In Search of the Economic Meaning and Role of the Fama-French Factors in Japan: Implications for Investment Management

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Abstract: This paper explores and clarifies the economic meaning and role of Fama and French's (FF) size return premia, small-minus-big (SMB) factor, and value premia, high-minus-low (HML) factor, in Japan. In contrast to FF's suggestion, our analysis reveals that SMB but not HML has meaning as a proxy for distress risk. Moreover, by using a multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, our analysis confirms that both SMB and HML are well-priced state variables in Merton's Intertemporal Capital Asset Pricing Model (ICAPM). Furthermore, even after controlling for macroeconomic variables, when adjusting the lag orders we find that both lagged HML and SMB demonstrate clear predictability for future real GDP growth. Hence, we empirically support FF's argument that HML and SMB are state variables that predict future changes in the investment opportunity set in the context of Merton's ICAPM. This finding has the practical implication that SMB and HML can be used for predicting the future investment environment. As an ancillary finding, we also conclude that lagged credit and term spread are strongly priced factors in the ICAPM in Japan. One implication for investment management is that bearing the risks included in the credit spread and the term spread is rewarded with future return in the Japanese stock market.

Keywords: Asset pricing, distress risk, Fama-French factors, ICAPM, multivariate GARCH model.

I. INTRODUCTION

The Fama-French (FF) [1-4] model is a well-known model that has achieved much empirical success. However, what is the economic meaning and role of the FF model's small-minus-big (SMB) and high-minus-low (HML) factors?[1] Regarding this matter, the first argument is that "*FF (1993) interpret the average HML returns as a premium for a state-variable risk related to relative distress (FF (1996, p.77))*". Namely, they suggest that the economic meaning of HML is as a proxy for distress risk. Then what economic meaning does SMB have? As far as the authors are aware, comprehensive research on this issue has not yet been undertaken.

The second argument is that the FF model's three factors are the state variables in Merton's [5] Intertemporal Capital Asset Pricing Model (ICAPM) as "... *asset pricing is rational and conforms to a three-factor ICAPM or APT (FF (1996, p.75))*".[2]

Subsequent to FF [1-3], several interesting studies, including Liew and Vassalou [14] and Petkova [15], have investigated the role of the SMB and HML factors.[3] Petkova [15] also interpreted the economic meaning of HML as a distress factor. However, we consider that the economic meaning and role of HML and SMB have not yet been fully clarified, and more detailed research and deeper interpretation are needed for the following reasons. First, it is not clear whether HML is really a proxy for distress risk. If HML is a proxy for distress risk, from the viewpoint of the business cycle, it should be strongly related to a measure of default risk in the form of the credit spread. However, such a relation is not seen in Japan. Moreover, as already mentioned, the economic meaning of SMB is also unclear in the existing literature. Second, Liew and Vassalou [14] examined the role of SMB and HML in the context of Merton's ICAPM, and their analysis included Japan. However, their results concerning Japan were statistically unclear. As detailed in a later section, we consider that this is because they did not flexibly take the variables' lead-lag

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[1] SMB and HML are well-known factors in the field of investment management. SMB is a factor that captures the observed return premia of small market capitalization stocks over large market capitalization stocks. HML is a factor that captures the observed return premia of high market-to-book ratio stocks over low market-to-book ratio stocks. Put differently, SMB is the return premia from the size effect, and HML is the return premia from the value effect. In the area of investment management, the size effect and value effect are widely known, and thus analyzing the meaning or role of the SMB and the HML is a generally and widely interesting topic, not only for investment managers, but also for those engaging in corporate management.

[2] Other explanations for the success of the HML and SMB factors also exist. To start with, there are data snooping and other biases in the data (Lo and MacKinlay [6], Kothari *et al*. [7], Berk *et al*. [8], Gomes *et al*. [9], and Ferson *et al*. [10]). Next, Lakonishok *et al*. [11] argue that the book-to-market effect arises because investors overvalue companies that have performed well in the past. Lastly, Daniel and Titman [12] and Daniel *et al*. [13] suggest that stock characteristics, rather than risk, are priced in the cross-section of average returns.

[3] Petkova [15] found that SMB and HML are correlated with innovations in variables that describe investment opportunities in the context of Merton's ICAPM. Liew and Vassalou [14] consider that GDP growth is representative of the investment opportunities in Merton's ICAPM, and that HML and SMB are linked to future GDP growth in 10 major countries.

1874-9488/10 2010 Bentham Open

relations into account. In addition, Petkova [15] mainly investigated the variables' contemporaneous relations.

Therefore, based on our introductory review of the existing literature, the objective of this paper is to explore and clarify the economic meaning and role of SMB and HML from the viewpoint of both business cycles and the ICAPM framework in Japan. In our empirical analysis, we attempt to carefully analyze the lead-lag relationships of the variables. By carefully considering lead-lag relations, this paper aims to derive new evidence on the economic meaning and role of SMB and HML from a different viewpoint to existing studies in this area.[4] We also attempt to consider the implications for practical investment management from the evidence derived.

The contribution of the paper is as follows. First, we reveal that the economic meaning of HML is not as a proxy for distress risk. Rather, SMB plays this role in Japan. This is a different result from that in FF [1-4], Petkova [15], and Chen and Zhang [26]. Second, we find a negative lead-lag relation between HML and the term spread in Japan, and this is inconsistent with the suggestions of Cornell [27] and Campbell and Vuolteenaho [28] that growth stocks are high-duration assets. Third, we confirm the time varying covariances of SMB and HML, as derived from the multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model,[5] are well priced in the conditional ICAPM in Japan. Therefore, we consider that both SMB and HML are the state variables in Merton's ICAPM, as suggested by FF [1; 2; 3]. Solving this with our innovative multivariate GARCH-ICAPM approach is generally new. Fourth, we find that even after controlling for macroeconomic variables, when we adjust the lag orders, all lagged HML and SMB demonstrate clear predictability for future real GDP growth in Japan. This is also a different finding from the less clear evidence in Liew and Vassalou [14]. Hence, we again, and more strongly than the preceding studies, empirically support Fama and French's argument that HML and SMB are state variables that predict future changes in the investment opportunity set in the context of Merton's ICAPM.

Apart from these findings, we find new related evidence. First, we reveal that real GDP growth and the credit spread have strong lead and lag negative relationships, while the term spread has almost no forecasting power for future GDP in Japan. Thus, the credit spread more clearly represents business cycles than the term spread in Japan. Second, we find that the two-quarter lagged credit spread and the two-quarter lagged term spread are generally well priced in 25 portfolios formed based on size, book-equity to market-equity (BE/ME), and size and BE/ME in Japan. Hence, lagged credit and term spread are other important factors in the ICAPM in Japan.

The remainder of the paper is organized as follows. Section II provides a detailed discussion, and Section III describes the data. The empirical results and their interpretation are in Sections IV through VII. Section VIII presents some conclusions.

II. DISCUSSION

Before undertaking the empirical analysis, we discuss the economic characteristics and role of SMB and HML in the following FF [1-4] model (1):

$$R_{i,t} - R_{f,t} = \alpha_i + b_i(R_{M,t} - R_{f,t}) + s_i SMB_t + h_i HML_t + e_{i,t} \qquad (1)$$

where $R_{M,t}-R_{f,t}$ is the market factor, SMB_t is the small-minus-big factor, and HML_t is the high-minus-low factor. Our arguments are conducted from the viewpoint of business cycles and Merton's ICAPM.

A. Discussion from the Viewpoint of Business Cycles

1. Characteristics of HML

We begin by discussing HML. First, we note that the term spread is not only a business cycle variable but also a proxy for interest rate risk. This viewpoint is also discussed by Cornell [27] and Campbell and Vuolteenaho [28]. Petkova [15, p.591] posited "*The argument is that growth stocks are high-duration assets, which makes them similar to long-term bonds and more sensitive to innovations in the long end of the term structure.*"

In accordance with this argument, growth (low BE/ME) stocks are more sensitive to changes in the slope of the yield curve. Hence, when the term spread expands because of an increase in interest rate risk, the returns of growth (low BE/ME) stocks decrease more than those of value (high BE/ME) stocks, and HML increases. Hence, from this perspective, we expect a positive intertemporal relation between HML and the term spread.

There is yet another argument. As evidenced by Estrella and Hardouvelis [42], for example, it is well known that term spread values are high before economic expansions and low before recessions. In relation to this, Petkova [15] suggested that because value (high BE/ME) stocks are riskier than growth (low BE/ME) stocks in bad times and less risky during good times (Petkova and Zhang [43]), HML and term spread would be related.

In light of this argument, when considering the case of bad times, after the term spread shrinks, the returns of riskier value (high BE/ME) stocks decline more than those of growth (low BE/ME) stocks, and HML decreases. The above account again suggests a positive intertemporal relation between HML and the term spread.

