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

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Abstract

This paper investigates whether the size and book-to-market factors of Fama and French (1993) proxy for the risks associated with business cycle fluctuations. 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: small stock portfolios have higher loadings on Δdef than large stock portfolios, while high book-to-market portfolios have higher loadings on $\Delta term$ than low book-to-market portfolios. 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 changing credit market conditions and interest rates proxied by Δdef and $\Delta term$.

I. 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" (p. 38).

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[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), and Pastór and Stambaugh (2003).

[2]See Daniel and Titman (1997) and Lakonishok, Shleifer, and Vishny (1994) for behavioral interpretations and Lewellen (1999), Liew and Vassalou (2000), Vassalou (2003), Vassalou and Xing (2004), and Zhang (2005) for risk-based interpretations.

The fundamental reason for considerable debate over what underlies the size and book-to-market effects is that the Fama-French factors are the returns on the portfolios formed on the same characteristics, size and book-to-market, 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 also acknowledge that they "have not identified the two state variables of special hedging concern to investors that lead to three-factor asset pricing" (p. 76).

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. The selection 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 explain the cross-sectional pattern of asset returns. The default and term spreads are well known to forecast aggregate stock market returns (see, for example, Keim and Stambaugh (1986), Fama and French (1989)). 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 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 the cross-sectional pattern of stock returns in size and book-to-market.

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 opportunities 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 selection of state variable proxies, we specify a three-factor model in which the factors are the market portfolio excess return, changes in the default spread (Δdef), and changes in the term spread ($\Delta term$). Using Fama and

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

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

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' loadings on Δdef and *SMB* share the same systematic pattern along the size dimension, and the loadings on $\Delta term$ and *HML* show the same systematic pattern along the book-to-market dimension. Consistent with the evidence from time-series regressions, the Fama-MacBeth regression and generalized method of moments (GMM) cross-sectional estimation and test results show that Δdef and $\Delta term$ are important determinants for 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, regardless of the estimation method. The model diagnostics, in terms of the cross-sectional regression F test of Shanken (1985), the HJ-distance of Hansen and Jagannathan (1997), and a Wald test also show that the alternative model performs as well as or better than the FF3 model in explaining the cross section of the FF25 portfolio returns. 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., Daniel and Titman (1997) and Ferson, Sarkissian, and Simin (1999)). The macroeconomic variables Δdef and $\Delta term$ are, however, 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 business cycle fluctuations and, in particular, to revisions in the market's expectation of future interest rates proxied by $\Delta term$.

The implications of 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., versions of the conditional CAPM in Berk, Green, and Naik (1999), Ferson and Harvey (1999), Gomes, Kogan, and Zhang (2003), 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

[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.

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 III, we examine whether Δdef and $\Delta term$ capture the cross-sectional variation of the FF25 portfolio returns in the way *SMB* and *HML* do, paying particular attention to the pattern of factor loadings. In Section IV, we discuss how the findings in this paper are related to Fama and French's (1993) five-factor model that includes bond market factors similar to Δdef and $\Delta term$. Section V presents the cross-sectional estimation results from the Fama-MacBeth regressions, and Section VI contains the results of the GMM estimation of risk premia and model diagnostics. Section VII offers concluding remarks.

II. *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 index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10-year and one-year Treasury constant maturity rates. Stock and Watson (1989) find that the spread between six-month commercial paper and six-month Treasury bill rates and the yield spread between 10- and one-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 selecting 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 the 10-year Treasury rate.[6] The Baa yield is Moody's seasoned Baa corporate bond yield from Moody's Investors Service, and the 10- and one-year Treasury rates are from the Federal Reserve Board of Governors. The sample period for our analysis is 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 of 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 is commonly interpreted as signaling 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

[6] Using the yield spread between the Baa and Aaa corporate bond portfolios as the default spread does not alter the main findings.

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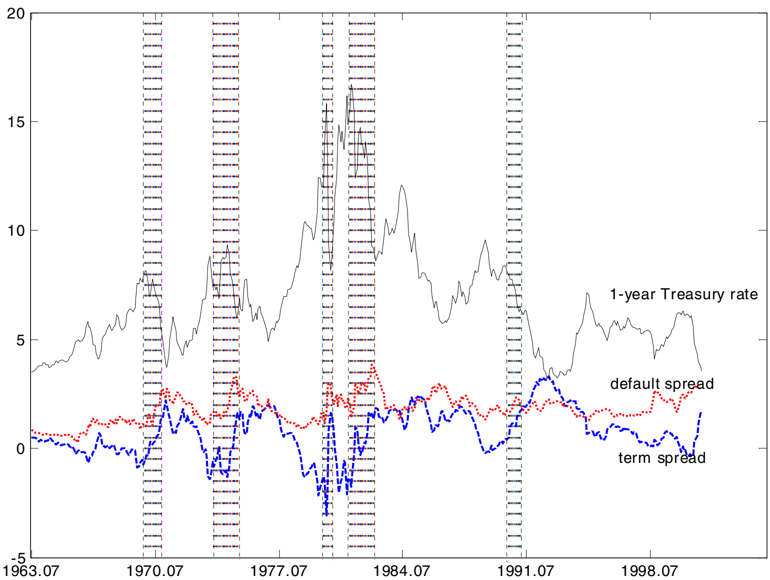
returns on *SMB* on average. Hence, we use the negative of changes in the default spread as an alternative macroeconomic proxy for *SMB*.

Figure 1 plots the term spread, default spread, and one-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 one-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) note 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 *HML*.

FIGURE 1

Default Spread, Term Spread, and the Business Cycle

The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. The default spread is the dotted line, the term spread is the dashed line, and the one-year Treasury constant maturity rate is the solid line. Shaded areas indicate periods of U.S. recession from NBER peaks to troughs. The sample period is July 1963 to June 2001.



