



## **Predicting Returns for Growth and Value Stocks: A Forecast Assessment Approach Using Global Asset Pricing Models**

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### **ABSTRACT**

The present study tests the forecasting strength of widely used asset pricing models, using monthly stock returns of two style-based, large-cap US growth and value index funds for 1993–2015. Global variables are added to the models to test the global linkage impact. As we impose a positive forecast returns constraint, there is a considerable reduction in the root mean squared error (RMSE), providing significant economic implications. RMSE of constrained models for non-negativity restriction outperforms the unconstrained models improving them by an average of 17%. As evidenced by the forecasting power measured by RMSE, we found the value stocks to be more predictable with lower overall RMSE when compared to growth stocks. The global models provide better forecast for growth stocks, whereas there are mixed implications for value stocks. The Global Carhart consistently ranks as one of the best models for both growth and value stocks.

**Keywords:** Forecasting Stock Returns, International Asset Pricing, Global Linkage, Growth Versus Value, Predictive Regressions, Root Mean Squared Error

**JEL Classifications:** G170, G150, G110

### **1. INTRODUCTION**

Portfolio managers, analysts, and numerous investors all seek tools to predict future stock returns as accurately as possible. While it is hardly controversial to suggest that predictability is a common goal, the appropriate tool or tools to use has been a topic of study for generations (e.g. Timmermann (2008)). Currently, a number of tools exist, but tests of their accuracy have led researchers to suggest that improvements are needed (e.g. Harvey et al., (2016); Narayan and Liu (2018); Timmermann (2008)).

Studies on stock return predictability have generally fallen under one of two different perspectives. The first perspective asserts that historical average returns are the best predictor of future returns and consequently, that stock prices are not actually predictable (Welch and Goyal, 2007). The Efficient Market Hypothesis and

the Radom Walk Theory (Fama, 1970) are both supportive of this general idea of unpredictability.

The second perspective, however, suggests that returns are predictable to some degree. Varying degrees of support for this predictability perspective come from Cassella and Gulen (2018); Fama and French (1998); Ferreira and Santa-Clara (2011); and Pesaran and Timmermann (1995) to name a few. This research has found weak, but meaningful, predictability from the models used.

Interestingly, the studies supporting predictability of returns generally are attempting to predict the returns of an aggregate index (e.g., the S&P 500). This focus on an aggregate stock index, however, may create structural difficulties due to the nature of index of stocks. More specifically, since a stock index consists of multiple entities grouped together, effects may be

dampened or lost due to the disparate nature of the underlying securities.

Subsequent research has asserted that disaggregating market indexes may be a more productive path to pursue when it comes to forecasting returns. Welch and Goyal (2007) suggested that disaggregating indexes and looking at more meaningful components like investment themes (e.g. Bekaert et al., (2009); Capaul et al., (1993)) may offer an improved ability to be predicted with increased accuracy. This disaggregation argument could offer a viable explanation as to why the predictability record is weak, potentially leading to mis-specified pricing models, which will consequently result in the misallocation of investment funds. In this paper, we explore an alternate solution by disaggregating the S&P 500 into two style-based index funds (i.e., growth and value investing) and examining the predictability of these two fund types.

As a second, interrelated attempt at increasing the predictability of returns, we are also including multiple models of asset pricing. Since the growth and value categories have very distinct characteristics (e.g. Fama and French (1998)), it is important to explore their predictability separately. To do this more effectively, we predict the returns of growth and value stocks using multiple asset pricing models, namely the Capital asset pricing model (CAPM), Fama-French 3-factor model, Carhart's 4-factor model, and several other variations of these models.

While disaggregating the S&P 500 and using multiple pricing models are two relevant steps, simultaneously exploring the influence of globalization is an important third step. As a result, we extend these asset pricing models by adding global factors to determine whether the predictability of the models improve. Globalization of equity markets is not a new theme. There is ample literature with the consensus that the effects of globalization are pervasive and increasing (cf., Chan et al., (1992); Diermeier and Solnik (2001); Fraser and Oyefeso (2005); Santis and Gerard (1997); and Thenmozhi and Chand (2016)). More recently, the findings of Rana and Phillips (2016) confirmed the evidence of a strong and significant global economic influence on the US stocks' risk premium over the years 1993-2014. Similar results were reported by Thenmozhi and Chand (2016), endorsing a strong influence on US stocks from Asian markets specifically. Even with the supportive extant research, international factors do not appear to be currently prevalent in common asset pricing modeling used for equity analysis. To remedy this problem, we incorporate these global linkage factors, and test whether widely used models such as CAPM, Fama French 3-Factor (FF3), Fama French 3-Factor using international factors (IFF3), and Carhart 4-Factor (Carhart 4), can explain returns with more accuracy when we add additional factors into the models to capture global linkage of US stocks, and specifically for the two categories, growth and value.

Of interest in the current research is to address the question of whether the previously discussed models can be used for the purpose of forecasting stock returns. If so, does the forecasting improve when additional global linkage factors are used? This paper attempts to address these important questions that have not been widely explored in the literature. We study a recent time

period to bring the literature more current and relevant in terms of application for current fund managers. Thus, we extend and update the work on forecasting stock returns by approaching the issues from multiple angles. More specifically, we explore whether the approaches taken by Campbell and Thompson (2008) and Welch and Goyal (2007) can be extended and refined by (1) disaggregating data (2) using asset pricing models and (3) adding global linkage factors.

In the next section, we discuss relevant literature within the topic, after which we cover the various methodological approaches and data used. Empirical results, implications, and applications are presented in the fourth section. The final section concludes with suggestions for future model extensions.

## 2. LITERATURE REVIEW

The major theoretical risk/return asset pricing models in finance focus on capturing and modeling domestic asset returns. Further, the focus is on understanding what influences aggregate market returns, such as the S&P 500 index. There have been numerous explanatory variables tested to explain and predict stock returns. In fact, in a recent meta-analysis of works done in this context, Harvey et al. (2016) report a total of 316 different factors studied in various papers during only the previous ten year period. In one such attempt, Welch and Goyal (2007) use state variables such as dividend to price ratio, earnings to price ratio, corporate bond returns, investment to capital ratio, etc. Similarly, Campbell and Thompson (2008) use additional state variables such as ROE, net equity issuance, and consumption-wealth ratio. Using a similar approach, Ferreira and Santa-Clara (2011) use dividend-price ratio, earnings growth, and price-earnings ratio growth. Some studies use higher order moments as predictor variables (Narayan and Liu, 2018), while some limit the study to the sign of return (positive vs. negative) instead of the actual level of return (Christoffersen and Diebold, 2006; Chronopoulos et al., 2018). Yet another study uses option pricing of S&P 500 Index (Schneider, 2019). The research on predictability of stock returns are not only limited to fundamentals but also include behavioral studies such as Cassella and Gulen (2018), which asserts that the predictability of returns are contingent upon variables such as investor sentiment.

Another set of relevant studies analyze market factors and assess their power to explain stock returns. These models are known as asset pricing models. The first prominent model is CAPM, which primarily uses the overall domestic market returns variability to explain individual stock returns. The CAPM has been extensively studied by researchers and extended or revised to reflect the risk/return framework more realistically; examples include the Intertemporal CAPM of Merton (1973); Merton (1980), Arbitrage Pricing Theory of Ross (1976), 3-Factor Model proposed by Fama and French (1993), 4-Factor Model of Carhart (1997), 5-Factor Model of Fama and French (2015), 8-Factor Model of Skočir and Lončarski (2018), and numerous other proprietary models. While these models have been studied to assess their power to explain returns, in this paper, we are specifically interested in assessing their power to forecast returns. We narrow our study and focus on two specific categories of stock values to predict, growth and value stocks.

In light of increasing global linkages between US and world markets, we also explore if the international asset pricing models can forecast stock returns more accurately when compared to domestic pricing models. The effects of globalization have become increasingly supported by a pattern of global market integration as mentioned earlier. So, if the markets are showing signs of integration, then asset pricing models such as CAPM, Fama-French 3-Factor, and Carhart 4-Factor should be expanded to capture returns more accurately. In the case where markets are segmented, then a local model is better suited. However, where integration exists, the risk factors can be sourced from a variety of global factors, and thus the domestic models need some modification to accommodate for these influences.

Although international asset pricing models have long been discussed in academic journals (e.g. Solnik (1974); Solnik (1983); Stulz (1981), etc.), they are not widely used. One such global extension can be found in the seminal work of Solnik (1974), where the author introduced a version applicable to global market pricing, termed the International Asset Pricing Model (IAPM). Here, the author states that CAPM generally implies that the return on any security is a function of systematic risk, which largely reflects domestic risk environment. However, as also indicated in Chan et al. (1992); Diermeier and Solnik (2001); Harvey (1991); Longin and Solnik (1995); Ng (2004); Santis and Gerard (1997); and Zhang (2006), Solnik argues that this may not completely represent the true risk/return attribute of that security, because there could be an additional component of risk that it could be exposed to – that of international exposure (e.g. foreign subsidiaries, foreign competition, export/import, mergers/acquisitions etc.). So, in order to incorporate international risk, the author augments the CAPM model and proposes a multinational index model, which he considers to capture international risk of securities. Solnik and his colleagues, although convinced of the usefulness of this model, outline the shortcomings that the sample studied is relatively small and the period is limited. Another study done by Zhang (2006) exploring a more recent time period, 1981-1997, endorses the efficacy of a similar model as IAPM, when using time-varying betas, and incorporating currency exchange rate risk.

A study done by Ferson and Harvey (1993) models national stock returns of 18 developed countries (including the United States). In line with the above identified studies of Chan et al. (1992) and Solnik (1974), substantial amounts of explanation were provided by the global variables used, with only marginal explanation coming from the local/domestic variables. Similar results are documented by studies of Diermeier and Solnik (2001) and Hau (2011). Taken together, this research stream reinforces the persistence of global influence on stocks worldwide, including the US.

The above findings underscore the importance of global market forces, and incorporate direct tests of how international markets play an eminent role in the stock prices of one country, in the context of increasing globalization. They provide a comprehensive overview from multiple angles utilizing various methodologies to determine how risk is articulated and captured in global markets with evolving trend of globalization. Following this theoretical

background, in this paper we extend the domestic versions of various asset pricing models utilizing influential global market forces found in Rana and Phillips (2016) that capture the global risk premium of US stocks. The four prominent global markets identified by Rana and Phillips (2016) are the UK's FTSE, Singapore's STI, the Swiss SSML, and the Japanese N225; their study shows these markets to have a significant impact on the US markets over various business cycles during the period 1993 - 2014. A similar study done by Thenmozhi and Chand (2016) also confirms these findings of global impact on US stocks. Their study finds strong influence on US stocks coming specifically from the Hong Kong Index (HSI) and Singapore Index (STI).

