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An inquiry into the economic fundamentals of the Fama and French equity factors

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ABSTRACT

This study investigates the economic underpinnings of the Fama and French three-factor (FF3) model. We evaluate the impact of surprises in 23 different types of macroeconomic announcements on stock returns in the framework of the CAPM and the FF3 model. The relative merit of the FF3 model is demonstrated whenever macroeconomic surprises have a smaller impact on the returns within an FF3 model versus their impact within the CAPM. In general, there is strong evidence to suggest that the FF3 model outperforms the CAPM. The relative merit of the FF3 model is highlighted by its ability to capture information related to Personal Consumption, Retail Sales, CPI, PPI, Factory Orders, Leading Indicators, Construction Spending, Housing Starts, and New Home Sales. An attribution analysis of the relative performance of SMB and HML equity factors indicate that both factors, in isolation, equally account for macroeconomic surprises. Lastly, there is evidence that the FF3 model can be marginally improved by incorporating credit variables.

1. Introduction

There is now a substantial body of empirical work in finance that has reported patterns in average stock returns that are inconsistent with the Capital Asset Pricing Model (CAPM) of Sharpe (1964) and Lintner (1965). For example, Fama and French (hereafter FF), taking an admittedly ad hoc approach, in a series of articles (1992, 1993, 1995, 1996), show the pragmatic utility of firm size (ME, market value of equity) and book-to-market value of equity (BE/ME) in explaining the cross-sectional returns on stocks.[2] The interpretation of this evidence has received a lot of attention in the literature and continues to be a subject of ample debate. On the one hand, researchers argue that ME and BE/ME are company-specific factors–which means that the risk associated with them might be eliminated through diversification–rather than pervasive risk factors or state variables, and therefore the observed significance of the FF factors is indicative of irrational investor behavior or market inefficiencies (see for example, Lakonishok et al., 1994; LaPorta, 1996; LaPorta et al., 1997; Mun et al., 2000). Still others, such as Kothari, Shanken and Sloan (1995) and MacKinlay (1995), cite several reasons, including: sample selection biases, data mining, beta estimation, and trading frictions, in downplaying the economic importance of the FF factors.

In responding to these concerns, FF posit that while size and BE/ME variables are ad hoc, and do not technically meet the definition of pervasive risk factors, they may still proxy for such variables.[3] Along this line of inquiry Perez-Quiros and

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[2] The importance of pre-determined, firm-specific fundamental variables such as size, BE/ME ratio and earnings/price ratio in determining the average stock returns was earlier established by studies such as Basu (1977), Banz (1981), Reinganum (1981), Jaffe, Keim and Westerfield (1989), and Dimson and Marsh (1999).

[3] Fama and French (1996) present evidence that their three-factor model is a three-factor version of the APT or ICAPM.

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Timmermann (2000) indicate that small firms have high average returns because they are more susceptible to changes in credit market conditions. Since the availability of credit is tied to underlying economic factors, the higher returns to small firms can be viewed as a compensation for the high sensitivity to a credit-related risk factor. The relationship between FF factors and economic state variables is further supported by Liew and Vassalou (2000) who show that the FF factors are able to predict future GDP growth in some countries, and Hahn and Lee (2006) who find that changes in term and default yield spreads capture most of the systematic risks proxied by the size and BE/ME factors (also see Vassalou and Xing, 2004). Interestingly, changes in term and default yield spreads are, themselves, theoretically linked to underlying macroeconomic risk factors (see, for example, Ramchander et al., 2005).

In summary, there appears to be a divergence of evidence regarding the economic argumentation and interpretation of the FF factors. Furthermore, existing studies are inadequate in comprehensively exploring the relationship between the FF factors and specific types of macroeconomic variables with which they may be associated. This led Lewellen (1999) to conclude that, "the rational pricing story [of the FF factors] will remain incomplete, and perhaps unconvincing, until we know more about the underlying risks." Therefore, any meaningful resolution to this debate would have to answer questions such as, "Can specific fundamentals be identified as state variables that lead to common variation in returns that is independent of the market and carries a different premium than general market risk?" (FF 1993), and "What are the underlying economic state variables that produce variation in earnings and returns related to size and BE/ME?" (FF 1994).