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 to estimate a type of vector autoregressive models and 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-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.[7]

Table 1 reports summary statistics of the factors. R_m denotes the excess return on a market portfolio, for which we use the market factor of Fama and French's (1993) three factors. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME), which are constructed from six size BE/ME portfolios.[8] The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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.

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	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		
Factors	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

Note that since the Fama-French factors are in the form of portfolio excess returns, their sample means can be interpreted as estimates of their risk premia

[7]The results from using estimated innovations, not reported for brevity, are available from the authors.

[8]We thank Kenneth French for making the portfolio and factor data available on his Website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

if they proxy for systematic priced risks. The sample means of R_m and *HML* are fairly large (0.49% and 0.42% per month, respectively) and statistically different from zero. The sample mean of *SMB* is also positive (0.20% per month), but it is statistically insignificant. In contrast to the Fama-French factors, Δdef and $\Delta term$ are not in the form of portfolio excess returns and, therefore, their sample means may not be interpreted as estimates of their risk premia. The factor risk premium in this case can be estimated, for example, using a cross-sectional estimation method.[9]

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

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

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

Table 2 reports the coefficient estimates and the corresponding *t*-statistics (in parentheses) from the above regressions. After 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*.

TABLE 2

Factor Regressions

The numbers reported are coefficient estimates of the regressions with the associated *t*-statistics in parentheses. The *t*-statistics are computed using Newey-West heteroskedastic-robust standard errors with three lags. The R^2s are adjusted for the number of degrees of freedom. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. The sample period is July 1963 to June 2001.

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

[9]For more details, see Cochrane (2001).

We also investigate 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 six-month commercial paper and six-month Treasury bill rates in place of or in addition to Δdef, and the yield spread between a one-year Treasury bond and a three-month Treasury 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 $\Delta term$. Moreover, 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 cycle.[10] 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 in the way that *SMB* and *HML* do? The next section addresses this question.

III. Fama-French Portfolios' Loadings on Δdef and $\Delta term$

We estimate the factor loadings of the FF25 portfolios on our alternative three-factor model by the following time-series regression,

$$R_{j,t} \quad = \quad a_j + \beta_j^m R_{m,t} + \beta_j^{def} \Delta def_t + \beta_j^{term} \Delta term_t + e_{j,t}, \tag{3}$$

where $R_{j,t}$ is the excess return on portfolio j at time t. 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 presents summary statistics for the FF25 portfolio returns, which clearly show a systematic pattern of the portfolios' average returns along the size and book-to-market dimensions. Our goal here is to investigate whether the loadings on Δdef and $\Delta term$ show that the pattern is consistent with this cross-sectional variation in average returns.

The results from the time-series regressions specified in equation (3) 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 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 load-

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

TABLE 3

Summary Statistics for Excess Returns on FF25 Portfolios

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

	Book-to-Market Quintiles									
Size Quintiles	Low	2	3	4	High	Low	2	3	4	High
	Mean					*t*-Statistic				
Small	0.28	0.79	0.84	1.02	1.10	0.73	2.40	2.91	3.81	3.98
2	0.42	0.66	0.90	0.95	1.01	1.20	2.33	3.56	3.98	3.85
3	0.43	0.71	0.71	0.85	0.98	1.32	2.77	3.07	3.87	4.01
4	0.56	0.48	0.69	0.84	0.94	1.95	1.97	3.03	3.93	3.77
Big	0.47	0.49	0.53	0.63	0.65	2.07	2.27	2.63	3.12	3.00

ings 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 regressions that 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 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 the size quintile from one (smallest) to five (biggest) and *j* indexing the book-to-market quintile from one (lowest) to five (highest). Note that in the middle panels, five portfolios of the same book-to-market quintile are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintile 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 may be due to the varying degrees of exposure to the risks proxied by Δdef and $\Delta term$. Note that the factor proxies Δdef and $\Delta term$ are not portfolio excess returns, which implies that the usual time-series regression test of the intercepts being jointly zero, such as the F test of Gibbons, Ross, and Shanken (1989), is not strictly applicable to our model. We provide formal tests and comparison of the models below in Sections V and VI in the cross-sectional estimation framework.

In contrast to the size and book-to-market effects, the momentum effect of Jegadeesh and Titman (1993) does not seem to arise from the business cycle-related risks proxied by Δdef and $\Delta term$. Time-series regression results show

TABLE 4

Time-Series Regressions: Alternative Model

Table 4 reports the time-series regression results for the following regression specification,

$$R_{j,t} = a_j + \beta_j^m R_{m,t} + \beta_j^{def} \Delta def_t + \beta_j^{term} \Delta term_t + e_{j,t},$$

where $R_{j,t}$ is the monthly return (in percentage) on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. The sample period is July 1963 to June 2001. $t()$ denotes t-statistics for the estimated coefficients. The t-statistics are computed using Newey-West heteroskedastic-robust standard errors with three lags.

	Book-to-Market Quintiles									
Size 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

that the loser portfolios load more on Δdef and $\Delta term$ than the winner portfolios, which is the opposite of what we would expect if the higher average returns on short-term winners are compensation for higher exposure to the risks proxied by Δdef and $\Delta term$.[11] 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*.

IV. Relation to Fama and French's (1993) Five-Factor Model

Fama and French (1993) investigate the pricing implications of the bond market factors similar to Δdef and $\Delta term$ for 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

[11]Time-series regression results for the momentum portfolios, not reported for brevity, are available from the authors.

