Yield Spreads as Alternative Risk Factors for Size and Book-to-Market*

Jaehoon Hahn[†] and Hangyong Lee[‡]

First Draft: October 2001
This Version: July 2003

Abstract

This paper investigates whether the size and book-to-market factors of Fama and French's (1993) three-factor model proxy for the risks associated with fluctuations of the business cycle. We find that changes in default spread (Δdef) and changes in term spread ($\Delta term$) capture the systematic differences in average returns along the size and book-to-market dimensions in the way that the Fama-French factors do. Furthermore, in the presence of Δdef and $\Delta term$, the Fama-French factors are superfluous in explaining the size and book-to-market effects. The results suggest that the size and value premiums are compensation for higher exposure to the risks related to variation of credit market conditions and interest rates proxied by Δdef and $\Delta term$.

*We thank Andrew Ang, John Donaldson, Robert Hodrick, Avi Kamara, Maria Vassalou, Yuhang Xing, Xiaoyan Zhang, and seminar participants at Baruch College, Columbia University, the Federal Reserve Board of Governors, University of California at Riverside, University of Notre Dame, and University of Washington for helpful comments on earlier drafts of this paper. All remaining errors are ours.

[†]University of Washington Business School, 320 Mackenzie Hall, Seattle, WA 98195, Tel: 206-221-5140, Fax: 206-221-6856, Email: hahnj@u.washington.edu.

[‡]The Bank of Korea, 110, 3-Ga, Namdaemun-Ro, Jung-Gu, Seoul, Korea. Phone: 82-2-759-5442. Fax: 82-2-759-5410. E-mail: hlee@bok.or.kr.

1. Introduction

The three-factor model of Fama and French (1993) has become the benchmark model for risk adjustment in the empirical asset pricing literature.[1] However, the interpretation of the economic link between the Fama-French factors and systematic risk is rather contentious and continues to be a subject of debate.[2] Indeed, Lewellen (1999) succinctly summarizes the state of the debate over the size and book-to-market effects, which in our view, remains valid: "the rational pricing story will remain incomplete, and perhaps unconvincing, until we know more about the underlying risks."

The fundamental reason for considerable debate over what underlies the size and book-to-market effects is that the Fama-French factors are basically returns on the portfolios formed on the same characteristics, size and book-to-market ratio, which in themselves, lack clear economic links to systematic risk: although Fama and French (1996) argue that the size factor (SMB) and the book-to-market factor (HML) proxy for common sources of variance in returns that are not fully captured by the market beta, they admit that they "have not identified the two state variables of special hedging concern to investors that lead to three-factor asset pricing."

In this paper, we suggest macroeconomic variables closely linked to fluctuations of the business cycle as alternative proxies for SMB and HML. The alternative macroeconomic variables are default spread and term spread. This choice is motivated by the criteria noted in Campbell (1996) that proxies for state variables of time-varying investment opportunities should be chosen based on their ability to forecast the market return and also, on their ability to explain the cross-sectional pattern of asset returns. The default and term spreads are well known to forecast aggregate stock

[1] Some of the recent papers in empirical asset pricing that use the three-factor model of Fama and French (1993) for risk adjustment before examining other potential sources of risk include Ang, Chen, and Xing (2002), Lamont, Polk, and Saá-Requejo (2001), Pastór and Stambaugh (2002).

[2] See Daniel and Titman (1997) and Lakonishok, Shleifer, and Vishny (1994) for behavioral interpretations, and Lewellen (1999), Liew and Vassalou (2000), Vassalou (2001), Vassalou and Xing (2002), Zhang (2002) for risk-based interpretations.

market returns (see Keim and Stambaugh (1986), Fama and French (1989), among others). Furthermore, these yield spread variables have long been used as proxies for credit market conditions and the stance of monetary policy[3], which suggests that innovations (changes) in the default and term spreads would capture revisions in the market's expectation about future credit market conditions and interest rates. To the extent that small firms tend to be young, poorly collateralized, and have limited access to external capital markets (Gertler and Gilchrist (1994)) and that high book-to-market firms tend to have high financial leverage and cash flow problems (Fama and French (1992, 1995)), small and high book-to-market firms would be more vulnerable to worsening credit market conditions and higher interest rates. Thus, we can expect that the default and term spreads would be good state variable proxies for capturing cross-sectional pattern of stock returns in firm size and book-to-market ratio.

The default and term spreads are also good candidates for state variable proxies in the context of Merton's (1973) Intertemporal Capital Asset Pricing Model (ICAPM). Merton notes stochastic interest rates as a prime example inconsistent with constant investment opportunities. Since the term spread is one of the most widely used proxies for the market's expectation about future interest rates, it is likely to capture well the hedging concerns to investors associated with variations in interest rates. Ample evidence on time-varying risk premia is another example of shifts in investment opportunity set investors face. Since variations in the default spread have been widely used as a proxy for time-varying risk premia (see, e.g., Jagannathan and Wang (1996)), we can expect that the default spread is likely to capture well the hedging concerns to investors associated with variations in risk premia.[4]

Based on this choice for state variable proxies, we specify a three-factor model in which the factors are the market portfolio return, changes in the default spread (Δdef), and changes in the

[3] See for example, Gertler, Hubbard, and Kashyap (1991), and Kashyap, Lamont, and Stein (1994).

[4] Brennan, Wang, and Xia (2002) develop a model of ICAPM with stochastic interest rate and Sharpe ratio as state variables.

term spread ($\Delta term$). Using Fama and French's (1993) 25 size/book-to-market (FF25) portfolios as test assets, we directly compare the pricing implications and performance of Δdef and $\Delta term$ to those of SMB and HML. We find Δdef and $\Delta term$ capture most of the pricing implications contained in SMB and HML. The FF25 portfolios' risk exposures (factor loadings) to Δdef and SMB share the same systematic pattern along the size dimension, and the risk exposures to $\Delta term$ and HML show the same systematic pattern along the book-to-market dimension. Consistent with this evidence from time-series regressions, the Generalized Method of Moments (GMM) cross-sectional estimation and test results show that Δdef and $\Delta term$ are important determinants for explaining the cross-section of the FF25 portfolio returns. The risk premiums for the factors in the Fama-French three-factor (FF3) model and our alternative three-factor model are both qualitatively and quantitatively similar, and the model diagnostics, the HJ-distance of Hansen and Jagannathan (1997) and a Wald test, also show that the two models are quite comparable. Furthermore, the "χ^2 difference test" of Newey and West (1987) shows that in the presence of Δdef and $\Delta term$, SMB and HML are superfluous in explaining the cross-section of the FF25 portfolio returns, indicating that Δdef and $\Delta term$ contain most of the pricing implications of SMB and HML.

The results support a risk-based interpretation of the size and book-to-market effects. Because SMB and HML are constructed from the returns on portfolios sorted on firm characteristics known to be related to average returns, the pattern of covariances may not necessarily indicate that these factors proxy for risk (see e.g., Ferson, Sarkissian, and Simin (1999)). Δdef and $\Delta term$, however, are common macroeconomic variables unrelated to the manner in which portfolios are formed. Therefore, the pattern of covariances with Δdef and $\Delta term$ is not subject to such critique, and suggests that higher returns on small stocks and high book-to-market stocks are compensation for higher risks. The findings are also consistent with previous studies that link higher stock returns on small firms to their vulnerability to variations in credit market conditions (see e.g., Chan and

Chen (1991) and Perez-Quiros and Timmermann (2000)).[5] A novel empirical finding in this paper is that higher stock returns on high book-to-market firms are also systematically related to fluctuations of the business cycle, in particular, revisions in the market's expectation of future interest rates captured in $\Delta term$.