The current study offers a novel approach to uncovering the economic underpinnings of the FF factors by examining the precise manner in which the factor premiums relate to 23 types of periodic macroeconomic announcements. Through this analysis we are able to show, across firms with different size and BE/ME characteristics, the types of macroeconomic information that are better represented by the three-factor FF (FF3) model than the CAPM. We extend this analysis to examine two additional issues. First, we examine whether the performance of the FF3 model in controlling for the impact of different categories of macroeconomic surprises can be attributed to either the SMB or HML factor. Second, we compare the FF3 model with an enhanced five-factor model that includes quality and term spread variables in terms of their ability to reflect macroeconomic information.

The rest of the paper is organized as follows. Section 2 discusses the data used in the analyses, while Section 3 explains the methodology. Section 4 presents the results and Section 5 offers some concluding remarks.

2. Data

There are two sets of data used in our analysis: returns on Fama–French portfolios sorted by ME and BE/ME, and the unanticipated component in 23 types of macroeconomic announcements. The monthly data cover the twelve-year time period beginning from January 1, 1991 through December 31, 2002.[4]

The analysis of FF (1993, 1995, and 1996) provides the basis for the creation of portfolios that represent common factors. Specifically, all non-financial stocks listed on the NYSE, AMEX, and NASDAQ are divided into six intersecting portfolios on the basis of two size portfolios and three portfolios based on book-to-market ratios. The threshold point for dividing stocks between big and small is the median value of market capitalization on the NYSE at mid-year. The breakpoints of the BE/ME ratios are the 30th and 70th percentiles corresponding with growth, neutral, and value portfolios. The SMB portfolio is created by subtracting the average return on the three large portfolios from the average return on the three small portfolios: SMB = 1/3(Small Value + Small Neutral + Small Growth) − 1/3(Big Value + Big Neutral + Big Growth). The HML portfolio is created by subtracting the average return on the two growth portfolios from the two value portfolios: HML = 1/2(Small Value + Big Value) − 1/2(Small Growth + Big Growth).[5]

This study examines whether the FF factors capture news related to underlying economic state variables to a greater degree than does the CAPM. This approach will help us identify those economic variables that are most likely to be represented by the book-to-market and size-based factors. Therefore, we estimate both the FF3 model and the CAPM using 25 portfolios formed by the intersection of the quintiles of the universe of stocks sorted by size (ME) and book value (BE/ME).[6]

With regards to the second data set, the study employs consensus (median) forecasts of 23 types of periodic macroeconomic news releases provided by Money Market Services (MMS), together with the actual values of the macroeconomic announcements to compute the unanticipated component, or surprise, in each announcement (i.e., Surprise = Actual − Forecast). These announcements, which are instantaneously disseminated to the market, are released periodically on pre-announced dates, and hence not clustered in time.[7] In the analysis, we regress the dependent variables on the surprise component of the announcements, regardless of when during the month the announcement was made.

[4] This time frame is chosen because this is the longest period over which the survey data on the macroeconomic announcements is available. The majority of these series begin in 1990 or 1991, and there is no consistent data available for the series before that.

[5] The returns on the six component portfolios are obtained from Kenneth French's website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/.

[6] The size (BE/ME) quintiles are arranged from small (low) to big (high) and correspond with quintiles 1 through 5, respectively.

[7] For instance, the employment report which contains information on average hourly earnings, non-farm payroll and the unemployment rate is announced on the first Friday of the month. Furthermore, the use of this survey data is particularly appealing in that the surprises generated by their use display very low correlation with each other, thus mitigating any concerns about multicollinearity. The average correlation among the surprises in the macroeconomic announcements is 0.01, while the standard deviation of the correlations among the surprises in the macroeconomic announcements is 0.12.

The value of the surprise is normalized by its standard deviation in order to help us compare the magnitude of each macroeconomic announcement's impact on the dependent variables. Several studies such as Pearce and Roley (1985) and Almeida, Goodhart and Payne (1998), among others, have noted the unbiased nature of the forecast provided by MMS.

It must be emphasized that, in well-functioning capital markets, macroeconomic survey forecasts provide useful information to agents as they update their expectations about the future state of the economy. For the most part, such changes in expectations are unobservable to the econometrician. It is in this framework that survey-based expectations data have become increasingly popular in the financial economics literature as they offer a unique window into the nature and process of expectations formation. For instance, it is only at the time of the news release that market participants learn how accurate their past expectations have been, and consequently adjust their current expectations accordingly. Consequently, survey data on macroeconomic forecasts have been used in a variety of contexts. Studies have examined the impact of surprises in macroeconomics announcements on currency markets (Andersen et al., 2003), yield curve modeling (Balduzzi et al., 2001), and Treasury futures prices (Simpson and Ramchander, 2004), among others.