TABLE 5

Time-Series Regressions: Three-Factor Model of Fama and French (1993)

Table 5 reports the time-series regression results for the three-factor model of Fama-French (1993) specified as

$$R_{j,t} = a_j + \beta_j^m R_{m,t} + \beta_j^{SMB} SMB_t + \beta_j^{HML} HML_t + e_{j,t},$$

where $R_{j,t}$ is the monthly return (in percentage) on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. R_m denotes the excess return on a market portfolio, for which we use the market factor of Fama and French's (1993) three factors. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. The sample period is July 1963 to June 2001. $t()$ denotes t-statistics for the estimated coefficients. The t-statistics are computed using Newey-West heteroskedastic-robust standard errors with three lags.

Size Quintiles	Book-to-Market 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

bond return, which we denote *FFdef*, and the difference between the long-term government bond return and the one-month Treasury bill rate, which we denote *FFterm*.[12] 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? One of the reasons for the difference is that 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 spec-

[12]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 describes the composition of the corporate bond index (high grades and maturities of approximately 20 years) and the long-term government bond (maturities of 20 years).

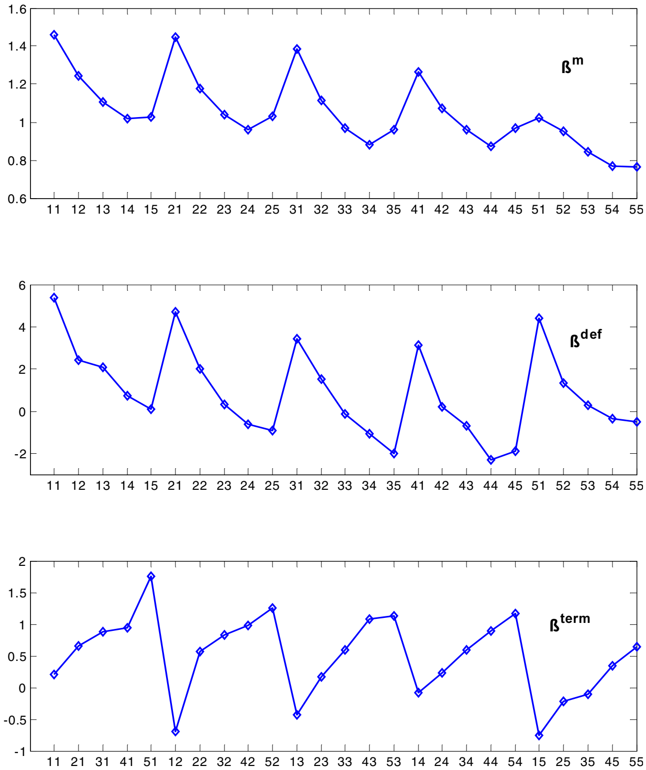
FIGURE 2

Loadings of the FF25 Portfolios: Alternative Model

The three panels in Figure 2 display the loadings of the FF25 portfolios estimated from the following time-series regression specification,

$$R_{j,t} \quad = \quad a_j + \beta_j^m R_{m,t} + \beta_j^{def} \Delta def_t + \beta_j^{term} \Delta term_t + e_{j,t},$$

where $R_{j,t}$ is the monthly return on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. The sample period is July 1963 to June 2001. The portfolio numbers on the x-axis are numbered *ij* with *i* indexing the size quintile increasing from one to five and *j* indexing the book-to-market quintile increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintile are grouped together in the order of increasing size, whereas in the rest of the panels, five portfolios of the same size quintile are grouped together in the order of increasing book-to-market ratio.



ification is not a problem in the context of the 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. Therefore, 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

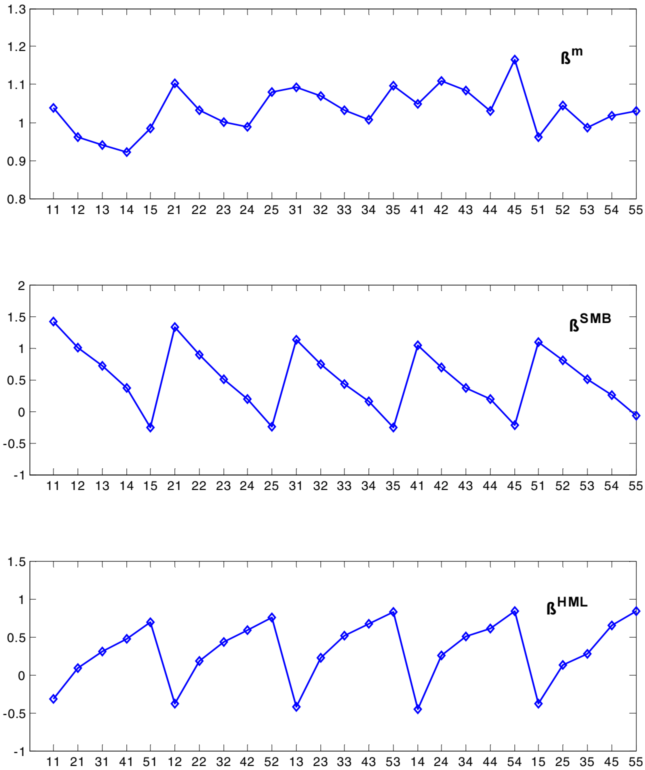
FIGURE 3

Loadings of the FF25 Portfolios: Fama-French Three-Factor Model

The three panels in Figure 3 display the loadings of the FF25 portfolios estimated from the following time-series regression specification,

$$R_{j,t} \quad = \quad a_j + \beta_j^m R_{m,t} + \beta_j^{SMB} SMB_t + \beta_j^{HML} HML_t + e_{j,t},$$

where $R_{j,t}$ is the monthly return on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. The sample period is July 1963 to June 2001. The portfolio numbers on the x-axis are numbered *ij* with *i* indexing the size quintile increasing from one to five and *j* indexing the book-to-market quintile increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintile are grouped together in the order of increasing size, whereas in the rest of the panels five portfolios of the same size quintile are grouped together in the order of increasing book-to-market ratio.