Our current paper extends the work of Rana and Phillips (2016) who asserted that there are different international linkages for growth and values stock categories. The possible differences between value and growth stocks is important to the US asset management industry, which views growth stocks and value stocks as two separate investment categories. If asset pricing models for one or the other, or both, are mis-specified by excluding international components, then asset allocation decisions could be potentially disadvantageous. Differences between value and growth stocks in other areas have been previously addressed. For example, some claim the value premium to be a timing issue or mispricing (Chan and Lakonishok, 2004; Lakonishok et al., 1994); others claim it to be a true risk-based premium due to distress (Campbell et al., 2010; Campbell and Vuolteenaho, 2004; Fama and French, 1998; Kuo and Satchell, 2001); and numerous other studies simply realize the importance of these two sectors (Bekaert et al., 2009; Capaul et al., 1993; Rana and Phillips, 2016; Sharpe, 1992; Walter, 1999).

Our paper thus tries to fill this important literature gap where stock returns have not been disaggregated; we accomplish this by disaggregating the broader market into style-based growth and value portfolios. We then test the predictability of these portfolios using global asset pricing models. Our study, assessing the differential importance of international factors in asset pricing models for growth and value stocks will extend the literature providing new direction for research.

In light of these discussions, we propose the following four interrelated research questions:

- RQ1. What is the forecasting strength of widely used current asset pricing models?
- RQ2. Does the degree of predictability vary for two style-based index funds, namely growth and value?
- RQ3. Does the explanatory power improve if global variables are added to the model?
- RQ4. What are the overall implications on growth and value stocks in terms of global linkage?

### 3. METHODS AND DATA

#### 3.1. Methods

We test the forecasting strength of models used in our study by assessing their out-of-sample forecasting power, mainly using root mean square error (RMSE). RMSE calculates the accuracy

of model forecasts by comparing them against the actual realized returns, thus allowing us to determine the forecasting strength of each model, and whether the degree of predictability varies between growth and value stocks, and between domestic and global models. We elaborate the specific methods used to accomplish these goals in detail below.

First, a series of in-sample forecasts were generated for all the models used in our study. In order to do so, we began by estimating the returns-generating-processes using rolling regression. One month realized excess returns<sup>1</sup> were computed for both the Vanguard Growth (VIGRX) and Value index (VIVAX) funds using monthly intervals from November 1993 until August 2015. Then, for each of the five asset pricing models evaluated (refer to equations 1 through 5), we regressed our dependent variable (excess Growth and Value fund returns) against the explanatory variables: which are the different factors used in CAPM, Fama French-3 factor, Fama French-3 factor using global factors (including and excluding US), and Carhart 4-factor models, such as: S&P500 excess returns, High book-value minus Low book-value (HML) premium, Small minus Big (SMB) premium, Winners minus Losers (WML) premium, etc. The regression equations are outlined below, in equations (1) through (5). We used 36 observations for a period of 3 years (monthly rolling realized returns, with monthly intervals) and estimated our parameters. These parameters were then re-estimated every month, dropping the first observation and adding a new observation. We conducted this process separately for growth and value index funds.

$$\text{CAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \epsilon \quad (1)$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \epsilon \quad (2)$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \epsilon \quad (3)$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \epsilon \quad (4)$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \epsilon \quad (5)$$

Where CAPM = capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart 4 = Carhart's 4-factor model, R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate,  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers).

1 The 3-month US Treasury bill rates were used to proxy the risk-free rate when calculating excess returns for all funds/indices; these were obtained from the Federal Reserve's website (<http://www.federalreserve.gov/releases/h15/data.htm>) in May, 2018.

With these parameters estimated for every month<sup>2</sup>, we then forecasted a "pure expectation of return" for the next period, simulating an ex-post in-sample forecast for the domestic models. Next, we repeated the same process for our extended global models (equations 6 through 10), labeled as: GCAPM (for global version of CAPM), GFF3 (for global version of Fama French 3-factor), GIFF3 (for global version of International Fama French 3-factor), GIFF3exus (for global version of International Fama French 3-factor excluding US), and GCarhart 4 (for global version of Carhart 4-factor). These equations incorporate the elements of global linkage by adding the additional factors reported by Rana and Phillips (2016) to the domestic models<sup>3</sup>. The regression equations (6) through (10) are outlined below for value fund (VIVAX). For the growth fund (VIGRX) equations, we replaced the STI (i.e., Singapore's index) with the N225 (i.e., the Japanese index), since the Singapore index was found to be more influential on the value fund, and the Japanese index on the growth fund. We included these global linkage factors and extended the test on each of the domestic models repeating the process described above.

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(r_{SSMI\text{ exc}}) + \beta_3(r_{STI\text{ exc}}) + \beta_4(r_{FTSE\text{ exc}}) + \epsilon \quad (6)$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(r_{SSMI\text{ exc}}) + \beta_5(r_{STI\text{ exc}}) + \beta_6(r_{FTSE\text{ exc}}) + \epsilon \quad (7)$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \beta_4(r_{SSMI\text{ exc}}) + \beta_5(r_{STI\text{ exc}}) + \beta_6(r_{FTSE\text{ exc}}) + \epsilon \quad (8)$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \beta_4(r_{SSMI\text{ exc}}) + \beta_5(r_{STI\text{ exc}}) + \beta_6(r_{FTSE\text{ exc}}) + \epsilon \quad (9)$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \beta_5(r_{SSMI\text{ exc}}) + \beta_6(r_{STI\text{ exc}}) + \beta_7(r_{FTSE\text{ exc}}) + \epsilon \quad (10)$$

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc., R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate,  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\text{ exc}}$  is the excess return on Swiss index,  $r_{STI\text{ exc}}$  is the excess return on Singapore index, and  $r_{FTSE\text{ exc}}$  is the excess return on UK index.

Next, we ran another set of regressions using these newly generated in-sample forecasts<sup>4</sup> as independent variables, against the realized returns. The period used for this regression is November 1996 - May

2 Robust standard errors are used to correct for heteroscedasticity for all OLS tests done in this study.

3 As explained earlier, these additional factors used (excess returns on UK's FTSE, Singapore's STI, Swiss SSMI, and Japanese N225) are the prominent global markets found to have a significant impact on the US markets over various business cycles during 1993-2014. See Rana and Phillips (2016).

4 Derived from Equations 1-10.

2012 (187 monthly return data points). We performed the regression for each of the ten models (Equations 1 through 10) separately for growth and value stocks, and recorded the estimated parameters. Then, these estimated parameters were used to generate an out-of-sample forecast for the remaining period of 36 monthly returns, June 2012 – May 2015. As a result, we have out-of-sample forecasts for each of the ten models. Finally, we evaluated the quality of these forecasts in order to assess the forecasting strength of each model.

Instead of using adjusted R<sup>2</sup> to evaluate the quality of our forecasts such as in Campbell and Thompson (2008) and Welch and Goyal (2007), we used RMSE to assess these models. The use and advantages of RMSE is well documented in literature in terms of measuring out-of-sample forecast accuracy (e.g. Bekaert et al. (2009); Corrado and Truong (2007); Hyndman and Koehler (2006)). While the adjusted R<sup>2</sup> provides an insight into the overall fit of the forecasted model, RMSE provides us with a more meaningful metric with which we can quantify how close (or far off) our forecasts are when compared to the realized returns. This relevant scale of measurement provides a better presentation of our results. RMSE is calculated as the square root of Mean Squared Error. In essence, RMSE is the standard deviation of forecast errors, which lets us determine the quality of the forecasts derived from each model.

The RMSE is calculated as:

$$\sqrt{\frac{\sum_{i=1}^n (P_i - O_i)^2}{n}} \quad (11)$$

Where P<sub>i</sub> represents the predicted or forecasted return, O<sub>i</sub> represents the observed or realized return, and n is the number of observations.

We also added another test to our study in order to investigate the extent of differences in global linkage of growth and value funds. More specifically, we utilized the Chow test on each of the five global models (Equations 6-10). This test works like a robustness check to validate our investigation on these two style-based indices. The Chow test (Chow, 1960) essentially tests whether the estimated coefficients are equal to the coefficients derived from another group. In our analyses, the two groups are growth stocks and value stocks. This procedure can be further explained as follows. First, we ran the unrestricted version, pooling both the growth and value data together. We then ran the individual growth and value tests as restricted models, and performed the Chow test. The null hypothesis being tested, is that there was no difference in global linkages between growth stocks and value stocks. The Chow test provides an F-statistic with which we can assess how different the restricted models were in terms of their linkage with global markets. The F-statistic is calculated as follows:

$$\text{Chow test (F-statistic)} = \frac{(S_p - (S_1 + S_2)) / k}{(S_1 + S_2) / (N_1 + N_2 - 2k)} \quad (12)$$

Where S<sub>p</sub> is the sum of squared residuals from the pooled data, S<sub>1</sub> is the sum of squared residuals from the growth data, and S<sub>2</sub> is the sum of

squared residuals from the value data; k is the number of parameters, and N<sub>1</sub> and N<sub>2</sub> represent the number of observations for growth and value groups respectively. The test statistic derived from above follows the F distribution with k and N<sub>1</sub> + N<sub>2</sub> – 2k degrees of freedom.

If the null hypothesis was rejected, then the growth and value stocks cannot be pooled together, since the parameters (slopes and intercept) of the two groups are statistically different. In other words, the test results help assess the degree of similarity in global responses between growth and value funds.

### 3.2. Data

We used monthly excess returns data (with monthly intervals) for all the indices used (Table 1). Excess returns were calculated as realized returns of the indices in excess of the 3-month T-bill rate used as proxy for the risk-free rate. Indices and funds used were: Vanguard Large-Cap Growth fund (VIGRX), Vanguard Large-Cap Value fund (VIVAX), and four global market indices (Japanese N225, Swiss SSMI, Singapore STI, and UK FTSE) for the period November 1993 – May 2015. We chose Vanguard large-cap funds as the proxies for U.S. growth and value portfolios since data was available for a substantially longer period of time compared to other indices. We used the database Telemet Orion to retrieve the domestic and international funds returns data series. The series for factors used in FF3, IFF3, IFF3exus and CARHART 4 were obtained from the Quandl database<sup>5</sup> which essentially extracts data provided by the Kenneth R. French Data Library<sup>6</sup>. Table 1 lists all the market variables used in this study and their descriptive statistics. Table 2 provides the correlation matrix.