Each of the 23 different types of macroeconomic announcements used in this study conveys unique information about some aspect of the state of the overall economy. In order to better understand the information content of each announcement, and to help interpret the empirical results, the twenty-three announcements are divided into five broad categories–consumer demand, inflation, interest rates, economic growth, and real estate–each related to the economy in a different way. The categorization of the macroeconomic announcements into these general categories is meant only as an aide to exposition, and is not meant to deny some amount of overlap among the announcements.

2.1. Consumer demand

Consumer demand is recognized as one of the important driving forces in the economy. Aside from the obvious short-run effects of an increase in consumer demand, a sustained increase in consumer demand can eventually lead to investment in capital equipment and a higher rate of growth for the overall economy.

Five of the twenty-three types of macroeconomic announcements considered in this study are hypothesized to reveal information on consumer demand. They are Auto Sales, Business Inventories, Personal Income, Personal Consumption Expenditures, and Retail Sales.

2.2. Inflation

Inflation is probably one of the most widely watched economic indicators given its impact on the real wealth and the real income of consumers, and its influence on interest rates (via the Fisher effect) and exchange rates (via the Purchasing Power Parity effect).

The most widely cited inflation indicator is the Consumer Price Index (CPI) which is a measure of the price level of a fixed market basket of goods and services purchased by consumers. In comparison, the Producer's Price Index (PPI) measures the price of inputs into the production process and hence provides an indication of wholesale inflation.

Capacity Utilization is also an important indicator of inflationary pressures. For instance, when an economy is operating at a high percentage of its productive capacity, ceteris paribus, there is likely to be more inflationary pressure than when it is at a low percentage of capacity.

The three remaining inflationary indicators in our study come from the Employment Situation Report: the Unemployment Rate, Non-farm Payrolls, and Hourly Earnings. An increase in the non-farm payroll number, or a decrease in the unemployment rate, is considered an indication of a strengthening economy. At the same time, increased demand for labor, and/or a higher price for labor–as indicated by the Hourly Earnings figure–could also lead to inflationary expectations.

2.3. Interest rates

The level of interest rates, which is closely tied to inflationary expectations, plays an important role in determining the demand for durable and capital goods, and thereby the rate of growth of the economy. Announcements on Consumer Credit and the Treasury Budget are hypothesized to influence domestic interest rates through demand and supply interactions in the loanable funds market.

2.4. Economic growth

We have classified 7 of the 23 types of macroeconomic variables to be primarily associated with economic growth.

The Durable Goods Orders release measures the dollar volume of orders, shipments, and unfilled orders of durable goods. Factory Orders consist of the earlier announced durable goods report plus non-durable goods orders. The index of Industrial Production is a constant-weighted measure of the physical output of the nation's factories, mines, and utilities.

The Leading Indicators report is, for the most part, a compendium of other economic indicators: new orders, jobless claims, money supply, average workweek, building permits, and stock prices. Also, included in the Leading Indicators report is the expectational component of the consumer sentiment index, and thus a possible link to consumer demand. Trade Balance is the country's merchandise exports minus its imports. An improvement in the trade balance benefits economic growth, and

furthermore influences the currency market as market participants revise their estimates of the supply and demand for dollars.

The final two economic growth variables are the Gross Domestic Product (GDP) growth rates and the United States National Association of Purchasing Manager's Index (NAPM, or the Institute of Supply Manager's, ISM, Index) which indicate the status of the overall economy and the manufacturing sector, respectively. The NAPM index is based on a survey of several hundred factory purchasing managers.

2.5. Real estate

Information about the real estate sector can be obtained from the announcements in the Construction Report, Housing Starts and New Home Sales.

The Construction Spending report is broken down between residential, non-residential, and public expenditures on new construction. As a component of investment, construction spending could be seen as a leading indicator of economic growth, but a lagging indicator of residential and commercial mortgage interest rates.

Similarly, Housing Starts and New Home Sales are indicators of conditions in the housing market and can signal economic growth, and/or lower mortgage interest rates.