portfolio return factor, they also include *SMB* and *HML* in the regression, which is their five-factor specification. Our finding indicates that the pricing implications of *SMB* and Δdef and *HML* and $\Delta term$ are very similar, as exemplified in the pattern of the FF25 portfolios' 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 a 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 pattern disappears in the five-factor specification.[13]

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.[14]

V. Fama-MacBeth (1973) Cross-Sectional Estimation

While the time-series regression results thus far are supportive of our hypothesis, they do not tell us whether our alternative three-factor specification performs better than or as well as the FF3 model in pricing the cross section of the FF25 portfolio returns. Note that our factor proxies Δdef and $\Delta term$ are not portfolio excess returns, which implies that the sample means of Δdef and $\Delta term$ do not correspond to their estimated risk premia. Therefore, the intercept in the time-series regression does not correspond to the pricing error of the model for a given portfolio, and the usual test of the null hypothesis of the pricing errors being jointly zero, such as the F test of Gibbons, Ross, and Shanken (1989), is not strictly applicable.[15]

When the factors are not portfolio returns, the factor risk premia can be estimated using a two-pass cross-sectional regression approach developed by Fama and MacBeth (1973) and Shanken (1992), or via a GMM estimation of a stochastic discount factor representation of a given linear factor model. While the GMM approach imposes less stringent statistical assumptions than the traditional Fama-MacBeth regression approach, the small sample properties of GMM may be a concern for the reliability of the estimates. Thus, for robustness, we report the estimation results from the Fama-MacBeth regression as well as from the GMM estimation.

Table 6 reports the results from the Fama-MacBeth regressions. The t-statistics for the slope coefficients are computed using Shanken's (1992) adjusted standard errors, which correct for the bias introduced by the sampling errors in the

[13]See Tables 3, 7a, and 8a in Fama and French (1993).

[14]The results on the statistical significance of these estimates (loadings on *FFdef* and *FFterm*) are available from the authors. Overall, the significance is much weaker than the significance for the estimates of the loadings on Δdef and $\Delta term$.

[15]Shanken (1992) and Cochrane (2001) provide detailed explanations.

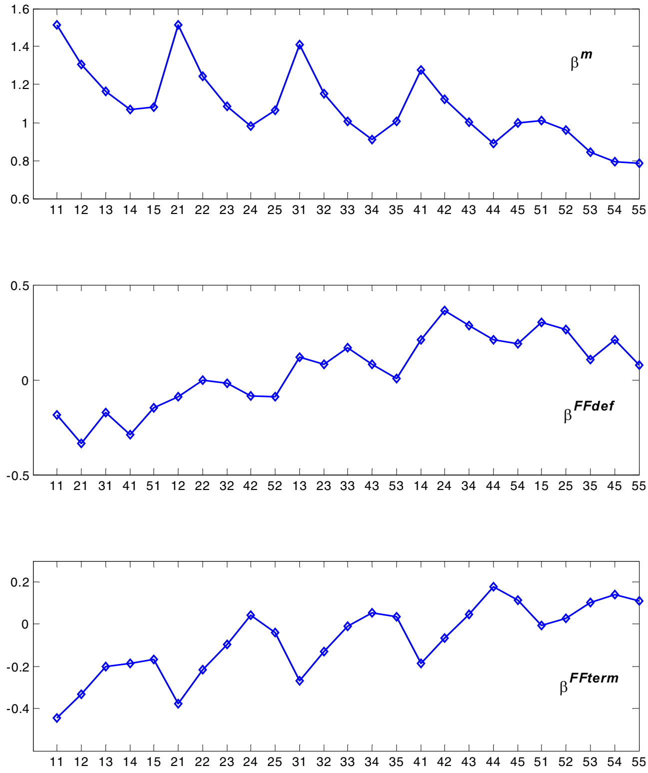
FIGURE 4

Loadings of the FF25 Portfolios: Fama and French's (1993) Bond Market Factors

The three panels in Figure 4 display the loadings of the FF25 portfolios estimated from the following time-series regression specification,

$$R_{j,t} \quad = \quad a_j + \beta_j^m R_{m,t} + \beta_j^{FFdef} FFdef_t + \beta_j^{FFterm} FFterm_t + e_{j,t},$$

where $R_{j,t}$ is the monthly return on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. $R_{m,t}$ is the value-weighted market return in excess of the one-month Treasury bill rate. The bond market factors from Fama and French (1993) 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 Treasury bill rate denoted *FFterm*. The sample period is July 1963 to June 2001. The portfolio numbers on the x-axis are numbered *ij* with *i* indexing the size quintile increasing from one to five and *j* indexing the book-to-market quintile increasing from one to five. Note that in the middle panel, five portfolios of the same book-to-market quintile are grouped together in the order of increasing size, whereas in the rest of the panels five portfolios of the same size quintile are grouped together in the order of increasing book-to-market ratio.



estimated betas. The R^2s of the regressions are adjusted R^2s from the regression of the average portfolio returns on a constant and the estimated betas.

