63	1.65
SH t-stats	0.11	-0.10	0.63	0.77	3.03				2.25	-1.80	-0.17	0.82	0.62	1.35
PM t-stats	0.09	-0.10	0.62	0.71	2.72				2.06	-1.68	-0.18	0.82	0.63	1.36
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.08	0.11	0.13	0.26	0.64	-0.06	0.91		1.03	-0.99	-0.25	0.93	0.65	1.60
SH t-stats	-0.17	0.20	0.63	1.42	3.11	-0.10	1.13		2.23	-1.78	-0.18	0.85	0.65	1.31
PM t-stats	-0.16	0.20	0.62	1.27	3.01	-0.09	1.15		2.05	-1.66	-0.19	0.85	0.67	1.34
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.30	-0.25	0.21	0.08	0.35	0.09	0.60	0.51	1.04	-1.01	-0.25	0.90	0.61	1.73
SH t-stats	0.62	-0.43	1.88	0.52	2.22	0.42	3.11	0.86	2.24	-1.79	-0.18	0.81	0.59	1.38
PM t-stats	0.56	-0.40	1.87	0.52	2.16	0.41	2.96	0.82	2.05	-1.67	-0.19	0.81	0.59	1.41
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.07	-0.06	0.20	0.07	0.33	0.10	0.66	0.66	1.02	-1.05	0.11	0.78	0.68	1.78
SH t-stats	0.16	-0.11	1.44	0.41	2.71	0.56	2.75	1.15	2.27	-1.83	0.10	0.73	0.66	1.53
PM t-stats	0.15	-0.10	1.42	0.40	2.59	0.56	2.71	1.06	1.99	-1.67	0.10	0.75	0.67	1.53

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Table 6.3 (Continued)				Panel E: Canadian size-B/M-industry portfolio returns										
	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.23	0.79	-0.09	0.16					0.36	0.24	0.31	1.35	-1.28	-0.89
SH t-stats	-1.01	2.36	-0.58	0.73					1.25	0.64	0.31	1.42	-1.33	-0.96
PM t-stats	-0.94	2.29	-0.57	0.70					1.11	0.63	0.28	0.93	-1.06	-0.61
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.34	0.95	-0.16	0.32	1.23				0.34	0.25	0.31	1.35	-1.38	-0.90
SH t-stats	-1.42	2.80	-1.02	1.41	2.04				1.20	0.68	0.31	1.42	-1.45	-0.98
PM t-stats	-1.18	2.51	-1.00	1.37	1.36				1.07	0.67	0.28	0.94	-1.15	-0.63
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.24	0.80	-0.09	0.15	0.17				0.34	0.25	0.32	1.34	-1.20	-0.95
SH t-stats	-1.05	2.38	-0.58	0.57	0.60				1.23	0.68	0.32	1.39	-1.22	-1.04
PM t-stats	-0.94	2.27	-0.57	0.52	0.55				1.09	0.67	0.28	0.91	-0.99	-0.67
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.34	0.96	-0.15	0.29	0.35	0.85	1.53		0.33	0.26	0.37	1.29	-1.29	-0.91
SH t-stats	-1.42	2.80	-1.01	1.07	1.15	1.40	2.14		1.18	0.72	0.37	1.35	-1.31	-1.01
PM t-stats	-1.15	2.45	-0.97	0.98	1.06	0.85	1.44		1.06	0.71	0.33	0.89	-1.07	-0.64
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.36	0.97	-0.03	-0.11	0.41	-0.42	0.47	0.64	0.34	0.26	0.39	1.37	-1.24	-0.90
SH t-stats	-1.49	2.82	-0.24	-0.67	1.68	-1.78	1.50	1.05	1.23	0.72	0.39	1.49	-1.29	-0.97
PM t-stats	-1.26	2.57	-0.21	-0.62	1.62	-1.64	1.39	0.80	1.08	0.71	0.35	0.97	-1.05	-0.62
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.36	1.15	-0.02	-0.11	0.32	-0.26	0.51	1.06	0.34	0.36	0.70	1.32	-1.18	-0.80
SH t-stats	-1.57	2.92	-0.15	-0.59	1.55	-0.94	1.68	1.77	1.23	0.82	0.50	1.18	-0.81	-0.70
PM t-stats	-1.36	2.70	-0.15	-0.59	1.53	-0.93	1.63	1.33	1.07	0.81	0.39	0.81	-0.62	-0.47

Table 6.4: Risk Premia (γ) Estimates of 25 size-momentum and 19 Industry Portfolios

This table presents the risk premiums for six return based factor models, along with ICAPM models based on macroeconomic innovations of each sample. The local innovations are obtained from the VAR model with respect to return based factor model in column 1 of the table, as explain in section 6.2. The models are estimated using monthly returns on 25 size-momentum and 19 industry portfolios. Table reports parameter estimates γ, Shanken (1992) *t*-statistics (SH *t*-stats) and model misspecification-robust *t*-statistics (PM *t*-stats).

Panel A: United States (US) size-momentum-industry portfolio returns														
	Return based risk factors								State variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	1.01	-0.29	0.41	-0.22					0.38	0.32	-1.19	1.30	-1.37	-1.20
SH t-stats	3.40	-0.76	2.42	-0.92					1.23	0.81	-1.04	1.34	-1.01	-1.10
PM t-stats	3.47	-0.77	2.46	-0.94					0.73	0.55	-0.76	0.69	-0.60	-0.53
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.69	0.03	0.35	-0.09	0.50				0.38	0.33	-1.30	1.35	-1.53	-1.08
SH t-stats	2.75	0.07	2.10	-0.38	1.89				1.18	0.83	-1.16	1.39	-1.12	-0.90
PM t-stats	2.66	0.07	2.11	-0.38	1.90				0.72	0.56	-0.82	0.69	-0.68	-0.45
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.92	-0.20	0.38	-0.19	-0.24				0.40	0.33	-1.05	1.29	-1.35	-0.76
SH t-stats	3.14	-0.52	2.24	-0.63	-0.92				1.32	0.84	-0.95	1.36	-1.02	-0.68
PM t-stats	3.01	-0.51	2.21	-0.61	-0.83				0.75	0.56	-0.65	0.68	-0.60	-0.35
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.63	0.07	0.37	-0.16	-0.05	0.62	0.28		0.38	0.35	-1.18	1.26	-1.44	-0.68
SH t-stats	2.39	0.21	2.19	-0.52	-0.20	2.31	0.96		1.22	0.87	-1.08	1.32	-1.09	-0.55
PM t-stats	2.31	0.20	2.30	-0.56	-0.19	2.29	0.96		0.74	0.61	-0.74	0.62	-0.64	-0.29
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.73	-0.01	0.16	0.18	0.03	-0.35	0.02	0.49	0.31	0.40	-1.45	0.91	-1.31	-1.01
SH t-stats	2.69	-0.02	1.52	1.25	0.12	-1.34	0.09	1.85	0.96	0.98	-1.27	0.95	-0.97	-0.86
PM t-stats	2.59	-0.02	1.47	1.23	0.11	-1.40	0.08	1.87	0.58	0.68	-0.84	0.43	-0.56	-0.48
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.66	-0.01	0.23	0.12	-0.10	-0.27	0.01	0.51	0.40	0.28	-1.97	1.49	-1.87	-0.39
SH t-stats	2.33	-0.02	1.68	0.79	-0.46	-0.87	0.02	1.91	1.18	0.66	-1.55	1.44	-1.27	-0.28
PM t-stats	2.28	-0.02	1.50	0.74	-0.46	-0.81	0.02	1.93	0.82	0.53	-1.18	0.84	-0.94	-0.20

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Table 6.4 (continued)	Panel B: International size-momentum-industry portfolio returns													
	Return based risk factors								Local state variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.48	-0.24	0.54	-0.26					-0.15	0.39	-2.26	0.98	-2.87	0.63
SH t-stats	2.35	-0.77	3.79	-1.30					-0.52	1.07	-1.48	1.25	-2.50	0.65
PM t-stats	2.20	-0.78	3.72	-1.28					-0.34	0.80	-0.90	0.83	-2.21	0.49
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.28	-0.03	0.50	-0.14	0.52				-0.18	0.41	-2.51	1.01	-3.08	0.63
SH t-stats	1.67	-0.12	3.54	-0.71	2.44				-0.58	1.10	-1.59	1.23	-2.44	0.63
PM t-stats	1.50	-0.12	3.45	-0.73	2.44				-0.41	0.86	-1.04	0.89	-2.19	0.51
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.51	-0.28	0.53	-0.40	-0.07				-0.14	0.39	-2.07	1.04	-2.91	0.53
SH t-stats	2.78	-0.93	3.73	-1.68	-0.25				-0.51	1.08	-1.42	1.32	-2.54	0.57
PM t-stats	2.40	-0.90	3.63	-1.61	-0.21				-0.33	0.80	-0.82	0.88	-2.19	0.41
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.33	-0.09	0.48	-0.44	0.40	0.59	0.31		-0.13	0.38	-1.96	1.23	-3.14	0.41
SH t-stats	1.84	-0.30	3.45	-1.84	1.52	2.76	1.26		-0.43	1.02	-1.32	1.55	-2.56	0.44
PM t-stats	1.67	-0.29	3.38	-1.95	1.34	2.67	1.25		-0.29	0.79	-0.78	1.09	-2.19	0.32
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.37	-0.09	0.20	0.31	0.01	-0.40	0.35	0.51	-0.18	0.41	-2.14	1.21	-3.05	0.38
SH t-stats	1.81	-0.29	2.17	2.33	0.06	-1.90	1.59	2.41	-0.60	1.12	-1.35	1.63	-2.60	0.38
PM t-stats	1.46	-0.27	1.80	1.92	0.04	-1.71	1.25	2.44	-0.40	0.84	-0.79	1.11	-2.11	0.29
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.15	0.06	0.62	-0.14	-0.27	0.14	0.12	0.52	-0.11	0.24	-1.80	1.58	-2.97	0.21
SH t-stats	0.90	0.20	3.13	-0.67	-1.29	0.64	0.57	2.45	-0.39	0.63	-1.18	2.23	-2.56	0.21
PM t-stats	0.73	0.18	2.69	-0.60	-1.17	0.57	0.51	2.45	-0.25	0.47	-0.70	1.44	-1.97	0.14

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Table 6.4 (continued)				Panel C: United Kingdom (UK) size-momentum-industry portfolio returns										
	Return based risk factors								Local state variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.56	0.97	0.05	-0.28					-0.81	1.18	0.21	0.93	1.36	-0.88
SH t-stats	-2.08	2.74	0.31	-1.32					-2.32	2.85	0.17	0.89	1.21	-0.90
PM t-stats	-1.54	2.32	0.29	-1.13					-1.19	1.69	0.04	0.31	0.68	-0.28
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.74	1.15	0.06	-0.01	0.75				-0.91	1.29	0.07	-0.31	1.46	0.24
SH t-stats	-2.82	3.29	0.33	-0.05	3.85				-2.64	3.15	0.05	-0.27	1.35	0.23
PM t-stats	-2.60	3.20	0.31	-0.05	3.72				-1.40	1.93	0.01	-0.10	0.66	0.08
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-1.01	1.41	0.21	-0.03	-1.12				-0.81	1.18	0.22	0.92	1.36	-0.88
SH t-stats	-3.31	3.67	1.11	-0.13	-2.21				-2.32	2.85	0.17	0.89	1.22	-0.90
PM t-stats	-2.49	3.05	0.99	-0.10	-1.63				-1.19	1.68	0.04	0.31	0.68	-0.28
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.77	1.18	0.07	-0.12	0.03	0.79	0.70		-0.91	1.30	-0.07	-0.12	1.50	0.03
SH t-stats	-2.71	3.21	0.38	-0.46	0.09	3.54	3.06		-2.62	3.13	-0.06	-0.11	1.38	0.03
PM t-stats	-2.45	3.00	0.37	-0.44	0.06	3.50	2.87		-1.48	2.01	-0.01	-0.04	0.71	0.01
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-1.28	1.72	0.24	-0.15	0.08	-0.05	-0.18	0.77	-0.94	1.33	-0.09	-0.37	1.57	0.16
SH t-stats	-3.86	4.24	1.58	-0.88	0.28	-0.14	-0.65	3.97	-2.72	3.24	-0.08	-0.31	1.51	0.15
PM t-stats	-2.67	3.22	1.27	-0.82	0.17	-0.09	-0.47	3.93	-1.48	1.98	-0.02	-0.13	0.78	0.05
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.67	1.27	0.31	-0.22	-0.78	1.82	0.13	0.77	-0.65	1.23	-0.13	-0.48	1.84	0.50
SH t-stats	-1.94	2.77	1.40	-0.97	-2.31	2.63	0.38	3.87	-2.17	2.99	-0.09	-0.35	1.42	0.41
PM t-stats	-1.69	2.44	1.35	-0.98	-1.56	1.64	0.32	3.70	-1.11	1.98	-0.02	-0.15	0.71	0.16

(Continued overleaf)

Table 6.4 (continued)	Panel D: Japanese size-momentum-industry portfolio returns													
	Return based risk factors								Local state variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.58	-0.55	0.31	-0.01					0.97	-0.95	-1.48	1.56	0.02	1.00
SH t-stats	0.92	-0.79	1.42	-0.03					1.95	-1.60	-0.92	1.40	0.02	0.97
PM t-stats	0.76	-0.71	1.38	-0.03					1.85	-1.54	-0.84	1.37	0.02	0.80
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.40	-0.36	0.34	-0.03	0.17				0.97	-0.95	-1.48	1.59	0.05	1.00
SH t-stats	0.68	-0.55	1.56	-0.09	0.63				1.95	-1.60	-0.92	1.41	0.04	0.98
PM t-stats	0.60	-0.51	1.53	-0.08	0.62				1.86	-1.54	-0.85	1.39	0.04	0.81
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.28	-0.28	0.37	-0.33	0.57				0.97	-0.95	-1.48	1.55	0.03	1.03
SH t-stats	0.46	-0.42	1.65	-0.78	1.31				1.95	-1.60	-0.92	1.41	0.03	1.00
PM t-stats	0.42	-0.40	1.65	-0.77	1.22				1.86	-1.55	-0.84	1.36	0.03	0.82
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.24	-0.24	0.37	-0.30	0.48	0.14	0.20		0.96	-0.95	-1.48	1.57	0.05	1.03
SH t-stats	0.42	-0.37	1.68	-0.74	1.12	0.56	0.60		1.95	-1.59	-0.92	1.42	0.05	1.01
PM t-stats	0.40	-0.36	1.66	-0.74	1.00	0.55	0.59		1.87	-1.55	-0.86	1.39	0.05	0.84
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.50	-0.47	0.26	0.14	-0.07	-0.09	0.44	0.18	0.98	-0.97	-1.51	1.58	-0.06	1.18
SH t-stats	0.94	-0.76	2.11	0.83	-0.23	-0.34	1.45	0.66	1.96	-1.61	-0.93	1.41	-0.06	1.12
PM t-stats	0.91	-0.75	2.08	0.82	-0.20	-0.34	1.32	0.66	1.89	-1.57	-0.87	1.37	-0.06	0.91
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	0.38	-0.41	0.27	0.10	-0.01	-0.05	0.40	0.19	0.83	-0.98	-0.96	1.41	-0.04	1.02
SH t-stats	0.76	-0.68	1.80	0.57	-0.05	-0.21	1.32	0.72	1.91	-1.71	-0.82	1.33	-0.03	1.01
PM t-stats	0.72	-0.65	1.79	0.56	-0.04	-0.21	1.27	0.72	1.73	-1.63	-0.80	1.35	-0.03	0.89

(Continued overleaf)