3. Methodological issues

The methodological framework is designed to explore three central issues: 1) identify a set of macroeconomic variables whose information is better captured by the FF3 model than by the CAPM, 2) determine which of the two extra-market factors in the FF3 model, SMB or HML, account for the increase in the performance of the model with respect to the different categories of macroeconomic variables, and 3) compare the performance of the FF3 model with a five- factor model in which the three-factor FF model is augmented with interest rate default and term spread variables.

3.1. Evaluating the relative merit of the Fama–French three-factor model versus the CAPM

If the factors related to firm size and book-to-market-value are proxies for fundamental economic state variables it should be possible, and indeed may be beneficial, to determine exactly which macroeconomic variables are explicitly represented by the three-factor model, that are not captured by the CAPM.

The empirical analysis comparing the FF3 with the CAPM is conducted in three steps. In the first step, each one of the 25 portfolio returns that are formed from the intersections of size and BE/ME quintiles are fitted to an *augmented* CAPM and an *augmented* FF3 model using *seemingly unrelated regression* analysis (SUR) (see Eqs. (1) and (2)). The augmented model is defined as one which includes various types of macroeconomic surprises as additional explanatory variables, estimated as follows:[8]

$$r_{t,s,b} - rf_t = \alpha_{c,s,b} + \beta_{c,s,b}(\mathrm{MKT}_t - rf_t) + \sum_{i=1}^{23} \lambda_{i,c,s,b} A_{i,t} + \varepsilon_{t,c,s,b} \tag{1}$$

$$r_{t,s,b} - rf_t = \alpha_{f,s,b} + \beta_{f,s,b}(\mathrm{MKT}_t - rf_t) + q_{f,s,b}\,\mathrm{SMB}_t + v_{f,s,b}\,\mathrm{HML}_t + \sum_{i=1}^{23} \lambda_{i,f,s,b} A_{i,t} + \varepsilon_{t,f,s,b} \tag{2}$$

where, $r_{t,s,b}$ is the monthly return, at time t, on the portfolio comprised of the stocks in the sth size quintile, and the bth BE/ME quintile, MKT_t is the return on the value-weighted CRSP index at time t, SMB_t is the FF size premium at time t, HML_t is the FF book value premium at time t, and rf_t is the one-month T-bill rate (as compiled by Ibbotson Associates). The variables ($A_{i,t}$) are the surprises in the 23 types of macroeconomic announcements. The coefficients carry the subscripts f, s, b or c, s, b, indicating that they are from the regression that fit the returns of the portfolio in the $_s$th size quintile and the bth BE/ME quintile, either to the Fama–French three-factor model (f) or to the CAPM (c).

In the second step, the performance of the FF3 model vis-à-vis CAPM is evaluated by comparing the impact of the surprises in the 23 types of macroeconomic announcements ($A_{i,t}$) in Eqs. (1) and (2).

To the extent that macroeconomic announcements have a larger influence in Eq. (1) versus Eq. (2) it can be said that the FF3 model is better at controlling for macroeconomic announcements than the CAPM. In order to ascertain the differential performance of the FF3 model relative to the CAPM, we compare the difference in the absolute values of the coefficients ($\mathrm{DIF}_{i,s,b}$) of each macroeconomic announcement for a given set of returns regressed in the augmented CAPM and FF3 equations. In other words,

$$\mathrm{DIF}_{i,s,b} = |\lambda_{i,c,s,b}| - |\lambda_{i,f,s,b}| \tag{3}$$

where, $\lambda_{i,c,s,b}$ and $\lambda_{i,f,s,b}$ are the announcement variable coefficients in Eqs. (1) and (2), respectively.

[8] The use of seemingly unrelated regression analysis and Wald Coefficient test statistics allows for the computation of the covariances among the coefficients in the separate regressions. This would ensure the asymptotic validity of the test statistics, given that the coefficients arise from related data. We thank one of the paper's anonymous reviewers for this suggestion.

The statistical significance of each DIF variable is determined by a Wald coefficient test statistic with the following null and alternate hypotheses:[9]

$$H_0 : |\lambda_{i,c,s,b}| = |\lambda_{i,f,s,b}| \tag{4}$$

$$H_a : |\lambda_{i,c,s,b}| > |\lambda_{i,f,s,b}| \tag{5}$$

A summary of the Wald test results is provided in Table 1, and discussed in the results section of the paper.