Panel A of Table 6 shows the well-known failure of the CAPM to explain the cross-sectional variation of the FF25 portfolio returns. The estimated market risk premium is negative and statistically insignificant (-0.54% with a t-statistic of -1.18). The R^2 of the regression is 15%, i.e., only 15% of the cross-sectional variation of the FF25 portfolios' average returns can be explained by this speci-

TABLE 6

Fama-MacBeth Regressions

Table 6 reports the regression coefficients and the associated *t*-statistics from the Fama-MacBeth (1973) regressions for the sample period July 1963 to June 2001. The dependent variable, R_t, is the cross section of the monthly return on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. In Panel A, the independent variables are a constant and the cross section of $\widehat{\beta}^m$, the estimated slope coefficients from a time-series regression of R_j on a constant and R_m for each portfolio j ($j = 1, \ldots, 25$). $R_{m,t}$ is the value-weighted market return in excess of the one-month Treasury bill rate. In Panel B, the independent variables are a constant and the cross section of $\widehat{\beta}^m$, $\widehat{\beta}^{SMB}$, and $\widehat{\beta}^{HML}$, which are the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, *SMB*, and *HML* for each portfolio j. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. In Panel C, the independent variables are a constant and the cross section of $\widehat{\beta}^m$, $\widehat{\beta}^{def}$, and $\widehat{\beta}^{term}$, which are the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, Δdef, and $\Delta term$ for each portfolio j. The *t*-statistics are computed using Shanken's (1992) adjusted standard errors. The R^2s of the regressions are adjusted R^2s from the regression of the average portfolio returns on a constant and the estimated betas. The *F* test statistic and the associated *p*-value (in parentheses) report Shanken's (1985) cross-sectional regression test of the linear expected return-beta relation.

Panel A. CAPM

$$R_t = \gamma_0 + \gamma_m \widehat{\beta}^m + \varepsilon_t$$

	γ_0	γ_m			R^2	*F* Test
Coefficient	1.29	−0.54			15%	2.32
t-statistic	3.16	−1.18				(0.0006)

Panel B. Fama-French Three-Factor Model

$$R_t = \gamma_0 + \gamma_m \widehat{\beta}^m + \gamma_{SMB} \widehat{\beta}^{SMB} + \gamma_{HML} \widehat{\beta}^{HML} + \varepsilon_t$$

	γ_0	γ_m	γ_{SMB}	γ_{HML}	R^2	*F* Test
Coefficient	1.16	−0.64	0.16	0.44	71%	2.05
t-statistic	3.20	−1.51	0.99	2.97		(0.0043)

Panel C. Alternative Model

$$R_t = \gamma_0 + \gamma_m \widehat{\beta}^m + \gamma_{def} \widehat{\beta}^{def} + \gamma_{term} \widehat{\beta}^{term} + \varepsilon_t$$

	γ_0	γ_m	γ_{def}	γ_{term}	R^2	*F* Test
Coefficient	0.75	−0.17	0.01	0.29	76%	1.72
t-statistic	1.61	−0.31	0.16	2.53		(0.0256)

fication. Panel B shows the substantial improvement in performance for the FF3 model, as indicated by the R^2 of 71%. Note that the slope coefficient on $\widehat{\beta}^{SMB}$ is not statistically different from zero, while the slope coefficient on $\widehat{\beta}^{HML}$ is both economically and statistically significant (0.44% per month with a *t*-statistic of 2.97).[16] The results for the alternative model, reported in Panel C, show that it performs better than the FF3 model in explaining the cross-sectional variation in the FF25 portfolio returns, as indicated by the R^2 of 76%. The slope coefficient on $\Delta term$ is both economically and statistically significant (0.29% per month with a *t*-statistic of 2.53), while the slope coefficient on $\widehat{\beta}^{def}$ is small in magnitude and statistically insignificant. Note, however, that this is not inconsistent with our argument for Δdef and $\Delta term$ being good proxies for the risks underlying *SMB* and *HML* since the slope coefficient on $\widehat{\beta}^{SMB}$ is also statistically insignificant as reported in Panel B.

The cross-sectional explanatory power of a given factor depends not only on the magnitude of the factor risk premium, but also on the dispersion of the factor loadings. Let us provide a comparison of the cross-sectional explanatory power of *HML* and $\Delta term$ in the following informal yet intuitively straightforward

[16]These results for the CAPM and the FF3 model are consistent with previous findings. For example, see Ferguson and Shockley (2003).

way. As reported in Table 3, the biggest dispersion in average returns along the book-to-market dimension within the same size group is 0.82% per month for small firms (0.28% average excess return for the Small/Low portfolio and 1.1% average excess return for the Small/High portfolio). How much of this dispersion is accounted for by the difference in the portfolios' loadings on *HML*? Similarly, how much of this dispersion is accounted for by the difference in the portfolios' loadings on $\Delta term$?

As reported in Table 5, the difference in the loadings on *HML* across these two portfolios is 1.0 (0.69 for the Small/High portfolio and -0.31 for the Small/Low portfolio). Since the estimated risk premium on *HML* is 0.44 (Table 6), we can say that 54% of the difference in average returns across these two portfolios can be accounted for by the difference in their loadings on *HML*. On the other hand, the difference in the loadings on $\Delta term$ across these two portfolios, as reported in Table 4, is 1.56 (1.76 for the Small/High portfolio and 0.2 for the Small/Low portfolio), and the estimated risk premium for $\Delta term$ is 0.29 (Table 6). Thus, 55% of the difference in average returns across these two portfolios can be accounted for by the difference in these two portfolio's loadings on $\Delta term$. This simple comparison suggests that the explanatory power of the $\Delta term$ factor is quite comparable to the explanatory power of the *HML* factor.

The last column in Table 6 presents Shanken's (1985) cross-sectional regression F test of the linear expected return-beta relation. Shanken proposes this F test as an alternative to the asymptotic χ^2 test to avoid the problem of a potentially large type I error associated with relying on an asymptotic theory when the sample size is small. Consistent with previous findings, the CAPM is rejected with a p-value of 0.0006. The FF3 model is also rejected with a p-value of 0.0043, while the p-value of our alternative model is 0.0256.[17] These test results are qualitatively consistent with the results from the GMM estimation discussed in Section VI.