The implications of fluctuations in the business cycle, or more broadly variations in investment opportunities on the cross-section of stock returns have been actively researched both theoretically and empirically in recent years. While the papers in this line of research differ in underlying theoretical models (e.g., conditional CAPM in Berk, Green, and Naik (1999), Ferson and Harvey (1999), Gomes, Kogan, and Zhang (2002), variants of the ICAPM in Brennan, Wang, and Xia (2002), Campbell (1996) and Chen (2002)), common to this literature is the idea that time-varying investment opportunities are likely to be a source of empirical success of multi-factor models such as the FF3 model. In that regard, the findings in this paper are consistent with this literature.

The paper is organized as follows. The next section further elaborates our argument for using Δdef and $\Delta term$ as alternative proxies for SMB and HML, and investigates their relations in a simple regression framework. In Section 3, we examine whether Δdef and $\Delta term$ capture the cross sectional variation in average returns of the FF25 portfolios in the way SMB and HML do, paying particular attention to the pattern of factor loadings. In Section 4, we discuss how the findings in this paper are related to Fama and French's (1993) five-factor model which includes bond market factors similar to Δdef and $\Delta term$, and Section 5 contains the results of the GMM estimation of risk premia and model diagnostics. Section 6 offers concluding remarks.

2. SMB, HML, and the alternative macroeconomic risk proxies

The default spread is defined as the spread between yield to maturity on a Baa corporate bond

[5] Chan and Chen (1991) find that a portfolio of small firms contains a large proportion of marginal firms that have high financial leverage and cash flow problems, and Perez-Quiros and Timmermann (2000) find that stock returns of small firms are more sensitive to measures of recession and tight monetary policy.

index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate.[6] The Baa yield is Moody's seasoned Baa corporate bond yield from Moody's Investors Service, and the 10-year and 1-year Treasury rates are from the Federal Reserve Board of Governors. The sample period for our analysis is from July 1963 to June 2001.

The default and term spreads have long been used as proxies for the state of business conditions, and in particular, as measures for credit market conditions and the stance of monetary policy (Gertler, Hubbard, and Kashyap (1991), Kashyap, Lamont, and Stein (1994)). An increase in the default spread signals the market's expectation of worsening credit market conditions. Research also suggests that small firms are more vulnerable to variation of credit market conditions over the business cycle (Perez-Quiros and Timmermann (2000)). Thus, we can expect stronger adverse effects on the stock prices of small firms in response to worsening credit market conditions. Since SMB is the return differential between the portfolios of small and large firms, increases (decreases) in the default spread would be associated with lower (higher) contemporaneous returns on SMB on average. Hence, we use the negative of changes in the default spread as an alternative macroeconomic proxy for the risk underlying SMB.

Figure 1 plots the term spread, default spread, and 1-year Treasury yield from July 1963 to June 2001. Consistent with Fama and French's (1989) finding, the term spread clearly exhibits a tendency of being low near business cycle peaks and high near troughs. Furthermore, the term spread and 1-year Treasury yield move in opposite directions. In other words, increases (decreases) in the term spread are associated with declining (rising) interest rates. Fama and French (1992)

[6] Stock and Watson (1989) find that the spread between 6-month commercial paper and 6-month T-bill rates and the yield spread between 10-year and 1-year Treasury bonds outperform most other variables as a forecaster of the business cycle. The paper-bill spread, however, is not appropriate for our purpose of choosing a proxy for variation of credit market conditions to which small firms are more vulnerable since most small firms do not have access to the commercial paper market. Accordingly, we use the spread between the Baa-rated corporate bond yield and 10-year Treasury rate. Using the yield spread between Baa and Aaa coporate bond portfolios as the default spread does not alter the main findings.

show that the book-to-market ratio is the difference between market leverage (the ratio of book value of assets to market value of equity) and book leverage (the ratio of book value of assets to book value of equity), thereby interpreting the effect captured by HML as an involuntary leverage effect, in the sense that firms with high book-to-market ratios (market leverage high relative to book leverage) have a large amount of market imposed leverage. Since declining interest rates are likely to have a greater positive effect on firms with heavier debt burden than on less levered firms, we can expect increases (decreases) in the term spread to be associated with higher (lower) returns on HML on average. Thus, we use changes in the term spread as an alternative macroeconomic proxy for the risk underlying HML.

We first examine the relations between SMB and the default factor, and HML and the term factor in the following simple regression framework:

$$SMB_t = a_1 + b_1 R_{m,t} + c_1 \Delta def_t + d_1 \Delta term_t + e_{1,t} \quad (1)$$

$$HML_t = a_2 + b_2 R_{m,t} + c_2 \Delta def_t + d_2 \Delta term_t + e_{2,t} \quad (2)$$

$R_{m,t}$ denotes the excess return on the market portfolio, $\Delta def_t \equiv -(def_t - def_{t-1})$, and $\Delta term_t \equiv term_t - term_{t-1}$, where def_t and $term_t$ are the default spread and term spread at time t. As a proxy for the excess return on the market portfolio, we use the market factor of Fama and French's (1993) three factors.[7]

Implementing our empirical specification of the ICAPM requires estimating innovations in the state variable proxies, the default and term spreads. Simple changes in the spreads are not, in general, innovations. One can specify time series processes for the spreads and estimate a type of vector autoregressive models to use the residuals as innovations, as in Campbell's (1996) implementation of his intertemporal asset pricing model. While a failure to filter out expected movements in the spreads may introduce an errors-in-variables problem, misspecification of the time

[7] We thank Kenneth French for generously making the Fama-French portfolios and factor data available on his website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/

series processes will also introduce errors in using estimated innovations. For the empirical investigation that follows, the results from using residuals estimated from a simple autoregressive specification for the spreads as state variable risk proxies were almost identical to the results from using simple changes in the spreads as state variable risk proxies. Thus, we report only the latter case.[8]

Table 1 contains summary statistics of the factors and Table 2 reports the estimates and the corresponding t-statistics (in parentheses) from the above regressions. Controlling for the excess return on the market portfolio, Δdef positively covaries with SMB and $\Delta term$ positively covaries with HML. Both coefficient estimates are statistically significant as well. However, Δdef is not a significant factor for HML, and similarly, $\Delta term$ is not a significant factor for SMB. The results suggest that Δdef and $\Delta term$ can be good alternative proxies for the risks underlying SMB and HML in the following sense: to the extent that Δdef and $\Delta term$ capture the variation in SMB and HML related to the business cycle, they clearly distinguish the information in SMB from the information in HML.

We also investigated the relation between the Fama-French factors and other measures of credit market conditions and interest rates in the above regression framework: the spread between 6-month commercial paper and 6-month T-bill rates in place of or in addition to Δdef and the yield spread between 1-year Treasury bond and 3-month T-bill in place of or in addition to $\Delta term$. These alternative, shorter maturity spread variables show much weaker covariation with SMB and HML than Δdef and $\Delta term$. Further, in the presence of Δdef and $\Delta term$, their marginal contribution to explaining the variation in SMB and HML is negligible.

The results are also consistent with Fama and French (1989), who argue that the default and term spreads capture distinct components of variation in expected stock returns related to the business

[8] The results from using estimated innovations, not reported for brevity, are available upon request.

cycle.[9] Here, we find that those distinct components are related to variations in SMB and HML. The significant covariation between these factors, of course, are merely suggestive of some business cycle risk components underlying SMB and HML. Do these alternative macroeconomic proxies, Δdef and $\Delta term$, explain the cross-sectional variation in returns associated with size and book-to-market ratio in a way that SMB and HML do? The next section addresses this question.