Compared to Campbell and Thompson (2008) and Welch and Goyal (2007), the current data has a number of advantages to test the research questions of interest. Their dependent variable is the monthly excess returns on S&P 500<sup>7</sup>, whereas we have disaggregated this into two categories of growth and value large-cap index monthly excess returns. Their independent variables were comprised of state variables such as dividend to price ratio, earnings to price ratio, price-earnings growth ratio, corporate bond returns, investment to capital ratio, ROE, net equity issuance, and consumption-wealth ratio. We used market variables which are used as part of the currently used asset pricing models, such as book-to-market ratio, small-minus-big premium, and winners-versus-losers premium. In addition, we also added global linkage factors discussed earlier. While their study spans a much longer period of time from 1927 – 2005, we use data from November 1993 – May 2015, as was available for the VIGRX and VIVAX fund indices.

We also compare our data with Zhang (2006) who investigates the efficacy of three international asset pricing models during the period 1981-1997. This provided a platform for us to analyze specifically how the performance of our international asset pricing models compared against the ones studied in Zhang (2006). She uses monthly observations of portfolios created according to size (Small vs. Big) and Book-to-Market ratios (High vs. Low). Tests on portfolios created on the basis of Book-to-Market ratios in her

5 <https://www.quandl.com>

6 [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)

7 Also known as the equity premium.

**Table 1: Descriptive statistics of all the market variables used**

Index/Fund	Observations	Min.	Max.	Mean	SD	Skewness	Kurtosis
VIVAX	259	-0.182	0.099	0.005	0.044	-0.979	2.329
VIGRX	259	-0.196	0.111	0.005	0.046	-0.832	1.427
SP500	259	-0.186	0.102	0.004	0.043	-0.880	1.771
SSMI	259	-0.214	0.125	0.003	0.045	-0.944	2.450
STI	259	-0.274	0.245	0.000	0.067	-0.359	3.517
FTSE	259	-0.141	0.082	0.001	0.040	-0.701	0.821
N225	259	-0.273	0.147	-0.002	0.059	-0.609	1.229
HML	259	-12.610	13.890	0.186	3.185	0.071	3.273
SMB	259	-16.410	22.020	0.175	3.388	0.866	8.515
IHML	259	-9.620	11.230	0.360	2.398	0.479	5.059
ISMB	259	-9.650	10.300	0.018	2.093	-0.066	3.595
IHMLexus	259	-11.020	9.640	0.473	2.243	-0.204	6.106
ISMBexus	259	-5.800	6.990	0.012	2.064	-0.176	0.479
MOM	259	-0.347	0.184	0.004	0.051	-1.589	10.904

Table 1 provides summary of descriptive statistics for all the market variables used. Time period used for analysis is from November 1, 1993 - May 1, 2015. Provided are number of observations for all the indices and factors used, followed by their minimum, maximum, mean statistics, standard deviation, skewness, and kurtosis values from the sample period. The observations for indices are monthly excess returns over risk-free rate (proxy taken as 3-month T-bill rate). (VIGRX = Vanguard growth fund index, VIVAX = Vanguard value fund index, SP500 = S&P500 market index, SSMI = Swiss market index, N225 = Japanese market index, STI = Singapore market index, and FTSE = UK market index). HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers)

paper simulates the test on growth versus value stocks that our paper tries to study. Zhang (2006) uses three countries - US, UK and Japan. The three models tested in her paper are: (1) single-beta International CAPM as specified in Grauer et al., (1976), (2) International CAPM with currency exchange rate risk of major markets (Deutsche mark, Japanese yen, UK pound, relative to the US dollar), and (3) Fama and French (1998) international model incorporating world Fama-French factors. These models are similar to what we have tested, so the comparison is meaningful.

### 3.3. Data Diagnostics

The shorter frequencies of data, such as daily interval data, normally show signs of autocorrelation in data and post-regression residuals. Although the monthly returns can be expected to be clear of such issues, we tested our data for autocorrelation using Box-Ljung. The first order lag of monthly excess growth returns was -0.339 and was not significant. Similarly, none of the 16 lags were statistically significant. We tested this statistic for the data set and did not find autocorrelation. Similarly, we tested the residuals from our regressions for autocorrelation using the Durbin-Watson test and these were also free of autocorrelation. As we ran the regression, to ensure our regression is bias-free, we imposed the t-statistic to be heteroscedasticity robust, with an attempt to alleviate any problem associated with potential heteroscedasticity<sup>8</sup>.

## 4. RESULTS

We were able to test many of our research questions through the regressions conducted. We focused directly on the RMSE obtained through our tests in order to compare the forecasting strength of the models. For robustness, we tested and report results from two out-of-sample periods. Both periods are for a duration of 36 months. First we use June 2012-May 2015 which is at the end of our in-sample data. Second, we study the period January 2005-December 2007. We do follow Campbell and Thompson

(2008) by reporting alternate sets of RMSE for both out-of-sample periods by constraining our forecast returns to be zero when they turn out to be negative, agreeing to the presumption that if the return for t+1 is forecasted by the model to be negative, the risk-averse investor will refrain from investing during that period and expect a zero return<sup>9</sup>.

Tables 3 and 4 provide the out-of-sample RMSE for each of the ten models, for growth and value stocks respectively. Columns 1-4 of each table provide detail on the period June 2012-May 2015, while Columns 5-8 cover the second period, January 2005-December 2007. Results cover both unconstrained and constrained models respectively. Appendices A and B elaborate the results to incorporate graphical display (Appendix A.1 through A.4 cover growth results and B.1 through B.4 cover value results).

$$\text{CAPM: } R - r_{rf} = \alpha + \beta^*(r_m - r_{rf}) + \epsilon \tag{1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \epsilon \tag{2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \epsilon \tag{3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHMLexus}) + \beta_3^*(\text{ISMBexus}) + \epsilon \tag{4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \epsilon \tag{5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(r_{\text{SSMI exc}}) + \beta_3^*(r_{\text{N225 exc}}) + \beta_4^*(r_{\text{FTSE exc}}) + \epsilon \tag{6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{N225 exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{7}$$

9 We refrain from complicating the model by considering a short position, thus assume that investors take no position and expect a zero return for the period when forecasting model predicts a negative return.

8 Data diagnostics are not presented in tables, but available upon request.

**Table 2: Correlation Matrix of all the market variables used**

	VIVAX	VIGRX	SP500 exc	SSMI exc	STI exc	FTSE exc	N225 exc	HML	SMB	IHML	ISMB	IHMLexcus	ISMBexcus	WML
VIVAX	-													
VIGRX	0.842**	-												
SP500 exc	0.957**	0.960**	-											
SSMI exc	0.699**	0.635**	0.696**	-										
STI exc	0.606**	0.602**	0.628**	0.463**	-									
FTSE exc	0.797**	0.768**	0.813**	0.720**	0.595**	-								
N225 exc	0.518**	0.554**	0.562**	0.476**	0.480**	0.506**	-							
HML	-0.047	-0.122*	-0.083	-0.040	-0.107	-0.035	-0.083	-						
SMB	0.039	0.016	0.030	0.036	0.033	-0.001	0.037	-0.351**	-					
IHML	-0.071	-0.171**	-0.123*	-0.067	-0.107	-0.063	-0.082	0.873**	-0.283**	-				
ISMB	0.042	0.083	0.068	0.032	0.110	0.004	0.068	-0.204**	0.762**	-0.201**	-			
IHMLexcus	-0.094	-0.194**	-0.149*	-0.083	-0.086	-0.082	-0.123*	0.636**	-0.256**	0.895**	-0.176**	-		
ISMBexcus	0.014	0.082	0.053	0.020	0.137**	0.013	0.063	-0.032	0.297**	-0.078	0.813**	-0.060	-	
WML	-0.031	-0.021	-0.023	-0.084	-0.202**	-0.046	-0.051	-0.156*	0.092	-0.130*	0.097	-0.118	0.084	-

\*\*Correlation is significant at the 0.01 level (2-tailed). \*Correlation is significant at the 0.05 level (2-tailed). This table displays the correlation (Pearson) matrix of all the market variables used. VIGRX = Vanguard growth fund index, VIVAX = Vanguard value fund index, SP500 = S&P500 market index, SSMI = Swiss market index, N225 = Japanese market index, STI = Singapore market index, and FTSE = UK market index. HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexcus is the value premium with international stocks excluding US (international high minus low), ISMBexcus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers)

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHML}) + \beta_3*(\text{ISMB}) + \beta_4*(r_{\text{SSMI exc}}) + \beta_5*(r_{\text{N225 exc}}) + \beta_6*(r_{\text{FTSE exc}}) + \epsilon \quad (8)$$

$$\text{GIFF3excus: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHMLexcus}) + \beta_3*(\text{ISMBexcus}) + \beta_4*(r_{\text{SSMI exc}}) + \beta_5*(r_{\text{N225 exc}}) + \beta_6*(r_{\text{FTSE exc}}) + \epsilon \quad (9)$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{HML}) + \beta_3*(\text{SMB}) + \beta_4*(\text{WML}) + \beta_5*(r_{\text{SSMI exc}}) + \beta_6*(r_{\text{N225 exc}}) + \beta_7*(r_{\text{FTSE exc}}) + \epsilon \quad (10)$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3excus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart’s 4-factor model.