In the second step, we examine the combined impact of specific categories of macroeconomic announcements on portfolios comprised of different size and BE/ME quintiles of stocks. For the sake of illustration, the following discussion outlines the procedure followed in determining the aggregate impact on each size quintile that spans across the five BE/ME quintiles. The corresponding analysis of evaluating the response of each BE/ME quintile that spans across the five size quintiles is undertaken in an analogous fashion.

For each size quintile, *s*, the following 10 equation system is estimated via SUR:

$$r_{t,s,1} - rf_t = \alpha_{c,s,1} + \beta_{c,s,1}(\mathrm{MKT}_t - rf_t) + \sum_{i=1}^{23} \lambda_{i,c,s,1} A_{i,t} + \varepsilon_{t,c,s,1} \tag{6}$$

$$r_{t,s,2} - rf_t = \alpha_{c,s,2} + \beta_{c,s,2}(\mathrm{MKT}_t - rf_t) + \sum_{i=1}^{23} \lambda_{i,c,s,2} A_{i,t} + \varepsilon_{t,c,s,2} \tag{7}$$

$$\vdots$$

$$r_{t,s,5} - rf_t = \alpha_{c,s,5} + \beta_{c,s,5}(\mathrm{MKT}_t - rf_t) + \sum_{i=1}^{23} \lambda_{i,c,s,5} A_{i,t} + \varepsilon_{t,c,s,5} \tag{8}$$

and

$$r_{t,s,1} - rf_t = \alpha_{f,s,1} + \beta_{f,s,1}(\mathrm{MKT}_t - rf_t) + q_{f,s,1}\mathrm{SMB}_t + v_{f,s,1}\mathrm{HML}_t + \sum_{i=1}^{23} \lambda_{i,f,s,1} A_{i,t} + \varepsilon_{t,f,s,1} \tag{9}$$

$$\vdots$$

$$r_{t,s,5} - rf_t = \alpha_{f,s,5} + \beta_{f,s,5}(\mathrm{MKT}_t - rf_t) + q_{f,s,5}\mathrm{SMB}_t + v_{f,s,5}\mathrm{HML}_t + \sum_{i=1}^{23} \lambda_{i,f,s,5} A_{i,t} + \varepsilon_{t,f,s,5} \tag{10}$$

In Eqs. (6)–(10), the number after *s* indicates the BE/ME quintile of the portfolio. Thus, each 10 equation SUR estimation analyses the portfolios across the five BE/ME quintiles within a particular size quintile, *s*.

In order to measure the relative performance of the two asset pricing models in controlling for macroeconomic announcements across the portfolios in a particular quintile we calculate the sum of the difference in the absolute values of the coefficients on a particular announcement from the matched sets of equations for the augmented FF3 and augmented CAPM (i.e., $|\lambda_{i,c,s,b}| - |\lambda_{i,f,s,b}|$). These are summed across the five sets of equations in each size quintile, *s*, and summed across all of the macroeconomic announcements in a particular category, *g*, where *g* is one of the five groups of macroeconomic announcements. For example, there are 5 announcements in

[9] For our purposes, in Eq. (4) we wish to test the null hypothesis that the absolute value of the coefficient on the surprise in the *i*th macroeconomic announcement from the augmented CAPM and those obtained from the augmented FF3 model are equal to each other. That is, the null hypothesis is:

$$|\lambda_{i,c,s,b}| = |\lambda_{i,f,s,b}|$$

or

$$|\lambda_{i,c,s,b}| - |\lambda_{i,f,s,b}| = 0.$$

The Wald test for the difference between the two coefficients is calculated as:

$$W = \frac{\left(\lambda_{i,c,s,b} - \lambda_{i,f,s,b}\right)^2}{s_p^2},$$

where s_p^2 is the estimated pooled variance of the two coefficients and is given as:

$$\mathrm{Var}\left(\lambda_{f,s,i,1}\right) + \mathrm{Var}\left(\lambda_{c,s,i,1}\right) + d\left[2\mathrm{Cov}\left(\lambda_{f,s,i,1}, \lambda_{c,s,i,1}\right)\right],$$