3. Risk exposures of the FF25 portfolios on Δdef and $\Delta term$

We estimate the β's of the FF25 portfolios on our alternative three-factor model by the following time-series regression for the period from July 1963 to June 2001.

$$R^e_{j,t} = a_j + \beta^m_j R_{m,t} + \beta^{def}_j \Delta def_t + \beta^{term}_j \Delta term_t + e_{j,t}, \quad (3)$$

where $R^e_{j,t}$ is the excess return on the portfolio j at time t. β^{def}_j and β^{term}_j are the amounts of exposure of the portfolio j to Δdef factor risk and $\Delta term$ factor risk, respectively. The content of the expected return-beta representation of asset pricing models is that the cross-sectional variation of average returns arises from the cross-sectional variation of the betas, or loadings on the factors. Table 3 contains summary statistics for the FF25 portfolio returns, which clearly shows the systematic pattern of average returns along the size and book-to-market dimensions. Our goal here is to investigate if the loadings on Δdef and $\Delta term$ show the pattern consistent with this cross-sectional variation in average returns.

The results of the above time-series regression are reported in Table 4 and they are broadly consistent with our hypothesis. The loadings on Δdef, β^{def}'s, are significantly positive for all the portfolios in the smallest quintile regardless of the book-to-market ratio. β^{def}'s are also significantly positive for some of the portfolios in the second and third smallest quintiles. On the other hand, β^{def}'s for some of the portfolios in the bigger quintiles are significantly negative, potentially

[9] Fama and French (1989) find that the default and term spreads not only forecast returns on stocks and bonds, they also contain distinct information on overall macroeconomic conditions: variation in the default spread is related long-term business conditions while variation in the term spread tracks short-term business cycles.

reflecting investors' hedging behavior (i.e. holding the equities of large firms could be a good hedge against the state variable risk proxied by Δdef). The loadings on $\Delta term$, β^{term}'s, also exhibit a pattern similar to the loadings on Δdef. They are significantly positive for most of the high book-to-market portfolios regardless of the size.

Aside from the significance of the estimated coefficients, the qualitative pattern of the coefficients is monotone, which is consistent with the hypothesis and very similar to those from the FF3 model time-series regression, which are reported in Table 5. For all the book-to-market quintiles, the magnitudes of β^{def}'s are decreasing in size, switching signs from positive for smaller size portfolios to negative for larger size portfolios. For all the size quintiles, the magnitudes of β^{term}'s are increasing in the book-to-market ratio dimension, switching signs from negative for lower book-to-market portfolios to positive for higher book-to-market portfolios.

Figures 2 and 3 illustrate the extent to which the loadings of the FF25 portfolios on Δdef and $\Delta term$ are similar to those on SMB and HML. The portfolio numbers on the x-axis are numbered ij with i indexing size increasing from one (smallest) to five (biggest) and j indexing book-to-market ratio increasing from one (lowest) to five (highest). Note that in the middle panels, five portfolios of the same book-to-market quintiles are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintiles are grouped together in the order of increasing book-to-market ratio. The loadings on Δdef and SMB both show a clear monotonically decreasing pattern along the size dimension and no discernible pattern along the book-to-market dimension. Similarly, the loadings on $\Delta term$ and HML show a clear monotonically increasing pattern along the book-to-market dimension and no discernible pattern along the size dimension.

Overall, the time-series regression results suggest that the cross-sectional variation in average returns associated with size and book-to-market ratio arises from the varying degrees of exposure to the risks proxied by Δdef and $\Delta term$. While SMB and HML of the FF3 model clearly show the pattern of loadings consistent with a risk-based interpretation for the size and value premiums, the fact that SMB and HML are formed from the portfolio returns sorted on the same firm characteristics, size and book-to-market ratio, may be a concern for drawing inferences about economic risks underlying SMB and HML (see e.g., Ferson, Sarkissian, and Simin (1999)). Δdef and $\Delta term$, on the other hand, are macroeconomic variables unrelated to the manner in which portfolios are formed. Hence, the pattern of loadings on these factors indicates that firm size and book-to-market ratio proxy dimensions of firms' risks not captured by the market beta, and that the size and value premiums are compensation for higher exposure to the risks proxied by Δdef and $\Delta term$.

The momentum effect of Jegadeesh and Titman (1993), however, does not seem to arise from the business cycle related risks proxied by Δdef and $\Delta term$. Time-series regression results show that the loser portfolio load more on Δdef and $\Delta term$ than the winner portfolios, which is opposite to what we expect if the higher average returns on short-term winners are compensation for higher exposure to the risks proxied by Δdef and $\Delta term$.[10] Nevertheless, the results are in line with the failure of the FF3 model to price the momentum effect (see Fama and French (1996)), and hence not inconsistent with our claim that Δdef and $\Delta term$ capture most of the systematic risks underlying SMB and HML.

4. Relation to Fama and French's (1993) default and term factor specification

Fama and French (1993) investigate the pricing implications of the bond market factors similar to Δdef and $\Delta term$ in explaining the cross-section of the FF25 portfolios. Their bond market factors are the difference between the return on a portfolio of corporate bonds (high grades) and the long-term (20 years) government bond return, which we denote $FFdef$, and the difference

[10] Time-series regression results for the momentum portfolios, not reported for brevity, are available upon request.

between the long-term government bond return and the one-month T-bill rate, which we denote $FFterm$.[11] Their choice of these common bond market factors builds on Chen, Roll, and Ross (1986), and Fama and French (1989), among others. While they find that $FFdef$ and $FFterm$ capture common variation in stock returns as well as bond returns, they conclude that the average premiums for $FFdef$ and $FFterm$ are too small to explain much variation in the cross-section of average stock returns, and in particular, the size and book-to-market effects of the FF25 portfolios.

In contrast to their results, we find that Δdef and $\Delta term$ capture the size and book-to-market effects in average stock returns precisely in the way that SMB and HML do. Why the difference? First, Fama and French left out the market portfolio return factor when examining the explanatory power of $FFdef$ and $FFterm$ for stock returns. While this two-factor specification is not a problem in the context of Arbitrage Pricing Theory (APT) of Ross (1976), it is a misspecification in the context of the ICAPM of Merton (1973). State variable risks of the ICAPM arising from time variation in investment opportunities are part of systematic risks not captured by the market beta, and hence, the market portfolio return factor should not be omitted when assessing the role of proxies for state variable risks. When they do include the market portfolio return factor, they also include SMB and HML in the regression, i.e. their five-factor specification. Our finding indicates that the pricing implications of SMB and Δdef, and HML and $\Delta term$ are very much similar, as exemplified in the pattern of factor loadings. Since SMB and HML are constructed from the returns on the portfolios sorted on the same firm characteristics as the FF25 portfolios, one can expect that SMB and HML will dominate other regressors with similar information in the time-series regression. Indeed, while Fama and French find the pattern of loadings on $FFdef$ and $FFterm$ along the size and book-to-market dimensions in the two-factor specification, the

[11] Fama and French (1993) do not explicitly describe the bond ratings and maturities of the bond portfolios they use to construct $FFdef$ and $FFterm$.. Their data source is Ibbotson Associates, and the 2001 Yearbook on Stocks, Bonds, Bills, and Inflation published by Ibbotson Associates describe the composition of the corporate bond index (high grades and the maturities of approximately 20 years) and the long-term government bond (the maturities of 20 years).