Where the prefix “G” in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexcus is the value premium with international stocks excluding US (international high minus low), ISMBexcus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{\text{SSMI exc}}$  is the excess return on Swiss index,  $r_{\text{N225 exc}}$  is the excess return on Japanese index, and  $r_{\text{FTSE exc}}$  is the excess return on UK index.

$$\text{CAPM: } R - r_{rf} = \alpha + \beta*(r_m - r_{rf}) + \epsilon \quad (1)$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{HML}) + \beta_2*(\text{SMB}) + \epsilon \quad (2)$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHML}) + \beta_2*(\text{ISMB}) + \epsilon \quad (3)$$

$$\text{IFF3excus: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHMLexcus}) + \beta_2*(\text{ISMBexcus}) + \epsilon \quad (4)$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{HML}) + \beta_2*(\text{SMB}) + \beta_2*(\text{WML}) + \epsilon \quad (5)$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(r_{\text{SSMI exc}}) + \beta_3*(r_{\text{STI exc}}) + \beta_4*(r_{\text{FTSE exc}}) + \epsilon \quad (6)$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{HML}) + \beta_3*(\text{SMB}) + \beta_4*(r_{\text{SSMI exc}}) + \beta_5*(r_{\text{STI exc}}) + \beta_6*(r_{\text{FTSE exc}}) + \epsilon \quad (7)$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHML}) + \beta_3*(\text{ISMB}) + \beta_4*(r_{\text{SSMI exc}}) + \beta_5*(r_{\text{STI exc}}) + \beta_6*(r_{\text{FTSE exc}}) + \epsilon \quad (8)$$

$$\text{GIFF3excus: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{IHMLexcus}) + \beta_3*(\text{ISMBexcus}) + \beta_4*(r_{\text{SSMI exc}}) + \beta_5*(r_{\text{STI exc}}) + \beta_6*(r_{\text{FTSE exc}}) + \epsilon \quad (9)$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(\text{HML}) + \beta_3*(\text{SMB}) + \beta_4*(\text{WML}) + \beta_5*(r_{\text{SSMI exc}}) + \beta_6*(r_{\text{STI exc}}) + \beta_7*(r_{\text{FTSE exc}}) + \epsilon \quad (10)$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using

**Table 3: Forecasting strength of asset pricing models for growth stocks**

Asset-pricing model	Unconstrained Model June 2012-May 2015 (%)	Rank	Constrained Model June 2012-May 2015 (%)	Rank	Unconstrained Model June 2005-Dec 2007 (%)	Rank	Constrained Model June 2005-Dec 2007 (%)	Rank
CAPM	3.684	8	3.054	7	2.937	8	2.387	7
FF3	3.712	10	3.057	9	2.905	5	2.390	9
IFF3	3.704	9	3.065	10	2.951	9	2.408	10
IFF3exus	3.683	7	3.056	8	2.958	10	2.365	6
CARHART 4	3.682	4	3.020	2	2.892	3	2.387	7
GCAPM	3.666	3	3.031	3	2.898	4	2.314	3
GFF3	3.682	4	3.033	4	2.844	1	2.301	2
GIFF3	3.682	4	3.048	6	2.906	6	2.327	4
GIFF3exus	3.663	2	3.035	5	2.919	7	2.300	1
GCARHART 4	3.616	1	2.966	1	2.862	2	2.350	5

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for two periods: June 2012-May 2015, and June 2005-Dec 2007, along with their performance ranking. The constrained models assume forecast returns to be zero when they turn out to be negative. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

**Table 4: Forecasting strength of asset pricing models for value stocks**

Asset-pricing model	Unconstrained Model June 2012-May 2015 (%)	Rank	Constrained Model June 2012-May 2015 (%)	Rank	Unconstrained Model June 2005-Dec 2007 (%)	Rank	Constrained Model June 2005-Dec 2007 (%)	Rank
CAPM	3.306	9	2.672	4	2.837	9	2.457	10
FF3	3.237	3	2.647	2	2.839	10	2.444	8
IFF3	3.262	5	2.653	3	2.799	6	2.425	5
IFF3exus	3.299	8	2.738	10	2.774	4	2.434	6
CARHART 4	3.205	1	2.638	1	2.811	7	2.421	4
GCAPM	3.307	10	2.694	9	2.793	5	2.445	9
GFF3	3.258	4	2.680	6	2.816	8	2.443	7
GIFF3	3.271	6	2.681	7	2.766	2	2.414	2
GIFF3exus	3.290	7	2.688	8	2.731	1	2.415	3
GCARHART 4	3.231	2	2.672	4	2.766	2	2.398	1

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for two periods: June 2012-May 2015, and June 2005-Dec 2007, along with their performance ranking. The constrained models assume forecast returns to be zero when they turn out to be negative. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{STI\ exc}$  is the excess return on Singapore index, and  $r_{FTSE\ exc}$  is the excess return on UK index.

The first finding is that the RMSE of the constrained models outperform the unconstrained models; this is true for both growth and value stocks. On average, the reduction in RMSE obtained by imposing the non-negativity in forecast returns when considering

both growth and value stocks, is about 0.5% (comparing RMSE in Tables 5 and 6 for growth stocks). A gain of such reduction on an average RMSE of about 2.9% is 17% (i.e., 0.5% divided by 2.9% = 17%). This forecast error improvement can translate into a significant advantage for fund managers when taking into consideration the large size of these fund balances. To put the fund balances into perspective, the Vanguard Growth Index Fund used in this paper (VIGRX) had \$84 billion net assets as of June 1, 2019. In other words, the constrained models provide more accuracy in their predictions. This is in line with findings of Campbell and Thompson (2008) who report predictability of returns when using these types of constrained models.

The second implication of the results is that when conducting the analyses by disaggregating the data into growth and value stocks as suggested in Welch and Goyal (2007), the results are strong with a relatively low RMSE on average of about 2.9%, considering this is a forecasting exercise where large errors are naturally expected. Results in Tables 3 and 4 show that the value stocks are more predictable than growth stocks using these models. Or, stated differently, the models work better for value stocks than for growth stocks. This is likely due to a lower RMSE on average and consistently, for value stocks. The average difference in RMSE between growth and value stocks is about 0.20%, which when translated as a percentage of 2.9% RMSE is about 7%.



The third inference from Tables 3 and 4 is that the RMSE gets consistently better for global models for the growth stocks when compared to value stocks. While the five global models are consistently ranked higher for growth stocks for both out-of-sample periods, the value stocks results are inconsistent. The models that consistently get higher ranking for growth stocks is GCARHART 4, GFF3, and GCAPM. For Value stocks, GCARHART 4 and CARHART 4 consistently performed well. This finding confirms the expectation that global models improve performance in forecasting monthly returns, specifically for the growth fund, providing support for the use of global linkage factors in asset pricing models. The RMSE is smaller for global models for growth funds when compared to domestic models. Table 3 shows the RMSE improvement around 0.07% for the global Carhart model compared to its domestic version. Similar information can be obtained for other models. As mentioned earlier, this small improvement can translate into significant advantage when considering the large amounts of money invested in these funds.

The results, however, are not consistent for value models, as reported in Table 4. The global models improve forecasting for the first time period, as evidenced by higher rank of global models. This improvement, however, does not hold true during the second period. This perhaps implies that value stocks are less heavily invested and linked with global markets than growth stocks<sup>10</sup>. Or, these could be seen as more volatile stocks shifting sources of risk premium. This explanation could be in line with the findings of Fama and French (1998) who claim that value stocks are more risky in nature than growth stocks. Perhaps further segmentation of data is needed to fully confirm this; however, a reasonably limited yet sufficient period of years analyzed such as what we have used in this study supports model stability, and so, we refrained from further segmenting the data.

Our results are relatively more consistent and stronger compared to the findings of Campbell and Thompson (2008) and Welch and Goyal (2007). We believe this could be true because we take an integrated approach in our paper where we consider both the historical information of the stock returns itself, and also incorporate additional factors such as the ones used in different asset pricing models. The independent variables used in the out-of-sample forecasts are in essence, derived from a prior regression. Thus, this slightly mixed approach of regression on regression refines the results and makes it more adaptive toward enriching forecast outputs.

Next, we discuss the implications of our results specifically in context of the literature in international asset pricing. Zhang (2006) reports strong results for the three international models used in her study. The author compares three international asset pricing models and tests their respective performance to price portfolios based on different book/market ratios and size (small vs. big), utilizing monthly observations during the period 1981 – 1997. Although the time period is different with only a few years of overlap, we believe there are sufficient similarities to compare results. More

importantly, she uses portfolios sorted by book-to-market ratios, which makes the results comparable to our test results on growth versus value fund global linkages. Although she does not compare the international models used in her study with the specific domestic versions, the author finds that the conditional versions of international models used provide strong explanation for US stocks pricing. The International CAPM used in her paper is analogous to our GCAPM model, and her Fama and French model to our IFF3 model. The combined results of our study and hers point to a compelling story of asset prices being priced internationally. While her study does not focus specifically on providing explanation of different findings on growth and value stocks, our paper has provided in-depth insights on this issue. Overall, similar to Zhang (2006), our results support for the efficacy of using global models in forecasting US stock returns, specifically for the growth stocks.

At this point, we turn to Chow test results as another robustness check for our results and further as a justification for disaggregating stock returns into growth and value stocks. With this test, we analyzed the growth and value stock categories separately to investigate the extent of the difference in their global linkages. Specifically after the findings above showing different results between growth and value stocks, it is essential to pursue this test to verify whether the two categories of stocks are fundamentally different, and if they are, then they support the results in Tables 3 and 4. From the Chow test results provided in Table 5, we reject the null hypothesis of “same global linkages for both growth and value funds.” The Chow test results using each of the five global models (Table 5) indicate that we cannot pool the growth and value stocks together in any of these models.

$$GCAPM: R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(r_{SSMI\ exc}) + \beta_3*(r_{STI\ exc}) + \beta_4*(r_{FTSE\ exc}) + \epsilon \tag{6}$$

$$GFF3: R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(HML) + \beta_3*(SMB) + \beta_4*(r_{SSMI\ exc}) + \beta_5*(r_{STI\ exc}) + \beta_6*(r_{FTSE\ exc}) + \epsilon \tag{7}$$

$$GIFF3: R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(IHML) + \beta_3*(ISMB) + \beta_4*(r_{SSMI\ exc}) + \beta_5*(r_{STI\ exc}) + \beta_6*(r_{FTSE\ exc}) + \epsilon \tag{8}$$

$$GIFF3\ excus: R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(IHML\ excus) + \beta_3*(ISMB\ excus) + \beta_4*(r_{SSMI\ exc}) + \beta_5*(r_{STI\ exc}) + \beta_6*(r_{FTSE\ exc}) + \epsilon \tag{9}$$

$$GCARHART\ 4: R - r_{rf} = \alpha + \beta_1*(r_m - r_{rf}) + \beta_2*(HML) + \beta_3*(SMB) + \beta_4*(WML) + \beta_5*(r_{SSMI\ exc}) + \beta_6*(r_{STI\ exc}) + \beta_7*(r_{FTSE\ exc}) + \epsilon \tag{10}$$

Where GCAPM = Global Capital asset pricing model, GFF3 = Global Fama-French 3-factor model, GIFF3 = Global Fama-French

**Table 5: Results: chow test**

Asset-pricing model	F-Statistic	P-value
GCAPM	3.563	0.003***
GFF3	2.958	0.012**
GIFF3	3.078	0.009***
GIFF3excus	3.799	0.002***
GCARHART 4	2.525	0.028**

\*\*\*, \*\*, \* indicate significance at the 1%, 5%, and 10% levels respectively. The Chow test results strongly rejects the null hypothesis of “same global linkages for growth and value stocks” when each of the global models (Equations 6-10 shown below) are tested. The F-stat and p-value from the Chow test are reported

10 Similar evidence was noted in Rana and Phillips (2016) resembling home-bias type of behavior associated with value stocks when compared to growth stocks.