However, by focusing on good times, we can consider the alternative. Namely, in good times, the term spread expands, and given the risk-return trade-off, the returns of less risky value (high BE/ME) stocks increase less than growth (low BE/ME) stocks, and HML decreases. According to this account, we expect a negative intertemporal relation between HML and the term spread.

[4] In addition to the above-mentioned studies, recent researches using HML and SMB include Busse *et al*. [16], George and Hwang [17], Lewellen *et al*. [18], Asparouhova *et al*. [19], Jiang [20], Li *et al*. [21], Ozoguz [22], Chava and Purnanandam [23], Huang *et al*. [24], and Campbell *et al*. [25]. However, their research aims are different from ours.

[5] The multivariate GARCH model is crucially important for ICAPM pricing tests because by using this model, the degree of pricing of the time-varying covariances can be directly tested. Bollerslev *et al*. [29] undertook one of the first multivariate tests of CAPM. Other studies that use the multivariate GARCH model in asset pricing include Chan *et al*. [30], Braun *et al*. [31], Kroner and Ng [32], Scruggs [33], and Bali [34]. In addition, many studies on the variation in financial asset prices using univariate GARCH models exist, including Engle [35], Bollerslev [36], French *et al*. [37], Nelson [38], Campbell and Hentchel [39], Glosten *et al*. [40], and Lundblad [41], among others.

Taking all of the above discussion into account, in real-world markets, either a positive or negative relation between HML and the term spread may be observed. Alternatively, if the various effects cancel each other out, we can also predict little relation between HML and the term spread. Therefore, it is meaningful to inspect the relation between HML and the term spread using real data, and this is considered to be an important empirical task.

2. Characteristics of SMB

Next, we move to the discussion of SMB. Petkova [15, p.591] explained *"Chan and Chen (1991) have argued that small firms examined in the literature tend to be marginal firms, that is, they generally have lost market value because of poor performance, they are likely to have high financial leverage and cash flow problems, and they are less likely to survive poor economic conditions."* In accordance with this argument, it appears reasonable to assume that small firms will be more sensitive to the business cycle. Hence, we can predict a significant relation between SMB and the term spread. We note here that we should consider the possibility that credit spread is more strongly related to the business cycle than the term spread, and a relation between SMB and the credit spread is found. Furthermore, as discussed earlier, FF [3] provided an interpretation of HML as a measure of distress risk. From this viewpoint, because credit spread is considered to be a measure of default risk in general, a negative relation between HML and the credit spread should be found. However, noting the explanation by Chan and Chen [44], as small stocks have problems with high leverage and cash flow uncertainty, it appears reasonable to consider that SMB is a proxy for distress risk.

B. Discussion of the ICAPM Framework

Regarding the economic role of SMB and HML, FF [2, p.57] suggested that *"…the empirical successes of the Fama-French model suggest that it is an equilibrium pricing model, a three-factor version of Merton's (1973) intertemporal capital asset pricing model (ICAPM) or Ross's (1976) arbitrage pricing theory (APT). In this view, SMB and HML mimic combinations of two underlying risk factors or state variables of special hedging concern to investors".* Subsequent to FF [2], Petkova [15] found that SMB and HML are correlated with innovations in variables that describe investment opportunities in the context of Merton's ICAPM. Also, Liew and Vassalou [14] considered that GDP growth is representative of the investment opportunities in Merton's ICAPM and found that HML and SMB are linked to future GDP growth in 10 major countries. That is to say, both studies tested whether SMB and HML are related to variables that describe investment opportunities in Merton's ICAPM, and this is the first testing methodology in the context of ICAPM.

In terms of asset pricing, Cochrane [45] expressed Merton's ICAPM as:

$$\begin{aligned} E_t(R_{i,t+1}) - R_{f,t} &\approx rra_t Cov_t(R_{i,t+1}, \Delta W_{t+1}/W_t) \\ &\quad + \lambda_{zt} Cov_t(R_{i,t+1}, \Delta z_{t+1}), \end{aligned} \tag{2}$$

where $E_t(R_{i,t+1})$ is the conditional expected return of asset i, $R_{f,t}$ is the risk-free rate, rra_t is the relative risk aversion coefficient, $Cov_t(R_{i,t+1}, \Delta W_{t+1}/W_t)$ is the conditional covariance between the return of asset i and the change in wealth (or return on the market portfolio), $Cov_t(R_{i,t+1}, \Delta z_{t+1})$ is the conditional covariance between the return of asset i and the change in state variable z, and λ_{zt} is the risk price for the state variable. Thus, by testing the pricing degrees of the state variables in model (2), we can directly investigate whether they are the state variables in Merton's ICAPM. This is the second, direct, and generally new, testing methodology for ICAPM.

C. Two Research Questions

Based on the above arguments, we have the following focus that differs from other work in this area. First, there is the clarification of the economic meaning of SMB and HML. In particular, we aim to reveal whether HML is a proxy for distress risk in Japan as FF [3] suggest. We consider that this will be clarified by detailed investigation of the lead-lag relationships between SMB, HML, and the credit and term spread.

Second, there is the question in Japan whether HML and SMB are really the state variables in Merton's ICAPM. More specifically, this includes the following two subtopics. First, we are interested in the pricing difference between HML, SMB, (lagged) credit spread, and (lagged) term spread in the ICAPM. Because the economic characteristics of these four variables are controversial, the pricing degree of these variables in the ICAPM is a meaningful test.[6]

For the second subtopic, although Liew and Vassalou [14] included Japan in their analysis, their evidence concerning the predictability of HML and SMB for real GDP growth in Japan was not clear.[7] Therefore, by more precisely considering the lead-lag relation between real GDP growth and SMB and HML, we can more carefully test the predictability of SMB and HML for future real GDP growth in Japan. If the clearer forecastability of SMB and HML is not obtained, we cannot consider that SMB and HML are related to variables that describe investment opportunities in Merton's ICAPM, at least in Japan. The above focus points are the two research questions derived in our detailed discussion.

III. DATA

Quarterly data are used in this paper, and the full sample period is from the fourth quarter of 1981 to the first quarter of 2004. Because of the limits of data availability, this is the longest period we can analyze for Japan.[8] We use three categories of data. The first is macroeconomic data, the second is data on the three factors in the FF model, and the third is return data on portfolios formed based on size, BE/ME, and size and BE/ME. More specifically, our quarterly macroeconomic data are DEF: the credit spread (Fama and French [46]), TERM: the term spread (Campbell [47]), RF: the risk-free rate (Fama and Schwert [48]), DY: the dividend yield (Campbell and Shiller [49]), IDP: the growth rate of seasonally adjusted industrial production

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[6] This differs from the focus in Petkova [15] on 'innovations' in variables that describe investment opportunity.

[7] Tables 5, 6, 7, 8, and 9 in Liew and Vassalou [14] displayed statistically insignificant predictability for SMB and HML in Japan.

[8] Because we use many kinds of data, it is difficult to extend the period analyzed. It would then be interesting to reexamine our analysis, say, in 10 years, when the sample period can be extended.

(Chen *et al*. [50]), EX: the US-Yen exchange rate (Hamao [51]), and GDP: the growth rate of real Gross Domestic Product (Liew and Vassalou [14]).

We now explain the data sources and details of the macroeconomic factors. First, DEF is the default spread between the yields of the long-term Nikkei Bond Index (from Nikkei, Inc.) and 10-year government bonds (from the Bank of Japan). Second, the risk-free rate, RF, is the gensaki rate (from the Japan Securities Dealers Association) from the fourth quarter of 1981 to the second quarter of 1984 and the one-month median rate on negotiable time certificates of deposit (CD) (from the Bank of Japan) from the third quarter of 1984 to the first quarter of 2004.[9] Third, TERM is the term spread between the yields of the Japanese 10-year government bond (from the Bank of Japan) and the risk-free rate, RF. Fourth, DY is the dividend yield of the Tokyo Stock Exchange (TSE) First Section (from the TSE). Fifth, IDP is the growth rate of seasonally adjusted industrial production (from the Ministry of Economy, Trade, and Industry). Sixth, EX is the US-Yen (dollar/yen) exchange rate (from the Bank of Japan). Finally, GDP is the growth rate of seasonally adjusted Gross Domestic Product (from the Cabinet Office, Government of Japan).

Next, the quarterly FF factor return data are MKT: the excess market factor return of the FF model, SMB: the SMB factor return of the FF model, and HML: the HML factor return of the FF model.