pattern disappears in the five-factor specification.[12]

Another difference is how the factors are defined. Their two bond market factors, especially $FFdef$, are not likely to capture the risks related to the variation of credit market conditions to which small firms are more exposed. Recall that the default spread used for Δdef is the difference between the yields on a BAA-rated corporate bond index and the 10-year government bond. In contrast, $FFdef$ contains information only on the firms whose bond ratings are high, i.e. on the firms that are least exposed to the risks of worsening credit market conditions. Figure 4 illustrates the loadings on the factors of our alternative model with $FFdef$ and $FFterm$ in place of Δdef and $\Delta term$. The middle and bottom panels clearly show that $FFdef$ and $FFterm$, Fama and French's (1993) bond market factors, do not capture the risk characteristics of the FF25 portfolios in the way that Δdef and $\Delta term$ do. While the loadings on $FFterm$ show some increasing pattern along the book-to-market dimension, the loadings on $FFdef$ do not show a systematic pattern along the size dimension.[13]

5. SDF parameter estimation and model diagnostics

In this section, we estimate the FF3 model and our alternative three-factor model in their stochastic discount factor representations using the GMM and formally test if the state variable risk factors Δdef and $\Delta term$ help to price the FF 25 portfolios given the market return.

The absence of arbitrage opportunities implies the existence of a stochastic discount factor m such that $E_t(m_{t+1}R_{j,t+1}) = p_{j,t}$, where $R_{j,t+1}$ is the return on the portfolio j at time $t+1$, and $p_{j,t}$ is the price for the portfolio j at time t. We specify the following linear model for the stochastic discount factor:

$$y_{t+1} = b_0 + b'F_{t+1}, \tag{4}$$

12 See Tables 3, 7a, and 8a in Fama and French (1993).

13 The results on the statistical significance of these estimates (loadings on $FFdef$ and $FFterm$), not reported, are available upon request. Overall, the significance is much weaker than the significance for the estimates of the loadings on Δdef and $\Delta term$.

where y_{t+1} is a proxy for the stochastic discount factor (SDF) m_{t+1}. F_{t+1} denotes a vector of variable factors, i.e., $F_{t+1} \equiv [R_{m,t+1}, \Delta def_{t+1}, \Delta term_{t+1}]'$. For the FF3 model, the variable factors are $F_{t+1} = [R_{m,t+1}, SMB_{t+1}, HML_{t+1}]'$. The elements of b that are significantly different from zero imply that the factors are important determinants of the SDF, i.e. the factors have marginal explanatory power for pricing assets.

As noted in Cochrane (1996), a linear model for the stochastic discount factor such as (4) has an equivalent beta pricing model representation.

$$E(R) = R^0 p + \beta' \Lambda, \tag{5}$$

where p is the vector of p_j's, $R^0 = \frac{1}{E(y)}$, $\beta = cov(F, F')^{-1} cov(F, R')$, and $\Lambda = -R^0 cov(F, F')b$. R^0 is the riskless or zero beta rate, β is a vector of multiple regression coefficients of returns on the variable factors, and Λ is a vector of the risk premium associated with the variable factors.

The basic asset returns to be priced by the models are the FF25 portfolio returns in excess of the T-bill rate and the gross return on the T-bill. We estimated the models using the optimal GMM of Hansen (1982) as well as the HJ-distance approach of Hansen and Jagannathan (1997), and found only marginal differences in the results from the two estimation methods. The parameter estimates are quite similar both in terms of their magnitudes and significance, and the model diagnostics show no qualitative difference.

While the optimal GMM produces the most efficient estimates of the model parameters among the estimates that use linear combinations of pricing errors as moments, the weighting matrix used is model dependent, and hence comparison of diagnostics across models is problematic. On the other hand, estimation by the HJ-distance approach uses a common weighting matrix across models, and therefore, the HJ-distance and Wald tests can be the metrics for comparing the pricing errors of the asset pricing models under consideration. For these reasons, we report the estimation results from the HJ-distance approach. The model diagnostics are the HJ-distance of Hansen and Jagannathan (1997) with the test statistic calculated following Jagannathan and Wang (1996), and a Wald test on the joint pricing error. In addition, we also test the parameter stability using the supLM test, developed by Andrews (1993) and implemented in the asset pricing context by Ghysels (1998) and Hodrick and Zhang (2001). Ghysels finds that the parameters of conditional models tend to be more unstable relative to unconditional models, and Hodrick and Zhang show that while Campbell's (1996) model cannot be rejected for correct pricing of the FF25 portfolios, it fails the stability test. Following Ghysels and Hodrick and Zhang, the LM statistics are evaluated at 5% increments between 20% and 80% of the sample, the largest of which is the supLM statistic.

Are the factors Δdef and $\Delta term$ marginally useful in pricing assets given the market return? Since the three factors in our alternative model are correlated, an appropriate test to answer the above question is to see if $b = 0$ in equation (4), $y_{t+1} = b_0 + b'F_{t+1}$. Table 6 reports the GMM estimation results. b's for $\Delta term$ and HML are significantly different from zero, while b's for Δdef and SMB are not. With respect to the risk premium estimates, the FF3 model and our alternative model produce quite similar results, qualitatively as well as in terms of the magnitudes of the estimates. For the FF3 model, the risk premiums for the market return and HML are significantly positive while the risk premium for SMB is not significantly different from zero. Similarly for our alternative model, the risk premiums for the market return and $\Delta term$ are significantly positive while the risk premium for Δdef is not significantly different from zero. The risk premiums for the market return in the FF3 model and our alternative model are 0.5245 and 0.5507, respectively, and the risk premiums for HML and $\Delta term$ are 0.4246 and 0.2437, respectively. While the two models pass the supLM parameter stability test, they fare less well in terms of the HJ-distance test and Wald test. The p-values for the HJ-distance and Wald test statistics are 0.0000 and 0.0040 for the FF3 model, while those for our alternative model are 0.0159 and 0.0819, respectively.

To formally test our hypothesis that Δdef and $\Delta term$ summarize the information in SMB and HML relevant for pricing the FF25 portfolios, we conduct the χ^2 difference test of Newey and West (1987). This test can be implemented as follows. First, estimate an unrestricted model and then, using the optimal weighting matrix from the unrestricted model, estimate a restricted model. The factors of the unrestricted model are R_m, Δdef , $\Delta term$, SMB, and HML, while the factors of the restricted model are R_m, Δdef , and $\Delta term$. Hence, the restriction is that the coefficients on SMB, and HML are jointly zero. If the restriction is true, we can expect the difference in the J-statistics of the two models to be small. The test statistic is then defined as follows:

$$\chi^2 \text{ difference} \equiv TJ_T(\text{restricted}) - TJ_T(\text{unrestricted}) \sim \chi^2(\text{number of restrictions}). \quad (6)$$

We implement this test using our model as the restricted model to investigate if SMB and HML are superfluous in the presence of Δdef and $\Delta term$. Table 7 reports the estimation results for both the unrestricted and restricted models. As the χ^2 difference in the bottom row indicates, with our three-factor model as the null, the restriction that SMB and HML are superfluous in explaining the cross-section of the excess returns on the FF 25 portfolios and the return on the T-bill is not rejected. The test statistic is 2.3635 with the p-value of 0.3067, and this result suggests that Δdef and $\Delta term$ capture most of the pricing implications contained in SMB and HML.