Figure 5 illustrates the performance of these models in three fitted versus actual average monthly excess returns plots. The top panel illustrates the poor performance of the CAPM, while the middle panel shows the improvement of the FF3 model over the CAPM. The bottom panel shows that the alternative model exhibits the best performance, graphically illustrating the model's highest R^2.

Next, we investigate whether *SMB* and *HML* are superfluous in explaining the cross section of the FF25 portfolio returns in the presence of Δdef and $\Delta term$.[18] We first construct the portion of *SMB* orthogonal to Δdef and $\Delta term$, $SMB^{\perp}$, as the estimated intercept plus the monthly series of residuals from the following time-series regression,

$$SMB_t = a_0 + a_1 \Delta def_t + a_2 \Delta term_t + e_t. \tag{4}$$

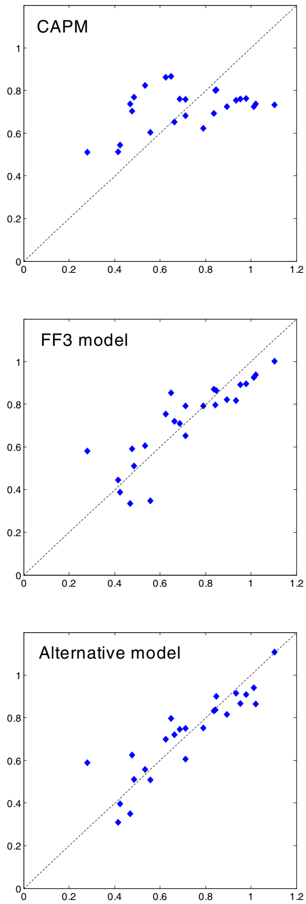
[17]The qualitative difference in the test statistics of the FF3 model and our alternative model appears to be mostly attributable to the greater sampling error in the estimated betas $\widehat{\beta}^{def}$ and $\widehat{\beta}^{term}$. Without the errors-in-variables adjustment, the alternative model is also rejected at the 1% level of significance. The asymptotic χ^2 test also yields qualitatively similar results.

[18]The design of this test is similar to the one performed in Ferguson and Shockley (2003).

FIGURE 5

Fitted versus Realized Returns for the FF25 Portfolios

The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate from July 1963 to June 2001. The realized average monthly excess returns are on the x-axis, and the fitted monthly excess returns are on the y-axis. The fitted returns for the three panels are computed based on the Fama-MacBeth (1973) regression estimates presented in Table 6 for the three models. In the top panel, the fitted returns are computed as $\gamma_0 + \gamma_m \widehat{\beta}_j^m$. $\widehat{\beta}_j^m$ is the estimated slope coefficient from a time-series regression of R_j on a constant and R_m for each portfolio j ($j = 1, \ldots, 25$). γ_0 and γ_m are the Fama-MacBeth regression coefficients reported in Panel A of Table 6. In the middle panel, the fitted returns are computed as $\gamma_0 + \gamma_m \widehat{\beta}_j^m + \gamma_{SMB} \widehat{\beta}_j^{SMB} + \gamma_{HML} \widehat{\beta}_j^{HML}$. $\widehat{\beta}_j^m$, $\widehat{\beta}_j^{SMB}$, and $\widehat{\beta}_j^{HML}$ are the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, SMB, and HML for each portfolio j. SMB and HML are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. γ_0, γ_m, γ_{SMB}, and γ_{HML} are the Fama-MacBeth regression coefficients reported in Panel B of Table 6. In the bottom panel, the fitted returns are computed as $\gamma_0 + \gamma_m \widehat{\beta}_j^m + \gamma_{def} \widehat{\beta}_j^{def} + \gamma_{term} \widehat{\beta}_j^{term}$. $\widehat{\beta}_j^m$, $\widehat{\beta}_j^{def}$, and $\widehat{\beta}_j^{term}$ are the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, Δdef, and $\Delta term$ for each portfolio j. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. γ_0, γ_m, γ_{def}, and γ_{term} are the Fama-MacBeth regression coefficients reported in Panel C of Table 6.



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The portion of HML orthogonal to Δdef and $\Delta term$, $HML^{\perp}$, is constructed similarly from the following time-series regression,

$$HML_t \quad = \quad a_0 + a_1 \Delta def_t + a_2 \Delta term_t + e_t. \tag{5}$$

Then, we run the Fama-MacBeth regression using the estimated betas from the time-series regression of the FF25 portfolios using the five factors, R_m, $SMB^{\perp}$, $HML^{\perp}$, Δdef, and $\Delta term$. Panel A of Table 7 reports the results. Augmenting the alternative model with orthogonalized SMB and HML does not improve the performance: the slope coefficients on $\widehat{\beta}^{SMB\perp}$ and $\widehat{\beta}^{HML\perp}$ are both statistically insignificant and the R^2 remains at 76%, showing no improvement over the alternative model. In other words, most of the cross-sectional explanatory power of $\widehat{\beta}^{SMB}$ and $\widehat{\beta}^{HML}$ are captured by $\widehat{\beta}^{def}$ and $\widehat{\beta}^{term}$.