Table 6.4 (continued)	Panel E: Canadian size-momentum-industry portfolio returns													
	Return based risk factors								Local state variable innovations					
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.36	0.90	-0.16	-0.06					-0.39	0.94	2.15	-8.70	-3.36	7.59
SH t-stats	-2.23	2.92	-0.96	-0.21					-0.97	1.90	1.01	-2.43	-1.31	2.24
PM t-stats	-1.12	2.27	-0.78	-0.17					-0.82	1.68	0.93	-1.72	-1.07	1.80
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.40	0.99	-0.27	0.23	1.36				-0.39	0.93	2.13	-9.06	-3.21	8.02
SH t-stats	-2.28	3.17	-1.54	0.83	6.29				-0.95	1.85	0.98	-2.48	-1.24	2.31
PM t-stats	-1.76	3.05	-1.55	0.81	6.16				-0.80	1.62	0.90	-1.81	-1.00	1.96
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.35	0.89	-0.14	-0.21	0.05				-0.41	0.96	1.88	-9.06	-3.19	7.60
SH t-stats	-2.10	2.86	-0.78	-0.46	0.11				-1.01	1.89	0.86	-2.44	-1.21	2.17
PM t-stats	-0.91	2.05	-0.33	-0.09	0.03				-0.90	1.71	0.78	-1.85	-1.01	1.80
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.47	1.05	-0.27	-0.03	0.35	1.42	1.13		-0.41	0.95	1.81	-9.43	-3.02	8.03
SH t-stats	-2.58	3.28	-1.39	-0.06	0.79	6.52	3.91		-0.97	1.84	0.82	-2.48	-1.14	2.25
PM t-stats	-2.16	3.21	-1.23	-0.04	0.60	6.36	3.69		-0.86	1.65	0.74	-1.95	-0.95	1.97
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.50	1.10	-0.44	0.08	0.67	-0.61	0.04	1.36	-0.38	0.90	1.82	-8.92	-3.27	7.72
SH t-stats	-2.70	3.41	-1.75	0.34	1.41	-1.01	0.09	6.29	-0.95	1.79	0.83	-2.47	-1.28	2.23
PM t-stats	-2.05	3.18	-1.40	0.27	0.98	-0.72	0.07	6.22	-0.83	1.60	0.74	-1.83	-1.07	1.89
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}
Estimate	-0.43	1.21	-0.28	-0.05	0.55	-0.59	0.15	1.34	-0.33	1.12	1.26	-10.95	-4.83	9.36
SH t-stats	-2.44	3.28	-1.18	-0.22	1.33	-0.92	0.31	6.19	-0.77	1.86	0.41	-2.28	-1.31	2.05
PM t-stats	-1.96	3.12	-0.86	-0.18	1.01	-0.71	0.26	6.04	-0.67	1.68	0.31	-2.09	-1.03	2.01

Panel B in Tables 6.3 and 6.4 present risk premiums for the international sample. For the size-B/M-industry portfolios, only the decomposed 4F model and the ICAPM model with respect to the index-based 7F model have significant excess zero-beta rates using both the SH and PM *t*-statistics. The premiums on innovations to the term spread are significantly priced. For innovations with respect to standard and decomposed models, the innovations to the term premium are significant for SH *t*-statistics only. However, they are priced for the modified 7F and index-based 7F models using PM *t*-statistics at the 10% level. From the factor models, the size and momentum premiums are consistently significant across different models for both size-B/M-industry and size-momentum-industry portfolios. For the size-momentum-industry portfolios, the innovations to the default spread are negative and significant across different ICAPM models. However, the factor models have significant excess zero-beta rates, giving the ICAPM models the edge over the factor models. Therefore, the ICAPM models should be preferred at least over the standard 3F and decomposed 4F models based on the risk premium results, in conjunction with results of Table 6.2.

Panel C of Tables 6.3 and 6.4 presents UK risk premiums. The market premium for both sets of portfolios and momentum premiums for size-momentum-industry portfolios are consistently priced for the factor models. The market premium is also priced for the ICAPM models for size-momentum-industry portfolio returns, while none of the innovations are priced in either set of portfolios. For the size-momentum-industry portfolio returns, the excess zero-beta rate is negative and significant for all factor models, while it is significant only using SH t-statistics for ICAPM models. Thus, clearly the ICAPM models are better at capturing the variation in the returns of the UK size-momentum-industry portfolios.

For Japanese risk premiums in Panel D of Tables 6.3 and 6.4, none of the state variable innovations have significant risk premiums. The value premium is consistently significant for size-B/M-industry portfolio returns, and the size premium is significant for size-momentum-industry portfolio returns, except in the standard models. Interestingly, the excess zero-beta rates of ICAPM models are significant for both sets of test portfolio. These high and positive zero-beta rates rate make ICAPM models' performance inferior compared to factor models, overshadowing their better explanatory power in Table 6.2.

Panel E of Tables 6.3 and 6.4 present the pricing results for Canada. For factor models, the market premium is priced for both sets of test portfolio returns while the momentum premium is priced only for size-momentum-industry portfolio returns. The market premium and the innovations to the term spread and risk-free rate are priced for the ICAPM models for only size-momentum-industry portfolio returns. None of the innovations are priced for size-B/M-industry portfolio returns. Moreover, the excess zero-beta rate in factor models is negative and significant for size-momentum-industry portfolios. Clearly, the size-momentum-industry portfolio returns for Canada are better priced by the ICAPM models than the factor models.

Overall, ICAPM models appear to be a better alternative, at least better than the standard 3F and decomposed 4F models in the international sample, US, UK, and Canada. ICAPM models perform well in Japan, but they have high excess zero-beta rates, in most cases larger than 1% per month. From results of Tables 6.1, 6.3 and 6.4, it is clear that ICAPM models perform quite well compared to factor models. The next sub-section examines if there is a relation between the return based factors and state variable innovations, by investigating whether, in the presence of state variable innovations, the returns based factors are still priced.

6.3.3 Incremental Explanatory Power of Return Based Factors

This subsection examines the pricing performance of each of the six factor models augmented with state variable innovations. The models are based on innovations obtained from the VAR model. The objective is to determine which risk factors are important determinants of average returns in the full set of state variables. The extent to which the innovations to the return based factors lose their pricing power, or equally do not lose their pricing power, in the presence of state variable innovations determine their relative importance. The extended models are:

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{SMB},t}\hat{\beta}_{i,\mu^{SMB}} + \gamma_{\mu^{HML},t}\hat{\beta}_{i,\mu^{HML}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.4}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{SMB},t}\hat{\beta}_{i,\mu^{SMB}} + \gamma_{\mu^{HML},t}\hat{\beta}_{i,\mu^{HML}} + \gamma_{\mu^{WML},t}\hat{\beta}_{i,\mu^{WML}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.5}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{SMB},t}\hat{\beta}_{i,\mu^{SMB}} + \gamma_{\mu^{HML_s},t}\hat{\beta}_{i,\mu^{HML_s}} + \gamma_{\mu^{HML_b},t}\hat{\beta}_{i,\mu^{HML_b}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.6}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{SMB},t}\hat{\beta}_{i,\mu^{SMB}} + \gamma_{\mu^{HML_s},t}\hat{\beta}_{i,\mu^{HML_s}} + \gamma_{\mu^{HML_b},t}\hat{\beta}_{i,\mu^{HML_b}} + \gamma_{\mu^{WML_s},t}\hat{\beta}_{i,\mu^{WML_s}} + \gamma_{\mu^{WML_b},t}\hat{\beta}_{i,\mu^{WML_b}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.7}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{SMM},t}\hat{\beta}_{i,\mu^{SMM}} + \gamma_{\mu^{MMB},t}\hat{\beta}_{i,\mu^{MMB}} + \gamma_{\mu^{SHML},t}\hat{\beta}_{i,\mu^{SHML}} + \gamma_{\mu^{MHML},t}\hat{\beta}_{i,\mu^{MHML}} + \gamma_{\mu^{BHML},t}\hat{\beta}_{i,\mu^{BHML}} + \gamma_{\mu^{WML},t}\hat{\beta}_{i,\mu^{WML}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}, \tag{6.8}$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{INDMKT,t}\hat{\beta}_{i,INDMKT} + \gamma_{\mu^{INDSMM},t}\hat{\beta}_{i,\mu^{INDSMM}} + \gamma_{\mu^{INDMMB},t}\hat{\beta}_{i,\mu^{INDMMB}} + \gamma_{\mu^{INDSHML},t}\hat{\beta}_{i,\mu^{INDSHML}} + \gamma_{\mu^{INDMHML},t}\hat{\beta}_{i,\mu^{INDMHML}} + \gamma_{\mu^{INDBHML},t}\hat{\beta}_{i,\mu^{INDBHML}} + \gamma_{\mu^{WML},t}\hat{\beta}_{i,\mu^{WML}} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + e_{i,t}\ , \tag{6.9}$$

Panels A to E of Table 6.5 present the cross-sectional risk premiums for the full set of state variables. All the return based factors that were significantly priced in Tables 6.3 and 6.4 for the US, international, UK, Japanese, and Canadian size-B/M-industry and size-momentum-industry portfolios are still priced. Most of the results for state variable innovations in Table 6.5 are not the same, as loadings on the innovations to the risk-free rate is now negatively priced in the standard 4F and decomposed 6F augmented models for the US size-momentum-industry portfolio returns (Panel A). Similarly, loadings on the innovations to the default spread are significant in the standard 4F and decomposed 6F augmented models for the UK size-momentum-industry portfolio returns. However, pricing of these state variable innovations does not affect the pricing power of return based factor innovations, which suggests that state variable innovations and factors do not capture the same information in the average returns.

For the international sample in Panel B, loadings on innovations to the term spread for size-B/M-industry portfolio returns and innovations to the default spread for the size-momentum-industry portfolio returns are no longer priced, both spreads were priced in Panel B of Tables 6.3 and 6.4. Moreover, none of the state variable innovations are priced for size-B/M-industry and size-momentum-industry portfolio returns for Japan in Panel D, a result similar to those in Panel D of Tables 6.3 and 6.4. The fact that the returns based factors are priced in the extended models, combined with the insignificance of the loadings on the state variable innovations shows that the return based factor retain their pricing power.

The pricing results for Canada in Panel E of Table 6.5 deviate considerably from their counterparts in Panel E of Table 6.3 and 6.4. Loadings on innovations to the default spread are now negatively priced for both size-B/M-industry and size-momentum-industry portfolios, while none of the innovations were priced previously. Moreover, loadings on innovations to the term spread in standard 3F and decomposed 4F augmented models and dividend yield in decomposed 6F augmented model are significantly priced for size-momentum-industry portfolios. However, despite the pricing of the state variable innovation, none of the return based factors lose their explanatory power. Instead, the value premium for the Canadian size-B/M-industry portfolio returns appears to be priced.

Table 6.5: Cross-Sectional Regressions Showing the Incremental Explanatory Power of the Return Based Factor Loadings

This table presents Fama-Macbeth cross-sectional coefficients using the excess returns on 25 size-B/M and 25 size-momentum plus19 industry portfolios. The innovations are obtained from the VAR model with respect to return based factor model in column 1 of the table, as explain in section 6.2. Table reports parameter estimates *γ*, Shanken (1992) *t*-statistics (SH *t*-stats) and model misspecification-robust *t*-statistics (PM *t*-stats).

Panel A: United States (US) size-B/M-industry portfolio returns												
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.83	-0.16	-0.39	0.44	0.53	-1.38	0.37	0.05				
SH t-stats	2.85	-0.42	-0.35	0.51	0.54	-1.21	1.37	0.17				
PM t-stats	2.63	-0.42	-0.31	0.48	0.46	-0.79	1.31	0.17				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.65	0.06	-0.38	0.09	1.08	-1.42	0.28	0.16	0.82			
SH t-stats	2.17	0.15	-0.34	0.10	1.07	-1.14	1.04	0.56	1.37			
PM t-stats	1.94	0.14	-0.30	0.09	0.99	-0.85	1.02	0.55	1.14			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.79	-0.11	-0.53	0.57	0.38	-0.72	0.37	0.05	-0.01			
SH t-stats	2.64	-0.29	-0.49	0.65	0.38	-0.68	1.35	0.18	-0.04			
PM t-stats	2.29	-0.28	-0.40	0.60	0.30	-0.40	1.31	0.18	-0.04			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.59	0.12	-0.39	0.15	1.01	-0.77	0.27	0.21	0.03	0.88	0.81	
SH t-stats	1.98	0.31	-0.34	0.16	0.96	-0.67	1.00	0.71	0.11	1.64	1.35	
PM t-stats	1.76	0.30	-0.27	0.15	0.88	-0.47	0.99	0.73	0.10	1.28	1.13	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	0.61	0.11	-0.40	0.18	0.76	-0.30	0.32	0.26	0.32	-0.18	0.03	0.92
SH t-stats	2.04	0.28	-0.37	0.22	0.80	-0.25	1.14	0.86	1.10	-0.62	0.08	1.60
PM t-stats	1.86	0.27	-0.31	0.21	0.71	-0.20	1.14	0.82	1.06	-0.64	0.08	1.44
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	0.65	0.04	0.04	0.44	0.82	-0.81	0.23	0.26	0.28	-0.23	-0.13	0.91
SH t-stats	2.05	0.10	0.04	0.52	0.86	-0.70	0.68	0.86	0.99	-0.64	-0.46	1.59
PM t-stats	1.95	0.10	0.03	0.48	0.80	-0.53	0.62	0.82	0.97	-0.66	-0.44	1.41

United States (US) size-momentum-industry portfolio returns												
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.83	-0.15	-1.62	0.89	-0.39	-0.58	0.78	-0.26				
SH t-stats	3.15	-0.42	-1.44	0.97	-0.33	-0.65	2.73	-0.81				
PM t-stats	2.87	-0.41	-1.45	0.94	-0.34	-0.48	2.73	-0.82				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.78	-0.09	-0.74	0.56	0.64	-1.61	0.63	-0.06	0.45			
SH t-stats	2.93	-0.24	-0.73	0.62	0.59	-1.98	2.21	-0.20	1.77			
PM t-stats	2.88	-0.25	-0.70	0.59	0.59	-1.70	2.23	-0.21	1.78			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.85	-0.16	-1.53	0.90	-0.34	-0.49	0.79	-0.39	-0.10			
SH t-stats	3.09	-0.43	-1.31	0.94	-0.29	-0.53	2.62	-1.03	-0.26			
PM t-stats	2.91	-0.43	-1.30	0.91	-0.30	-0.39	2.71	-1.10	-0.24			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.79	-0.09	-0.29	0.38	0.78	-1.41	0.64	-0.17	0.03	0.55	0.27	
SH t-stats	2.88	-0.26	-0.26	0.39	0.73	-1.76	2.15	-0.46	0.07	2.11	1.06	
PM t-stats	2.82	-0.26	-0.25	0.38	0.71	-1.64	2.30	-0.50	0.07	2.07	1.04	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	0.81	-0.10	-0.64	0.65	0.33	-1.33	0.60	0.49	-0.11	-0.43	0.15	0.45
SH t-stats	2.87	-0.27	-0.59	0.75	0.32	-1.63	1.79	1.54	-0.27	-1.20	0.38	1.73
PM t-stats	2.74	-0.26	-0.59	0.68	0.29	-1.45	1.83	1.51	-0.28	-1.20	0.34	1.79
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	0.80	-0.17	-0.71	0.70	0.20	-1.23	0.55	0.42	-0.26	-0.44	0.05	0.44
SH t-stats	2.76	-0.43	-0.66	0.76	0.19	-1.53	1.26	1.31	-0.63	-1.05	0.11	1.72
PM t-stats	2.83	-0.44	-0.64	0.70	0.17	-1.27	1.24	1.23	-0.66	-1.06	0.10	1.74