6. Conclusion

We find that changes in the default spread (Δdef) and changes in the term spread ($\Delta term$) capture most of the systematic risks proxied by Fama and French (1993)'s size (SMB) and book-to-market (HML) factors. The Fama-French 25 portfolios' risk exposures (factor loadings) to Δdef and SMB share the same systematic pattern along the size dimension, and the risk exposures to $\Delta term$ and HML show the same systematic pattern along the book-to-market dimension. Consistent with this evidence from time-series regressions, the Generalized Method of Moments cross-sectional estimation and test results show that Δdef and $\Delta term$ are not only important risk factors in pricing the Fama-French 25 portfolios, but also contain most of the pricing implications of the Fama-French factors.

The empirical evidence in this paper suggests that higher average returns on small stocks and value stocks are compensation for higher risks not captured by the market beta, as exemplified in the pattern of covariances with Δdef and $\Delta term$. The default and term spreads are common macroeconomic variables unrelated to the manner in which portfolios are formed, and furthermore, as commonly used proxies for the market's expectation about credit market conditions and future interest rates, they are economically interpretable state variable proxies. Hence, this paper provides empirical support for a risk-based interpretation of the size and book-to-market effects and contributes to the debate on the economic link between the Fama-French factors and systematic risks.

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Table 1: Table 1. Summary statistics of the factors

Summary statistics of the factors					
Factors	R_m	SMB	HML	Δdef	$\Delta term$
			mean		
	0.4897	0.1952	0.4183	-0.0040	0.0020
			standard deviation		
	4.4463	3.2697	2.9906	0.1859	0.3062
			autocorrelation		
	0.0415	0.0976	0.1297	0.1700	0.2997
			correlation coefficient		
	R_m	SMB	HML	Δdef	$\Delta term$
R_m		0.2930	-0.4276	-0.1310	0.1361
SMB			-0.2929	0.1150	0.0511
HML				-0.0288	0.0848
Δdef					-0.2322

R_m, SMB, and HML are the three factors of Fama and French (1993). R_m is the value-weighted market return in excess of the one-month T-bill rate. SMB and HML are the Fama-French factors related to size and book-to-market ratio (BE/ME), which are constructed from six size-BE/ME portfolios. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. The sample period is from 1963:07 to 2001:06.

Table 2: Table 2. Factor regression

Dependent variable	Independent variables				
	constant	R_m	Δdef	$\Delta term$	R^2
SMB	0.10	0.23	2.93	0.51	0.11
	(0.66)	(5.69)	(3.41)	(1.32)	
	0.09	0.23	2.75		0.11
	(0.65)	(5.81)	(3.20)		
	0.09	0.21		0.12	0.08
	(0.61)	(5.47)		(0.29)	
HML	0.56	-0.31	-0.92	1.30	0.20
	(3.85)	(-7.04)	(-1.21)	(3.20)	
	0.56	-0.30	-1.39		0.19
	(3.76)	(-6.51)	(-1.91)		
	0.56	-0.30		1.42	0.20
	(3.89)	(-7.14)		(3.74)	

The numbers are coefficient estimates of the regressions with the associated t-statistics in parentheses. T-statistics are computed using Newey-West heteroscedastic-robust standard errors with 3 lags. The R^2 is adjusted for the number of degrees of freedom. R_m, SMB, and HML are the three factors of Fama and French (1993). R_m is the value-weighted market return in excess of the one-month T-bill rate. SMB and HML are the Fama-French factors related to size and book-to-market ratio (BE/ME), which are constructed form six size-BE/ME portfolios. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. The sample period is from 1963:07 to 2001:06.

Table 3: Table 3. Summary statistics for excess returns on FF25 portfolios

Summary statistics for excess returns on FF25 portfolios										
Size	Book-to-market quintiles									
quintiles	Low	2	3	4	High	Low	2	3	4	High
	means					standard deviations				
Small	0.28	0.79	0.84	1.02	1.10	8.21	7.04	6.14	5.72	5.93
2	0.42	0.66	0.90	0.95	1.01	7.42	6.01	5.37	5.12	5.62
3	0.43	0.71	0.71	0.85	0.98	6.85	5.48	4.96	4.68	5.22
4	0.56	0.48	0.69	0.84	0.94	6.10	5.18	4.84	4.58	5.30
Big	0.47	0.49	0.53	0.63	0.65	4.83	4.58	4.33	4.29	4.62
	t-statistics									
Small	0.73	2.40	2.91	3.81	3.98					
2	1.20	2.33	3.56	3.98	3.85					
3	1.32	2.77	3.07	3.87	4.01					
4	1.95	1.97	3.03	3.93	3.77					
Big	2.07	2.27	2.63	3.12	3.00					

The data are monthly returns (in percentage) on the Fama-French 25 portfolios in excess of the one-month T-bill rate from 1963:07 to 2001:06. Low to High denote the book-to-market ratio quintiles, and Small to Big denote the size (market capitalization) quintiles.

Table 4: Table 4. Time-series regression of alternative model

$$R^e_{j,t} = a_j + \beta^m_j R_{m,t} + \beta^{def}_j \Delta def_t + \beta^{term}_j \Delta term_t + e_{j,t}$$

Size quintiles	Book-to-market quintiles									
	Low	2	3	4	High	Low	2	3	4	High
			a					$t(a)$		
Small	−0.41	0.20	0.31	0.53	0.61	−1.43	0.85	1.50	2.72	2.86
2	−0.28	0.09	0.39	0.48	0.51	−1.33	0.53	2.48	2.96	2.73
3	−0.25	0.17	0.24	0.41	0.51	−1.51	1.17	1.62	2.75	2.77
4	−0.06	−0.05	0.21	0.41	0.46	−0.41	−0.38	1.57	3.08	2.73
Big	−0.03	0.02	0.11	0.24	0.27	−0.30	0.18	1.00	1.71	1.60
			β^m					$t(\beta^m)$		
Small	1.46	1.24	1.11	1.02	1.03	21.12	18.88	17.99	16.59	15.89
2	1.45	1.18	1.04	0.96	1.03	27.17	21.18	19.08	18.57	16.17
3	1.39	1.11	0.97	0.88	0.96	32.48	27.33	19.40	18.06	15.27
4	1.26	1.07	0.96	0.87	0.97	35.48	25.07	20.30	20.25	16.41
Big	1.02	0.95	0.84	0.77	0.77	37.67	31.35	20.63	17.37	13.65
			β^{def}					$t(\beta^{def})$		
Small	5.40	4.70	3.42	3.12	4.41	3.51	3.27	3.08	2.95	3.66
2	2.40	1.99	1.52	0.22	1.34	2.34	2.38	1.99	0.28	1.38
3	2.08	0.30	−0.13	−0.70	0.29	2.32	0.45	−0.16	−0.88	0.31
4	0.75	−0.60	−1.08	−2.32	−0.35	1.19	−1.07	−1.40	−3.34	−0.36
Big	0.10	−0.93	−2.02	−1.89	−0.52	0.17	−1.66	−2.66	−2.33	−0.55
			β^{term}					$t(\beta^{term})$		
Small	0.20	0.66	0.88	0.94	1.76	0.23	1.01	1.69	1.77	3.06
2	−0.70	0.57	0.83	0.98	1.26	−1.00	1.32	2.08	2.69	2.66
3	−0.43	0.17	0.60	1.08	1.13	−0.84	0.52	1.53	2.76	2.04
4	−0.08	0.23	0.60	0.89	1.17	−0.20	0.83	1.50	2.28	2.35
Big	−0.76	−0.22	−0.10	0.34	0.64	−2.31	−0.72	−0.26	0.77	1.36

$R^e_{j,t}$ is the monthly return (in percentage) on the Fama-French 25 portfolios in excess of the one-month T-bill rate. The sample period is from 1963:07 to 2001:06. Alternative model is our three-factor model where the risk factors are R_m, Δdef, and $\Delta term$. R_m is the value-weighted market return in excess of the one-month T-bill rate. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. $t()$ denotes t-statistics for the estimated coefficients. T-statistics are computed using Newey-West heteroscedastic-robust standard errors with 3 lags.