TABLE 7

Fama-MacBeth Regressions: Fama-French Three-Factor Model versus Alternative Model

Table 7 reports the regression coefficients and the associated t-statistics from the Fama-MacBeth (1973) regressions for the sample period July 1963 to June 2001. The dependent variable, R_t, is the cross section of the monthly return on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate. In Panel A, the independent variables are a constant and the cross section of $\widehat{\beta}^{m}$, $\widehat{\beta}^{SMB}$, $\widehat{\beta}^{HML}$, $\widehat{\beta}^{def\perp}$, and $\widehat{\beta}^{term\perp}$, which are the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, SMB, HML, $\Delta def^{\perp}$, and $\Delta term^{\perp}$ for each portfolio j. R_m denotes the excess return on a market portfolio, for which we use the market factor of Fama and French's (1993) three factors. SMB and HML are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. $\Delta def_t^{\perp}$ is the sum of the intercept and residual from regressing Δdef on a constant, SMB and HML. $\Delta term_t^{\perp}$ is the sum of the intercept and residual from regressing $\Delta term$ on a constant, SMB and HML. In Panel B, the independent variables are a constant and the cross section of $\widehat{\beta}^{m}$, $\widehat{\beta}^{SMB\perp}$, $\widehat{\beta}^{HML\perp}$, $\widehat{\beta}^{def}$, and $\widehat{\beta}^{term}$, the estimated slope coefficients from a time-series regression of R_j on a constant, R_m, $SMB^{\perp}$, $HML^{\perp}$, Δdef, and $\Delta term$ for each portfolio j. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. $SMB_t^{\perp}$ is the sum of the intercept and residual from regressing SMB on a constant, Δdef, and $\Delta term$. $HML_t^{\perp}$ is the sum of the intercept and residual from regressing HML on a constant, Δdef, and $\Delta term$. The t-statistics are computed using Shanken's (1992) adjusted standard errors. The R^2s of the regressions are adjusted R^2s from the regression of the average portfolio returns on a constant and the estimated betas. The F test statistic and the associated p-value (in parentheses) report Shanken's (1985) cross-sectional regression test of the linear expected return-beta relation.

Panel A. Alternative Model with Marginal Contribution of SMB and HML Factors

$$R_t = \gamma_0 + \gamma_m \widehat{\beta}^{m} + \gamma_{SMB\perp} \widehat{\beta}^{SMB\perp} + \gamma_{HML\perp} \widehat{\beta}^{HML\perp} + \gamma_{def} \widehat{\beta}^{def} + \gamma_{term} \widehat{\beta}^{term} + \varepsilon_t$$

	γ_0	γ_m	$\gamma_{SMB\perp}$	$\gamma_{HML\perp}$	γ_{def}	γ_{term}	R^2	F Test
Coefficient	1.15	−0.59	−0.04	0.20	−0.02	0.27	76%	1.88
t-statistic	2.48	−1.08	−0.17	0.95	−0.46	2.63		(0.0142)

Panel B. Fama-French Three-Factor Model with Marginal Contribution of Δdef and $\Delta term$ Factors

$$R_t = \gamma_0 + \gamma_m \widehat{\beta}^{m} + \gamma_{SMB} \widehat{\beta}^{SMB} + \gamma_{HML} \widehat{\beta}^{HML} + \gamma_{def\perp} \widehat{\beta}^{def\perp} + \gamma_{term\perp} \widehat{\beta}^{term\perp} + \varepsilon_t$$

	γ_0	γ_m	γ_{SMB}	γ_{HML}	$\gamma_{def\perp}$	$\gamma_{term\perp}$	R^2	F Test
Coefficient	1.15	−0.59	0.15	0.42	−0.02	0.26	76%	1.88
t-statistic	2.48	−1.08	0.74	2.16	−0.49	2.58		(0.0142)

We also investigate whether Δdef and $\Delta term$ are superfluous in explaining the cross section of the FF25 portfolio returns in the presence of SMB and HML. The portion of Δdef orthogonal to SMB and HML, $\Delta def^{\perp}$, is constructed as the estimated intercept plus the monthly series of residuals from the following time-series regression,

$$\Delta def_t \quad = \quad a_0 + a_1 SMB_t + a_2 HML_t + e_t. \tag{6}$$

The portion of $\Delta term$ orthogonal to SMB and HML, $\Delta term^{\perp}$, is also constructed similarly as the estimated intercept plus the monthly series of residuals from the following time-series regression,

$$\Delta term_t \quad = \quad a_0 + a_1 SMB_t + a_2 HML_t + e_t. \tag{7}$$

Then, we run the Fama-MacBeth regression using the estimated betas from the time-series regression of the FF25 portfolios using the five factors, R_m, SMB, HML, $\Delta def^{\perp}$, and $\Delta term^{\perp}$. Panel B of Table 7 reports the results. Notice that the slope coefficient on $\widehat{\beta}^{term\perp}$ is both economically and statistically significant (0.26% per month with a t-statistic of 2.58), indicating that SMB and HML do not fully capture the cross-sectional explanatory power of $\Delta term$. Taken together, the results in Table 7 suggest that Δdef and $\Delta term$ capture most of the cross-sectional explanatory power of SMB and HML.

VI. GMM Cross-Sectional 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 present several test diagnostics for our hypothesis.

The law of one price 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 portfolio j at time $t+1$, and $p_{j,t}$ is the price for portfolio j at time t. We specify the following linear model for the stochastic discount factor,

$$y_{t+1} \quad = \quad b_0 + b' F_{t+1}, \tag{8}$$

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.

Ross (1978) and Dybvig and Ingersoll (1982) show that a linear model for the stochastic discount factor such as (8) has an equivalent beta pricing model representation,[19]

$$E(R) \quad = \quad R^0 p + \beta' \Lambda, \tag{9}$$

where p is the vector of p_js, $R^0 = 1/E(y)$, $\beta = \mathrm{cov}(F, F')^{-1}\,\mathrm{cov}(F, R')$, and $\Lambda = -R^0\,\mathrm{cov}(F, F')b$. 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 Treasury bill rate and the gross return on the Treasury bill.