3-factor model using international factors, GIFF3exus = Global Fama-French 3-factor model using international factors excluding US, and GCarhart4 = Global Carhart's 4-factor model;

Where  $R$  is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate,  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHML<sub>exus</sub> is the value premium with international stocks excluding US (international high minus low), ISMB<sub>exus</sub> is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{STI\ exc}$  is the excess return on Singapore index (for growth stocks,  $r_{STI\ exc}$  was replaced with excess return on Japanese index  $r_{N225\ exc}$  in order to accurately capture the relative influences on the funds), and  $r_{FTSE\ exc}$  is the excess return on UK index.

The results discussed above from all the tests we performed demonstrates the importance of using global models in conjunction with domestic models to explain and predict US growth and value fund returns. Further, we build a case to study and model growth and value stocks separately due to their inherently distinct characteristics. This information can be readily used by fund managers for forecasting purposes of growth and value stocks.

## 5. CONCLUSION

This paper provides a new dimension for forecasting US stock returns driven by the motivation of disaggregating the broader US equity market into two prominent categories of growth and value stocks, and assessing predictability of each category, utilizing widely used asset pricing models. The paper also incorporates the effect of globalization into the models for deeper insight. To our knowledge, there hasn't been any study done assessing the use of global linkage factors on forecasting growth and value stocks, and further assessing their forecasting strength, to this extent.

We find that the Global Carhart model consistently ranks as the best predictor for both growth and value stocks leading us to believe that it captures relevant risk premiums on US equity markets. We find that value stocks have more predictability compared to growth stocks; another implication is that the models we consider predict value stocks better than growth stocks. On the other hand, the addition of global factors improve the predictability of growth stocks while the result is dubious for value stocks, perhaps indicating that the growth stocks are more connected to international markets than value stocks. Finally, there is a significant reduction in root mean square error (RMSE) for all models tested as we apply non-negativity constraints on the forecasting parameters, suggesting these constraints should be included when conducting these type of studies. Future studies can test these models on different time periods and also possibly during various business cycles; test on five-factor Fama-French model could be another extension.

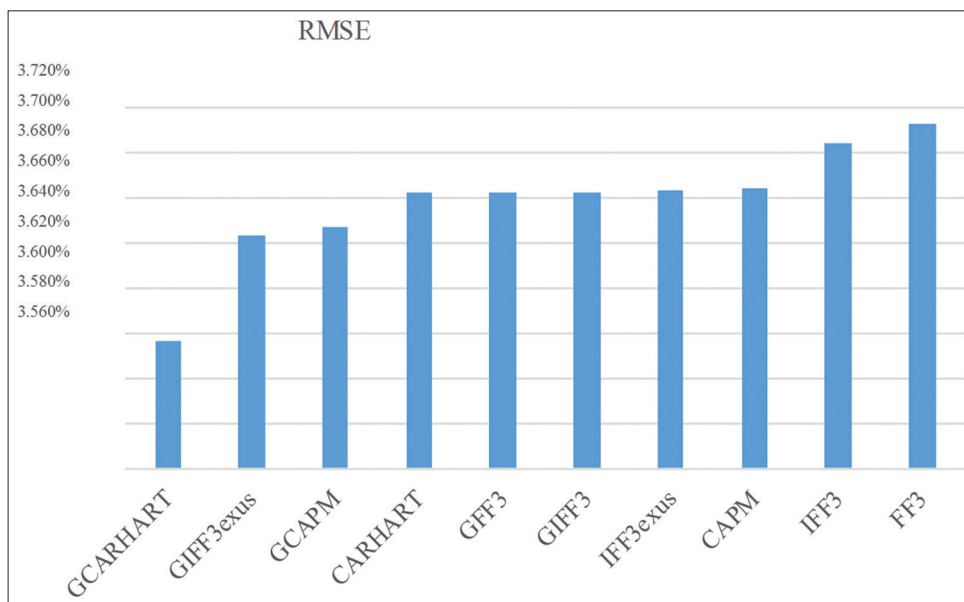
## REFERENCES

- Bekaert, G., Hodrick, R.J., Zhang, X. (2009), International stock return comovements. *The Journal of Finance*, 64(6), 2591-2626.
- Campbell, J.Y., Polk, C., Vuolteenaho, T. (2010), Growth or glamour? Fundamentals and systematic risk in stock returns. *Review of Financial Studies*, 23(1), 305-344.
- Campbell, J.Y., Thompson, S.B. (2008), Predicting excess stock returns out of sample: Can anything beat the historical average? *Review of Financial Studies*, 21(4), 1509-1531.
- Campbell, J.Y., Vuolteenaho, T. (2004), Bad beta, good beta. *The American Economic Review*, 94(5), 1249-1275.
- Capaul, C., Rowley, I., Sharpe, W.F. (1993), International value and growth stock returns. *Financial Analysts Journal*, 49(1), 27-36.
- Carhart, M.M. (1997), On persistence in mutual fund performance. *The Journal of Finance*, 52(1), 57-82.
- Cassella, S., Gulen, H. (2018), Extrapolation bias and the predictability of stock returns by price-scaled variables. *The Review of Financial Studies*, 31(11), 4345-4397.
- Chan, K.C., Karolyi, G.A., Stulz, R. (1992), Global financial markets and the risk premium on US equity. *Journal of Financial Economics*, 32(2), 137-167.
- Chan, L.K., Lakonishok, J. (2004), Value and growth investing: Review and update. *Financial Analysts Journal*, 60(1), 71-86.
- Chow, G.C. (1960), Tests of equality between sets of coefficients in two linear regressions. *Econometrica: Journal of the Econometric Society*, 28(3), 591-605.
- Christoffersen, P.F., Diebold, F.X. (2006), Financial asset returns, direction-of-change forecasting, and volatility dynamics. *Management Science*, 52(8), 1273-1287.
- Chronopoulos, D.K., Papadimitriou, F.I., Vlastakis, N. (2018), Information demand and stock return predictability. *Journal of International Money and Finance*, 80, 59-74.
- Corrado, C., Truong, C. (2007), forecasting stock index volatility: Comparing implied volatility and the intraday high-low price range. *Journal of Financial Research*, 30(2), 201-215.
- Diermeier, J., Solnik, B. (2001), Global pricing of equity. *Financial Analysts Journal*, 57(4), 37-47.
- Fama, E.F. (1970), Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417.
- Fama, E.F., French, K.R. (1993), Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, 33(1), 3-56.
- Fama, E.F., French, K.R. (1998), Value versus growth: The international evidence. *Journal of Finance*, 53(6), 1975-1999.
- Fama, E.F., French, K.R. (2015), A five-factor asset pricing model. *Journal of Financial Economics*, 116(1), 1-22.
- Ferreira, M.A., Santa-Clara, P. (2011), Forecasting stock market returns: The sum of the parts is more than the whole. *Journal of Financial Economics*, 100(3), 514-537.
- Ferson, W.E., Harvey, C.R. (1993), The risk and predictability of international equity returns. *Review of Financial Studies*, 6(3), 527-566.
- Fraser, P., Oyefeso, O. (2005), US, UK and European stock market integration. *Journal of Business Finance and Accounting*, 32(1□2), 161-181.
- Grauer, F.L., Litzenberger, R.H., Stehle, R.E. (1976), Sharing rules and equilibrium in an international capital market under uncertainty. *Journal of Financial Economics*, 3(3), 233-256.
- Harvey, C.R. (1991), The world price of covariance risk. *The Journal of Finance*, 46(1), 111-157.
- Harvey, C.R., Liu, Y., Zhu, H. (2016), ... and the cross-section of expected returns. *The Review of Financial Studies*, 29(1), 5-68.
- Hau, H. (2011), Global versus local asset pricing: A new test of market

- integration. *Review of financial Studies*, 24(12), 3891-3940.
- Hyndman, R.J., Koehler, A.B. (2006), Another look at measures of forecast accuracy. *International Journal of Forecasting*, 22(4), 679-688.
- Kuo, W., Satchell, S.E. (2001), Global equity styles and industry effects: The pre-eminence of value relative to size. *Journal of International Financial Markets, Institutions and Money*, 11(1), 1-28.
- Lakonishok, J., Shleifer, A., Vishny, R.W. (1994), Contrarian investment, extrapolation, and risk. *The Journal of Finance*, 49(5), 1541-1578.
- Longin, F., Solnik, B. (1995), Is the correlation in international equity returns constant: 1960-1990? *Journal of International Money and Finance*, 14(1), 3-26.
- Merton, R.C. (1973), An intertemporal capital asset pricing model. *Econometrica: Journal of the Econometric Society*, 41(5), 867-887.
- Merton, R.C. (1980), On estimating the expected return on the market: An exploratory investigation. *Journal of Financial Economics*, 8(4), 323-361.
- Narayan, P.K., Liu, R. (2018), A new GARCH model with higher moments for stock return predictability. *Journal of International Financial Markets, Institutions and Money*, 56, 93-103.
- Ng, D.T. (2004), The international CAPM when expected returns are time-varying. *Journal of International Money and Finance*, 23(2), 189-230.
- Pesaran, M.H., Timmermann, A. (1995), Predictability of stock returns: Robustness and economic significance. *The Journal of Finance*, 50(4), 1201-1228.
- Rana, S., Phillips, G.M. (2016), Are U.S. growth and value stocks similarly integrated with the world markets? A test across business cycles. *Applied Economics*, 48(53), 5168-5185.
- Ross, S.A. (1976), The arbitrage theory of capital asset pricing. *Journal of Economic Theory*, 13(3), 341-360.
- Santis, G., Gerard, B. (1997), International asset pricing and portfolio diversification with time-varying risk. *The Journal of Finance*, 52(5), 1881-1912.
- Schneider, P. (2019), An anatomy of the market return. *Journal of Financial Economics*, 132(2), 325-350.
- Sharpe, W.F. (1992), Asset allocation: Management style and performance measurement. *The Journal of Portfolio Management*, 18(2), 7-19.
- Skočir, M., Lončarski, I. (2018), Multi-factor asset pricing models: Factor construction choices and the revisit of pricing factors. *Journal of International Financial Markets, Institutions and Money*, 55, 65-80.
- Solnik, B. (1983), International arbitrage pricing theory. *The Journal of Finance*, 38(2), 449-457.
- Solnik, B.H. (1974), The international pricing of risk: An empirical investigation of the world capital market structure. *Journal of Finance*, 29(2), 365-378.
- Stulz, R. (1981), A model of international asset pricing. *Journal of Financial Economics*, 9(4), 383-406.
- Thenmozhi, M., Chand, G.S. (2016), Forecasting stock returns based on information transmission across global markets using support vector machines. *Neural Computing and Applications*, 27(4), 805-824.
- Timmermann, A. (2008), Elusive return predictability. *International Journal of Forecasting*, 24(1), 1-18.
- Walter, I. (1999), The global asset management industry: Competitive structure and performance. *Financial Markets, Institutions and Instruments*, 8(1), 1-78.
- Welch, I., Goyal, A. (2007), A comprehensive look at the empirical performance of equity premium prediction. *The Review of Financial Studies*, 21(4), 1455-1508.
- Zhang, X. (2006), Specification tests of international asset pricing models. *Journal of International Money and Finance*, 25(2), 275-307.