Table 5: Table 5. Time-series regression of the three-factor model of Fama and French (1993)

$$R^e_{j,t} = a + \beta^m_j R_{m,t} + \beta^{SMB}_j SMB_t + \beta^{HML}_j HML_t + e_{j,t}$$

Size	Book-to-market quintiles									
quintiles	Low	2	3	4	High	Low	2	3	4	High
			a					$t(a)$		
Small	−0.37	0.02	0.03	0.17	0.12	−3.06	0.27	0.35	2.51	1.67
2	−0.16	−0.09	0.08	0.09	0.01	−1.81	−1.16	1.06	1.16	0.11
3	−0.07	−0.01	−0.10	0.00	−0.01	−0.93	−0.06	−1.09	0.01	−0.05
4	0.16	−0.21	−0.09	0.05	−0.04	1.59	−2.03	−0.95	0.54	−0.37
Big	0.21	−0.03	−0.02	−0.10	−0.20	2.87	−0.43	−0.15	−1.21	−1.90
			β^m					$t(\beta^m)$		
Small	1.04	0.96	0.94	0.92	0.99	36.50	33.61	49.40	41.51	39.16
2	1.10	1.03	1.00	0.99	1.08	45.30	41.50	42.29	54.23	48.53
3	1.09	1.07	1.03	1.01	1.10	46.53	35.63	30.89	48.06	36.91
4	1.05	1.11	1.09	1.03	1.17	40.96	32.67	32.86	36.91	33.53
Big	0.96	1.05	0.99	1.02	1.03	40.45	44.53	32.47	45.47	29.79
			β^{SMB}					$t(\beta^{SMB})$		
Small	1.42	1.34	1.14	1.05	1.09	32.42	22.67	36.90	30.26	23.46
2	1.00	0.89	0.74	0.70	0.81	23.49	18.13	15.53	24.40	24.74
3	0.72	0.51	0.44	0.37	0.51	21.05	7.32	6.48	8.14	8.73
4	0.37	0.19	0.15	0.19	0.26	7.44	3.10	2.40	5.14	4.08
Big	−0.26	−0.24	−0.25	−0.23	−0.07	−7.98	−6.62	−5.94	−7.28	−1.53
			β^{HML}					$t(\beta^{HML})$		
Small	−0.31	0.09	0.31	0.47	0.69	−5.18	1.57	9.12	13.37	15.27
2	−0.38	0.19	0.43	0.59	0.76	−8.08	3.09	7.26	13.57	21.26
3	−0.42	0.23	0.52	0.67	0.83	−12.87	3.06	7.33	10.48	16.86
4	−0.45	0.26	0.51	0.61	0.84	−9.21	3.35	7.18	11.03	14.92
Big	−0.38	0.13	0.27	0.65	0.84	−9.76	2.40	5.20	12.41	17.92

$R^e_{j,t}$ is the monthly return (in percentage) on the Fama-French 25 portfolios in excess of the one-month T-bill rate. The sample period is from 1963:07 to 2001:06. R_m, SMB, and HML are the three factors of Fama and French (1993). R_m is the value-weighted market return in excess of the one-month T-bill rate. SMB and HML are the Fama-French factors related to size and book-to-market ratio (BE/ME), which are constructed form six size-BE/ME portfolios. $t()$ denotes t-statistics for the estimated coefficients. T-statistics are computed using Newey-West heteroscedastic-robust standard errors with 3 lags.

Table 6: Table 6. SDF estimation and model diagnostics

Panel A: Alternative model				
	constant	R^m	Δdef	$\Delta term$
	parameters of SDF			
b	1.0013	-0.0049	-0.3268	-2.6228
$s.e.$	(0.0410)	(0.0172)	(0.8014)	(0.8746)
	risk premium			
Λ		0.5507	-0.0240	0.2437
$s.e.$		(0.3273)	(0.0285)	(0.0812)
	model diagnostics			
supLM		10.7582	$pass$	
Wald		31.7406	(0.0819)	
HJ-distance		0.4045	(0.0159)	
Panel B: Fama-French three-factor model				
	constant	R^m	SMB	HML
	parameters of SDF			
b	1.0563	-0.0457	-0.0216	-0.0832
$s.e.$	(0.0260)	(0.0131)	(0.0169)	(0.0207)
	risk premium			
Λ		0.5245	0.1886	0.4246
$s.e.$		(0.2436)	(0.1846)	(0.1657)
	model diagnostics			
supLM		14.9742	$pass$	
Wald		43.5550	(0.0040)	
HJ-distance		0.4049	(0.0000)	

The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month T-bill rate and the return on the T-bill from 1963:07 to 2001:06. The three factors of alternative model are R_m, Δdef, and $\Delta term$. R_m is the value-weighted market return in excess of the one-month T-bill rate. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. The estimated parameters, b and Λ are defined in equations (4) and (5), respectively. $s.e.$ denotes the standard errors for the parameter estimates. P-values for Wald and HJ-distance test statistics are in parentheses. For the supLM statistics, $pass$ indicates the model passes the stability test at the 5% significance level, based on Table 1 in Andrews (1993).

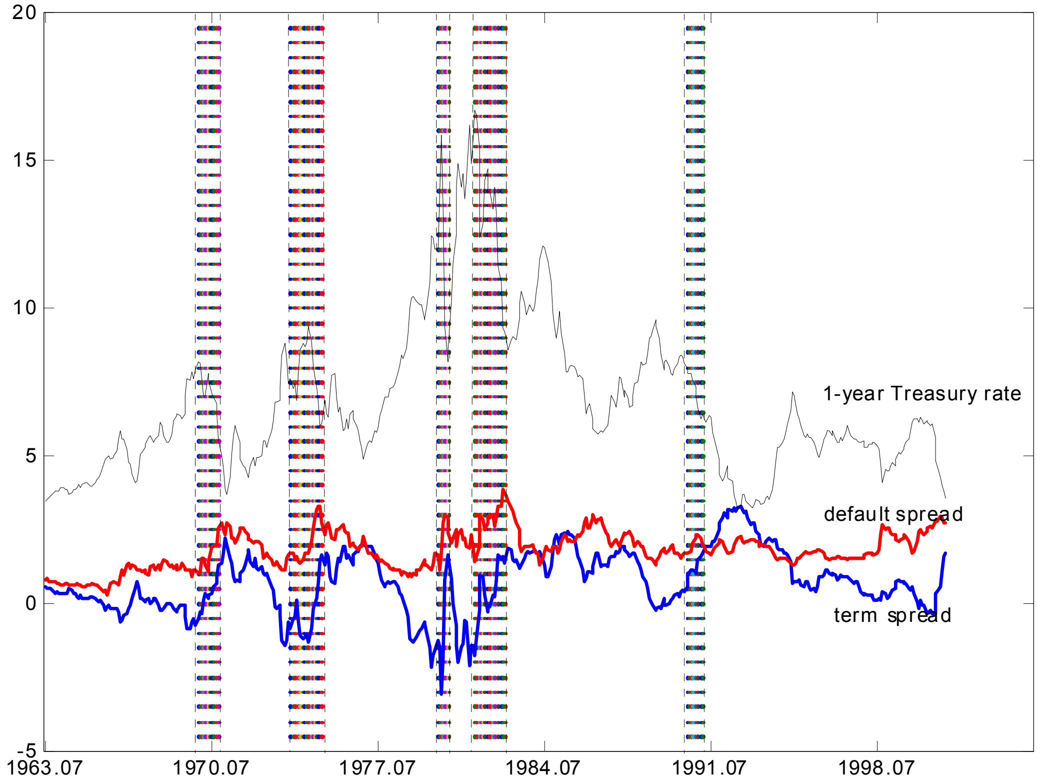
Table 7: Table 7. Chi-square difference test