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Table 6.5 (continued)			Panel B: International size-B/M-industry portfolio returns									
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.67	-0.45	-0.04	0.15	0.40	1.43	0.65	0.25				
SH t-stats	2.82	-1.37	-0.03	0.18	0.57	1.64	2.74	0.91				
PM t-stats	2.05	-1.20	-0.02	0.13	0.41	1.03	2.53	0.90				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.35	-0.08	0.12	-0.14	1.01	1.27	0.59	0.50	1.87			
SH t-stats	1.23	-0.21	0.08	-0.16	1.26	1.33	2.42	1.59	2.59			
PM t-stats	0.76	-0.15	0.04	-0.11	0.80	0.80	2.23	1.44	1.21			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.64	-0.42	-0.42	0.00	0.43	1.81	0.67	0.02	0.43			
SH t-stats	2.36	-1.19	-0.30	-0.01	0.53	1.85	2.79	0.07	1.64			
PM t-stats	1.67	-0.97	-0.18	0.00	0.39	1.06	2.60	0.06	1.49			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.30	-0.04	-0.12	-0.43	1.00	2.23	0.63	0.35	0.51	1.87	1.47	
SH t-stats	0.88	-0.10	-0.08	-0.45	0.98	1.87	2.55	0.95	1.81	2.42	1.82	
PM t-stats	0.53	-0.07	-0.04	-0.27	0.66	1.00	2.39	0.75	1.54	1.21	0.99	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	0.18	0.11	-1.09	-0.16	0.50	2.38	0.59	0.62	0.92	-0.18	0.58	1.78
SH t-stats	0.51	0.26	-0.65	-0.18	0.53	1.97	1.89	2.34	2.68	-0.59	1.90	2.24
PM t-stats	0.37	0.20	-0.45	-0.16	0.42	1.43	1.46	1.99	2.27	-0.57	1.52	1.49
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	-0.13	0.42	1.33	0.43	1.25	-0.06	1.39	-0.44	0.44	0.77	0.39	2.47
SH t-stats	-0.33	0.89	0.87	0.46	1.30	-0.05	4.05	-1.43	1.33	1.34	1.03	3.02
PM t-stats	-0.27	0.72	0.57	0.37	0.98	-0.03	3.56	-1.36	1.19	1.13	0.87	2.28
				International size-momentum-industry portfolio returns								
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.24	0.02	-0.85	0.46	-1.58	0.30	0.92	-0.45				
SH t-stats	1.13	0.06	-0.64	0.70	-2.05	0.40	3.65	-1.21				
PM t-stats	0.63	0.04	-0.38	0.53	-1.40	0.30	3.41	-1.11				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.06	0.17	-2.05	0.71	-1.11	0.63	0.84	-0.23	0.58			
SH t-stats	0.32	0.57	-1.75	1.03	-1.48	0.85	3.31	-0.61	2.44			
PM t-stats	0.20	0.45	-0.94	0.86	-0.99	0.65	3.17	-0.60	2.43			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.21	0.05	-0.96	0.40	-1.55	0.58	0.92	-0.63	-0.20			
SH t-stats	1.01	0.16	-0.79	0.58	-1.90	0.66	3.66	-1.49	-0.37			
PM t-stats	0.60	0.12	-0.48	0.45	-1.37	0.39	3.43	-1.16	-0.31			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.08	0.12	-2.45	-0.24	-0.24	1.61	0.92	-0.73	0.49	0.70	0.31	
SH t-stats	0.36	0.36	-1.92	-0.27	-0.27	1.48	3.51	-1.67	1.09	2.86	1.29	
PM t-stats	0.26	0.31	-1.34	-0.18	-0.22	0.78	3.36	-1.37	0.68	2.82	1.34	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	-0.01	0.24	-2.23	0.79	-0.96	-0.47	0.83	0.63	-0.53	-0.57	0.79	0.56
SH t-stats	-0.05	0.71	-1.92	1.21	-1.12	-0.54	2.21	2.19	-1.09	-1.54	1.82	2.34
PM t-stats	-0.02	0.46	-0.97	0.89	-0.63	-0.34	1.45	1.46	-0.74	-1.11	1.06	2.33
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	0.06	0.12	-1.36	0.88	-0.40	-0.33	0.87	-0.11	-0.45	0.13	0.36	0.60
SH t-stats	0.29	0.39	-1.38	1.38	-0.54	-0.41	2.42	-0.36	-1.08	0.27	0.81	2.44
PM t-stats	0.20	0.32	-0.62	0.92	-0.36	-0.33	1.88	-0.31	-0.82	0.21	0.62	2.41

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Table 6.5 (Continued) **Panel C: United Kingdom (UK) size-B/M-industry portfolio returns**

Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	-0.17	0.60	0.18	-0.98	-0.40	0.67	-0.03	0.12				
SH t-stats	-0.54	1.53	0.15	-1.45	-0.59	1.00	-0.11	0.44				
PM t-stats	-0.50	1.42	0.12	-1.09	-0.48	0.83	-0.11	0.45				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	-0.28	0.71	-0.14	-0.70	-0.71	0.39	-0.02	0.09	0.63			
SH t-stats	-0.81	1.74	-0.11	-0.98	-0.94	0.59	-0.06	0.31	0.92			
PM t-stats	-0.74	1.59	-0.09	-0.74	-0.76	0.47	-0.06	0.32	0.76			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	-0.26	0.68	-0.02	-0.96	-0.56	0.77	-0.02	0.21	-0.11			
SH t-stats	-0.77	1.69	-0.02	-1.40	-0.90	1.13	-0.07	0.76	-0.40			
PM t-stats	-0.69	1.52	-0.02	-1.03	-0.69	0.92	-0.07	0.76	-0.38			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	-0.30	0.73	-0.21	-0.47	-0.44	0.26	0.01	0.21	-0.16	-0.04	0.75	
SH t-stats	-0.89	1.80	-0.18	-0.62	-0.61	0.41	0.04	0.74	-0.60	-0.06	1.11	
PM t-stats	-0.77	1.60	-0.15	-0.47	-0.48	0.31	0.04	0.75	-0.56	-0.05	0.97	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	-0.53	0.97	0.43	-1.17	-0.08	0.76	0.25	-0.22	0.37	-0.11	-0.19	0.33
SH t-stats	-1.45	2.25	0.38	-1.61	-0.12	1.11	0.91	-0.90	1.25	-0.40	-0.66	0.46
PM t-stats	-1.26	1.94	0.31	-1.21	-0.09	0.88	0.85	-0.87	1.24	-0.40	-0.61	0.40
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	-0.46	1.06	0.24	-1.72	0.18	1.25	0.57	-0.35	0.36	0.00	-0.31	0.31
SH t-stats	-1.42	2.47	0.17	-1.82	0.23	1.45	1.43	-1.00	1.05	0.01	-0.86	0.37
PM t-stats	-1.26	2.21	0.13	-1.35	0.16	1.11	1.27	-0.96	1.00	0.01	-0.80	0.31

Panel C: United Kingdom (UK) size-momentum-industry portfolio returns

Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	-0.60	0.99	0.13	1.99	1.13	-1.97	0.14	-0.69				
SH t-stats	-1.69	2.32	0.09	1.93	0.99	-1.79	0.50	-1.65				
PM t-stats	-0.84	1.37	0.02	0.53	0.60	-0.53	0.41	-1.19				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	-0.28	0.71	0.11	2.27	-1.91	-1.77	0.15	-0.35	0.96			
SH t-stats	-0.73	1.57	0.08	2.01	-1.95	-1.52	0.53	-0.81	3.64			
PM t-stats	-0.60	1.33	0.05	1.24	-1.68	-0.95	0.53	-0.76	3.48			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	-0.98	1.38	-1.18	2.29	-0.32	-1.80	0.34	-0.04	-1.93			
SH t-stats	-2.33	2.87	-0.82	2.09	-0.28	-1.49	1.19	-0.08	-3.15			
PM t-stats	-1.22	1.66	-0.21	0.64	-0.13	-0.51	0.82	-0.05	-1.46			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	-0.45	0.89	-0.63	1.60	-2.88	-0.86	0.20	-0.01	-0.82	0.81	0.78	
SH t-stats	-1.07	1.83	-0.47	1.42	-2.77	-0.78	0.69	-0.02	-1.47	2.84	2.89	
PM t-stats	-0.86	1.53	-0.27	0.76	-2.33	-0.42	0.66	-0.01	-1.18	2.65	2.67	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	-0.80	1.24	-0.03	2.09	-1.88	-1.36	0.56	-0.21	0.37	-0.36	-0.87	0.91
SH t-stats	-1.74	2.37	-0.02	1.52	-2.02	-1.06	1.44	-0.63	0.55	-0.64	-1.66	3.40
PM t-stats	-1.09	1.56	-0.01	0.86	-1.32	-0.65	1.12	-0.50	0.33	-0.40	-1.07	3.11
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	-0.35	0.92	-2.39	4.05	-2.27	-2.73	0.59	0.00	-1.79	2.55	-0.39	1.18
SH t-stats	-0.69	1.45	-1.02	1.97	-1.52	-1.34	0.89	-0.01	-1.80	1.96	-0.48	3.45
PM t-stats	-0.61	1.27	-0.60	1.31	-1.30	-0.96	0.79	-0.01	-1.22	1.19	-0.43	3.01

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Table 6.5 (Continued)				Panel D: Japanese size-B/M-industry portfolio returns								
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.41	-0.40	0.31	0.65	-0.20	1.51	0.30	1.04				
SH t-stats	0.89	-0.69	0.26	0.69	-0.20	1.33	0.84	2.34				
PM t-stats	0.79	-0.64	0.26	0.65	-0.19	1.23	0.84	2.26				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.32	-0.27	0.85	0.58	0.01	1.24	0.27	1.17	0.77			
SH t-stats	0.71	-0.49	0.80	0.63	0.01	1.09	0.75	2.80	0.98			
PM t-stats	0.61	-0.44	0.74	0.55	0.01	0.97	0.74	2.69	0.95			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.39	-0.38	0.35	0.62	-0.21	1.51	0.30	0.57	1.09			
SH t-stats	0.84	-0.66	0.28	0.62	-0.20	1.32	0.84	1.30	2.59			
PM t-stats	0.75	-0.61	0.27	0.57	-0.19	1.22	0.83	1.23	2.61			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.36	-0.31	0.38	0.72	0.54	0.88	0.27	0.65	1.03	0.43	1.02	
SH t-stats	0.80	-0.56	0.30	0.71	0.58	0.76	0.75	1.59	2.44	0.53	1.15	
PM t-stats	0.68	-0.50	0.25	0.61	0.43	0.64	0.75	1.43	2.30	0.46	1.12	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	0.30	-0.25	0.43	0.81	-0.37	1.07	0.65	0.21	0.71	0.54	1.20	0.89
SH t-stats	0.65	-0.44	0.39	0.85	-0.32	0.88	1.74	0.60	1.71	1.27	2.55	1.15
PM t-stats	0.55	-0.39	0.35	0.72	-0.29	0.70	1.71	0.60	1.60	1.14	2.65	1.07
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	0.26	-0.28	0.13	0.81	-0.19	0.98	0.55	0.17	0.89	0.61	1.00	0.76
SH t-stats	0.57	-0.48	0.13	0.83	-0.16	0.83	1.37	0.42	2.02	1.28	2.00	0.98
PM t-stats	0.50	-0.44	0.11	0.70	-0.15	0.69	1.36	0.42	1.86	1.21	1.96	0.89
				Panel D: Japanese size-momentum-industry portfolio returns								
Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	0.45	-0.46	-0.58	1.13	-0.39	1.00	0.53	0.77				
SH t-stats	0.76	-0.70	-0.41	1.12	-0.41	1.01	1.36	0.73				
PM t-stats	0.66	-0.63	-0.34	1.01	-0.39	0.90	1.32	0.69				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	0.69	-0.66	0.21	0.74	0.31	1.11	0.62	0.04	0.17			
SH t-stats	1.27	-1.04	0.17	0.79	0.35	1.14	1.59	0.04	0.50			
PM t-stats	1.18	-0.99	0.16	0.70	0.33	1.03	1.59	0.04	0.49			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	0.42	-0.42	-0.23	0.67	-0.16	1.25	0.62	-0.34	1.22			
SH t-stats	0.68	-0.62	-0.17	0.72	-0.18	1.23	1.56	-0.38	1.16			
PM t-stats	0.62	-0.59	-0.15	0.64	-0.17	1.14	1.51	-0.32	1.14			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	0.59	-0.56	0.53	0.40	0.17	1.56	0.66	-0.44	0.66	0.23	0.11	
SH t-stats	1.01	-0.85	0.41	0.42	0.20	1.40	1.63	-0.49	0.70	0.65	0.30	
PM t-stats	0.98	-0.83	0.40	0.38	0.19	1.25	1.62	-0.47	0.64	0.65	0.29	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	0.59	-0.58	-0.38	0.84	-0.14	1.24	0.92	0.40	-0.91	-0.09	0.80	0.17
SH t-stats	1.00	-0.87	-0.29	0.90	-0.15	1.11	2.26	1.00	-1.05	-0.11	0.95	0.49
PM t-stats	0.95	-0.83	-0.24	0.82	-0.14	0.95	2.25	0.96	-0.87	-0.11	0.88	0.49
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	0.64	-0.72	-0.04	0.83	0.23	1.03	0.70	0.18	-0.51	0.06	0.40	0.19
SH t-stats	1.21	-1.12	-0.03	0.86	0.25	0.96	1.66	0.37	-0.58	0.08	0.52	0.51
PM t-stats	1.08	-1.04	-0.02	0.70	0.23	0.83	1.63	0.36	-0.48	0.08	0.47	0.51

(Continued overleaf)

Table 6.5 (Continued) **Panel E: Canadian size-B/M-industry portfolio returns**

Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	-0.07	0.60	-0.65	1.26	-1.78	-0.49	-0.19	0.59				
SH t-stats	-0.26	1.67	-0.71	1.27	-1.98	-0.51	-0.67	1.76				
PM t-stats	-0.23	1.54	-0.44	0.89	-1.06	-0.30	-0.55	1.53				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	-0.24	0.81	-0.79	1.14	-2.12	-0.44	-0.34	0.93	1.57			
SH t-stats	-0.84	2.20	-0.81	1.07	-2.20	-0.43	-1.15	2.66	1.98			
PM t-stats	-0.71	1.91	-0.55	0.81	-1.33	-0.28	-0.97	2.31	1.48			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	-0.06	0.60	-0.58	1.34	-1.65	-0.50	-0.20	0.47	0.50			
SH t-stats	-0.23	1.63	-0.63	1.29	-1.78	-0.54	-0.70	1.26	1.57			
PM t-stats	-0.20	1.52	-0.37	0.93	-0.92	-0.32	-0.57	1.01	1.38			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	-0.26	0.84	-0.64	1.22	-1.93	-0.44	-0.37	0.76	0.81	1.40	1.46	
SH t-stats	-0.91	2.25	-0.65	1.10	-1.93	-0.45	-1.24	2.01	2.36	1.73	2.00	
PM t-stats	-0.72	1.94	-0.43	0.86	-1.15	-0.29	-1.08	1.66	2.14	1.25	1.52	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	-0.26	0.80	-0.80	-0.03	-2.98	0.56	-0.18	0.04	0.91	-0.42	0.75	0.73
SH t-stats	-0.90	2.09	-0.80	-0.03	-3.16	0.54	-0.47	0.12	2.16	-1.22	2.18	0.90
PM t-stats	-0.69	1.71	-0.61	-0.02	-1.85	0.36	-0.40	0.11	1.82	-1.11	2.09	0.74
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	-0.13	0.83	-0.11	0.86	-3.50	0.08	-0.26	0.17	0.97	-0.30	0.94	1.55
SH t-stats	-0.43	1.90	-0.08	0.67	-2.99	0.07	-0.49	0.42	2.14	-0.61	2.38	1.61
PM t-stats	-0.35	1.62	-0.06	0.49	-1.67	0.05	-0.42	0.40	1.82	-0.57	2.27	1.27