Finally, the quarterly portfolio return data are (1) the returns of 25 portfolios formed based on size, (2) the returns of 25 portfolios formed based on BE/ME, and (3) the returns of 25 portfolios formed based on size and BE/ME. We follow FF [1, 3] in construction of all three sets of portfolios. The returns on all three sets of portfolios are denoted $r_{i,t}$, and the return of market portfolio is denoted $r_{m,t}$.

IV. LEAD-LAG RELATIONSHIPS OF FACTOR RETURNS AND THE MACROECONOMY

A. Univariate Quarterly Regressions

First, from the viewpoint of business cycles, and to consider the lead-lag relationships between MKT, SMB, HML, GDP, DEF, and TERM, we specify the following regressions on a quarterly basis:

$$DEF_t = \nu + \xi Factor_{t-k} + \eta_t, \qquad (3)$$

$$Factor_t = \nu + \xi DEF_{t-k} + \eta_t, \qquad (4)$$

$$TERM_t = \nu + \xi Factor_{t-k} + \eta_t, \qquad (5)$$

$$Factor_t = \nu + \xi TERM_{t-k} + \eta_t, \qquad (6)$$

where k=0 to 8, and 'Factor' in equations (3) to (6) includes MKT, SMB, HML, and GDP.

The results are displayed in Table **1**. First, Panel A of Table **1** shows the relations among these variables by focusing on the credit spread, DEF. Using Panel A, we can see that (1) real GDP growth and the credit spread have strong negative lead and lag relationships, and (2) the lagged credit spread has forecasting power for future SMB.

Panel B in Table **1** displays the relation among these variables by focusing on the term spread, TERM. Panel B shows that: (1) lagged real GDP growth has a negative relation with the future term spread, while the term spread has almost no forecasting power for future GDP growth, and (2) the few-quarter lagged HML has a negative relation with the future term spread.

Interpreting the above results indicates a strong negative lead-lag relation between DEF and GDP, implying that credit spread is a clear business cycle variable in Japan. However, we also note no statistically significant relation between lagged TERM and GDP, indicating no forecastability of the term spread for future GDP growth in Japan. This contrasts with US evidence where the term spread forecasts future GDP growth. (See Estrella and Hardouvelis [42], among others.) As a consequence, we consider that (1) the credit spread, but not the term spread, is strongly related to business cycles in Japan.

Next, (2) the negative lead-lag relation between HML and TERM is inconsistent with the hypothesis of Cornell [27] and Campbell and Vuolteenaho [28] that growth stocks are high-duration assets. Instead, (3) the negative relation is consistent with the higher performance of growth stocks than value stocks in an economic expansion, as discussed earlier.

Finally, and more importantly for our research question, (4) the negative lead-lag relation between SMB and DEF in Table **1** is consistent with the hypothesis that SMB is a proxy for distress risk. In contrast, (5) the weak lead-lag relation between HML and DEF in Table **1** questions whether HML is a proxy for distress risk in Japan.

B. Impulse Response Analysis

Next, to check further whether HML is a proxy for distress risk in Japan, we investigate the variables' relations by especially focusing on the responses of SMB and HML to the default spread. More concretely, after estimating VAR models, we depict the impulse responses of the HML and SMB to DEF in Fig. (**1**). Drawing the response functions is beneficial because we can clarify the direction of the effects to SMB and HML from DEF. Panel A shows that the response of SMB to a one standard deviation shock to the innovation of DEF is almost negative with a certain magnitude. In Panel B, however, we cannot find whether the response of HML to a one standard deviation shock to the innovation of DEF is positive or negative.

In sum, from our impulse response analysis, in Japan, the response of SMB to shocks to the credit spread is clearly negative. This means that SMB return drops after an increase in the credit risk. This is again interpreted as showing that SMB but not HML is a proxy for distress risk in Japan.

V. TIME-VARYING RELATIONS BETWEEN HML, SMB, CREDIT SPREAD, AND TERM SPREAD

Based on the basic analysis in the previous section, this section explores the time-varying intertemporal relationships between HML, SMB, the credit spread, and the term spread

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[9] This is because before June 1984, one-month CD rates are not available. Thus, following Hamao [51], we specified the gensaki rate as the risk-free rate until the second quarter of 1984.

using a multivariate GARCH model.[10] To understand more precisely the lead-lag relations of the variables and to reveal the economic meaning of SMB and HML, it is beneficial to analyze the time-varying comovements using modern econometrical techniques. This methodological aspect of this paper is also novel and different from that employed in existing work.

To evaluate the time-varying intertemporal comovements, we employ the following multivariate BEKK GARCH model (Engle and Kroner [52], Kroner and Ng [32]). The BEKK model ensures that the **H** matrix is always positive definite, and is specified by:

$$\mathbf{H}_t = \mathbf{W} + \mathbf{B}'\mathbf{H}_{t-1}\mathbf{B} + \mathbf{A}'\Xi_{t-1}\Xi'_{t-1}\mathbf{A}, \quad (7)$$

where **W**, **A**, and **B** are 2×2 matrices of parameters, and **W** is assumed to be symmetric and positive definite.

Regarding the estimation of model (7), the parameters can be estimated by maximizing the log-likelihood function:

$$l(\vartheta) = -\frac{TN}{2}\log 2\pi - \frac{1}{2}\sum_{t=1}^{T}(\log|\mathbf{H}_t| + \Xi'_t\mathbf{H}_t^{-1}\Xi_t), \quad (8)$$

where θ denotes all of the unknown parameters to be estimated, N is the number of assets, T is the number of observations, and $\mathbf{H_t}$ and $\mathbf{\Xi_t}$ are as previously defined.

A. Time-Varying Cross-Correlations Between HML, SMB, Credit Spread, and Term Spread

First, we derive the cross-correlations by using the multivariate GARCH model (7), and display the average values of the time-varying correlation coefficients in Table **2**. The absolute values of the correlation coefficients larger than 0.2 are in bold.

Panel A, which shows the intertemporal relation between the credit spread and SMB or HML, indicates that (1) negative time-varying cross-correlation is found between SMB and the credit spread; however, (2) unclear time-varying cross-correlation is seen between the credit spread and HML. This again provides support that SMB is a proxy for distress risk in Japan. Panel B, which displays the intertemporal relation between the term spread and SMB or HML, indicates that (1) SMB can be forecast by the lagged term spread with a negative relation, and (2) HML can be predicted by the lagged term spread with a negative relation. This negative intertemporal relation between TERM and HML again lies against the high-duration assets hypothesis of growth stocks by Cornell [27] and Campbell and Vuolteenaho [28], and the result is consistent with the account that growth stocks perform better than value stocks in economic expansions. Furthermore, the above results suggest the usefulness of the lagged credit and term spread in obtaining SMB and HML returns when we take time-varying variable relations into account.

Focusing on the forecastability of SMB and HML using the lagged credit or term spread, in Fig. (**2**), we depict the time-varying cross-correlation coefficients whose values are largest in the lower sections of Panels A and B in Table **2**. In Fig. (**2**). Panel A displays the time-varying cross-correlation coefficients between the credit spread and the six-quarter lead series of SMB; Panel B shows the time-varying cross-correlation coefficients between the credit spread and the two-quarter lead series of HML; Panel C exhibits those between the term spread and the one-quarter lead series of SMB; Panel D displays those between the term spread and the two-quarter lead series of HML.

As shown in Fig. (**2**), with the exception of Panel B (where the correlation dynamics are almost negative but the absolute values are relatively small), the intertemporal relations in Panels A, C, and D move while retaining relatively high negative time-varying relations. Therefore, we graphically confirm the predictability of SMB using the lagged credit and term spread, and the forecastability of HML using the lagged term spread.

VI. THE PRICING OF LAGGED CREDIT AND TERM SPREAD

By taking time-varying variable relations into account, we have obtained the implication that by using the lagged credit and term spreads, we can acquire future returns relating to size and BE/ME. Hence, while taking this implication into consideration, in this section, we move to our second research question; namely, clarifying whether SMB and HML are priced state variables in ICAPM in Japan.

More specifically, we compute not only the time-varying covariances between HML or SMB and the returns of 25 portfolios formed on size, BE/ME, and size and BE/ME but also the time-varying covariances between the lagged credit or term spread and the returns of 25 portfolios formed on size, BE/ME, and size and BE/ME. We use six-quarter lagged credit spread, two-quarter lagged credit spread, one-quarter lagged term spread, and two-quarter lagged term spread, because these four variables show the highest correlations in the lower sections of Panels A and B in Table **2**. After deriving the time-varying covariances, again using the multivariate GARCH model (7), we examine the pricing of SMB and HML by comparing them with the pricing of the lagged credit and term spread covariance risks in the ICAPM.