where the value of *d* depends on the linear restrictions that are imposed to calculate the absolute difference in the coefficients. The linear restrictions, themselves, depend on the initial signs of the coefficients. If the two coefficients are, initially, of the same sign, then the absolute difference between them would be found via subtraction and *d* would be equal to -1, and if the two coefficients are, initially, of different signs, then the absolute difference between them would be found via addition and *d* would be equal to 1. For instance,

if $\lambda_{c,s,i,1}>0$ and $\lambda_{f,s,i,1}<0$, then $|\lambda_{c,s,i,1}| - |\lambda_{f,s,i,1}|$ is calculated as $\lambda_{c,s,i,1} + \lambda_{f,s,i,1}$ and $d = 1$
if $\lambda_{c,s,i,1}<0$ and $\lambda_{f,s,i,1}>0$, then $|\lambda_{c,s,i,1}| - |\lambda_{f,s,i,1}|$ is calculated as $-\lambda_{c,s,i,1} - \lambda_{f,s,i,1}$ and $d = 1$
if $\lambda_{c,s,i,1}>0$ and $\lambda_{f,s,i,1}>0$, then $|\lambda_{c,s,i,1}| - |\lambda_{f,s,i,1}|$ is calculated as $\lambda_{c,s,i,1} - \lambda_{f,s,i,1}$ and $d = -1$
if $\lambda_{c,s,i,1}<0$ and $\lambda_{f,s,i,1}<0$, then $|\lambda_{c,s,i,1}| - |\lambda_{f,s,i,1}|$ is calculated as $-\lambda_{c,s,i,1} + \lambda_{f,s,i,1}$ and $d = -1$

The value of the Wald test statistic is then compared to the critical values for a one-sided chi-squared test. The Wald statistic to test the null and alternate hypotheses in Eqs. (12) and (13) are calculated in an analogous fashion.

the consumer demand category; thus, if we allow i to indicate the ith announcement in the set of 5 consumer demand related announcements, the $\mathrm{SUM}_{g,s}$ variable for the portfolios of stocks in the sth size quintile is computed as follows:

$$\mathrm{SUM}_{g,s} = \sum_{i=1}^{5}\sum_{b=1}^{5}|\lambda_{i,c,s,b}| - |\lambda_{i,f,s,b}| \tag{11}$$

Subsequently, a Wald coefficient test is conducted with the following null and alternate hypotheses:

$$H_0 : \sum_{i=1}^{5}\sum_{b=1}^{5}|\lambda_{i,c,s,b}| = \sum_{i=1}^{5}\sum_{b=1}^{5}|\lambda_{i,f,s,b}|, \tag{12}$$

$$H_a : \sum_{i=1}^{5}\sum_{b=1}^{5}|\lambda_{i,c,s,b}| > \sum_{i=1}^{5}\sum_{b=1}^{5}|\lambda_{i,f,s,b}|. \tag{13}$$

The $\mathrm{SUM}_{g,s}$ statistic along with the p-scores from the Wald coefficient tests are computed in a similar manner for the remaining categories of macroeconomic announcements, and are plotted in Figs. 1–6, and discussed below.

The analysis of the differential performance of the FF3 in controlling for the macroeconomic surprises on portfolios in different BE/ME quintiles is performed in a completely analogous fashion. These results are also reported in Figs. 1–6.

3.2. Analyzing the relative merit of the HML versus SMB in the FF three-factor model

The analysis of the marginal role of SMB versus HML in controlling for macroeconomic surprises in the FF3 model is undertaken in a series of steps that are similar to the ones that are outlined in the previous section. Specifically, in the first step, the following two 2-factor models are estimated:

$$r_{t,s,b} - rf_t = \alpha_{h,s,b} + \beta_{h,s,b}(\mathrm{MKT}_t - rf_t) + \nu_{h,s,b}\mathrm{HML}_t + \sum_{i=1}^{23}\lambda_{i,h,s,b}A_{i,t} + \varepsilon_{t,h,s,b} \tag{14}$$

$$r_{t,s,b} - rf_t = \alpha_{m,s,b} + \beta_{m,s,b}(\mathrm{MKT}_t - rf_t) + q_{m,s,b}\mathrm{SMB}_t + \sum_{i=1}^{23}\lambda_{i,m,s,b}A_{i,t} + \varepsilon_{t,m,s,b} \tag{15}$$

where, the combined impact of specific categories of macroeconomic announcements on various size and BE/ME based portfolios are measured by computing the SUM metric (analogous to that in Eq. (11)). This metric, along with related p-scores from Wald coefficient tests, is used to compare the relative performance of the two-factor HML model versus the two-factor SMB model. These results are exhibited in Figs. 7–12.