## APPENDIX

Appendix A.1: Growth Stocks Results: Forecasting Strength assessment using RMSE for the period June 2012-May 2015



	GCARHART	GIFF3exus	GCAPM	CARHART	GFF3	GIFF3	IFF3exus	CAPM	IFF3	FF3
RMSE	3.616%	3.663%	3.666%	3.682%	3.682%	3.682%	3.683%	3.684%	3.704%	3.712%
RANK	1	2	3	4	4	4	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for the period: June 2012-May 2015, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta^*(r_m - r_{rf}) + \epsilon \tag{A.1.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_2^*(\text{SMB}) + \epsilon \tag{A.1.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_2^*(\text{ISMB}) + \epsilon \tag{A.1.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}_{\text{exus}}) + \beta_2^*(\text{ISMB}_{\text{exus}}) + \epsilon \tag{A.1.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_2^*(\text{SMB}) + \beta_2^*(\text{WML}) + \epsilon \tag{A.1.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(r_{\text{SSMI exc}}) + \beta_3^*(r_{\text{N225 exc}}) + \beta_4^*(r_{\text{FTSE exc}}) + \epsilon \tag{A.1.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{N225 exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{A.1.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{N225 exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{A.1.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}_{\text{exus}}) + \beta_3^*(\text{ISMB}_{\text{exus}}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{N225 exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{A.1.9}$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \beta_5^*(r_{\text{SSMI exc}}) + \beta_6^*(r_{\text{N225 exc}}) + \beta_7^*(r_{\text{FTSE exc}}) + \epsilon \tag{A.1.10}$$

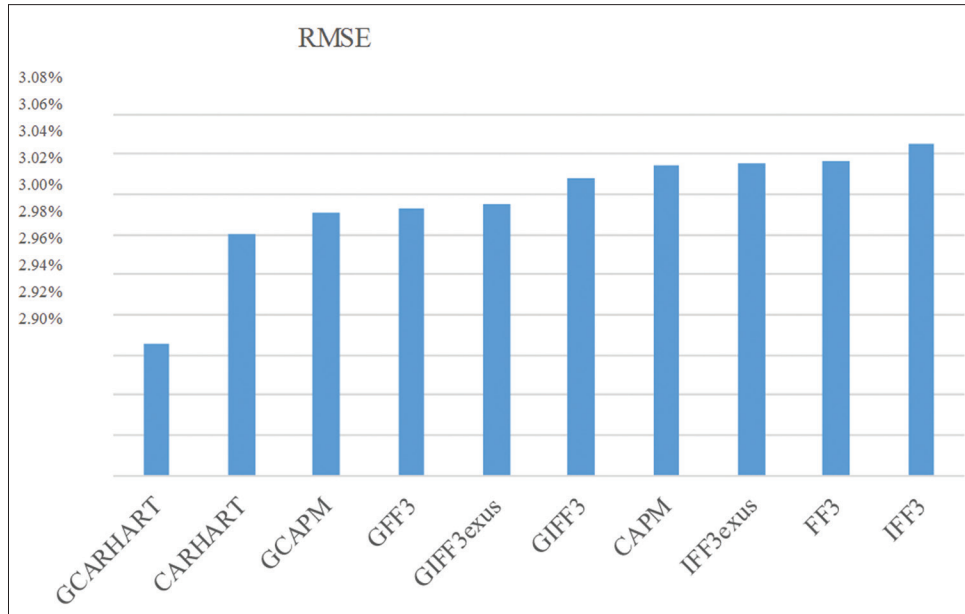
Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHML<sub>exus</sub> is the value premium with international stocks excluding US (international high minus low), ISMB<sub>exus</sub> is the international stocks size

premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{N225\ exc}$  is the excess return on Japanese index, and  $r_{FTSE\ exc}$  is the excess return on UK index.

Appendix A.2: Growth stocks results: Forecasting strength assessment using RMSE obtained using positive returns forecast constraint for the period June 2012-May 2015



	GCARHART	CARHART	GCAPM	GFF3	GIFF3exus	GIFF3	CAPM	IFF3exus	FF3	IFF3
RMSE	2.966%	3.020%	3.031%	3.033%	3.035%	3.048%	3.054%	3.056%	3.057%	3.065%
RANK	1	2	3	4	5	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) using positive returns forecast constraint for the period: June 2012-May 2015, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \epsilon \tag{A.2.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \epsilon \tag{A.2.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \epsilon \tag{A.2.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \epsilon \tag{A.2.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \epsilon \tag{A.2.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(r_{SSMI\ exc}) + \beta_3(r_{N225\ exc}) + \beta_4(r_{FTSE\ exc}) + \epsilon \tag{A.2.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.2.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.2.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.2.9}$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \beta_5(r_{SSMI\ exc}) + \beta_6(r_{N225\ exc}) + \beta_7(r_{FTSE\ exc}) + \epsilon \tag{A.2.10}$$

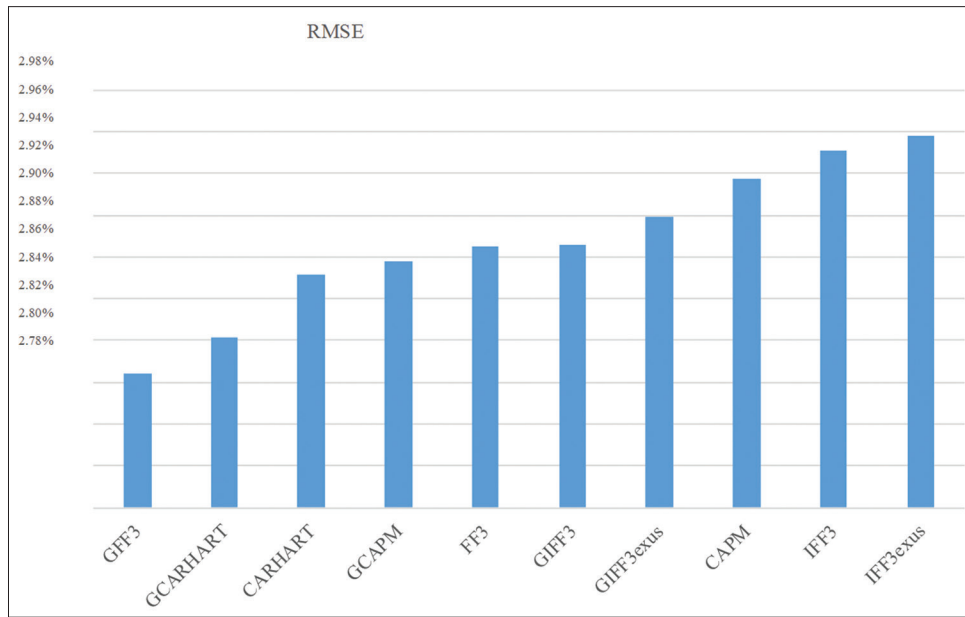
Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size

premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{N225\ exc}$  is the excess return on Japanese index, and  $r_{FTSE\ exc}$  is the excess return on UK index.

Appendix A.3: Growth Stocks Results: Forecasting Strength assessment using RMSE for the period January 2005-December 2007



	GFF3	GCARHART	CARHART	GCAPM	FF3	GIFF3	GIFF3exus	CAPM	IFF3	IFF3exus
RMSE	2.844%	2.862%	2.892%	2.898%	2.905%	2.906%	2.919%	2.937%	2.951%	2.958%
RANK	1	2	3	4	5	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for the period: January 2005 — December 2007, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta^*(r_m - r_{rf}) + \epsilon \tag{A.3.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(HML) + \beta_3^*(SMB) + \epsilon \tag{A.3.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(IHML) + \beta_3^*(ISMB) + \epsilon \tag{A.3.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(IHML_{exus}) + \beta_3^*(ISMB_{exus}) + \epsilon \tag{A.3.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(HML) + \beta_3^*(SMB) + \beta_4^*(WML) + \epsilon \tag{A.3.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(r_{SSMI\ exc}) + \beta_3^*(r_{N225\ exc}) + \beta_4^*(r_{FTSE\ exc}) + \epsilon \tag{A.3.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(HML) + \beta_3^*(SMB) + \beta_4^*(r_{SSMI\ exc}) + \beta_5^*(r_{N225\ exc}) + \beta_6^*(r_{FTSE\ exc}) + \epsilon \tag{A.3.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(IHML) + \beta_3^*(ISMB) + \beta_4^*(r_{SSMI\ exc}) + \beta_5^*(r_{N225\ exc}) + \beta_6^*(r_{FTSE\ exc}) + \epsilon \tag{A.3.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(IHML_{exus}) + \beta_3^*(ISMB_{exus}) + \beta_4^*(r_{SSMI\ exc}) + \beta_5^*(r_{N225\ exc}) + \beta_6^*(r_{FTSE\ exc}) + \epsilon \tag{A.3.9}$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(HML) + \beta_3^*(SMB) + \beta_4^*(WML) + \beta_5^*(r_{SSMI\ exc}) + \beta_6^*(r_{N225\ exc}) + \beta_7^*(r_{FTSE\ exc}) + \epsilon \tag{A.3.10}$$