Panel A: Unrestricted model						
	constant	R^m	Δdef	$\Delta term$	SMB	HML
	parameters of SDF					
b	1.0240	-0.0289	-0.0899	-1.6466	-0.0197	-0.0408
$s.e.$	(0.0397)	(0.0195)	(0.7501)	(0.8866)	(0.0179)	(0.0283)
	risk premium					
Λ		0.7287	-0.0214	0.1650	0.3117	0.2744
$s.e.$		(0.2711)	(0.0257)	(0.0800)	(0.1786)	(0.1765)
	model diagnostics					
J-statistics			33.4234	(0.0303)		

Panel B: Restricted model						
	constant	R^m	Δdef	$\Delta term$		
	parameters of SDF					
b	0.9845	-0.0125	-0.3401	-2.4098		
$s.e.$	(0.0308)	(0.0145)	(0.6845)	(0.7264)		
	risk premium					
Λ		0.6743	-0.0220	0.2295		
$s.e.$		(0.2695)	(0.0240)	(0.0682)		
	model diagnostics					
J-statistics			35.7869	(0.0320)		
χ^2-difference			2.3635	(0.3067)		

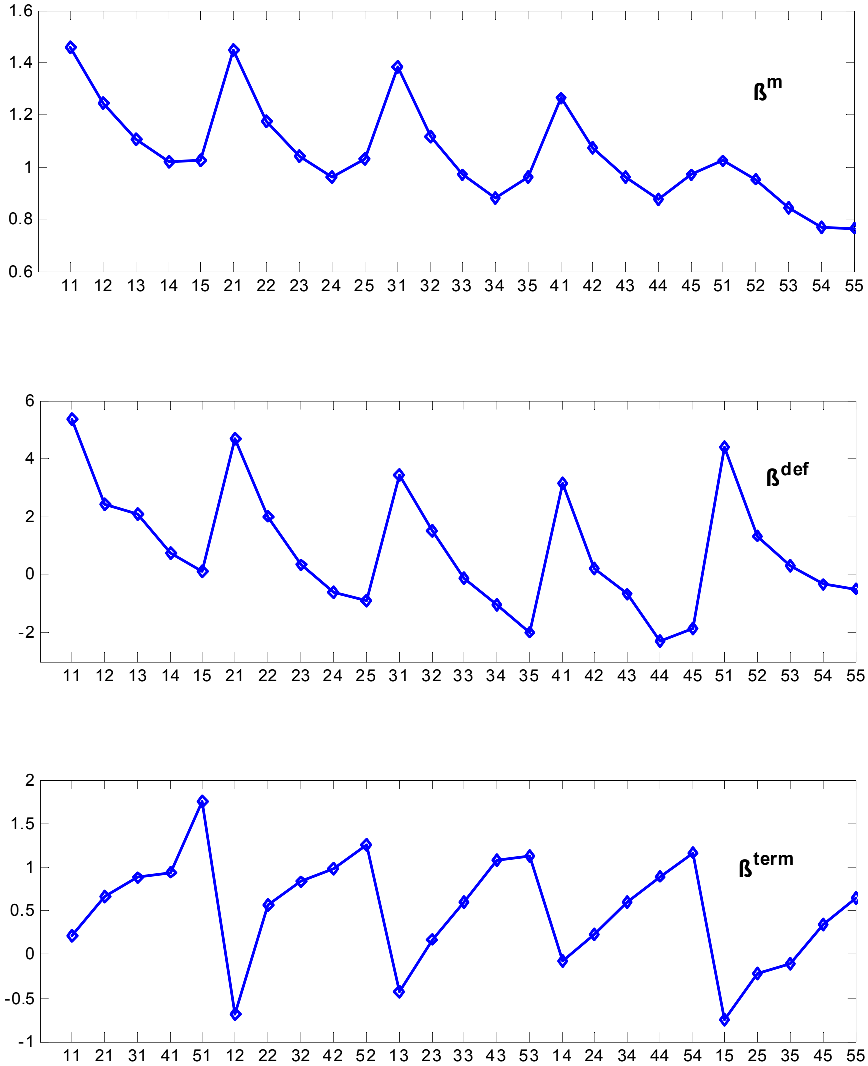
The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month T-bill rate and the return on the T-bill from 1963:07 to 2001:06. The factors of the unrestricted model are R_m, Δdef , $\Delta term$, SMB, and HML, while the factors of the restricted model are R_m, Δdef , and $\Delta term$. R_m, SMB, and HML are the three factors of Fama and French (1993). R_m is the value-weighted market return in excess of the one-month T-bill rate. SMB and HML are the Fama-French factors related to size and book-to-market ratio. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be the spread between 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. The estimated parameters, b and Λ are defined in equations (4) and (5), respectively. $s.e.$ denotes the standard errors for the parameter estimates. P-values for J-statistics and χ^2-difference test statistics are in parentheses.