A. Pricing Testing Framework

More specifically, following Cochrane [45], we perform tests using the following conditional version of the ICAPM:

$$E[(r_{i,t} - r_{f,t}) \mid \Omega_{t-1}] = \delta_t Cov[r_{i,t}, r_{m,t} \mid \Omega_{t-1}] + \sum_{j=1}^{k} \lambda_{z_{j,t-l},t} Cov[r_{i,t}, z_{j,t-l} \mid \Omega_{t-1}], \quad (9)$$

where $r_{i,t}$ is portfolio i's return, $r_{f,t}$ is the risk-free rate (the same as RF in the data section), δ_t is the price of market risk, $Cov\ [r_{i,t}, r_{m,t}\ |\Omega_{t-1}]$ is the time-varying conditional covariance between portfolio i's return and the market portfolio return: $r_{m,t}$. Furthermore, $Cov[r_{i,t}, z_{j,t-l}|\Omega_{t-1}]$ denotes the time-varying conditional covariance between portfolio i's return and

[10] As argued in an excellent survey by Bauwens *et al*. [53], the multivariate GARCH model is crucially important in the context of asset pricing because it is useful for inspecting the time-varying comovements of asset prices. (See Lundblad [41] and Bali [34], among others.) There are several versions of the multivariate GARCH models, however, where there is no established consensus as to the best model to be used in the area of asset pricing.

SMB, HML, the l lagged term or credit spread: $z_{j,t-l}$, and $\lambda_{z_{j,t-l},t}$ is the price of the covariance risk, $Cov\ [r_{i,t}, z_{j,t-l}\,|\Omega_{t-1}]$.[11]

In this paper, we assume that the prices of the covariance risks δ_t and $\lambda_{z_{j,t-l},t}$ are time varying. In addition, as $z_{j,t-l}$ in equation (9), other than the nonlagged SMB and HML, mentioned above, we use the six-quarter lagged credit spread, two-quarter lagged credit spread, one-quarter lagged term spread, and two-quarter lagged term spread.

Using the time-varying conditional covariances, $Cov\ [r_{i,t}, r_{m,t}\,|\Omega_{t-1}]$ and $Cov\ [r_{i,t}, z_{j,t-l}\,|\Omega_{t-1}]$, and by taking both cross-sectional and time-series aspects into account, we undertake panel data analysis. By pooling the monthly data on the 25 size portfolios, 25 BE/ME portfolios, and 25 size-BE/ME portfolios, we conduct a balanced panel data analysis.[12]

B. The Pricing of the Lagged Credit and Term Spread

To specify the lagged DEF and TERM that should be compared in ICAPM, we first test the pricing by not including SMB and HML, and display the results of panel data analysis in Table **3**. This table exhibits the results of four kinds of tests for the three types of portfolios: Test 1 shows the pricing results of market risk only, Test 2 exhibits the pricing results of market risk and the lagged credit spread, Test 3 displays the results of market risk and the lagged term spread, and Test 4 shows the results of all three kinds of covariance risks.

The results in order are as follows. First, Panel A, which displays the results of the 25 portfolios formed based on size, indicates that market risk is always statistically significantly priced at the 1% level in Tests 1 to 4. However, neither the lagged term nor credit spread (TERM (-1) nor DEF (-6)) is priced. Second, Panel B, which exhibits the results of the 25 portfolios formed based on BE/ME, also shows that market risk is always significantly positively priced at the 1% level as is the two-quarter lagged credit spread, DEF (-2), at the 1 % level in Tests 2 and 4. Third, Panel C, which displays the results of the 25 portfolios formed based on size and BE/ME, demonstrates that market risk is again always strongly positively priced at the 1 % level in Tests 1 to 4, and the lagged credit spread, DEF (-2), and lagged term spread, TERM (-2), are well priced at the 1% level of significance.

Based on the above tests, we consider that (1) market covariance risk, as derived from the multivariate GARCH model, is very effective in the conditional ICAPM. In addition, we find new evidence that (2) the two-quarter lagged credit spread is strongly priced in both the 25 BE/ME portfolios and the 25 size-BE/ME portfolios, and the two-quarter lagged term spread is also well priced in the 25 portfolios formed based on size and BE/ME in Japan.

C. The Pricing of SMB, HML, Lagged Credit, and Term Spread

This subsection examines the pricing of SMB and HML in ICAPM so as to respond to our second research question. In the test, we compare the pricing degrees of the lagged credit and term spread with those of SMB and HML to check the robustness of the pricing of SMB and HML. The two-quarter lagged credit spread and the two-quarter lagged term spread are tested because both variables are shown to be well priced in Table **3**. The results of our panel data analysis are displayed in Table **4**. As shown, Test 1 shows the pricing results for market risk, SMB, and HML, Test 2 exhibits the pricing results for the three factors and lagged credit spread, Test 3 displays the results for the three factors and lagged term spread, and Test 4 gives the results for all five kinds of covariance risk.

The results in order are as follows. First, Panel A, which displays the results of the 25 portfolios formed based on size, indicates that market risk, SMB, and HML are always statistically significantly priced, at least at the 5% level, in Tests 1 to 4. The lagged term and credit spread, DEF (-2) and TERM (-2), are also well priced at the 1% level of significance. Second, Panel B, which exhibits the results of the 25 portfolios formed based on BE/ME, shows that market risk and HML are always positively significantly priced at the 1% level, and the lagged credit spread, DEF (-2), is well priced at the 1% level in Tests 2 and 4. SMB and the lagged term spread, TERM (-2), are statistically significantly or marginally priced. Third, Panel C, which displays the results of the 25 portfolios formed based on size and BE/ME, shows that market risk and SMB are always strongly positively priced at the 1% level in Tests 1 to 4, and DEF (-2) and TERM (-2) are always well priced at the 1% significant level. As for HML, it is also either statistically significantly priced or weakly priced (at the 10% level of significance, it is also priced in Test 1).

Using the above tests, we consider that (1) market covariance risk, SMB, and HML derived from a multivariate GARCH model are generally effective in the conditional ICAPM. SMB and HML are generally well priced in the ICAPM framework, and this means that both SMB and HML are state variables of ICAPM as suggested by FF [1-3]. Moreover, we show that (2) the two-quarter lagged credit spread and the two-quarter lagged term spread are generally well priced in all three types of portfolios in Japan. This result is robust, even if we include the market factor, SMB, and HML covariances in the conditional ICAPM.

VII. DO HML AND SMB FORECAST FUTURE REAL ECONOMIC GROWTH IN JAPAN?

As discussed earlier, FF [1-3] argue that HML and SMB are state variables that predict future changes in the investment opportunity set in the context of Merton's ICAPM. In addition to the direct ICAPM pricing tests, and so as to address our second research question from a different perspective, this section tests the validity of this argument in Japan using the methodology in Liew and Vassalou [14].

A. Tests Using the Past Four Quarters' Factor Returns

Our first test is performed using Liew and Vassalou's [14] model as follows:

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[11] In the case of SMB and HML, contemporaneous covariances are computed as $Cov\ [r_{i,t}, r_{m,t}\,|\Omega_{t-1}]$, thus $l = 0$ in $Cov\ [r_{i,t}, z_{j,t-l}\,|\Omega_{t-1}]$.

[12] In our tests of covariance risk pricing in the context of the conditional ICAPM, the use of the multivariate GARCH model enables us to implement not only (1) direct tests of the time-varying risk pricing but also (2) a less restrictive test that no assumption is put on the state variables in the model conditioning. In particular, the latter differs from several interesting and influential studies, including Shanken [54], Fersen and Schadt [55], and Lettau and Ludvigson [56]. This is one advantage of the multivariate GARCH methodology used in this paper.