Panel E: Canadian size-B/M-industry portfolio returns

Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}				
Estimate	-0.32	0.83	1.93	-8.57	-4.01	7.12	0.26	-0.72				
SH t-stats	-0.76	1.61	0.85	-2.29	-1.89	2.09	0.42	-0.77				
PM t-stats	-0.63	1.27	0.59	-1.68	-0.79	1.51	0.27	-0.82				
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HML}	Υ_μ^{WML}			
Estimate	-0.30	0.74	-2.25	-2.20	-4.24	1.65	0.04	0.44	1.51			
SH t-stats	-1.04	1.84	-1.60	-1.02	-2.90	0.82	0.08	0.74	5.06			
PM t-stats	-0.97	1.66	-1.31	-0.58	-2.25	0.49	0.07	0.60	4.85			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}			
Estimate	-0.33	0.83	1.69	-9.00	-3.77	6.96	0.28	-0.70	-0.58			
SH t-stats	-0.73	1.50	0.72	-2.26	-1.71	1.98	0.39	-0.48	-0.49			
PM t-stats	-0.58	1.17	0.50	-1.78	-0.73	1.46	0.26	-0.30	-0.39			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMB}	Υ_μ^{HMLs}	Υ_μ^{HMLb}	Υ_μ^{WMLs}	Υ_μ^{WMLb}	
Estimate	-0.37	0.82	-2.36	-1.35	-3.14	0.84	-0.05	-0.30	0.99	1.69	0.92	
SH t-stats	-1.42	2.13	-1.80	-0.70	-2.40	0.47	-0.11	-0.35	1.43	5.37	3.04	
PM t-stats	-1.31	1.91	-1.72	-0.46	-1.77	0.32	-0.09	-0.29	1.28	5.41	2.86	
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{SMM}	Υ_μ^{MMB}	Υ_μ^{SHML}	Υ_μ^{MHML}	Υ_μ^{BHML}	Υ_μ^{WML}
Estimate	-0.32	0.77	-1.75	-2.15	-4.73	1.65	-0.40	0.41	-0.01	-0.51	0.59	1.48
SH t-stats	-1.05	1.84	-1.27	-1.03	-3.04	0.87	-0.34	0.57	-0.01	-0.39	0.73	4.97
PM t-stats	-0.95	1.64	-0.70	-0.53	-2.17	0.49	-0.29	0.52	-0.01	-0.27	0.43	4.83
Index 7F	Υ_0	Υ_{INDMKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_μ^{INDSMM}	Υ_μ^{INDMMB}	$\Upsilon_\mu^{INDSHML}$	$\Upsilon_\mu^{INDMHML}$	$\Upsilon_\mu^{INDBHML}$	Υ_μ^{WML}
Estimate	-0.39	1.00	-2.75	-2.88	-5.58	2.23	0.49	0.10	-0.02	0.03	0.96	1.70
SH t-stats	-1.25	2.06	-1.42	-1.04	-2.85	0.89	0.36	0.12	-0.02	0.02	0.97	4.76
PM t-stats	-1.20	1.92	-1.05	-0.64	-2.08	0.58	0.33	0.11	-0.02	0.01	0.76	4.56

Petkova (2006) reports that in the presence of state variable innovations, the returns based factors are no longer priced in the cross-sectional regressions in the US size-B/M portfolios. The factors priced were the innovations to the default spread and risk-free rate. Hence, Petkova (2006) concludes that the state variable innovations proxy for the size and value premiums. However, I find no evidence for such association between shocks to state variable and the size, value and momentum factors, and most of the innovations are not priced. Moreover, contrary to Petkova's (2006) evidence, the returns based factors do not lose their explanatory power in the extended models. Thus, the results show that the size, value and momentum factors do not proxy for state variable innovations in my sample. This implies that these factors cannot be rationalized using the ICAPM model representing the investment opportunity set. Although, the ICAPM models perform quite well compared to the factor models, this performance does not materialise into an explanation of the size, value and momentum factors.

6.3.4 State Variable Innovations as Conditioning Information

This subsection examines the role of lagged state variable innovations as conditioning information in explaining cross-sectional stock returns. The discussion follows Petkova (2006) and Ferson and Harvey (1999), who show that time-series loadings on lagged state variables have significant explanatory power for cross-sectional stock returns in the standard 3F model. Similarly, I examine whether the loadings with respect to the lagged innovations to the dividend yield, term spread, default spread, and risk-free rate have explanatory power in the returns based and ICAPM models. A single univariate time-series regression coefficient is first estimated for each of the lagged state variable innovations on each of the test portfolio returns. A generalized univariate model is given by,

$$R_{i,t} = \alpha_i + \hat{\delta}_i \mu_{t-1}^k + \varepsilon_{i,t} \tag{6.10}$$

where μ_{t-1}^{k} represents lagged innovations to dividend yield, term spread, default spread, and risk-free rate taken one at a time. So I regress six different versions of these innovations, taking one at a time, obtain from VAR model with respect to each of the six factor models. After obtaining the univariate loadings ($\hat{\delta}_i$) for lagged innovations, the insignificance of the $\hat{\delta}_i$ in the presence of risk factors of each of the factor and ICAPM models is examined in the cross-sectional regression. If the model based on risk factors is a true model explaining the average returns, then the loadings on lagged innovations should not have explanatory power over and above the variables in the model. Following are the generic cross-sectional specifications to test the role of conditional information in the factor models and ICAPM models.

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT}\big(\hat{\beta}_{i,INDMKT}\big) + \textstyle\sum_{k=1}^{K}\gamma_{K,t}\hat{\beta}_{i,RBF}^{K} + \gamma_{\delta,t}\hat{\delta}_i + e_{i,t}, \qquad (6.11)$$

$$R_{i,t} = \gamma_{0,t} + \gamma_{MKT,t}\hat{\beta}_{i,MKT} + \gamma_{\mu^{DY},t}\hat{\beta}_{i,\mu^{DY}} + \gamma_{\mu^{TERM},t}\hat{\beta}_{i,\mu^{TERM}} + \gamma_{\mu^{DEF},t}\hat{\beta}_{i,\mu^{DEF}} + \gamma_{\mu^{RF},t}\hat{\beta}_{i,\mu^{RF}} + \gamma_{\delta,t}\hat{\delta}_i + e_{i,t}, \qquad (6.12)$$

The $\hat{\beta}_{i,RBF}^{K}$ in equation (6.11) represent the vector of factor loadings for the return based factors except market returns, and that vector changes for each of the six factor models. The risk premiums in both equations are estimated for each factor model and ICAPM model, the same models as in Tables 6.3 and 6.4, and each lagged innovation loading separately. Given the five samples two test portfolios examined in this study, it is not possible to report results for each conditioning variable in each model. Therefore, only the results for which lagged conditional variables have explanatory power over risk factors are reported. The null hypothesis is that the $E\big(\gamma_{\delta,t}\big) = 0$, the premium on the univariate time-series loadings should be zero. Both Petkova (2006) and Ferson and Harvey (1999) find that loadings to the lagged state variables capture important variations in expected stock returns left unexplained by the standard 3F model, which shows the model cannot capture important information in these lagged instrument variables.

However, there is no such evidence in the results of the conditional models tested in my sample. Table 6.6 reports only selected results for the conditional models for the sake of brevity.

Panel A of Table 6.6 reports results for the international size-momentum-industry portfolio returns using the lagged innovations to the term spread as the conditioning variable. The premium on the loadings of lagged term spread innovations is positive and significant only for the six ICAPM models, whereas none of the contemporaneous state variable innovations are priced. Similarly, the lagged term premium innovation is priced in the ICAPM models for Canadian size-momentum-industry portfolio returns (Panel B of Table 6.6) along with the market risk premium and contemporaneous innovations to the risk-free rate. For the return based models, the lagged term spread innovation is not priced for either the international or Canadian size-momentum-industry portfolios. Following the intuition of Ferson and Harvey (1999), the return based models provide a better explanation of average size-momentum-industry portfolio returns while the innovations based models leave important variation unexplained which is captured by lagged term spread innovations.

For the Canadian size-B/M-industry portfolios (Panel C), the lagged default spread is priced in the modified 7F and index-based 7F models, whereas it is only priced using SH *t*-statistics not PM *t*-statistics in the ICAPM models. Apparently, the two 7F models leave some important information unexplained for Canadian size-B/M-industry portfolios along with the ICAPM models. In short, the risk based models capture the time-varying patterns in returns better compared to the ICAPM models for at least the international and Canadian portfolio returns. The insignificance of the univariate loadings of lagged innovations shows that factor models successfully capture the information content of lagged state variable innovations.

6.6: Cross-sectional Regressions Showing the Incremental Explanatory Power of Lagged Values of State variable Innovations

This table presents Fama-MacBeth cross-sectional coefficients using the excess returns on 25 size-B/M and 25 size-momentum plus19 industry portfolios. The innovations are obtained from the VAR model with respect to return based factor models in column 1 of the table, as explain in section 6.2. The variables δ^{DY}, δ^{TERM}, δ^{DEF}, and δ^{RF} are the loadings of each portfolio return on lagged values of DY, TERM, DEF, and RF, respectively, computed in separate time-series regressions. Table reports parameter estimates *γ*, Shanken (1992) *t*-statistics (SH *t*-stats) and model misspecification-robust *t*-statistics (PM *t*-stats).

Panel A: International size-momentum-industry portfolio returns

Return based risk factors

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_δ^{TERM}				
Estimate	0.45	-0.19	0.42	-0.16	1.54				
SH t-stats	2.28	-0.63	2.47	-0.74	1.09				
PM t-stats	2.17	-0.59	1.98	-0.71	0.81				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}	Υ_δ^{TERM}			
Estimate	0.31	-0.07	0.51	-0.14	0.51	0.08			
SH t-stats	1.87	-0.25	3.16	-0.66	2.10	0.07			
PM t-stats	1.54	-0.25	2.48	-0.65	1.66	0.04			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_δ^{TERM}			
Estimate	0.54	-0.27	0.38	-0.31	0.15	1.87			
SH t-stats	2.71	-0.88	2.25	-1.19	0.52	1.32			
PM t-stats	2.58	-0.83	1.75	-1.17	0.43	0.97			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}	Υ_δ^{TERM}	
Estimate	0.36	-0.15	0.56	-0.51	0.45	0.68	0.38	-0.82	
SH t-stats	1.96	-0.50	3.38	-1.92	1.67	2.77	1.41	-0.69	
PM t-stats	1.73	-0.49	3.17	-2.07	1.47	2.52	1.36	-0.61	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_δ^{TERM}
Estimate	0.46	-0.15	0.17	0.29	0.09	-0.38	0.36	0.42	0.88
SH t-stats	2.19	-0.48	1.73	2.05	0.38	-1.67	1.60	1.85	0.93
PM t-stats	1.81	-0.43	1.40	1.45	0.30	-1.38	1.21	1.62	0.50
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_δ^{TERM}
Estimate	0.21	0.08	0.66	-0.24	-0.11	0.19	0.09	0.41	1.67
SH t-stats	1.18	0.25	3.30	-1.11	-0.41	0.84	0.41	1.84	1.33
PM t-stats	0.99	0.22	3.10	-0.92	-0.28	0.75	0.37	1.66	0.70

State variable innovations

Standard 3F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.23	0.10	-2.05	1.05	-0.47	0.02	3.90
SH t-stats	0.76	0.27	-1.65	0.72	-0.37	0.02	1.92
PM t-stats	0.62	0.25	-1.59	0.57	-0.29	0.02	2.14
Standard 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.26	0.08	-1.99	1.03	-0.49	-0.10	3.83
SH t-stats	0.84	0.21	-1.60	0.68	-0.37	-0.08	1.90
PM t-stats	0.70	0.20	-1.55	0.56	-0.30	-0.07	2.11
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.23	0.11	-2.06	0.99	-0.41	-0.02	3.96
SH t-stats	0.74	0.28	-1.63	0.68	-0.32	-0.02	1.94
PM t-stats	0.61	0.26	-1.59	0.55	-0.26	-0.02	2.19
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.23	0.11	-2.15	0.95	-0.55	0.19	4.08
SH t-stats	0.71	0.28	-1.55	0.61	-0.41	0.15	1.84
PM t-stats	0.59	0.25	-1.55	0.48	-0.32	0.13	2.08
Modified 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.20	0.24	-1.92	0.59	-0.61	0.26	4.24
SH t-stats	0.61	0.59	-1.48	0.39	-0.48	0.20	2.01
PM t-stats	0.52	0.55	-1.45	0.32	-0.40	0.17	2.19
Index 7F	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	0.32	0.19	-1.99	0.64	-1.11	0.58	4.67
SH t-stats	0.97	0.45	-1.50	0.40	-0.79	0.38	2.00
PM t-stats	0.82	0.42	-1.41	0.31	-0.63	0.31	2.13

(Continued Overleaf)

Table 6.6 (Continued) **Panel B:Canadian size-momentum-industry portfolio returns**

	Return based risk factors									**Local state variable innovations**						
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_δ^{TERM}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.35	0.90	-0.18	-0.04	0.08					-0.81	1.42	1.58	-1.24	3.28	-6.52	-5.25
SH t-stats	-2.07	2.82	-1.03	-0.15	0.09					-1.68	2.43	0.95	-0.55	1.47	-2.63	-2.16
PM t-stats	-0.64	1.15	-0.33	-0.08	0.01					-1.24	1.84	0.85	-0.33	1.22	-2.23	-1.05
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}	Υ_δ^{TERM}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.47	1.12	-0.17	0.17	1.39	-1.48				-0.92	1.59	1.50	-1.05	2.38	-6.62	-6.26
SH t-stats	-2.53	3.42	-0.94	0.60	6.33	-1.46				-1.77	2.54	0.88	-0.45	1.05	-2.53	-2.41
PM t-stats	-1.67	2.84	-0.72	0.57	6.13	-0.63				-1.46	2.06	0.84	-0.32	0.86	-2.24	-1.58
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_δ^{TERM}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.36	0.93	-0.13	-0.21	0.04	-0.33				-0.85	1.50	1.42	-1.47	3.15	-6.43	-5.35
SH t-stats	-2.12	2.90	-0.67	-0.43	0.11	-0.35				-1.81	2.56	0.86	-0.67	1.46	-2.60	-2.18
PM t-stats	-0.65	1.13	-0.16	-0.08	0.03	-0.04				-1.36	1.95	0.75	-0.39	1.22	-2.24	-1.09
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}	Υ_δ^{TERM}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.54	1.19	-0.14	-0.24	0.41	1.43	1.18	-1.61		-0.90	1.59	1.29	-1.30	2.30	-6.41	-6.08
SH t-stats	-2.79	3.56	-0.68	-0.44	0.89	6.49	4.02	-1.49		-1.82	2.61	0.78	-0.58	1.05	-2.56	-2.41
PM t-stats	-2.14	3.25	-0.46	-0.27	0.64	6.24	3.68	-0.69		-1.51	2.13	0.73	-0.41	0.87	-2.34	-1.55
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_δ^{TERM}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.59	1.24	-0.44	0.22	0.47	-0.64	0.07	1.40	-1.59	-0.98	1.67	1.17	-1.11	2.45	-6.57	-6.34
SH t-stats	-2.98	3.68	-1.68	0.82	0.90	-1.05	0.13	6.35	-1.46	-1.87	2.60	0.73	-0.49	1.10	-2.58	-2.33
PM t-stats	-2.07	3.11	-1.29	0.61	0.59	-0.78	0.10	6.22	-0.62	-1.55	2.19	0.68	-0.35	0.90	-2.37	-1.71
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_δ^{TERM}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{TERM}
Estimate	-0.51	1.35	-0.25	0.05	0.37	-0.62	0.18	1.38	-1.92	-0.91	1.73	1.44	-1.05	2.75	-8.52	-6.99
SH t-stats	-2.74	3.52	-1.02	0.21	0.82	-0.95	0.37	6.27	-1.50	-1.75	2.41	0.76	-0.39	1.05	-2.65	-2.14
PM t-stats	-1.98	3.08	-0.70	0.16	0.60	-0.74	0.30	6.07	-0.63	-1.37	1.91	0.70	-0.27	0.83	-2.44	-1.44

(Continued Overleaf)