[19]Cochrane (1996) also provides a simple proof of the relation.

We estimate the models using the optimal GMM of Hansen (1982) as well as the HJ-distance approach of Hansen and Jagannathan (1997), and find 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. Therefore, 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 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 $\sup LM$ 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. 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 $\sup LM$ statistic.

Are the factors Δdef and $\Delta term$ marginally useful in pricing assets given the market return? Table 8 reports the GMM estimation results. The bs for $\Delta term$ and HML are significantly different from zero, while bs 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 portfolio and HML are significantly positive while the risk premium for SMB is not significantly different from zero. Similarly, for the alternative model, the risk premiums for the market portfolio and $\Delta term$ are significantly positive while the risk premium for Δdef is not significantly different from zero. The risk premiums for the market portfolio 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 $\sup LM$ parameter stability test, they fare less well in terms of the HJ-distance and Wald tests. The p-values for the HJ-distance and Wald test statistics are 0.0001 and 0.0036 for the FF3 model, while those for our alternative model are 0.0151 and 0.0770.

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

TABLE 8

SDF Estimation and Model Diagnostics

The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate and the return on the Treasury bill from July 1963 to June 2001. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME), which are constructed from six size BE/ME portfolios. The estimated parameters, b and Λ, are defined in equations (8) and (9), respectively. S.E. denotes the standard errors for the parameter estimates. The p-values for the Wald and HJ-distance test statistics are in parentheses. For the sup *LM* statistics, Pass indicates the model passes the stability test at the 5% significance level based on Table 1 in Andrews (1993).

Panel A. Alternative Model

	Constant	R^m	Δdef	$\Delta term$
	Parameters of SDF			
b	1.0013	−0.0049	−0.3268	−2.6228
S.E.	(0.0408)	(0.0171)	(0.7978)	(0.8708)
	Risk Premium			
Λ		0.5507	−0.0240	0.2437
S.E.		(0.3258)	(0.0284)	(0.0809)
	Model Diagnostics			
sup *LM*		10.8534	Pass	
Wald		32.0215	(0.0770)	
HJ-distance		0.4045	(0.0151)	

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.	(0.0259)	(0.0131)	(0.0169)	(0.0207)
	Risk Premium			
Λ		0.5245	0.1886	0.4246
S.E.		(0.2425)	(0.1838)	(0.1650)
	Model Diagnostics			
sup *LM*		15.1067	Pass	
Wald		43.9404	(0.0036)	
HJ-distance		0.4049	(0.0001)	

expect the difference in the J-statistics of the two models to be small. The test statistic is then defined as

$$\text{(10)} \qquad \begin{aligned} \chi^2 \text{ difference} &\equiv TJ_T(\text{restricted}) - TJ_T(\text{unrestricted}) \\ &\sim \chi^2(\text{number of restrictions}). \end{aligned}$$

We implement this test using our model as the restricted model to investigate whether *SMB* and *HML* are superfluous in the presence of Δdef and $\Delta term$. Table 9 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 FF25 portfolios and the return on the Treasury bill is not rejected. The test statistic is 2.3950 with a p-value of 0.3020, and this result suggests that Δdef and $\Delta term$ capture most of the pricing implications contained in *SMB* and *HML*. Notice that this result is also consistent with the finding from the Fama-MacBeth (1973) regression reported in Panel A of Table 7.

TABLE 9

χ^2 Difference Test

The portfolio data are monthly returns on the Fama-French 25 portfolios in excess of the one-month Treasury bill rate and the return on the Treasury bill from July 1963 to June 2001. R_m denotes the excess return on a market portfolio for which we use the market factor of Fama and French's (1993) three factors. The default and term spread factors are defined as follows: $\Delta def_t \equiv -(def_t - def_{t-1})$, 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. The default spread is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate, and the term spread is defined as the spread between 10- and one-year Treasury constant maturity rates. *SMB* and *HML* are the Fama-French factors related to size and book-to-market (BE/ME) that are constructed from six size BE/ME portfolios. The estimated parameters, b and Λ, are defined in equations (8) and (9), respectively. S.E. denotes the standard errors for the parameter estimates. The p-values for the J-statistics and χ^2 difference test statistic are in parentheses.

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.	(0.0395)	(0.0194)	(0.7402)	(0.8807)	(0.0177)	(0.0281)
			Risk Premium			
Λ		0.7287	−0.0214	0.1650	0.3117	0.2744
S.E.		(0.2693)	(0.0256)	(0.0795)	(0.1774)	(0.1754)
			Model Diagnostics			
J-statistic			33.8691	(0.0270)		

Panel B. Restricted Model

	Constant	R^m	Δdef	$\Delta term$
			Parameters of SDF	
b	0.9845	−0.0125	−0.3401	−2.4098
S.E.	(0.0306)	(0.0144)	(0.6800)	(0.7216)
			Risk Premium	
Λ		0.6743	−0.0220	0.2295
S.E.		(0.2677)	(0.0234)	(0.0677)
			Model Diagnostics	
J-statistic			36.2640	(0.0284)
χ^2 difference			2.3950	(0.3020)

VII. 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's (1993) size (*SMB*) and book-to-market (*HML*) factors. The Fama-French 25 portfolios' factor loadings on Δdef and *SMB* share the same systematic pattern along the size dimension, and the factor loadings on $\Delta term$ and *HML* show the same systematic pattern along the book-to-market dimension. Consistent with this evidence from time-series regressions, cross-sectional estimation and test results show that Δdef and $\Delta term$ are important factors in pricing the Fama-French 25 portfolios and contain most of the pricing implications of the Fama-French factors.

The findings in this paper suggest 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 macroeconomic variables unrelated to the manner in which portfolios are formed. 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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