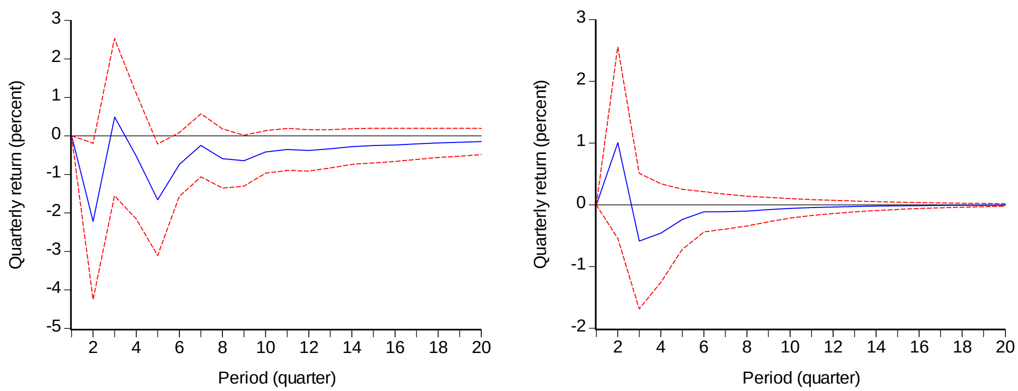
Table 1. Univariate Quarterly Regressions for the Credit Spread, Term Spread, Real GDP Growth, MKT, HML, and SMB Factors: The Case of Japan

Panel A. Regression for the credit spread										
		Regressions by using lagged factors: $DEF_t = \nu + \xi Factor_{t-k} + \eta_t$								
		k=0	*k*=1	*k*=2	*k*=3	*k*=4	*k*=5	*k*=6	*k*=7	*k*=8
MKT	Coef.	-0.003	0.000	-0.003	-0.003	-0.004	-0.003	-0.002	-0.003	-0.008**
	p-value	0.245	0.893	0.120	0.209	0.219	0.295	0.259	0.098	0.002
	Adj.R^2	0.006	-0.011	0.006	0.008	0.012	0.001	-0.003	0.008	0.097
SMB	Coef.	-0.001	-0.003	-0.004	-0.004	-0.005	-0.008	-0.005	-0.005	-0.003
	p-value	0.551	0.192	0.202	0.161	0.081	0.053	0.230	0.160	0.372
	Adj.R^2	-0.010	0.000	0.011	0.008	0.021	0.062	0.023	0.024	0.002
HML	Coef.	0.001	0.000	-0.005	-0.002	0.002	-0.001	-0.003	-0.004	-0.001
	p-value	0.814	0.897	0.122	0.518	0.478	0.827	0.415	0.374	0.830
	Adj.R^2	-0.011	-0.011	0.011	-0.008	-0.007	-0.012	-0.005	-0.003	-0.012
GDP	Coef.	-0.111*	-0.122**	-0.144**	-0.140**	-0.103*	-0.100*	-0.081	-0.060	-0.004
	p-value	0.014	0.005	0.001	0.006	0.017	0.021	0.079	0.127	0.915
	Adj.R^2	0.096	0.118	0.171	0.161	0.082	0.076	0.046	0.021	-0.012
		Regressions by using lagged credit spread: $Factor_t = \nu + \xi DEF_{t-k} + \eta_t$								
		k=0	*k*=1	*k*=2	*k*=3	*k*=4	*k*=5	*k*=6	*k*=7	*k*=8
MKT	Coef.	-5.351	-0.841	1.619	-1.035	0.680	-2.437	-6.219	-3.670	-8.308*
	p-value	0.306	0.859	0.707	0.823	0.885	0.552	0.122	0.455	0.032
	Adj.R^2	0.006	-0.011	-0.010	-0.011	-0.012	-0.009	0.011	-0.004	0.028
SMB	Coef.	-1.415	-8.380*	-4.433	-6.663*	-6.982	-3.718	-6.736*	-3.822	-0.201
	p-value	0.552	0.040	0.246	0.035	0.093	0.210	0.029	0.312	0.944
	Adj.R^2	-0.010	0.046	0.004	0.024	0.027	-0.001	0.025	0.000	-0.012
HML	Coef.	0.625	0.311	-3.114	-4.314	-1.498	-1.547	-2.236	-2.673	-0.810
	p-value	0.807	0.901	0.289	0.273	0.754	0.613	0.574	0.459	0.811
	Adj.R^2	-0.011	-0.011	0.002	0.014	-0.009	-0.009	-0.005	-0.003	-0.012
GDP	Coef.	-0.956**	-1.084**	-0.989**	-1.008**	-0.818*	-0.465	-0.798*	-0.863**	-0.709*
	p-value	0.001	0.000	0.000	0.001	0.011	0.174	0.012	0.005	0.025
	Adj.R^2	0.096	0.126	0.103	0.107	0.066	0.013	0.062	0.074	0.046
Panel B. Regression for the term spread										
		Regressions by using lagged factors: $TERM_t = \nu + \xi Factor_{t-k} + \eta_t$								
		k=0	*k*=1	*k*=2	*k*=3	*k*=4	*k*=5	*k*=6	*k*=7	*k*=8
MKT	Coef.	0.004	0.008	0.011	0.006	0.004	-0.001	-0.004	-0.008	-0.010
	p-value	0.650	0.359	0.311	0.595	0.716	0.939	0.668	0.325	0.177
	Adj.R^2	-0.009	-0.003	0.004	-0.007	-0.010	-0.012	-0.010	-0.004	0.000
SMB	Coef.	-0.018	-0.018	-0.019	-0.020	-0.020	-0.015	-0.021	-0.025*	-0.024*
	p-value	0.062	0.056	0.053	0.074	0.080	0.225	0.081	0.040	0.049
	Adj.R^2	0.019	0.019	0.022	0.025	0.027	0.008	0.028	0.042	0.038
HML	Coef.	-0.015	-0.019	-0.024*	-0.022*	-0.018	-0.009	-0.007	-0.019	-0.015
	p-value	0.083	0.073	0.029	0.020	0.133	0.455	0.535	0.100	0.196
	Adj.R^2	0.002	0.009	0.020	0.017	0.006	-0.008	-0.010	0.008	0.000
GDP	Coef.	-0.356**	-0.427**	-0.428**	-0.517**	-0.545**	-0.496**	-0.566**	-0.576**	-0.593**
	p-value	0.002	0.001	0.002	0.002	0.000	0.001	0.000	0.000	0.000
	Adj.R^2	0.075	0.111	0.112	0.168	0.189	0.154	0.203	0.212	0.226

Table 1. Contd….

		Regressions by using lagged term spread: $Factor_t = \nu + \xi TERM_{t-k} + \eta_t$								
		k=0	*k*=1	*k*=2	*k*=3	*k*=4	*k*=5	*k*=6	*k*=7	*k*=8
MKT	Coef.	0.583	0.435	0.589	0.799	0.202	-0.023	0.090	0.375	0.871
	p-value	0.653	0.785	0.690	0.621	0.899	0.987	0.944	0.760	0.522
	Adj.R^2	-0.009	-0.010	-0.009	-0.007	-0.012	-0.012	-0.012	-0.011	-0.007
SMB	Coef.	-1.713*	-1.564	-1.068	-0.424	-0.299	-0.804	-0.806	-0.609	-0.964
	p-value	0.049	0.132	0.337	0.740	0.804	0.477	0.457	0.562	0.331
	Adj.R^2	0.019	0.014	0.000	-0.010	-0.011	-0.005	-0.005	-0.008	-0.003
HML	Coef.	-0.862	-1.193	-0.912	-0.628	0.053	-0.163	-0.709	-0.427	-0.519
	p-value	0.146	0.057	0.142	0.282	0.925	0.755	0.224	0.393	0.314
	Adj.R^2	0.002	0.014	0.003	-0.005	-0.012	-0.012	-0.003	-0.009	-0.008
GDP	Coef.	-0.239**	-0.158	-0.181	-0.172	-0.147	-0.165	-0.150	-0.151	-0.123
	p-value	0.002	0.052	0.067	0.103	0.210	0.223	0.287	0.309	0.399
	Adj.R^2	0.075	0.026	0.038	0.033	0.021	0.029	0.022	0.023	0.011

Notes: MKT denotes the market factor return calculated using Japanese data and Fama and French [1, 3]. HML denotes the high-minus-low factor return calculated using Japanese data and Fama and French [1,3]. SMB denotes the small-minus-big factor return calculated using Japanese data and Fama and French [1, 3]. Panel A shows the results of the relation between the credit spread: DEF and MKT, HML, SMB factor returns, or real GDP growth: GDP. Panel B displays the results of the relation between the term spread: TERM and MKT, HML, SMB factor returns, or real GDP growth: GDP. The upper section of each panel displays the results of the univariate regressions using the lagged three factor returns or lagged GDP as explanatory variables. The lower section of each panel shows the results of the univariate regressions using the three factor returns or GDP as dependent variables. The sample period is from the fourth quarter of 1981 to the first quarter of 2004. *k* denotes the lag in quarters, and the *p*-values are corrected for heteroskedasticity and serial correlation, using the Newey and West [57] estimator. * denotes statistical significance at the 5% level, ** denotes statistical significance at the 1% level.



Panel A Response of the SMB to the credit spread   Panel B Response of the HML to the credit spread

Fig. (1). Impulse responses of the HML and SMB factors to the credit spread and term spread: The case in Japan.