Table 6.6 (Continued)			Panel C:Canadian size-B/M-industry portfolio returns													
			Return based risk factors										Local state variable innovations			
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_δ^{DEF}					Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.20	0.73	-0.07	0.12	1.05					0.24	0.27	0.44	0.01	0.15	-0.34	1.82
SH t-stats	-0.88	2.18	-0.49	0.55	1.33					0.73	0.65	0.65	0.01	0.15	-0.38	2.10
PM t-stats	-0.81	2.10	-0.47	0.52	0.91					0.63	0.60	0.46	0.01	0.13	-0.21	1.42
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}	Υ_δ^{DEF}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.32	0.90	-0.15	0.29	1.23	1.09				0.26	0.25	0.37	-0.02	0.00	0.09	1.80
SH t-stats	-1.33	2.63	-0.96	1.23	2.02	1.32				0.79	0.62	0.55	-0.02	0.00	0.09	2.09
PM t-stats	-1.08	2.33	-0.94	1.21	1.39	0.97				0.71	0.58	0.40	-0.01	0.00	0.06	1.40
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_δ^{DEF}				Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.19	0.73	-0.07	0.05	0.19	1.09				0.23	0.28	0.43	-0.04	0.18	-0.42	1.85
SH t-stats	-0.84	2.16	-0.46	0.16	0.68	1.33				0.71	0.70	0.65	-0.04	0.18	-0.47	2.15
PM t-stats	-0.77	2.04	-0.45	0.14	0.63	0.84				0.61	0.63	0.45	-0.03	0.15	-0.26	1.45
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HMLs}	Υ_{HMLb}	Υ_{WMLs}	Υ_{WMLb}	Υ_δ^{DEF}		Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.28	0.86	-0.13	0.15	0.40	0.70	1.55	1.37		0.26	0.26	0.32	-0.12	0.10	-0.10	1.88
SH t-stats	-1.14	2.47	-0.87	0.52	1.31	1.13	2.10	1.53		0.78	0.63	0.49	-0.12	0.10	-0.10	2.19
PM t-stats	-0.94	2.16	-0.84	0.46	1.24	0.74	1.48	1.07		0.70	0.59	0.34	-0.08	0.09	-0.06	1.44
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_δ^{DEF}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.36	0.90	-0.08	-0.05	0.27	-0.51	0.55	0.59	1.89	0.27	0.25	0.45	0.11	0.14	-0.16	1.82
SH t-stats	-1.39	2.52	-0.66	-0.26	1.01	-2.03	1.69	0.92	2.10	0.82	0.62	0.68	0.12	0.13	-0.17	2.12
PM t-stats	-1.18	2.31	-0.64	-0.25	0.98	-1.92	1.65	0.76	1.76	0.74	0.58	0.50	0.08	0.11	-0.11	1.42
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_δ^{DEF}	Υ_0	Υ_{MKT}	Υ_μ^{DIV}	Υ_μ^{TERM}	Υ_μ^{DEF}	Υ_μ^{RF}	Υ_δ^{DEF}
Estimate	-0.38	1.05	-0.10	-0.02	0.19	-0.42	0.62	0.98	2.43	0.27	0.30	0.70	-0.06	0.19	-0.32	2.06
SH t-stats	-1.54	2.56	-0.68	-0.11	0.85	-1.32	1.98	1.53	2.06	0.80	0.61	0.89	-0.06	0.17	-0.29	1.99
PM t-stats	-1.37	2.42	-0.73	-0.11	0.89	-1.33	2.00	1.33	1.67	0.73	0.59	0.66	-0.04	0.14	-0.17	1.39

6.4 Conclusion

This chapter attempts to link stock returns with the macro economy by comparing the returns based factor models with models based on the innovations to state variables representing an investor's opportunity set. The chapter follows Petkova (2006), who reported that innovations to the dividend yield, term spread, default spread, and T-bill rate proxy for Fama and French's size and value factors. She also argues that a model containing these innovations as risk factors along with the market risk premium outperforms the standard 3F model.

However, the results reported in this chapter do not show any empirical evidence to support a relation between the return based factors and innovations to dividend yield, term spread, default spread and T-bill rate. Most of the innovations are not priced for the US, UK, and Japanese portfolios returns. Moreover, when return based factors and state variable innovations are examined in combined extended models, the return based factors remain significantly priced while most of the state variable innovations are not priced. Conditional models also fail to rescue the ICAPM models and do not show any support for them. Therefore, it seems that Petkova's (2006) results are sample specific and do not extend to other countries and time periods. Also, as the size and value factors are not priced for most of the markets in my sample, which may be the cause of the absence of any relation between the returns based factor and state variable innovations.

When regressing individual innovations on returns based models, I still find indications of an association between the return based factors and the state variable innovations. However, these cannot be supported by the cross-sectional evidence. Nevertheless, as in Petkova (2006) and Kan et al. (2013), the ICAPM models perform better compared to the standard 3F and decomposed 4F models, and sometimes the standard 4F model. The ICAPM models always have higher explanatory power and pass the specification tests. Thus, the ICAPM models may provide good explanations of the cross-sectional stock returns compared to the standard 3F and 4F models, but there is no relationship between the state variable innovations and the size, value and momentum factors, at least in my sample.

The results of this chapter have important implications for investors and fund managers who wish to assess the effect of macroeconomic risk on their portfolio returns. Hence, if shocks to the state variables are significant in explaining stock returns, as confirmed by higher explanatory power, lower pricing errors, insignificant zero-beta rate of the ICAPM model, then investors and fund managers should adjust their positions on the basis of their expectations of any changes in the these state variables. Further, regulators will be interested in knowing the impact of any shock to the state variables on the performance of the stock market. Understanding the link between expected returns and the real economy will help them take precautionary steps and speed up their response to any undesired events such as the recent financial crises of 2008.

The question of what drives the returns on size, value and momentum factors remains unanswered. The possible areas to investigate may include considering other state variables related to investors' investment opportunity sets reported in the literature, such as the state variable identified by Chen et al. (1986) and Campbell (1996), which include real labour income growth, industrial production growth, relative bill rate (T-bill rate minus one-year moving average), expected and unexpected inflation rates and real interest rate. Also, one might examine diffusion indices obtained from a large set of macroeconomic variables, following the approach of Stock and Watson (2002), to consider a complete set of variables representing investment opportunities.

Chapter 07: Conclusion

7.1 Introduction

Common patterns in stock returns that are inconsistent with generally accepted asset pricing models are called empirical asset pricing anomalies. These anomalies indicate either market inefficiency or misspecification in the asset pricing models used to explain the stock returns. Persistence of these well-documented anomalies suggests that they do not arise because of market inefficiencies, as shown by various studies [see, for example, Fama and French (1993, 1996, and 2015)]. The inadequacy of currently used asset pricing models to capture these anomalies has led to the improvement of these models by incorporating these anomalies as factors in the pricing models.

This thesis has examined the relation between expected stock returns and risk factors. The focus was on the common patterns in the stock returns shown by the persistent anomalies based on the well-documented size, value and momentum effects. The size effect refers to the empirical finding of higher average returns for small market capitalization stocks than big market capitalization stocks. The value effect is an empirical finding of high B/M ratio stocks (value stocks) having higher average returns than low B/M ratio stocks (growth stocks). Fama and French (1993) propose a 3F model that contains the *SMB* and *HML* factors and capture the size and value effects, in addition to the market portfolio of CAPM. However, the 3F model fails to explain the momentum effect in stock returns. The momentum effect is the continuation of positive returns for the previous positive return earning stocks and negative returns for the previous negative earning stocks. The inability of the 3F model to explain the momentum effect lead Carhart (1997) to the 4F model that includes a *WML* factor capturing the momentum effect, in addition to the factors included in the 3F model.

This thesis is primarily motivated by two recent studies by Fama and French (2012) and Cremers et al. (2013). Fama and French (2012) study size, value and momentum effects in international stock returns and show that the global and regional versions of the standard 3F and 4F models fail to capture the momentum returns and returns on microcaps. While criticising the constructing methodology of the factors used in the standard 3F and 4F models, Cremers et al. (2013) argue that these models are expected to leave abnormal returns by construction. Therefore, they recommend some modifications in defining the risk factors and propose modified and index-based versions of the standard 3F and 4F models.

There are three objectives of this thesis. The first is to explain portfolio returns in four international equity markets sorted on size, value and momentum anomalies using newly proposed decomposed, modified and index-based models compared to Fama and French's (1993) standard 3F and Carhart's (1997) standard 4F models. The second objective is to test the performance of the international factor models constructed by combining data from four countries studied in this thesis. The measure of asset pricing model integration is the extent to which international models explain returns on international and country level portfolios. The third objective is to provide a economic explanation to the empirically motivated size, value, and momentum factors and their recently proposed modifications, using the ICAPM model of Petkova (2006).

7.2 Summary of the empirical findings

Using monthly returns for the US, UK, Japan and Canada, results in chapter 3 show that the factors constructed using the standard Fama and French (1993) method, the decomposed approach of Fama and French (2012), and the modified and index-based approaches of Cremers et al. (2013) have quite different average returns. Hence, it is important to test whether these differences in the average returns under these approaches influence the pricing performance of decomposed, modified, index-based models in the empirical chapters 4, 5 and 6. There is a statistically significant value premium in the international sample, Japan and Canada, and a statistically significant momentum premium in the international sample, US, UK, and Canada. Similar to Fama and French (2012), I also found disparities in the value and momentum premium between small and big size stocks. These differences support the use of separate factors in the decomposed asset pricing models, and indicate that the decomposed models are expected to capture more of the variations in the returns of small and big stocks than standard models. I found no size premium in any market, a result consistent with the recent literature [Fama and French (2012) and Gregory et al. (2013a)]. There is a market premium in the international sample, US, UK, and Canada based on the index-based market portfolio. However, the simple market portfolios only have significant returns for the US and Canada. Cremers et al. (2013) recommend the use of index-based market portfolio arguing that it is a more realistic and easily comparable measure of the market portfolio for the average investor. The difference in the returns of the two market portfolio measures across different countries indicates that the asset pricing models having these two different measures may perform differently.

Chapter 4 extends the empirical asset pricing literature by constructing and testing decomposed, modified and index-based specifications of the 3F and 4F models for an international sample. Using a time-series regression approach, I test whether the value and momentum patterns in average returns are captured by these alternative empirical asset pricing models and test whether such models suggest that asset pricing is integrated across the four countries. Integration is examined by assessing the ability of international models to capture the average returns on international and country portfolios. As expected, the pricing results show that local country models perform better than the international models, a result rejecting asset pricing integration and consistent with Griffin (2002), Hou et al. (2011) and Fama and

French (2012). In terms of the models, the local and international versions of the standard 3F and 4F models fail to capture variations in the average returns in all the markets, except for Japan where the local models adequately explain average returns. The alternative models improve the pricing performance and fare quite well. Specifically, the local version of the index-based 7F model satisfactorily explains the variations in average portfolios returns sorted on size and B/M in all equity markets. The model's international version also fares quite well in the tests on international, US, and Japanese portfolios. The model had a higher explanatory power compared to other international models. Although, the overall time-series results are not very encouraging for the integration hypothesis as the international models fail the specification tests and have very low explanatory power, the index-based 7F model shows some improvement both in terms of explanatory power and the specification test.

In chapter 5 I use the cross-sectional regression approach of Fama and MacBeth (1973) to investigate the cross-sectional performance of the asset pricing models. Ideally, the time-series and the cross-sectional tests should provide the same results for any asset pricing model under examination [Lewellen et al. (2010)]. However, researchers have reported discrepancies in the results for two approaches [Shanken and Zhou (2007), Fama and French (2008) and Gregory et al. (2013a)]. Therefore, I analyse and compare the cross-sectional results and the times-series results for the standard, decomposed, modified, and index-based models. This is one of the first studies that examines the cross-sectional asset pricing in the international context. Considering the critique of Lewellen et al. (2010) about the use of explanatory returns and test portfolios formed using the same characteristics, I use two sets of 44 portfolios as test assets. Each set is based on 25 size-B/M and 25 size-momentum portfolios, augmented by 19 industry portfolios. Moreover, I use recently developed model misspecification robust asymptotic test of Kan et al. (2013).

The results in Chapter 5 show that the international factor models do not work for the international portfolios as they are rejected by the specification tests, a result consistent with the time-series tests. The results show that none of the asset pricing models integrate for my international sample. The international size factors are priced consistently, and the international momentum factors are priced for size-momentum-industry portfolios only. For the country level portfolio returns, the international and local models perform equally well, and their performance is indistinguishable by specification tests and cross-sectional R^2. However, regarding factor pricing, the country factors are priced more accurately and reliably (if they are priced at all) than the international factors, that is their factor premiums are economically plausible. Hence, despite the good performance of the international models in the cross-sectional specifications tests and R^2, the international factor premiums are unreasonable in most of the cases, which make them unattractive and indicate the lack of asset pricing integration. The local factors that are reliably priced include the momentum factor for US size-momentum-industry portfolios, the market and momentum premiums for the UK, the value premium for Japanese size-B/M-industry portfolios, and the market premium for Canada.

From the individual model perspective, the standard 3F and decomposed 4F models are the worst performers for all the samples. These two models are without a momentum factor and they are dominated by other models. Thus, the momentum factor is crucial for the performance of the models in the cross-sectional tests. Although, the standard 4F model is not significantly dominated by other models, the model has lower explanatory compared to the decomposed 6F, modified 7F, and index-based 7F models. Therefore, these higher factor models should be preferred over the standard 4F model. The decomposed 6F, the modified 7F, and the index-based 7F models are almost indistinguishable from each other in terms of explanatory power. Moreover, if any factor is priced in a sample, it is priced consistently for these three models. Therefore, what matters more in the cross-sectional tests is that decomposed factors should be used for the small and big stocks, no matter which decomposition method is used. This is important since Cremers et al. (2013) advocate the use of decomposed factors for the size and value factors using modified and index-based approaches, but recommend the momentum factor be kept the same as in the standard 4F model. However, the results in Chapter 5 show that the decomposition of the momentum factor is equally important as the decomposition of the size and value factors.

Finally, I follow the empirical framework of Petkova (2006) in an attempt to relate the size, value, and momentum factors and their decomposed, modified, and index-based versions to the innovations in state variables representing investors' opportunity sets. Using US data, Petkova (2006) shows that the *SMB* and *HML* factors proxy for innovations in state variables, and in the presence of those innovations the *SMB* and *HML* factors lose their explanatory power. The state variables used are the dividend yield, term spread, default spread, and T-bill rate. However, my results do not show any empirical evidence of relationships between the size, value and momentum factors and innovations in these state variables. In the cross-sectional tests, most of the state variable innovations are not priced in any of the markets. In the tests of extended models that include the returns based factors and state variable innovations, the returns based factors do not lose their explanatory power. These results are in contradiction with those of Petkova (2006). Therefore, it seems that Petkova's (2006) results are sample specific and do not extend to other countries and time periods. Moreover, the absence of the relationship may have risen from the fact that the size, value and momentum factors are not priced for most of the markets. Hence, one may not expect support for their relationship with innovations to state variables. Nevertheless, this issue needs investigation in future work by considering other countries and larger sample

Although there is no evidence of any relation between size, value and momentum factors and the state variable innovations, the ICAPM models containing these innovations perform better than the standard 3F and 4F and decomposed 4F models. The ICAPM models have fewer rejections compared to all the returns based models. The models also have comparative explanatory power with the standard 3F, 4F and decomposed 4F models. Recent studies such as Kan et al. (2013) and Gospodinov et al. (2014) also report that the ICAPM models perform better than other models, including the standard 3F and 4F models.

This thesis contribute to the asset pricing literature by showing that the index-based 7F model outperform all the other models, including standard 3F and 4F models, in the time-series tests. Hence, this should encourage the use of the index-based 7F model in both academic research and practical industry applications. For example, financial analysts should consider the index-based 7F model in giving recommendations to investors about good and bad stocks. Researchers should consider the index-based 7F to estimate abnormal returns. Further, it will be useful for them for testing the robustness of the so-called anomalies (such as profitability, investment, etc) to the index-based 7F model. Investors, fund managers are also recommended to use the index-based 7F model in their cost of capital estimation, mutual fund evaluation and portfolio performance measurement.

7.3 Limitations and Future Research

I limit my study to the time-series and cross-sectional tests of the 3F and 4F models and their decomposed, modified, and index-based specifications and also compare their performance with the ICAPM models of Petkova (2006) using only cross-sectional tests. However, I acknowledge the existence of a wealth of literature covering asset pricing models that suggest either extensions to the Fama-French model such as the recent five-factor model of Fama and French (2015), or alternatives either in the form of conditional or unconditional asset pricing models. Those asset pricing models may be at work in the markets I examined. Hence, it will be useful to compare the performance of such models to the models examined in this thesis.