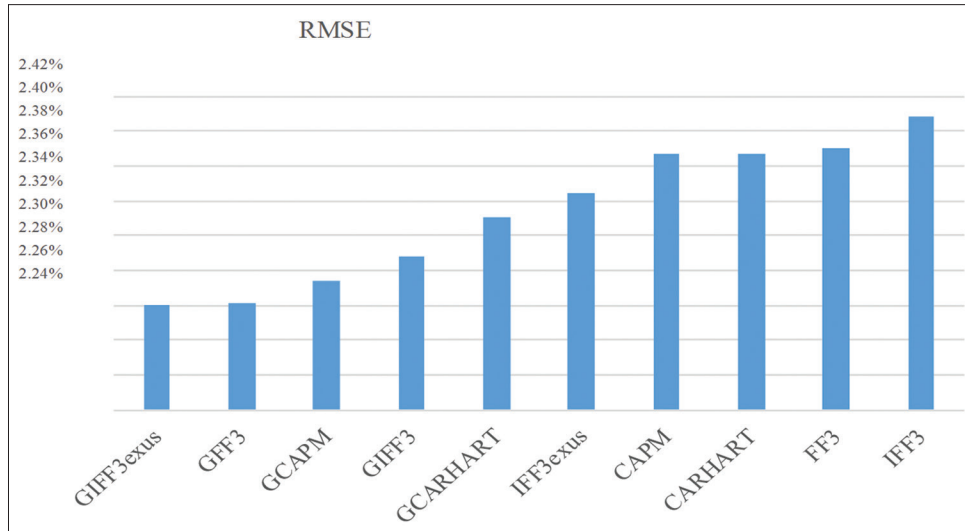
Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHML<sub>exus</sub> is the value premium with international stocks excluding US (international high minus low), ISMB<sub>exus</sub> is the international stocks size

premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{N225\ exc}$  is the excess return on Japanese index, and  $r_{FTSE\ exc}$  is the excess return on UK index.

Appendix A.4: Growth Stocks Results: Forecasting Strength assessment using RMSE obtained using positive returns forecast constraint for the period January 2005-December 2007



	GIFF3exus	GFF3	GCAPM	GIFF3	GCARHART	IFF3exus	CAPM	CARHART	FF3	IFF3
RMSE	2.300%	2.301%	2.314%	2.327%	2.350%	2.365%	2.387%	2.387%	2.390%	2.408%
RANK	1	2	3	4	5	6	7	7	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) using positive returns forecast constraint for the period: January 2005-December 2007, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \epsilon \tag{A.4.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \epsilon \tag{A.4.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \epsilon \tag{A.4.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \epsilon \tag{A.4.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \epsilon \tag{A.4.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(r_{SSMI\ exc}) + \beta_3(r_{N225\ exc}) + \beta_4(r_{FTSE\ exc}) + \epsilon \tag{A.4.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.4.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.4.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \beta_4(r_{SSMI\ exc}) + \beta_5(r_{N225\ exc}) + \beta_6(r_{FTSE\ exc}) + \epsilon \tag{A.4.9}$$

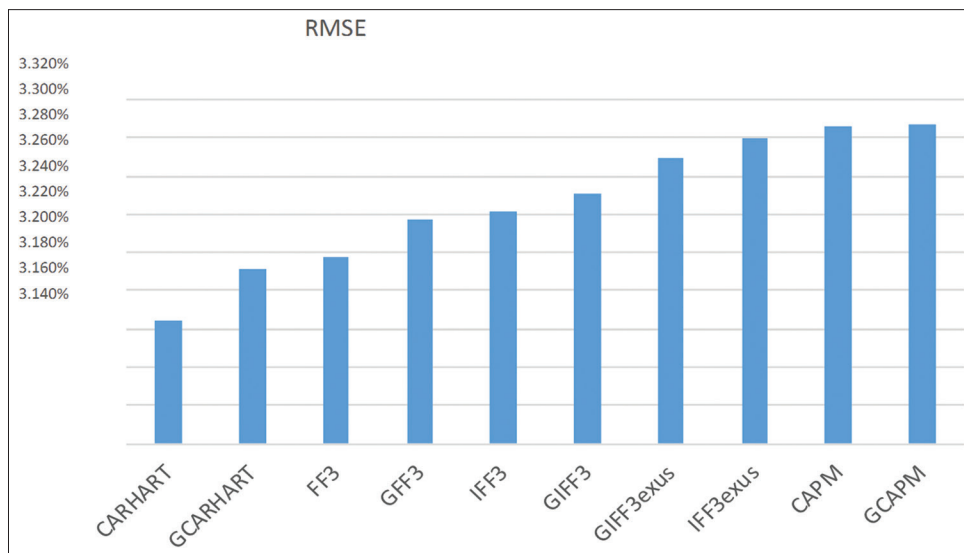
$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \beta_5(r_{SSMI\ exc}) + \beta_6(r_{N225\ exc}) + \beta_7(r_{FTSE\ exc}) + \epsilon \tag{A.4.10}$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{SSMI\ exc}$  is the excess return on Swiss index,  $r_{N225\ exc}$  is the excess return on Japanese index, and  $r_{FTSE\ exc}$  is the excess return on UK index.

Appendix B.1: Value Stocks Results: Forecasting Strength assessment using RMSE for the period June 2012-May 2015



	CARHART	GCARHART	FF3	GFF3	IFF3	GIFF3	GIFF3exus	IFF3exus	CAPM	GCAPM
RMSE	3.205%	3.231%	3.237%	3.258%	3.262%	3.271%	3.290%	3.299%	3.306%	3.307%
RANK	1	2	3	4	5	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for the period: June 2012-May 2015, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta^*(r_m - r_{rf}) + \epsilon \tag{B.1.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \epsilon \tag{B.1.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \epsilon \tag{B.1.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHMLexus}) + \beta_3^*(\text{ISMBexus}) + \epsilon \tag{B.1.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \epsilon \tag{B.1.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(r_{\text{SSMI exc}}) + \beta_3^*(r_{\text{STI exc}}) + \beta_4^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.1.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.1.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.1.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHMLexus}) + \beta_3^*(\text{ISMBexus}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.1.9}$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \beta_5^*(r_{\text{SSMI exc}}) + \beta_6^*(r_{\text{STI exc}}) + \beta_7^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.1.10}$$

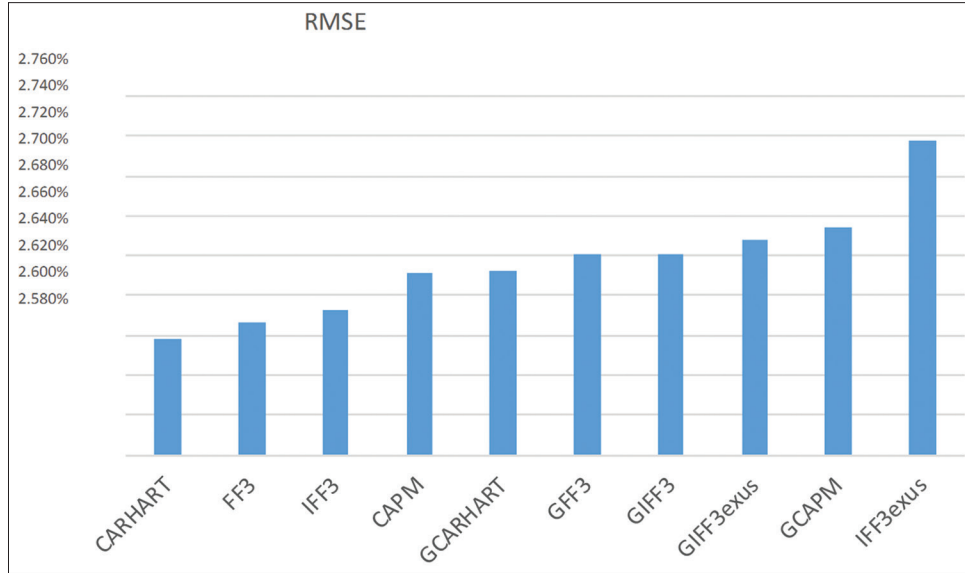
Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{\text{SSMI exc}}$  is the excess return on Swiss index,  $r_{\text{STI exc}}$  is the excess return on Singapore index, and  $r_{\text{FTSE exc}}$  is the excess return on UK index.



Appendix B.2: Value Stocks Results: Forecasting Strength assessment using RMSE obtained using positive returns forecast constraint for the period June 2012-May 2015



	CARHART	FF3	IFF3	CAPM	GCARHART	GFF3	GIFF3	GIFF3exus	GCAPM	IFF3exus
RMSE	2.638%	2.647%	2.653%	2.672%	2.672%	2.680%	2.681%	2.688%	2.694%	2.738%
RANK	1	2	3	4	4	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) using positive returns forecast constraint for the period: June 2012-May 2015, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \epsilon \tag{B.2.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \epsilon \tag{B.2.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \epsilon \tag{B.2.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \epsilon \tag{B.2.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \epsilon \tag{B.2.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(r_{\text{SSMI exc}}) + \beta_3(r_{\text{STI exc}}) + \beta_4(r_{\text{FTSE exc}}) + \epsilon \tag{B.2.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(r_{\text{SSMI exc}}) + \beta_5(r_{\text{STI exc}}) + \beta_6(r_{\text{FTSE exc}}) + \epsilon \tag{B.2.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHML}) + \beta_3(\text{ISMB}) + \beta_4(r_{\text{SSMI exc}}) + \beta_5(r_{\text{STI exc}}) + \beta_6(r_{\text{FTSE exc}}) + \epsilon \tag{B.2.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{IHMLexus}) + \beta_3(\text{ISMBexus}) + \beta_4(r_{\text{SSMI exc}}) + \beta_5(r_{\text{STI exc}}) + \beta_6(r_{\text{FTSE exc}}) + \epsilon \tag{B.2.9}$$