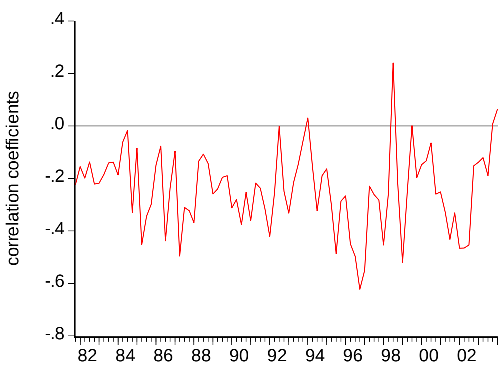
Table 2. Cross-Correlation Coefficients Between HML, SMB, the Credit Spread, and the Term Spread: The case of Japan

Panel A. Average time-varying cross-correlation coefficients between the credit spread via the multivariate GARCH model							
	Lags behind from the credit spread: forecastability for the credit spread by factor returns Lags in quarter						
	0	−1	−2	−3	−4	−5	−6
SMB	-0.02233	-0.16650	**-0.21731**	**-0.24103**	-0.11488	**-0.29697**	-0.15970
HML	0.09482	-0.03571	-0.18236	-0.15829	0.02022	-0.03073	-0.06541
	Leads from the credit spread: forecastability for factor returns by the credit spread Leads in quarter						
	1	2	3	4	5	6	
SMB	-0.16229	-0.12395	-0.14755	**-0.21505**	-0.09356	**-0.24145**	
HML	0.04721	-0.12733	-0.09323	0.03413	-0.05601	-0.09410	

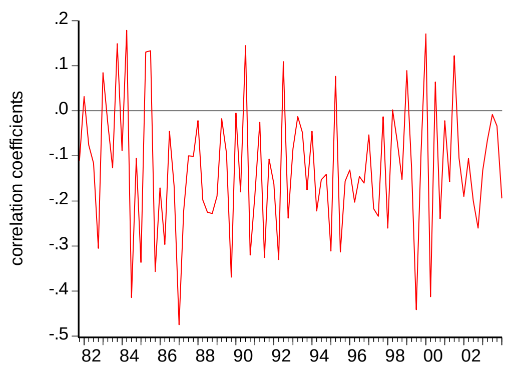
Table 2. Contd….

Panel B. Average time-varying cross-correlation coefficients between the term spread via the multivariate GARCH model							
	Lags behind from the term spread: forecastability for the term spread by factor returns Lags in quarter						
	0	−1	−2	−3	−4	−5	−6
SMB HML	**-0.24452** -0.19537	-0.15117 -0.11683	-0.19345 -0.19316	-0.12307 -0.11368	-0.10280 -0.06329	0.02237 0.01717	-0.10781 -0.03296
	Leads from the term spread: forecastability for factor returns by the term spread Leads in quarter						
	1	2	3	4	5	6	
SMB HML	**-0.25764** **-0.20002**	**-0.25202** **-0.25334**	-0.12472 -0.16068	0.02592 -0.01043	-0.06538 -0.09516	-0.04951 -0.17418	

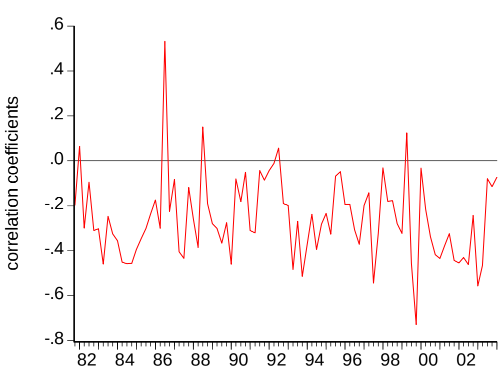
Notes: HML denotes the high-minus-low factor return and SMB denotes the small-minus-big factor return, calculated using Japanese data and Fama and French [1, 3]. Panel A displays the average of the time-varying cross-correlation coefficients between the credit spread and the HML or SMB factor returns. Panel B shows the average of the time-varying cross-correlation coefficients between the term spread and the HML or SMB factor returns. The time-varying cross-correlations are obtained using a multivariate GARCH model. The upper section of each panel displays the cross-correlation coefficients where the SMB and HML factors lag behind the credit spread or term spread. The lower section of each panel displays the cross-correlation coefficients where the SMB and HML factors lead the credit spread or term spread. The sample period is from the fourth quarter of 1981 to the first quarter of 2004. Figures in bold indicate that the absolute values of the correlation coefficients are greater than 0.2.



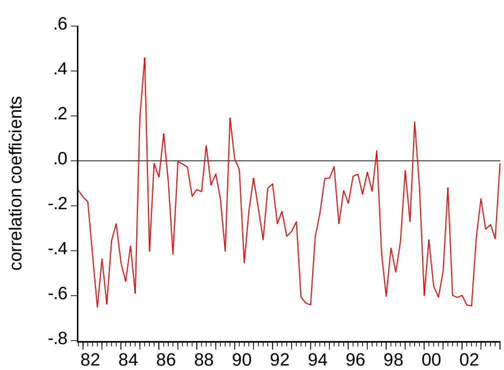
Panel A 6 quarters lead series of SMB and the credit spread



Panel B 2 quarters lead series of HML and the credit spread



Panel C 1 quarter lead series of SMB and the term spread



Panel D 2 quarters lead series of HML and the term spread

Fig. (2). The time-varying cross-correlation coefficients between the credit spread, term spread, HML, and SMB.

Table 3. Panel data Analysis of the Pricing of the Time-Varying Risk of Market Factor, Lagged Credit Spread, and Lagged Term Spread: Tests Using Portfolios Formed Based on Size, BE/ME, and Size and BE/ME in Japan

	Test 1 The pricing of market risk	**Test 2** The pricing of market risk and lagged credit spread			**Test 3** The pricing of market risk and lagged term spread			**Test 4** The pricing of market risk, lagged credit spread, and lagged term spread				
	Price of market risk	Price of market risk	Price of DEF(-6)	Price of DEF(-2)	Price of market risk	Price of TERM(-1)	Price of TERM(-2)	Price of market risk	Price of DEF(-6)	Price of DEF(-2)	Price of TERM(-1)	Price of TERM(-2)
Panel A. Results of the 25 portfolios formed based on size												
Coef.	0.035**	0.037**	0.336		0.037**	0.131		0.039**	0.359		0.129	
p-value	0.000	0.000	0.205		0.000	0.068		0.000	0.176		0.081	
Panel B. Results of the 25 portfolios formed based on BE/ME												
Coef.	0.026**	0.027**		0.792**	0.028**		0.114	0.028**		0.772**		0.081
p-value	0.000	0.000		0.000	0.000		0.178	0.000		0.000		0.341
Panel C. Results of the 25 portfolios formed based on size and BE/ME												
Coef.	0.035**	0.038**	0.494		0.037**	0.128		0.040**	0.535		0.133	
p-value	0.000	0.000	0.090		0.000	0.061		0.000	0.067		0.058	
Coef.		0.037**		1.063**	0.040**		0.262**	0.042**		1.076**		0.264**
p-value		0.000		0.000	0.000		0.000	0.000		0.000		0.000
Coef.								0.043**	0.549			0.265**
p-value								0.000	0.058			0.000
Coef.								0.038**		1.021**	0.085	
p-value								0.000		0.000	0.215	

Notes: The quarterly time-varying risk prices of market factor, lagged credit spread, and lagged term spread are evaluated. In the tests, the 25 portfolios formed on the basis of size, BE/ME, or size and BE/ME are used. Panel A shows the results for the 25 portfolios formed based on size, Panel B displays the results for the 25 portfolios formed based on BE/ME, and Panel C exhibits the results for the 25 portfolios formed on the basis of size and BE/ME. The samples are quarterly and the sample period is from the fourth quarter of 1981 to the first quarter of 2004. The tests are performed using panel data analysis. The risk prices are tested using the conditional ICAPM and the conditional time-varying covariances derived from the multivariate GARCH model. The size, BE/ME, and size and BE/ME portfolios are formed following Fama and French [1, 3]. ** and * denote statistical significance at the 1% and 5% level, respectively. DEF (-*k*) denotes the *k* quarters lagged credit spread and TERM (-*k*) denotes the *k* quarters lagged term spread.

Table 4. Panel Data Analysis of the Pricing of the Time-Varying Risk of Market Factor, SMB, HML, Lagged Credit Spread, and Lagged term Spread: The Tests Using the Portfolios Formed Based on Size, BE/ME, and Size and BE/ME in Japan

Panel A. Results of the 25 portfolios formed based on size									
Test 1 The pricing of market risk, SMB, HML					Test 2 The pricing of market risk, SMB, HML and lagged credit spread				
	Price of market risk	Price of SMB	Price of HML		Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	
Coef.	0.027**	0.008**	0.018*		0.029**	0.008**	0.019*	0.983**	
p-value	0.000	0.000	0.041		0.000	0.000	0.028	0.000	
Test 3 The pricing of market risk, SMB, HML and lagged term spread					Test 4 The pricing of market risk, SMB, HML lagged credit spread, and lagged term spread				
	Price of market risk	Price of SMB	Price of HML	Price of TERM(-2)	Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	Price of TERM(-2)
Coef.	0.031**	0.008**	0.025**	0.300**	0.033**	0.009**	0.027**	0.976**	0.299**
p-value	0.000	0.000	0.005	0.000	0.000	0.000	0.003	0.000	0.000

Table 4. Contd….