Moreover, the relative small sample size in the time dimension might lead to small sample bias in the results of Chapters 4, 5 and 6. Therefore, the result may change for a larger sample in the time dimension. However, it is not possible to get the larger sample in the time dimension for the stocks of all four countries studies in this thesis.

In Chapter 6 I use the innovations to dividend yield, default spread, term spread, and T-bill rate as proxies for the investment opportunity sets proposed by Petkova (2006). However, these are a small number of variables compared with a large number of macroeconomic variables available publicly and may represent variables that offer incremental information on investment opportunity sets. Thus, by following Petkova (2006), I may have omitted other important information for pricing stocks that is not accounted for by these variable. Therefore, it will be interesting to examine those factors in the ICAPM framework of Merton (1973) and see whether they improve the pricing performance of the model. In this regard, the empirical finance literature proposes a host of risk factors to explain stock returns and these may help explain the size, value and momentum anomalies. The prominent state variables considered to explain expected stock returns and asset pricing anomalies include labour income [Jagannathan and Wang (1996) and Heaton and Lucas (2000)], housing prices [Kullmann (2001)], real interest rate and maximum Sharpe ratio [Brennan et al. (2004)], growth in future consumption [Parker and Julliard (2005)], and aggregate market liquidity risk [Pástor and Stambaugh (2003) and Acharya and Pedersen (2005)].

Moreover, in Chapter 6, I use lagged innovations to the four state variables considered in this thesis to study the conditional performance of the factor models and the ICAPM models. The choice of the conditioning variables is limited to the four state variables and is somewhat arbitrary. However, the empirical asset pricing literature suggests many other conditional variables that capture the state of the economy, including interest rates [Ferson and Harvey (1999)], the consumption-wealth ratio [Lettau and Ludvigson (2001)], the housing collateral ratio [Lustig and Van Nieuwerburgh (2005)], the labour income to consumption ratio [Santos and Veronesi (2006)], and the non-housing expenditure ratio [Piazzesi et al. (2007)]. Therefore, the performance of the models may vary depending on the conditioning variables used.

Finally, in Chapters 5 and 6 I use the two-stage cross-sectional framework based on simple Ordinary Least Squares (OLS) regressions to analyse the models performance and estimate the factor risk premium. However, other methods, such as Generalised Least Squares (GLS), maximum likelihood (ML) and GMM, can also be used. In this regard, Shanken and Zhou (2007) provide finite sample distribution analysis of the two-stage regression methodology and compare it with GLS, ML and GMM estimation methods and report that different methods yield quite different results. Kan et al. (2013) also provide potential model misspecification robust analysis of both OLS and GLS cross-sectional regressions and show significant differences in the cross-sectional risk premiums between two approaches. The other issue related to the two-stage cross-sectional regressions is the use of time-variant time-series loadings. Fama and Macbeth (1993) use a rolling window of five years to estimate the time-series loadings and then use them as independent variables in the cross-sectional regressions. However, recent studies report that the use constant estimates or rolling estimates yield the same results [see Shanken and Zhou (2007) and Gregory et al. (2013a) among others].

Appendix

Table A1: Constituent Lists

Table displays the constituent lists, doe both live and dead firms, for the US, UK, Japan, and Canada. The US constituent list mnemonics, FAMERA-FAMERAZ, are the 26 different constituent lists for each letter of the alphabets, i.e., FAMERA, FAMERB, and so on. The constituents are the original number of 'constituents' for each country from all constituent lists. 'Stocks' is the number of stocks actually used for each country after applying the static filters described in section 3.2.

Country	Constituent List Mnemonic	Constituents	Stocks
US	FAMERA-FAMERAZ, DEADUS1-DEADUS6	57,850	15,196
UK	WSCOPEUK, FBRIT, DEADUK	12,014	6,746
Japan	WSCOPEJP, FJAP, DEADJP	8,754	3,710
Canada	WSCOPECN, DEADCN1, DEADCN2	16,991	3,868
Total		95,609	29,520

Table A2: Regression intercepts for tests of 25 size-B/M portfolio returns

The regressions use international models to explain the excess returns on the 25 size-B/M portfolios for the US, UK, Japan, and Canada. The models include the standard 3F and 4F models, the decomposed 4F and 6F models, the modified 7F model, and the index-based 7F model. Panels A to E report intercepts, α, and *t*-statistics for the intercepts, *t*(α). The *t*-statistics are corrected for autocorrelation and heteroskedasticity using the Newey-West estimator with five lags. With 321 monthly observations, the critical values of the *t*-statistics are 1.65, 1.96, 2.25, and 2.58 for the 10%, 5%, 2.5%, and 1% significance level, respectively.

Panel A: United States (US) size-B/M returns regressed on international factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	0.50	0.44	0.44	0.38	0.47	1.91	1.80	2.07	2.08	2.30
2	0.37	0.23	0.31	0.16	0.24	1.66	1.16	1.74	1.03	1.32
3	0.63	0.20	0.16	0.20	0.25	2.50	1.11	1.00	1.34	1.37
4	0.67	0.28	0.24	0.08	0.20	3.40	1.61	1.63	0.54	1.09
Big	0.51	0.34	0.16	0.22	-0.15	2.82	2.34	1.22	1.72	-0.76
Standard 4F										
Small	0.44	0.45	0.43	0.37	0.44	1.71	1.81	1.98	2.06	2.16
2	0.42	0.25	0.31	0.18	0.27	1.78	1.17	1.71	1.14	1.46
3	0.54	0.21	0.21	0.25	0.26	2.41	1.20	1.33	1.59	1.38
4	0.65	0.31	0.25	0.14	0.25	3.44	1.74	1.72	0.92	1.35
Big	0.53	0.37	0.18	0.26	-0.05	2.88	2.45	1.31	2.10	-0.26
Decomposed 4F										
Small	0.71	0.65	0.60	0.46	0.52	2.90	2.69	2.78	2.51	2.48
2	0.60	0.38	0.43	0.26	0.29	2.63	1.88	2.38	1.61	1.62
3	0.83	0.33	0.20	0.25	0.31	3.40	1.85	1.23	1.62	1.75
4	0.82	0.37	0.31	0.15	0.31	4.36	2.21	2.18	0.96	1.70
Big	0.50	0.38	0.26	0.33	0.01	2.65	2.57	1.88	2.55	0.05
Decomposed 6F										
Small	0.65	0.67	0.58	0.48	0.50	2.56	2.68	2.63	2.56	2.44
2	0.65	0.42	0.44	0.29	0.35	2.73	1.91	2.32	1.80	1.83
3	0.75	0.35	0.28	0.31	0.34	3.32	1.89	1.69	1.86	1.81
4	0.80	0.41	0.35	0.22	0.39	4.22	2.22	2.30	1.43	2.08
Big	0.54	0.41	0.28	0.38	0.10	2.73	2.57	1.89	2.80	0.53
Modified 7F										
Small	0.46	0.43	0.40	0.31	0.39	2.02	1.82	1.94	1.90	2.16
2	0.50	0.22	0.25	0.19	0.24	2.05	1.13	1.42	1.22	1.38
3	0.42	0.23	0.20	0.25	0.26	2.24	1.31	1.26	1.59	1.42
4	0.55	0.28	0.27	0.18	0.28	3.31	1.70	1.89	1.22	1.45
Big	0.45	0.38	0.23	0.36	0.05	2.61	2.63	1.96	3.05	0.26
Index 7F										
Small	0.22	0.28	0.29	0.21	0.28	1.29	1.72	1.91	1.71	1.88
2	0.21	0.06	0.20	0.00	0.10	1.36	0.47	1.47	0.04	0.78
3	0.36	0.11	0.06	0.10	0.12	2.47	0.87	0.54	0.88	0.89
4	0.41	0.17	0.15	0.02	0.13	3.21	1.45	1.41	0.20	0.94
Big	0.24	0.21	0.09	0.19	-0.17	2.03	1.86	0.98	2.05	-1.17

(Continued overleaf)

Table A2 (Continued)										
Panel B: United Kingdom (UK) size-B/M returns regressed on international factors										
	Low	2	3	4	High	Low	2	3	4	High
			α					t(α)		
Standard 3F										
Small	-0.11	-0.13	0.14	0.06	0.10	-0.38	-0.57	0.51	0.25	0.42
2	0.07	0.09	0.05	-0.06	0.09	0.31	0.36	0.22	-0.25	0.41
3	-0.03	-0.06	-0.04	-0.18	-0.18	-0.12	-0.24	-0.17	-0.81	-0.80
4	0.21	0.02	-0.04	-0.31	-0.18	0.89	0.10	-0.15	-1.33	-0.94
Big	0.12	0.21	0.00	-0.12	0.04	0.65	0.96	0.01	-0.50	0.14
Standard 4F										
Small	-0.12	-0.15	0.08	0.04	0.13	-0.39	-0.64	0.30	0.17	0.50
2	0.04	0.10	-0.02	-0.03	0.13	0.16	0.43	-0.08	-0.12	0.53
3	-0.03	-0.06	-0.03	-0.14	-0.16	-0.11	-0.22	-0.11	-0.64	-0.69
4	0.10	0.00	0.00	-0.29	-0.14	0.42	-0.01	0.00	-1.24	-0.70
Big	0.04	0.18	0.00	-0.14	0.06	0.23	0.82	0.02	-0.58	0.19
Decomposed 4F										
Small	0.15	0.03	0.36	0.23	0.23	0.56	0.14	1.39	0.96	0.98
2	0.29	0.31	0.20	0.05	0.18	1.26	1.32	0.82	0.22	0.76
3	0.26	0.15	0.09	-0.08	-0.09	1.17	0.67	0.36	-0.38	-0.41
4	0.45	0.13	0.08	-0.17	-0.04	2.10	0.64	0.34	-0.73	-0.20
Big	0.15	0.34	0.08	0.04	0.21	0.85	1.57	0.35	0.18	0.77
Decomposed 6F										
Small	0.15	0.01	0.30	0.21	0.25	0.52	0.02	1.18	0.86	1.11
2	0.26	0.30	0.13	0.08	0.20	1.10	1.28	0.51	0.33	0.81
3	0.25	0.13	0.08	-0.08	-0.09	1.06	0.55	0.31	-0.36	-0.38
4	0.33	0.09	0.09	-0.17	-0.04	1.49	0.42	0.38	-0.75	-0.19
Big	0.07	0.31	0.08	0.02	0.24	0.35	1.39	0.38	0.08	0.81
Modified 7F										
Small	0.14	0.01	0.19	0.19	0.26	0.47	0.06	0.76	0.71	1.06
2	0.26	0.27	0.08	0.09	0.25	1.07	1.12	0.32	0.39	1.00
3	0.21	0.12	0.13	-0.04	-0.05	0.85	0.50	0.54	-0.19	-0.20
4	0.24	0.08	0.11	-0.13	0.00	1.04	0.39	0.43	-0.58	0.00
Big	0.11	0.30	0.08	0.00	0.15	0.58	1.42	0.37	-0.01	0.47
Index 7F										
Small	-0.13	-0.14	0.10	0.07	0.13	-0.44	-0.58	0.37	0.26	0.49
2	-0.02	0.08	-0.09	-0.05	0.14	-0.10	0.34	-0.34	-0.22	0.60
3	-0.07	0.02	-0.03	-0.10	-0.13	-0.30	0.07	-0.10	-0.45	-0.56
4	0.06	0.03	0.12	-0.27	-0.12	0.28	0.17	0.48	-1.21	-0.62
Big	-0.01	0.21	-0.01	-0.14	0.06	-0.06	0.95	-0.02	-0.62	0.20

(Continued overleaf)

Table A2 (Continued)										
Panel C: Japanese size-B/M returns regressed on international factors										
	Low	2	3	4	High	Low	2	3	4	High
			α					t(α)		
Standard 3F										
Small	-0.69	-0.30	-0.20	-0.19	-0.14	-1.64	-0.78	-0.55	-0.56	-0.38
2	-0.58	-0.54	-0.38	-0.40	-0.30	-1.47	-1.58	-1.09	-1.23	-0.90
3	-0.61	-0.51	-0.53	-0.33	-0.20	-1.78	-1.71	-1.87	-1.10	-0.59
4	-0.63	-0.46	-0.40	-0.45	-0.27	-2.02	-1.72	-1.62	-1.68	-0.96
Big	-0.75	-0.40	-0.31	-0.25	-0.08	-2.89	-1.70	-1.32	-1.21	-0.31
Standard 4F										
Small	-0.50	-0.14	-0.06	-0.09	-0.03	-1.24	-0.39	-0.18	-0.28	-0.07
2	-0.42	-0.39	-0.22	-0.27	-0.22	-1.15	-1.23	-0.67	-0.88	-0.70
3	-0.50	-0.40	-0.43	-0.24	-0.15	-1.49	-1.30	-1.55	-0.85	-0.47
4	-0.54	-0.37	-0.31	-0.34	-0.21	-1.78	-1.41	-1.32	-1.34	-0.77
Big	-0.67	-0.41	-0.27	-0.25	-0.14	-2.68	-1.69	-1.19	-1.15	-0.51
Decomposed 4F										
Small	-0.98	-0.62	-0.54	-0.51	-0.49	-2.32	-1.59	-1.51	-1.49	-1.43
2	-0.84	-0.86	-0.71	-0.72	-0.64	-2.14	-2.52	-2.06	-2.25	-1.96
3	-0.84	-0.75	-0.83	-0.65	-0.54	-2.42	-2.48	-2.92	-2.25	-1.74
4	-0.78	-0.71	-0.65	-0.73	-0.58	-2.49	-2.74	-2.68	-2.82	-2.13
Big	-0.98	-0.62	-0.52	-0.41	-0.20	-3.87	-2.58	-2.25	-1.95	-0.72
Decomposed 6F										
Small	-0.83	-0.48	-0.41	-0.41	-0.39	-2.09	-1.34	-1.22	-1.25	-1.19
2	-0.71	-0.70	-0.56	-0.61	-0.55	-2.00	-2.20	-1.76	-2.03	-1.76
3	-0.76	-0.64	-0.73	-0.57	-0.49	-2.29	-2.08	-2.56	-1.99	-1.64
4	-0.71	-0.63	-0.56	-0.62	-0.54	-2.34	-2.49	-2.31	-2.52	-1.99
Big	-0.89	-0.62	-0.47	-0.40	-0.25	-3.56	-2.59	-2.04	-1.77	-0.90
Modified 7F										
Small	-0.46	-0.13	-0.10	-0.12	-0.08	-1.17	-0.38	-0.31	-0.35	-0.25
2	-0.36	-0.42	-0.28	-0.32	-0.30	-0.96	-1.33	-0.88	-1.10	-1.00
3	-0.43	-0.45	-0.53	-0.32	-0.24	-1.29	-1.50	-2.06	-1.29	-0.81
4	-0.53	-0.47	-0.43	-0.42	-0.32	-1.74	-1.95	-1.96	-1.81	-1.28
Big	-0.78	-0.51	-0.34	-0.31	-0.12	-2.98	-2.17	-1.52	-1.56	-0.45
Index 7F										
Small	-0.21	0.09	0.13	0.13	0.16	-0.68	0.33	0.61	0.64	0.74
2	-0.13	-0.10	0.02	-0.02	0.03	-0.54	-0.48	0.14	-0.12	0.20
3	-0.17	-0.08	-0.13	0.03	0.14	-0.82	-0.47	-0.89	0.20	0.86
4	-0.14	-0.10	0.00	-0.04	0.13	-0.89	-0.95	0.01	-0.33	1.02
Big	-0.44	-0.11	0.02	0.04	0.32	-2.72	-0.90	0.19	0.33	1.89

(Continued overleaf)

Table A2 (Continued)