Figure 1: Default spread and term spread



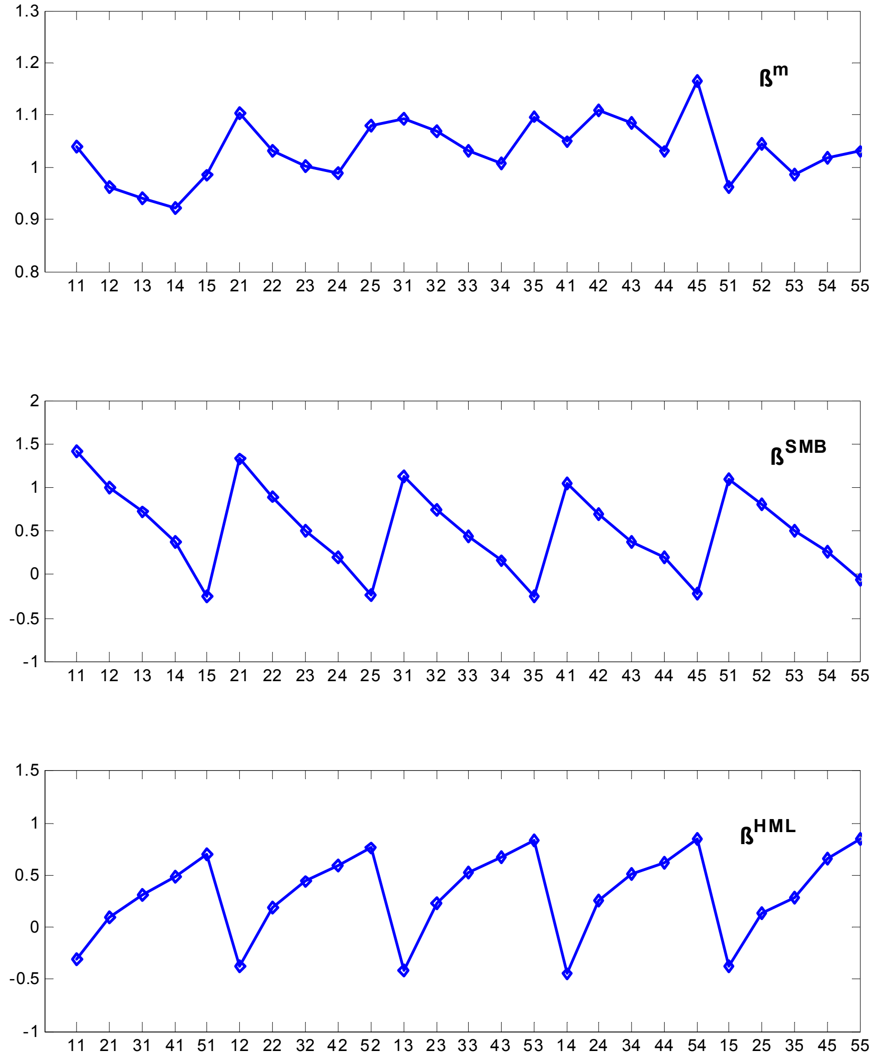
The default spread is defined as the spread between yield to maturity on Baa-rated corporate bond portfolio and 10-year Treasury constant maturity rate, and the term spread is defined to be 10-year Treasury constant maturity rate and 1-year Treasury constant maturity rate. The default spread is the dotted line, the term spread is the dashed line, and the 1-year Treasury constant maturity rate is the solid line. Shaded areas indicate periods of US recession, from NBER peaks to troughs. The sample period is from 1963:07 to 2001:06.

Figure 2: Loadings of the FF25 portfolios: Alternative model



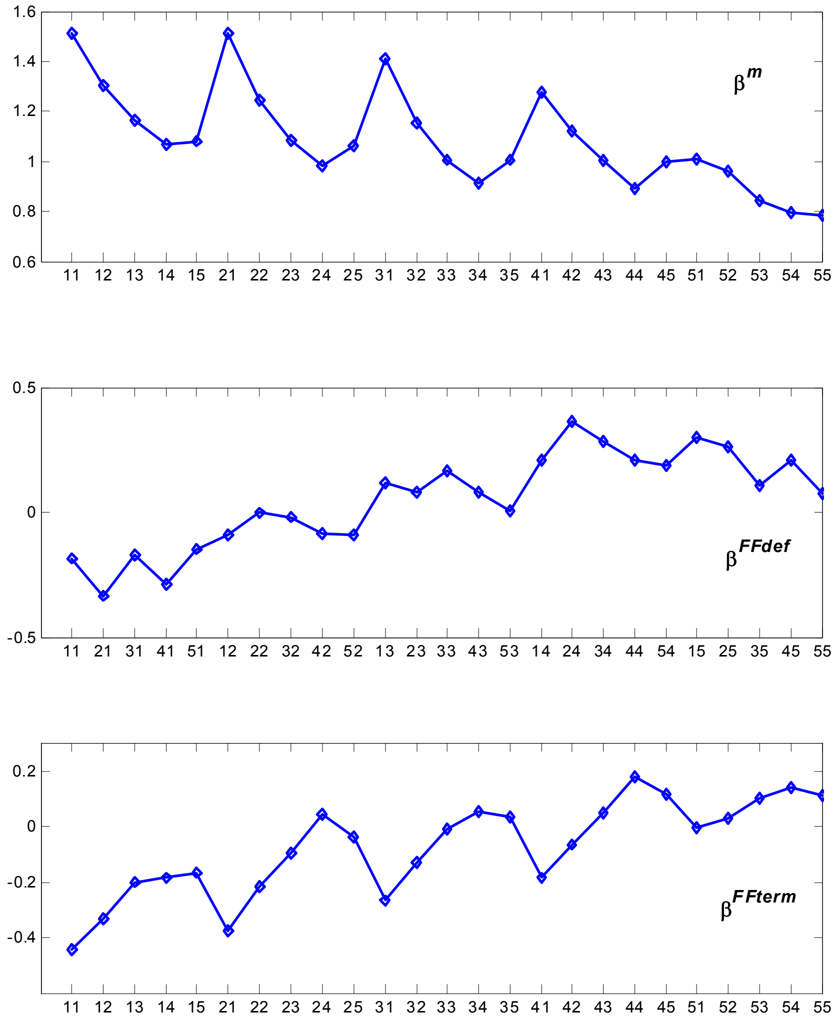
Alternative model is our three-factor model where the risk factors are R_m, Δdef, and $\Delta term$. R_m is the value-weighted market return in excess of the one-month T-bill rate. $\Delta def_{t+1} \equiv -(def_{t+1} - def_t)$, and $\Delta term_{t+1} \equiv term_{t+1} - term_t$, where def_t and $term_t$ are the default spread and term spread at time t. Top, middle, and bottom panels display the loadings of the FF 25 portfolios on these three factors, respectively, from the time-series regression $R^e_{j,t} = a_j + \beta^m_j R_{m,t} + \beta^{def}_j \Delta def_t + \beta^{term}_j \Delta term_t + e_{j,t}$. The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month T-bill rate from 1963:07 to 2001:06. The portfolio numbers on the x-axis are numbered ij with i indexing size increasing from one to five and j indexing book-to-market ratio increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintiles are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintiles are grouped together in the order of increasing book-to-market ratio.

Figure 3: Loadings of the FF25 portfolios: FF3 model



The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month T-bill rate from 1963:07 to 2001:06. The factors of the FF3 model are R_m, SMB, and HML. R_m is the value-weighted market return in excess of the one-month T-bill rate. SMB and HML are the Fama-French factors related to size and book-to-market ratio. Top, middle, and bottom panels display the loadings of the FF 25 portfolios on these three factors, respectively, from the time-series regression $R^e_{j,t} = a_j + \beta^m_j R_{m,t} + \beta^{SMB}_j SMB_t + \beta^{HML}_j HML_t + e_{j,t}$. The portfolio numbers on the x-axis are numbered ij with i indexing size increasing from one to five and j indexing book-to-market ratio increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintiles are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintiles are grouped together in the order of increasing book-to-market ratio.

Figure 4: Loadings of the FF25 portfolios: Fama and French's (1993) bond return factors



The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month T-bill rate from 1963:07 to 2001:06. The Fama-French bond return factors are the two bond market factors from Fama and French (1993). They are the difference between the return on a portfolio of corporate bonds (high grades) and the long-term (20 years) government bond return, denoted $FFdef$, and the difference between the long-term government bond return and the one-month T-bill rate, denoted $FFterm$. These bond market return data are from Ibbotson Associates. The three factors for the loadings are R_m, the value-weighted market return in excess of the one-month T-bill rate, $FFdef$, and $FFterm$. Top, middle, and bottom panels display the loadings of the FF 25 portfolios on these three factors, respectively, from the time-series regression $R^e_{j,t} = a_j + \beta^m_j R_{m,t} + \beta^{FFdef}_j FFdef_t + \beta^{FFterm}_j FFterm_t + e_{j,t}$. The portfolio numbers on the x-axis are numbered ij with i indexing size increasing from one to five and j indexing book-to-market ratio increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintiles are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintiles are grouped together in the order of increasing book-to-market ratio.