Panel B. Results of the 25 portfolios formed based on BE/ME

Test 1 The pricing of market risk, SMB, HML					Test 2 The pricing of market risk, SMB, HML and lagged credit spread				
	Price of market risk	Price of SMB	Price of HML		Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	
Coef. *p*-value	0.023** 0.000	0.004 0.119	0.022** 0.000		0.023** 0.000	0.005* 0.042	0.024** 0.000	0.970** 0.000	

Test 3 The pricing of market risk, SMB, HML and lagged term spread					Test 4 The pricing of market risk, SMB, HML lagged credit spread, and lagged term spread				
	Price of market risk	Price of SMB	Price of HML	Price of TERM(-2)	Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	Price of TERM(-2)
Coef. *p*-value	0.025** 0.000	0.004 0.081	0.023** 0.000	0.183* 0.032	0.025** 0.000	0.006* 0.025	0.025** 0.000	0.942** 0.000	0.153 0.073

Panel C. Results of the 25 portfolios formed based on size and BE/ME

Test 1 The pricing of market risk, SMB, HML					Test 2 The pricing of market risk, SMB, HML and lagged credit spread				
	Price of market risk	Price of SMB	Price of HML		Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	
Coef. *p*-value	0.028** 0.000	0.007** 0.000	0.012 0.059		0.030** 0.000	0.007** 0.000	0.015* 0.024	1.140** 0.000	

Test 3 The pricing of market risk, SMB, HML and lagged term spread					Test 4 The pricing of market risk, SMB, HML lagged credit spread, and lagged term spread				
	Price of market risk	Price of SMB	Price of HML	Price of TERM(-2)	Price of market risk	Price of SMB	Price of HML	Price of DEF(-2)	Price of TERM(-2)
Coef. *p*-value	0.033** 0.000	0.007** 0.000	0.019** 0.005	0.299** 0.000	0.035** 0.000	0.008** 0.000	0.022** 0.001	1.180** 0.000	0.305** 0.000

Notes: The quarterly time-varying risk prices of market factor, SMB, HML, lagged credit spread, and lagged term spread are evaluated. In the tests, the 25 portfolios formed on the basis of size, BE/ME, or size and BE/ME are used. Panel A shows the results for the 25 portfolios formed based on size, Panel B displays the results for the 25 portfolios formed based on BE/ME, and Panel C exhibits the results for the 25 portfolios formed on the basis of size and BE/ME. The samples are quarterly and the sample period is from the fourth quarter of 1981 to the first quarter of 2004. The tests are performed using panel data analysis. The risk prices are tested using the conditional ICAPM and the conditional time-varying covariances derived from the multivariate GARCH model. The size, BE/ME, and size and BE/ME portfolios are formed following Fama and French [1, 3]. ** and * denote statistical significance at the 1% and 5% level, respectively. DEF (-2) denotes the 2 quarters lagged credit spread and TERM (-2) denotes the 2 quarters lagged term spread.

$$GDP_{t,t+4} = \nu + \xi FactorRet_{t-4,t} + \eta_{t,t+4}, \quad (10)$$

where ‘FactorRet’ includes MKT, SMB, or HML.

The results are shown in Panel A in Table **5**. We can see that MKT and SMB display predictability for future real GDP growth; however, HML has no forecasting power in Japan.[13]

As an economic intuition, HML lags behind SMB from the viewpoint of the business cycle, and this can be appreciated using Fig. (**2**). Fig. (**2**) shows that HML lags four quarters behind SMB when we regard DEF as the benchmark of business cycles. Hence to take the real lead-lag relations more properly into account, we modify the above specification by adjusting the length of the lag order, *k*, of MKT, SMB, HML, using the Akaike Information Criterion (AIC), as follows:

$$GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \eta_{t,t+4}, \quad (11)$$

where ‘FactorRet’ again includes MKT, SMB, or HML, and k=0 in MKT, k=4 in HML, and k=−1 in SMB.

The results of model (11) are displayed in Panel B of Table **5**. The results indicate that this modification is rather

[13] These results are similar to those in Liew and Vassalou [14] where the statistically insignificant forecastability of MKT, SMB, and HML is often found for Japan. (See Tables 5, 6, 7, 8, and 9 in Liew and Vassalou [14]).

effective, and HML demonstrates, differently from the results in Panel A, statistically significant forecasting power. Furthermore, comparing the adjusted *R*-squared values in Panels A and B, model (11) with lag-modified HML and lag-modified SMB has much higher values of 0.163 (from 0.010 in Panel A) and 0.251 (from 0.186 in Panel A), respectively, in Panel B.

B. Tests in the Presence of Business Cycle Variables

Our next task is to undertake robustness checks. To do this, we first use our lag-modified model (11) while including the four lagged macroeconomic variables (RF, DY, TERM, and IDP) as follows:

$$GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \beta RF_{t-4-k,t-k} + \gamma DY_{t-4-k,t-k} + \delta TERM_{t-4-k,t-k} + \lambda IDP_{t-4-k,t-k} + \varepsilon_{t,t+4}, \quad (12)$$

where 'FactorRet' includes MKT, SMB, or HML, and k=0 in RF, DY, TERM, IDP, and MKT, and k=4 in HML, and k=−1 in SMB.

The results of model (12) are shown in Panel A of Table **6**. The panel shows that, even after controlling for macroeconomic variables, all lagged MKT, HML, and SMB exhibit statistically significant forecastability for future real GDP growth in Japan. Because only RF and IDP show weak predictability in model (12), we specify the following model (13) by changing DY and TERM to DEF and EX while retaining RF and IDP:

$$GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \beta RF_{t-4-k,t-k} + \gamma IDP_{t-4-k,t-k} + \delta DEF_{t-4-k,t-k} + \lambda EX_{t-4-k,t-k} + \varepsilon_{t,t+4}, \quad (13)$$

where 'FactorRet' includes MKT, SMB, or HML, and k=0 in RF, IDP, DEF, EX, and MKT, and k=4 in HML, and k=−1 in SMB.

The results of model (13) are displayed in Panel B of Table **6**. Once again, even after controlling for the macroeconomic variables, all lagged MKT, HML, and SMB demonstrate statistically significant predictability for future real GDP growth in Japan. Therefore, using the evidence from the results of models (11) to (13), we empirically support FF's [1-3] contention that in Japan, HML and SMB are state variables that predict future changes in the investment opportunity set in the context of Merton's ICAPM.

VIII. SUMMARY, INTERPRETATION, AND IMPLICATIONS

This paper explores the economic meaning and role of the FF factors in Japan from the viewpoint of business cycles and Merton's ICAPM framework. By originally incorporating the variables' lead-lag relationship and the variables' time-varying comovements into our analysis, we derive new evidence for the economic meaning and roles of the FF factors in Japan as follows.

First, HML is not considered to be a proxy for distress risk in Japan. Instead, SMB plays this role. This is because SMB and the credit spread demonstrate a strong negative relationship, while a clear relation between HML and the credit spread cannot be found. Recent research on credit risk, such as Das *et al*. [58], Giesecke *et al.* [59], and Jorion *et al*. [60], suggested that corporate defaults are systemic and show contagion. These suggestions and our results show that the clear relation between the expansion of the credit spread due to the increase in default risk and the decrease in SMB return are consistent, and thus our interpretation that SMB is more strongly related to distress risk than HML in Japan is very natural.

Second, related to this, a negative lead-lag relation between HML and the term spread is found in Japan. This is inconsistent with the hypothesis of Cornell [27] and Campbell and Vuolteenaho [28] that growth stocks are high-duration assets. Instead, this negative relation is consistent with an argument concerning the higher (lower) performance of growth stocks during an economic expansion (recession). We also find that HML is weakly related with business cycles, and this is consistent with the evidence in Lakonishok *et al*. [11]. Lakonishok *et al*. [11, p.1574] explained that "*value strategies appear to be no riskier than glamour strategies*." This means that low-risk value premia, such as HML, do not fluctuate with the dynamics of the business cycle. Accordingly, in bad times, HML does not behave badly like the distress risk factor but rather somewhat defensively against economic stagnation.

Third, in our direct ICAPM pricing tests, the time-varying covariances of SMB and HML derived from the multivariate GARCH model are generally effective and well priced in the conditional ICAPM in Japan. Therefore, we consider that both SMB and HML are state variables in Merton's ICAPM as suggested by FF [1-3].