Panel D: Canadian size-B/M returns regressed on international factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	0.14	0.31	0.35	0.47	0.26	0.34	0.91	1.31	1.55	1.12
2	-0.46	-0.29	-0.08	-0.05	0.25	-1.18	-0.85	-0.26	-0.16	0.93
3	-0.01	0.11	0.18	-0.05	-0.04	-0.03	0.42	0.67	-0.21	-0.19
4	0.56	0.15	-0.06	0.09	-0.08	1.87	0.41	-0.20	0.42	-0.34
Big	-0.10	0.41	-0.02	0.28	0.22	-0.34	1.40	-0.09	1.24	0.91
Standard 4F										
Small	0.00	0.28	0.36	0.43	0.22	0.01	0.83	1.36	1.38	0.92
2	-0.47	-0.26	-0.24	-0.07	0.25	-1.21	-0.77	-0.86	-0.26	0.88
3	-0.14	0.07	0.12	-0.07	-0.03	-0.42	0.25	0.43	-0.25	-0.16
4	0.54	-0.02	-0.04	0.09	-0.07	1.80	-0.06	-0.14	0.39	-0.27
Big	-0.08	0.32	-0.02	0.23	0.27	-0.27	1.22	-0.11	0.97	1.10
Decomposed 4F										
Small	0.41	0.40	0.41	0.56	0.31	1.02	1.18	1.52	1.84	1.40
2	-0.35	-0.14	0.09	0.02	0.32	-0.91	-0.43	0.31	0.07	1.17
3	0.11	0.20	0.35	0.00	-0.03	0.33	0.74	1.31	-0.02	-0.14
4	0.84	0.41	0.03	0.17	0.00	2.72	1.15	0.12	0.77	0.00
Big	0.06	0.47	0.12	0.39	0.35	0.20	1.57	0.55	1.72	1.48
Decomposed 6F										
Small	0.28	0.42	0.45	0.57	0.32	0.73	1.30	1.70	1.89	1.46
2	-0.37	-0.11	-0.03	0.04	0.36	-0.98	-0.34	-0.12	0.16	1.30
3	0.03	0.18	0.33	0.03	0.02	0.11	0.63	1.25	0.12	0.08
4	0.84	0.26	0.09	0.20	0.07	2.71	0.80	0.30	0.89	0.27
Big	0.10	0.42	0.11	0.36	0.42	0.33	1.54	0.52	1.53	1.78
Modified 7F										
Small	0.12	0.31	0.39	0.52	0.25	0.31	0.92	1.44	1.67	1.07
2	-0.38	-0.18	-0.21	-0.02	0.36	-0.97	-0.55	-0.73	-0.08	1.29
3	-0.07	0.09	0.20	-0.07	-0.02	-0.22	0.31	0.77	-0.23	-0.09
4	0.63	0.02	0.01	0.10	-0.01	2.15	0.07	0.03	0.47	-0.04
Big	-0.02	0.25	0.02	0.29	0.38	-0.06	1.07	0.11	1.23	1.56
Index 7F										
Small	0.04	0.21	0.34	0.47	0.16	0.11	0.62	1.32	1.50	0.72
2	-0.54	-0.25	-0.28	-0.11	0.19	-1.42	-0.76	-1.08	-0.38	0.68
3	-0.31	0.01	0.15	-0.10	-0.02	-0.95	0.03	0.58	-0.36	-0.10
4	0.50	-0.08	-0.09	0.07	-0.09	1.72	-0.23	-0.29	0.31	-0.36
Big	-0.17	0.22	-0.03	0.24	0.26	-0.59	0.82	-0.14	1.05	1.19

Table A3: Regression intercepts for tests of 25 size-momentum portfolio returns

The regressions use international models to explain the excess returns on the 25 size-momentum portfolios for the US, UK, Japan, and Canada. The models include the standard 3F and 4F models, the decomposed 4F and 6F models, the modified 7F model, and the index-based 7F model. Panels A to E report intercepts, α, and *t*-statistics for the intercepts, *t*(α). The *t*-statistics are corrected for autocorrelation and heteroskedasticity using the Newey-West estimator with five lags. With 321 monthly observations, the critical values of the *t*-statistics are 1.65, 1.96, 2.25, and 2.58 for the 10%, 5%, 2.5%, and 1% significance level, respectively.

Panel A: United States (US) size-momentum returns regressed on international factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	0.01	0.25	0.38	0.71	1.18	0.03	1.45	2.03	3.29	4.11
2	0.02	0.12	0.31	0.33	0.84	0.07	0.70	1.84	1.66	2.91
3	-0.06	0.14	0.24	0.27	0.81	-0.27	0.85	1.53	1.61	3.08
4	-0.15	0.11	0.25	0.31	0.78	-0.61	0.63	1.79	2.02	2.71
Big	0.00	0.19	0.10	0.41	0.63	-0.02	1.32	0.66	2.77	2.70
Standard 4F										
Small	0.42	0.37	0.37	0.60	0.89	1.62	2.02	1.90	2.86	3.66
2	0.49	0.29	0.32	0.21	0.49	1.98	1.57	1.79	1.09	2.17
3	0.42	0.32	0.28	0.17	0.44	1.94	1.91	1.64	0.97	2.06
4	0.35	0.29	0.29	0.19	0.35	1.76	1.65	1.99	1.24	1.79
Big	0.48	0.37	0.10	0.25	0.20	2.63	2.84	0.66	1.93	1.15
Decomposed 4F										
Small	0.20	0.34	0.45	0.75	1.23	0.70	1.91	2.34	3.46	4.41
2	0.22	0.20	0.38	0.39	0.92	0.79	1.10	2.25	1.93	3.10
3	0.11	0.22	0.30	0.34	0.91	0.42	1.31	1.86	2.02	3.43
4	0.02	0.18	0.32	0.34	0.91	0.06	1.03	2.20	2.19	2.97
Big	0.14	0.24	0.13	0.42	0.69	0.57	1.60	0.78	2.82	2.89
Decomposed 6F										
Small	0.64	0.48	0.46	0.65	0.95	2.39	2.68	2.32	3.16	4.03
2	0.72	0.39	0.43	0.29	0.59	2.87	2.16	2.38	1.48	2.63
3	0.59	0.42	0.36	0.24	0.57	2.62	2.44	2.02	1.36	2.66
4	0.53	0.38	0.37	0.24	0.51	2.57	2.04	2.37	1.49	2.62
Big	0.58	0.40	0.12	0.30	0.34	3.15	2.83	0.72	2.29	1.94
Modified 7F										
Small	0.47	0.39	0.39	0.57	0.79	1.80	2.29	2.08	2.93	4.05
2	0.53	0.28	0.34	0.20	0.37	2.09	1.61	2.00	1.10	1.91
3	0.44	0.33	0.30	0.17	0.36	2.00	1.98	1.79	1.02	1.90
4	0.39	0.30	0.31	0.17	0.29	1.97	1.80	2.17	1.19	1.64
Big	0.50	0.37	0.12	0.25	0.14	2.92	2.98	0.83	2.04	0.83
Index 7F										
Small	0.21	0.23	0.21	0.43	0.73	1.15	1.75	1.46	2.75	3.95
2	0.26	0.11	0.15	0.07	0.33	1.46	0.89	1.18	0.51	2.07
3	0.25	0.18	0.13	0.05	0.33	1.65	1.50	1.10	0.40	2.05
4	0.19	0.13	0.16	0.05	0.24	1.59	1.05	1.47	0.52	1.46
Big	0.29	0.22	-0.02	0.09	0.02	2.16	2.45	-0.15	1.02	0.16

(Continued overleaf)

Table A3 (Continued)										
Panel B: United Kingdom (UK) size-momentum returns regressed on international factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.76	-0.37	-0.36	0.25	0.92	-2.64	-2.16	-1.95	1.12	3.93
2	-0.76	-0.24	-0.45	0.09	0.73	-2.64	-1.35	-2.25	0.44	2.89
3	-0.43	-0.32	-0.49	0.05	0.52	-1.59	-1.72	-2.26	0.26	2.23
4	-0.31	-0.30	-0.37	0.02	0.47	-1.25	-1.52	-1.86	0.08	2.09
Big	-0.31	-0.38	-0.20	0.15	0.34	-1.50	-2.19	-0.98	0.78	1.47
Standard 4F										
Small	-0.54	-0.37	-0.40	0.17	0.81	-1.83	-2.05	-2.10	0.73	3.44
2	-0.45	-0.21	-0.51	0.00	0.59	-1.67	-1.11	-2.44	-0.01	2.34
3	-0.11	-0.28	-0.55	-0.06	0.29	-0.43	-1.43	-2.44	-0.29	1.26
4	0.00	-0.27	-0.44	-0.15	0.24	0.02	-1.30	-2.13	-0.74	1.11
Big	-0.09	-0.33	-0.28	-0.02	0.07	-0.47	-1.78	-1.32	-0.11	0.30
Decomposed 4F										
Small	-0.62	-0.33	-0.30	0.33	1.04	-2.22	-1.91	-1.63	1.47	4.53
2	-0.62	-0.20	-0.38	0.14	0.87	-2.12	-1.08	-1.85	0.71	3.57
3	-0.26	-0.28	-0.43	0.11	0.64	-0.95	-1.55	-2.00	0.53	2.87
4	-0.16	-0.26	-0.30	0.09	0.63	-0.60	-1.34	-1.52	0.44	2.89
Big	-0.16	-0.36	-0.15	0.22	0.45	-0.71	-2.08	-0.75	1.21	2.05
Decomposed 6F										
Small	-0.37	-0.32	-0.35	0.23	0.93	-1.38	-1.80	-1.85	1.02	4.09
2	-0.30	-0.16	-0.44	0.03	0.72	-1.18	-0.84	-2.13	0.14	2.96
3	0.05	-0.25	-0.50	-0.03	0.42	0.19	-1.30	-2.24	-0.15	1.85
4	0.14	-0.23	-0.39	-0.10	0.39	0.64	-1.15	-1.91	-0.51	1.86
Big	0.01	-0.30	-0.24	0.04	0.22	0.03	-1.70	-1.16	0.21	0.97
Modified 7F										
Small	-0.41	-0.32	-0.32	0.29	0.96	-1.41	-1.66	-1.61	1.25	4.14
2	-0.33	-0.16	-0.40	0.13	0.73	-1.21	-0.79	-1.85	0.64	2.98
3	0.04	-0.24	-0.45	0.08	0.45	0.14	-1.22	-2.01	0.35	2.02
4	0.09	-0.23	-0.34	-0.04	0.38	0.38	-1.08	-1.67	-0.18	1.72
Big	-0.01	-0.30	-0.22	0.11	0.20	-0.04	-1.68	-1.07	0.61	0.87
Index 7F										
Small	-0.56	-0.35	-0.34	0.21	0.83	-1.94	-1.90	-1.73	0.91	3.52
2	-0.49	-0.19	-0.43	0.02	0.59	-1.81	-1.02	-1.99	0.10	2.34
3	-0.13	-0.26	-0.47	-0.05	0.29	-0.48	-1.34	-2.11	-0.25	1.24
4	0.01	-0.23	-0.36	-0.09	0.24	0.03	-1.10	-1.70	-0.48	1.10
Big	-0.08	-0.30	-0.22	-0.02	0.06	-0.42	-1.63	-1.08	-0.13	0.28

(Continued overleaf)

Table A3 (Continued)

Panel C: Japanese size-momentum returns regressed on international factors

	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.26	-0.22	-0.02	0.03	-0.01	-0.64	-0.60	-0.06	0.09	-0.01
2	-0.59	-0.40	-0.23	-0.25	-0.09	-1.64	-1.21	-0.72	-0.69	-0.24
3	-0.57	-0.45	-0.38	-0.21	-0.20	-1.56	-1.42	-1.29	-0.68	-0.65
4	-0.55	-0.51	-0.31	-0.29	-0.22	-1.63	-1.77	-1.15	-0.99	-0.71
Big	-0.60	-0.62	-0.59	-0.29	-0.21	-1.66	-2.29	-2.31	-0.98	-0.63
Standard 4F										
Small	0.11	-0.01	0.09	0.04	-0.03	0.30	-0.04	0.27	0.11	-0.08
2	-0.21	-0.19	-0.13	-0.24	-0.17	-0.67	-0.61	-0.45	-0.70	-0.48
3	-0.17	-0.27	-0.31	-0.24	-0.33	-0.55	-0.89	-1.12	-0.79	-1.07
4	-0.14	-0.30	-0.24	-0.36	-0.41	-0.49	-1.11	-0.91	-1.27	-1.29
Big	-0.16	-0.42	-0.56	-0.47	-0.52	-0.49	-1.63	-2.24	-1.75	-1.70
Decomposed 4F										
Small	-0.58	-0.52	-0.34	-0.30	-0.38	-1.38	-1.40	-1.01	-0.86	-0.91
2	-0.86	-0.72	-0.55	-0.58	-0.38	-2.29	-2.15	-1.80	-1.73	-1.04
3	-0.85	-0.75	-0.65	-0.54	-0.49	-2.29	-2.37	-2.32	-1.85	-1.59
4	-0.76	-0.76	-0.58	-0.55	-0.48	-2.19	-2.62	-2.28	-1.95	-1.56
Big	-0.82	-0.80	-0.79	-0.52	-0.38	-2.27	-2.89	-3.00	-1.74	-1.10
Decomposed 6F										
Small	-0.20	-0.31	-0.25	-0.33	-0.42	-0.52	-0.90	-0.78	-0.98	-1.04
2	-0.46	-0.52	-0.47	-0.61	-0.49	-1.43	-1.64	-1.62	-1.94	-1.40
3	-0.45	-0.58	-0.59	-0.58	-0.63	-1.42	-1.91	-2.15	-2.12	-2.07
4	-0.38	-0.56	-0.52	-0.63	-0.67	-1.26	-2.06	-2.07	-2.34	-2.20
Big	-0.44	-0.61	-0.74	-0.66	-0.64	-1.38	-2.38	-2.80	-2.41	-2.07
Modified 7F										
Small	0.08	-0.03	0.06	0.03	-0.11	0.23	-0.09	0.21	0.08	-0.25
2	-0.24	-0.27	-0.20	-0.27	-0.17	-0.78	-0.92	-0.75	-0.87	-0.45
3	-0.27	-0.34	-0.34	-0.31	-0.34	-0.91	-1.25	-1.42	-1.13	-1.11
4	-0.22	-0.36	-0.30	-0.41	-0.43	-0.84	-1.45	-1.36	-1.59	-1.40
Big	-0.29	-0.45	-0.62	-0.53	-0.55	-0.90	-1.76	-2.43	-1.98	-1.81
Index 7F										
Small	0.34	0.19	0.24	0.21	0.18	1.32	0.88	1.15	0.86	0.55
2	0.07	0.03	0.07	-0.01	0.09	0.36	0.19	0.44	-0.03	0.34
3	0.14	-0.01	-0.10	-0.01	-0.07	0.77	-0.06	-0.69	-0.04	-0.31
4	0.22	-0.01	0.04	-0.10	-0.14	1.14	-0.10	0.30	-0.55	-0.68
Big	0.24	-0.12	-0.31	-0.15	-0.24	1.02	-0.72	-1.87	-0.76	-1.01

(Continued overleaf)