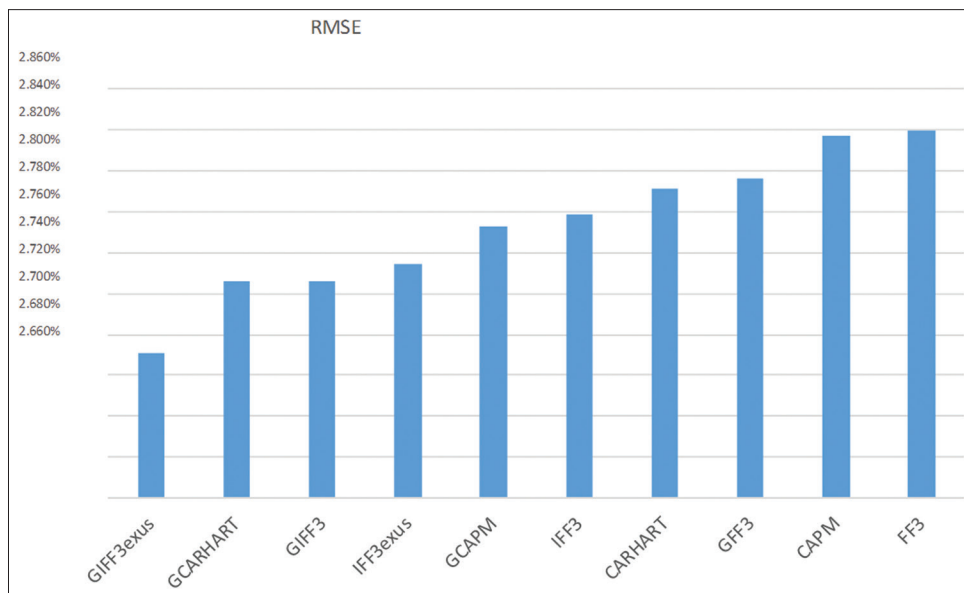
$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1(r_m - r_{rf}) + \beta_2(\text{HML}) + \beta_3(\text{SMB}) + \beta_4(\text{WML}) + \beta_5(r_{\text{SSMI exc}}) + \beta_6(r_{\text{STI exc}}) + \beta_7(r_{\text{FTSE exc}}) + \epsilon \tag{B.2.10}$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix "G" in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{\text{SSMI exc}}$  is the excess return on Swiss index,  $r_{\text{STI exc}}$  is the excess return on Singapore index, and  $r_{\text{FTSE exc}}$  is the excess return on UK index.

Appendix B.3: Value stocks results: Forecasting strength assessment using RMSE for the period January 2005-December 2007



	GIFF3exus	GCARHART	GIFF3	IFF3exus	GCAPM	IFF3	CARHART	GFF3	CAPM	FF3
RMSE	2.731%	2.766%	2.766%	2.774%	2.793%	2.799%	2.811%	2.816%	2.837%	2.839%
RANK	1	2	2	4	5	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) for the period: January 2005 — December 2007, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta * (r_m - r_{rf}) + \epsilon \tag{B.3.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{HML}) + \beta_3 * (\text{SMB}) + \epsilon \tag{B.3.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{IHML}) + \beta_3 * (\text{ISMB}) + \epsilon \tag{B.3.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{IHML}_{\text{exus}}) + \beta_3 * (\text{ISMB}_{\text{exus}}) + \epsilon \tag{B.3.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{HML}) + \beta_3 * (\text{SMB}) + \beta_4 * (\text{WML}) + \epsilon \tag{B.3.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (r_{\text{SSMI exc}}) + \beta_3 * (r_{\text{STI exc}}) + \beta_4 * (r_{\text{FTSE exc}}) + \epsilon \tag{B.3.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{HML}) + \beta_3 * (\text{SMB}) + \beta_4 * (r_{\text{SSMI exc}}) + \beta_5 * (r_{\text{STI exc}}) + \beta_6 * (r_{\text{FTSE exc}}) + \epsilon \tag{B.3.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{IHML}) + \beta_3 * (\text{ISMB}) + \beta_4 * (r_{\text{SSMI exc}}) + \beta_5 * (r_{\text{STI exc}}) + \beta_6 * (r_{\text{FTSE exc}}) + \epsilon \tag{B.3.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{IHML}_{\text{exus}}) + \beta_3 * (\text{ISMB}_{\text{exus}}) + \beta_4 * (r_{\text{SSMI exc}}) + \beta_5 * (r_{\text{STI exc}}) + \beta_6 * (r_{\text{FTSE exc}}) + \epsilon \tag{B.3.9}$$

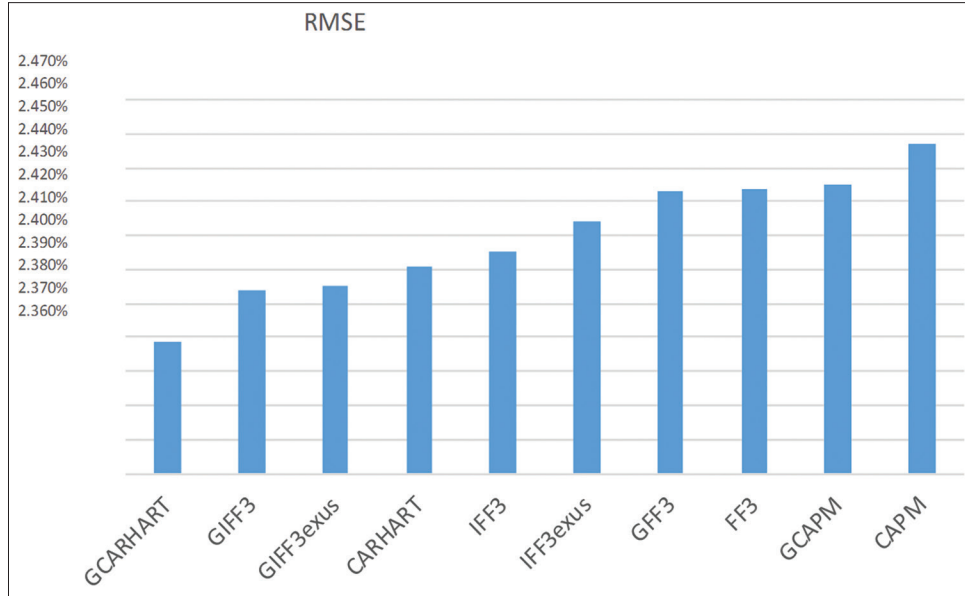
$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1 * (r_m - r_{rf}) + \beta_2 * (\text{HML}) + \beta_3 * (\text{SMB}) + \beta_4 * (\text{WML}) + \beta_5 * (r_{\text{SSMI exc}}) + \beta_6 * (r_{\text{STI exc}}) + \beta_7 * (r_{\text{FTSE exc}}) + \epsilon \tag{B.3.10}$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

Where the prefix “G” in GCAPM signifies it is the global version of CAPM, etc.

Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHML<sub>exus</sub> is the value premium with international stocks excluding US (international high minus low), ISMB<sub>exus</sub> is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{\text{SSMI exc}}$  is the excess return on Swiss index,  $r_{\text{STI exc}}$  is the excess return on Singapore index, and  $r_{\text{FTSE exc}}$  is the excess return on UK index.

Appendix B.4: Value Stocks Results: Forecasting Strength assessment using RMSE obtained using positive returns forecast constraint for the period January 2005-December 2007



	GCARHART	GIFF3	GIFF3exus	CARHART	IFF3	IFF3exus	GFF3	FF3	GCAPM	CAPM
RMSE	2.398%	2.414%	2.415%	2.421%	2.425%	2.434%	2.443%	2.444%	2.445%	2.457%
RANK	1	2	3	4	5	6	7	8	9	10

The results show each of the ten models' out-of-sample RMSE (Root mean square error) using positive returns forecast constraint for the period: January 2005 — December 2007, along with their performance ranking. RMSE is calculated as the square root of Mean Squared Error. The RMSE percentages show the mean deviation in forecasted monthly stock returns for the designated period

$$\text{CAPM: } R - r_{rf} = \alpha + \beta^*(r_m - r_{rf}) + \epsilon \tag{B.4.1}$$

$$\text{FF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \epsilon \tag{B.4.2}$$

$$\text{IFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \epsilon \tag{B.4.3}$$

$$\text{IFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHMLexus}) + \beta_3^*(\text{ISMBexus}) + \epsilon \tag{B.4.4}$$

$$\text{CARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \epsilon \tag{B.4.5}$$

$$\text{GCAPM: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(r_{\text{SSMI exc}}) + \beta_3^*(r_{\text{STI exc}}) + \beta_4^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.4.6}$$

$$\text{GFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.4.7}$$

$$\text{GIFF3: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHML}) + \beta_3^*(\text{ISMB}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.4.8}$$

$$\text{GIFF3exus: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{IHMLexus}) + \beta_3^*(\text{ISMBexus}) + \beta_4^*(r_{\text{SSMI exc}}) + \beta_5^*(r_{\text{STI exc}}) + \beta_6^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.4.9}$$

$$\text{GCARHART 4: } R - r_{rf} = \alpha + \beta_1^*(r_m - r_{rf}) + \beta_2^*(\text{HML}) + \beta_3^*(\text{SMB}) + \beta_4^*(\text{WML}) + \beta_5^*(r_{\text{SSMI exc}}) + \beta_6^*(r_{\text{STI exc}}) + \beta_7^*(r_{\text{FTSE exc}}) + \epsilon \tag{B.4.10}$$

Where CAPM = Capital asset pricing model, FF3 = Fama-French 3-factor model, IFF3 = Fama-French 3-factor model using international factors, IFF3exus = Fama-French 3-factor model using international factors excluding US, and Carhart4 = Carhart's 4-factor model.

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Where R is the realized rate of return on the fund,  $r_{rf}$  is the risk-free rate (3-month T-bill rate),  $r_m$  is the market return on S&P500 index, HML is the value premium (high minus low), SMB is the size premium (small minus big), IHML is the value premium within international stocks (international high minus low), ISMB is the international stocks size premium (small minus big), IHMLexus is the value premium with international stocks excluding US (international high minus low), ISMBexus is the international stocks size premium excluding US (small minus big), and WML is the momentum factor (winners minus losers),  $r_{\text{SSMI exc}}$  is the excess return on Swiss index,  $r_{\text{STI exc}}$  is the excess return on Singapore index, and  $r_{\text{FTSE exc}}$  is the excess return on UK index.