Fourth, using a different test following Liew and Vassalou [14], even after controlling for the macroeconomic variables, when we adjust the lag orders, all lagged HML and SMB demonstrate clear predictability for future real GDP growth in Japan. Therefore, we again empirically support FF's [1-3] argument that HML and SMB are state variables that predict future changes in the investment opportunity set in the context of Merton's ICAPM. In addition, in lag modifications of the Liew and Vassalou's [14] model, it is understood that HML lags behind SMB. This is also consistent with our interpretation that HML is more weakly related to business cycles than SMB, and suggests that it is not possible that HML is a proxy for distress risk in Japan. This evidence has an important practical implication in the field of investment management in that SMB and HML can be used for assessing the future investment environment. Our empirical results suggest that as economic indicators, SMB and HML are very useful factors in Japanese investment management.

Outside the above findings, in the process of investigating the FF factor, we have also found significant new evidence as follows. First, real GDP growth and the credit spread have strong negative lead and lag relationships, while the term spread has almost no forecasting power for future GDP in Japan. Thus, the credit spread more clearly represents business cycles than the term spread in Japan. This provides new implications for research into business cycles and asset pricing, not only in Japan but also in other countries.

Moreover, we reveal that the two-quarter lagged credit spread and the two-quarter lagged term spread are generally

Table 5. Univariate Regressions for Testing the Predictability for Future GDP Growth Rates Using Past 4 Quarters Factor Returns: The Case of Japan

Panel A. Regression: $GDP_{t,t+4} = \nu + \xi FactorRet_{t-4,t} + \eta_{t,t+4}$

		Explanatory variables					
Dependent variables		Const.	MKT	HML	SMB	Adj.R^2	AIC
$GDP_{t,\,t+4}$	Coef.	2.142**	0.047**			0.236	1.917
	p-value	0.000	0.002				
$GDP_{t,\,t+4}$	Coef.	2.054**		0.024		0.010	2.183
	p-value	0.000		0.402			
$GDP_{t,\,t+4}$	Coef.	1.846**			0.054**	0.186	1.979
	p-value	0.000			0.004		

Panel B. Regression: $GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \eta_{t,t+4}$

		Explanatory variables					
Dependent variables		Const.	MKT	HML	SMB	Adj.R^2	AIC
	Lag, *k*		k=0	k=4	k=−1		
$GDP_{t,\,t+4}$	Coef.	2.142**	0.047**			0.236	1.917
	p-value	0.000	0.002				
$GDP_{t,\,t+4}$	Coef.	1.698**		0.066*		0.163	2.040
	p-value	0.001		0.011			
$GDP_{t,\,t+4}$	Coef.	1.770**			0.061**	0.251	1.888
	p-value	0.000			0.001		

Notes: This table presents the forecastability of MKT, HML, and SMB for real Gross Domestic Product (GDP) growth rate in Japan. In the regression notation, 'FactorRet' stands for MKT, HML, and SMB. MKT denotes the market factor return, HML denotes the high-minus-low factor return, SMB denotes the small-minus-big factor return, calculated using Japanese data and Fama and French [1, 3]. GDP is the seasonally adjusted growth rate of Gross Domestic Product in Japan. The *p*-values are corrected for heteroskedasticity and serial correlation using the Newey and West [57] estimator. *k* denotes the lag of each factor. * denotes statistical significance at the 5% level, ** denotes statistical significance at the 1% level. The samples are quarterly and the sample period is from the third quarter of 1982 to the first quarter of 2004

Table 6. The Ability of Market Factors, HML, and SMB to Predict Future GDP Growth in the Presence of Business Cycle Variables: The Case of Japan

Panel A. Regression: $GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \beta RF_{t-4-k,t-k} + \gamma DY_{t-4-k,t-k} + \delta TERM_{t-4-k,t-k} + \lambda IDP_{t-4-k,t-k} + \varepsilon_{t,t+4}$

		Explanatory variables									
Dependent variables		Const.	MKT	HML	SMB	RF	DY	TERM	IDP	Adj.R^2	SE
	Lag, *k*		k=0	k=4	k=−1	k=0	k=0	k=0	k=0		
$GDP_{t,\,t+4}$	Coef.	1.419	0.041**			0.194	0.415	-0.480	0.110	0.466	1.603
	t-statisitc	1.578	3.688			1.719	0.430	-1.272	1.616		
	p-value	0.119	0.000			0.090	0.669	0.207	0.110		
$GDP_{t,\,t+4}$	Coef.	-0.366		0.062**		0.354*	0.720	0.133	0.140*	0.437	1.674
	t-statisitc	-0.269		5.072		2.479	0.734	0.387	2.486		
	p-value	0.789		0.000		0.016	0.465	0.700	0.015		
$GDP_{t,\,t+4}$	Coef.	1.095			0.047*	0.252	-0.532	0.208	0.129*	0.447	1.631
	t-statisitc	1.100			2.569	1.873	-0.590	0.660	2.348		
	p-value	0.275			0.012	0.065	0.557	0.511	0.022		

Table 6. Contd….

Panel B. Regression: $GDP_{t,t+4} = \nu + \xi FactorRet_{t-4-k,t-k} + \beta RF_{t-4-k,t-k} + \gamma IDP_{t-4-k,t-k} + \delta DEF_{t-4-k,t-k} + \lambda EX_{t-4-k,t-k} + \varepsilon_{t,t+4}$

		Explanatory variables									
Dependent variables		Const.	MKT	HML	SMB	RF	IDP	DEF	EX	Adj.R^2	SE
	Lag, *k*		*k*=0	*k*=4	*k*=−1	*k*=0	*k*=0	*k*=0	*k*=0		
$GDP_{t,t+4}$	Coef.	1.855*	0.033**			0.235	0.055	-1.883	-0.018	0.482	1.579
	t-statisitc	2.528	3.326			1.836	0.776	-1.557	-0.879		
	p-value	0.014	0.001			0.070	0.440	0.124	0.382		
$GDP_{t,t+4}$	Coef.	1.543**		0.051**		0.211	0.093	-1.884	-0.022	0.470	1.623
	t-statisitc	2.927		3.747		1.635	1.536	-1.766	-1.131		
	p-value	0.005		0.000		0.106	0.129	0.082	0.262		
$GDP_{t,t+4}$	Coef.	1.887**			0.050**	0.099	0.089	-1.930	-0.048*	0.532	1.500
	t-statisitc	3.197			3.752	0.960	1.777	-1.871	-2.182		
	p-value	0.002			0.000	0.340	0.080	0.065	0.032		

Notes: This table presents the ability of market factors, HML, and SMB to predict annual real Gross Domestic Product (GDP) growth in the presence of business cycle variables. In the regression notation, 'FactorRet' stands for MKT, HML, and SMB. MKT denotes the market factor return, HML denotes the high-minus-low factor return, SMB denotes the small-minus-big factor return, calculated using Japanese data and Fama and French [1, 3]. GDP denotes the seasonally adjusted growth rate of Gross Domestic Product in Japan, RF is the risk-free rate, DY denotes dividend yields, TERM denotes the term spread, IDP denotes seasonally adjusted industrial production, DEF denotes the credit spread, EX denotes the US-Yen exchange rate. Adj.R^2 denotes the adjusted *R*-squared values, and SE denotes the standard error of regressions. The *p*-values are corrected for heteroskedasticity and serial correlation using the Newey and West [57] estimator. *k* denotes the lag order of each factor. * denotes statistical significance at the 5% level, ** denotes statistical significance at the 1% level. The samples are quarterly and the sample period is from the third quarter of 1982 to the first quarter of 2004.

well priced in the 25 portfolios formed based on size, BE/ME, and size and BE/ME. This result is robust even if we include the market factor, SMB, and HML covariances in the conditional ICAPM. This robustness indicates that in Japan, not only SMB and HML but also the lagged credit and term spreads are important factors in asset pricing. The above evidence has a practical implication for investment management in that bearing the risk included in the credit spread and term spread is rewarded with future return in the Japanese stock markets. This also suggests that in other international markets, careful research focusing on the lead-lag relationships in other countries has the possibility of finding new structures for lagged risk factors and stock returns.

As above, we have derived numerous new significant findings, which are essential and will contribute widely to the financial literature and practical investment management. Related studies in other international markets are also expected in the future.

ACKNOWLEDGMENTS

The author acknowledges the generous financial assistance of the Japan Society for the Promotion of Science and the Zengin Foundation for Studies on Economics and Finance. I would also like to thank Jason McQueen, Laura Starks, Ike Mathur, Giorgio Szego, Geert Bekaert, Nick Wade, and Takao Kobayashi for their helpful comments and suggestions. Furthermore, I would like to thank two anonymous referees for their kind comments. Finally, we greatly appreciate the invitation of Bentham Open and Sana Zehra to write for this journal.

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Received: February 16, 2010 Revised: May 17, 2010 Accepted: June 04, 2010