Table A3 (Continued)										
Panel D: Canadian size-momentum returns regressed on international factors										
	Low	2	3	4	High	Low	2	3	4	High
	α					t(α)				
Standard 3F										
Small	-0.99	-0.40	-0.21	0.36	0.69	-3.65	-2.93	-1.27	1.94	2.61
2	-1.18	-0.41	-0.35	0.15	0.95	-4.25	-2.80	-2.15	0.66	3.19
3	-0.90	-0.42	-0.29	0.06	0.66	-2.93	-2.78	-1.67	0.23	2.19
4	-0.70	-0.27	-0.21	0.11	0.72	-2.63	-1.78	-1.09	0.56	2.98
Big	-0.39	-0.24	-0.07	0.25	0.55	-1.56	-1.23	-0.37	1.26	1.85
Standard 4F										
Small	-0.24	-0.04	0.05	0.12	0.23	-3.08	-2.57	-1.37	1.49	2.13
2	-0.44	-0.06	0.05	0.15	0.42	-3.45	-2.46	-2.19	0.27	2.43
3	-0.34	-0.07	0.09	0.17	0.37	-2.30	-2.48	-1.86	-0.20	1.46
4	-0.48	-0.07	0.13	0.18	0.39	-1.69	-1.46	-1.43	-0.01	2.08
Big	-0.54	-0.11	0.03	0.17	0.55	-0.29	-0.92	-0.48	0.74	0.81
Decomposed 4F										
Small	-0.86	-0.36	-0.14	0.40	0.76	-3.27	-2.58	-0.85	2.14	2.88
2	-1.06	-0.37	-0.28	0.23	1.04	-3.72	-2.57	-1.72	0.98	3.55
3	-0.74	-0.39	-0.21	0.10	0.75	-2.42	-2.59	-1.20	0.39	2.48
4	-0.55	-0.24	-0.13	0.18	0.77	-1.98	-1.57	-0.65	0.90	3.18
Big	-0.26	-0.17	0.00	0.30	0.66	-0.97	-0.95	0.01	1.50	2.25
Decomposed 6F										
Small	-0.67	-0.32	-0.16	0.34	0.63	-2.67	-2.26	-0.93	1.74	2.47
2	-0.76	-0.31	-0.32	0.14	0.81	-3.06	-2.16	-1.80	0.60	2.90
3	-0.51	-0.32	-0.27	0.01	0.55	-1.82	-2.21	-1.42	0.04	1.88
4	-0.21	-0.17	-0.20	0.08	0.56	-0.96	-1.15	-0.97	0.39	2.42
Big	0.04	-0.09	-0.01	0.22	0.39	0.17	-0.51	-0.08	1.09	1.65
Modified 7F										
Small	-0.80	-0.34	-0.19	0.34	0.67	-3.02	-2.29	-1.15	1.83	2.64
2	-0.89	-0.35	-0.33	0.12	0.77	-3.34	-2.31	-1.93	0.52	2.74
3	-0.66	-0.37	-0.31	-0.01	0.56	-2.23	-2.39	-1.68	-0.02	2.03
4	-0.34	-0.22	-0.24	0.05	0.52	-1.42	-1.40	-1.24	0.25	2.26
Big	-0.02	-0.19	-0.06	0.16	0.28	-0.09	-1.11	-0.32	0.84	1.09
Index 7F										
Small	-0.85	-0.37	-0.23	0.26	0.50	-3.10	-2.45	-1.38	1.46	2.06
2	-0.96	-0.35	-0.37	0.06	0.65	-3.64	-2.28	-2.20	0.26	2.45
3	-0.71	-0.38	-0.34	-0.10	0.42	-2.42	-2.46	-1.91	-0.41	1.51
4	-0.44	-0.21	-0.30	-0.04	0.47	-1.84	-1.34	-1.50	-0.19	2.21
Big	-0.17	-0.13	-0.11	0.10	0.19	-0.79	-0.70	-0.61	0.56	0.73

Table A4: Risk Premium (γ) Estimates for Local Models on Country Portfolios

This table presents the estimation results of six beta pricing models. The models include the local versions of the standard 3F and 4F models, decomposed versions of the 3F and 4F models, modified 7F model, and index-based 7F model. The models are estimated using monthly returns on international 25 size-B/M and 25 size-momentum plus 19 industry portfolios of individual countries. Table reports parameter estimates γ, Shanken (1992) SH *t*-statistics and model misspecification-robust PM *t*-statistics.

Panel A: United States (US)																
	Size-B/M and Industry Portfolios								**Size-Momentum and Industry Portfolios**							
Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}					Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.75	-0.07	0.18	0.05					1.01	-0.29	0.41	-0.22				
SH *t*-stats	2.78	-0.19	1.13	0.23					3.40	-0.76	2.42	-0.92				
PM *t*-stats	2.76	-0.19	1.12	0.23					3.47	-0.77	2.46	-0.94				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}				Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	0.54	0.16	0.17	0.06	0.71				0.69	0.03	0.35	-0.09	0.50			
SH *t*-stats	1.96	0.44	1.04	0.30	1.22				2.75	0.07	2.10	-0.38	1.89			
PM *t*-stats	1.80	0.41	1.04	0.30	0.99				2.66	0.07	2.11	-0.38	1.90			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}				Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.70	-0.01	0.18	0.10	-0.04				0.92	-0.20	0.38	-0.19	-0.24			
SH *t*-stats	2.51	-0.03	1.14	0.36	-0.22				3.14	-0.52	2.24	-0.63	-0.92			
PM *t*-stats	2.47	-0.03	1.11	0.37	-0.21				3.01	-0.51	2.21	-0.61	-0.83			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}		Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.45	0.26	0.18	0.11	-0.04	0.84	0.63		0.63	0.07	0.37	-0.16	-0.05	0.62	0.28	
SH *t*-stats	1.60	0.68	1.11	0.41	-0.20	1.50	0.90		2.39	0.21	2.19	-0.52	-0.20	2.31	0.96	
PM *t*-stats	1.50	0.63	1.10	0.42	-0.20	1.21	0.74		2.31	0.20	2.30	-0.56	-0.19	2.29	0.96	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.52	0.21	0.09	0.11	0.20	-0.18	-0.04	0.87	0.73	-0.01	0.16	0.18	0.03	-0.35	0.02	0.49
SH *t*-stats	1.83	0.56	0.93	0.82	0.91	-0.81	-0.22	1.51	2.69	-0.02	1.52	1.25	0.12	-1.34	0.09	1.85
PM *t*-stats	1.74	0.54	0.92	0.79	0.87	-0.85	-0.21	1.34	2.59	-0.02	1.47	1.23	0.11	-1.40	0.08	1.87
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.47	0.22	0.06	0.13	0.13	-0.20	-0.07	0.91	0.66	-0.01	0.23	0.12	-0.10	-0.27	0.01	0.51
SH *t*-stats	1.50	0.55	0.56	0.88	0.72	-0.70	-0.43	1.56	2.33	-0.02	1.68	0.79	-0.46	-0.87	0.02	1.91
PM *t*-stats	1.47	0.54	0.53	0.85	0.68	-0.73	-0.41	1.31	2.28	-0.02	1.50	0.74	-0.46	-0.81	0.02	1.93

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Table A4 (Continued) **Panel B: United Kingdom (UK)**

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.13	0.56	-0.02	0.10				
SH *t*-stats	-0.48	1.55	-0.14	0.62				
PM *t*-stats	-0.46	1.52	-0.14	0.61				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.14	0.56	-0.02	0.10	0.03			
SH *t*-stats	-0.45	1.48	-0.14	0.62	0.06			
PM *t*-stats	-0.42	1.37	-0.14	0.61	0.05			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.21	0.63	-0.02	0.08	0.07			
SH *t*-stats	-0.70	1.69	-0.10	0.38	0.34			
PM *t*-stats	-0.67	1.65	-0.10	0.38	0.33			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.20	0.62	-0.01	0.09	-0.01	-0.33	0.53	
SH *t*-stats	-0.60	1.55	-0.04	0.45	-0.07	-0.59	0.86	
PM *t*-stats	-0.54	1.43	-0.04	0.45	-0.07	-0.51	0.77	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.42	0.86	0.06	-0.09	0.19	-0.04	0.04	0.06
SH *t*-stats	-1.37	2.24	0.46	-0.70	1.15	-0.23	0.22	0.11
PM *t*-stats	-1.26	2.08	0.45	-0.68	1.12	-0.23	0.21	0.09
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.30	0.89	0.12	-0.16	0.17	-0.03	0.00	0.12
SH *t*-stats	-1.13	2.29	0.80	-0.97	1.08	-0.10	-0.03	0.21
PM *t*-stats	-1.05	2.19	0.77	-0.96	1.01	-0.09	-0.03	0.19

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.56	0.97	0.05	-0.28				
SH *t*-stats	-2.08	2.74	0.31	-1.32				
PM *t*-stats	-1.54	2.32	0.29	-1.13				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.74	1.15	0.06	-0.01	0.75			
SH *t*-stats	-2.82	3.29	0.33	-0.05	3.85			
PM *t*-stats	-2.60	3.20	0.31	-0.05	3.72			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-1.01	1.41	0.21	-0.03	-1.12			
SH *t*-stats	-3.31	3.67	1.11	-0.13	-2.21			
PM *t*-stats	-2.49	3.05	0.99	-0.10	-1.63			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.77	1.18	0.07	-0.12	0.03	0.79	0.70	
SH *t*-stats	-2.71	3.21	0.38	-0.46	0.09	3.54	3.06	
PM *t*-stats	-2.45	3.00	0.37	-0.44	0.06	3.50	2.87	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-1.28	1.72	0.24	-0.15	0.08	-0.05	-0.18	0.77
SH *t*-stats	-3.86	4.24	1.58	-0.88	0.28	-0.14	-0.65	3.97
PM *t*-stats	-2.67	3.22	1.27	-0.82	0.17	-0.09	-0.47	3.93
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.67	1.27	0.31	-0.22	-0.78	1.82	0.13	0.77
SH *t*-stats	-1.94	2.77	1.40	-0.97	-2.31	2.63	0.38	3.87
PM *t*-stats	-1.69	2.44	1.35	-0.98	-1.56	1.64	0.32	3.70

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Table A4 (Continued) **Panel C: Japan**

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.14	-0.14	0.14	0.35				
SH *t*-stats	0.30	-0.24	0.68	2.02				
PM *t*-stats	0.25	-0.21	0.67	1.77				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	0.01	0.02	0.14	0.43	0.64			
SH *t*-stats	0.03	0.04	0.71	2.83	1.05			
PM *t*-stats	0.02	0.03	0.70	2.45	0.94			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.05	-0.06	0.13	0.16	0.65			
SH *t*-stats	0.11	-0.10	0.63	0.77	3.03			
PM *t*-stats	0.09	-0.10	0.62	0.71	2.72			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.08	0.11	0.13	0.26	0.64	-0.06	0.91	
SH *t*-stats	-0.17	0.20	0.63	1.42	3.11	-0.10	1.13	
PM *t*-stats	-0.16	0.20	0.62	1.27	3.01	-0.09	1.15	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.30	-0.25	0.21	0.08	0.35	0.09	0.60	0.51
SH *t*-stats	0.62	-0.43	1.88	0.52	2.22	0.42	3.11	0.86
PM *t*-stats	0.56	-0.40	1.87	0.52	2.16	0.41	2.96	0.82
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.07	-0.06	0.20	0.07	0.33	0.10	0.66	0.66
SH *t*-stats	0.16	-0.11	1.44	0.41	2.71	0.56	2.75	1.15
PM *t*-stats	0.15	-0.10	1.42	0.40	2.59	0.56	2.71	1.06

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	0.58	-0.55	0.31	-0.01				
SH *t*-stats	0.92	-0.79	1.42	-0.03				
PM *t*-stats	0.76	-0.71	1.38	-0.03				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	0.40	-0.36	0.34	-0.03	0.17			
SH *t*-stats	0.68	-0.55	1.56	-0.09	0.63			
PM *t*-stats	0.60	-0.51	1.53	-0.08	0.62			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	0.28	-0.28	0.37	-0.33	0.57			
SH *t*-stats	0.46	-0.42	1.65	-0.78	1.31			
PM *t*-stats	0.42	-0.40	1.65	-0.77	1.22			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	0.24	-0.24	0.37	-0.30	0.48	0.14	0.20	
SH *t*-stats	0.42	-0.37	1.68	-0.74	1.12	0.56	0.60	
PM *t*-stats	0.40	-0.36	1.66	-0.74	1.00	0.55	0.59	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	0.50	-0.47	0.26	0.14	-0.07	-0.09	0.44	0.18
SH *t*-stats	0.94	-0.76	2.11	0.83	-0.23	-0.34	1.45	0.66
PM *t*-stats	0.91	-0.75	2.08	0.82	-0.20	-0.34	1.32	0.66
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	0.38	-0.41	0.27	0.10	-0.01	-0.05	0.40	0.19
SH *t*-stats	0.76	-0.68	1.80	0.57	-0.05	-0.21	1.32	0.72
PM *t*-stats	0.72	-0.65	1.79	0.56	-0.04	-0.21	1.27	0.72

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Table A4 (Continued) **Panel D: Canada**

Size-B/M and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.23	0.79	-0.09	0.16				
SH *t*-stats	-1.01	2.36	-0.58	0.73				
PM *t*-stats	-0.94	2.29	-0.57	0.70				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.34	0.95	-0.16	0.32	1.23			
SH *t*-stats	-1.42	2.80	-1.02	1.41	2.04			
PM *t*-stats	-1.18	2.51	-1.00	1.37	1.36			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.24	0.80	-0.09	0.15	0.17			
SH *t*-stats	-1.05	2.38	-0.58	0.57	0.60			
PM *t*-stats	-0.94	2.27	-0.57	0.52	0.55			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.34	0.96	-0.15	0.29	0.35	0.85	1.53	
SH *t*-stats	-1.42	2.80	-1.01	1.07	1.15	1.40	2.14	
PM *t*-stats	-1.15	2.45	-0.97	0.98	1.06	0.85	1.44	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.36	0.97	-0.03	-0.11	0.41	-0.42	0.47	0.64
SH *t*-stats	-1.49	2.82	-0.24	-0.67	1.68	-1.78	1.50	1.05
PM *t*-stats	-1.26	2.57	-0.21	-0.62	1.62	-1.64	1.39	0.80
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.36	1.15	-0.02	-0.11	0.32	-0.26	0.51	1.06
SH *t*-stats	-1.57	2.92	-0.15	-0.59	1.55	-0.94	1.68	1.77
PM *t*-stats	-1.36	2.70	-0.15	-0.59	1.53	-0.93	1.63	1.33

Size-Momentum and Industry Portfolios

Standard 3F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}				
Estimate	-0.36	0.90	-0.16	-0.06				
SH *t*-stats	-2.23	2.92	-0.96	-0.21				
PM *t*-stats	-1.12	2.27	-0.78	-0.17				
Standard 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML}	Υ_{WML}			
Estimate	-0.40	0.99	-0.27	0.23	1.36			
SH *t*-stats	-2.28	3.17	-1.54	0.83	6.29			
PM *t*-stats	-1.76	3.05	-1.55	0.81	6.16			
Decomposed 4F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}			
Estimate	-0.35	0.89	-0.14	-0.21	0.05			
SH *t*-stats	-2.10	2.86	-0.78	-0.46	0.11			
PM *t*-stats	-0.91	2.05	-0.33	-0.09	0.03			
Decomposed 6F	Υ_0	Υ_{MKT}	Υ_{SMB}	Υ_{HML_s}	Υ_{HML_b}	Υ_{WML_s}	Υ_{WML_b}	
Estimate	-0.47	1.05	-0.27	-0.03	0.35	1.42	1.13	
SH *t*-stats	-2.58	3.28	-1.39	-0.06	0.79	6.52	3.91	
PM *t*-stats	-2.16	3.21	-1.23	-0.04	0.60	6.36	3.69	
Modified 7F	Υ_0	Υ_{MKT}	Υ_{SMM}	Υ_{MMB}	Υ_{SHML}	Υ_{MHML}	Υ_{BHML}	Υ_{WML}
Estimate	-0.50	1.10	-0.44	0.08	0.67	-0.61	0.04	1.36
SH *t*-stats	-2.70	3.41	-1.75	0.34	1.41	-1.01	0.09	6.29
PM *t*-stats	-2.05	3.18	-1.40	0.27	0.98	-0.72	0.07	6.22
Index 7F	Υ_0	Υ_{INDMKT}	Υ_{INDSMM}	Υ_{INDMMB}	$\Upsilon_{INDSHML}$	$\Upsilon_{INDMHML}$	$\Upsilon_{INDBHML}$	Υ_{WML}
Estimate	-0.43	1.21	-0.28	-0.05	0.55	-0.59	0.15	1.34
SH *t*-stats	-2.44	3.28	-1.18	-0.22	1.33	-0.92	0.31	6.19
PM *t*-stats	-1.96	3.12	-0.86	-0.18	1.01	-0.71	0.26	6.04

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