3.3. Analyzing the relative merit of the FF three-factor model augmented by credit variables

Studies such as Vassalou and Xing (2004) and Hahn and Lee (2006) document the importance of quality spreads and term structure variables in asset pricing models. Therefore, it may be worthwhile to compare the performance of a five-factor (FF5) model that includes these additional factors along with the traditional three-factors in the FF model.[10]

In order to ascertain whether augmenting the FF3 model with term structure and default spread variables enhances the model's ability to control for macroeconomic announcements, the following five-factor model (FF5) is estimated:

$$r_{t,s,b} - rf_t = \alpha_{v,s,b} + \beta_{v,s,b}(\mathrm{MKT}_t - rf_t) + s_{v,s,b}\mathrm{SMB}_t + \nu_{v,s,b}\mathrm{HML}_t + \vartheta_{v,s,b}\mathrm{TRM}_t + \omega_{v,s,b}\mathrm{QAL}_t + \sum_{i=1}^{23}\lambda_{i,v,s,b}A_{i,t} + \varepsilon_{t,v,s,b} \tag{16}$$

where, TRM_t is the log change in the yield difference between a 10-year Treasury bond and a 1-month T-bill, and QAL_t is the difference between the yield on BAA-rated corporate bonds and the yield on the 10-year Treasury bond.

We perform SUR analysis for various size and BE/ME quintiles similar to Eqs. (6)–(10), where the equations are the augmented FF3 (Eq. (2)) and the augmented FF5 (Eq. (11)) models. We then calculate the SUM metric and Wald coefficient tests analogous to that in Eq. (11). The results of this analysis are plotted in Fig. 13, and discussed in the following section.

4. Empirical results

4.1. Analyzing the relative merit of the FF model versus the CAPM

Table 1 provides summary descriptions of the impact of each of the 23 surprise variables on stock returns associated with various size and BE/ME portfolios in the augmented CAPM and the augmented FF3 model. This involves the estimation of Eqs. (1) and (2). Such a comparison provides evidence of the relative merit of the two models in accounting for the underlying economic

[10] We thank one of the anonymous reviewers for this suggestion.

Table 1
Relative performance of CAPM versus FF three-factor model

Announcement	In FF's favor positive and significant	Positive and insignificant	Negative and insignificant	In CAPM's favor negative and significant
Consumer demand	12	82	31	0
Auto sales	0	17	8	0
Business invent.	0	15	10	0
Personal consumption	1	21	3	0
Personal income	0	19	6	0
Retail sales	11	10	4	0
Inflation	22	88	40	0
Capacity utilization	0	18	7	0
Consumer price index	9	11	5	0
Hourly earnings	0	19	6	0
Producer price index	13	10	2	0
Non-farm pay	0	21	4	0
Unemployment	0	9	16	0
Interest rates	0	29	21	0
Consumer credit	0	11	14	0
Treasury budget	0	18	7	0
Economic growth	7	120	48	0
Durable good orders	0	11	14	0
Factory orders	6	12	7	0
Industrial production	0	18	7	0
Leading indicators	1	22	2	0
Real G.D.P.	0	16	9	0
Trade balance	0	17	8	0
U.S. N.A.P.M.	0	24	1	0
Real estate	17	51	7	0
Construction spending	10	13	2	0
Housing starts	3	18	4	0
New home sales	4	20	1	0
Total	58	370	147	0

This table reports the number of DIF statistics from Eq. (5) that are: (a) significant and positive, which would be a finding in favor of the FF three-factor model, (b) insignificant and positive, (c) insignificant and negative, and (d) significant and negative, which would be a finding in favor of CAPM. A Wald test statistic (χ^2) is used to statistically test the difference between the absolute value of an announcement's impact on CAPM and FF3 residuals.

state variables. A one-tailed Wald test statistic (χ^2) is used to test the statistical difference between the absolute value of an announcement's impact on the CAPM and the FF3.

Table 1 indicates, by type of macroeconomic announcement, how many of the 575 possible differences in the absolute values of the coefficients (the DIF variable from Eq. (3)) are: (a) positive and statistically significant, which would indicate that the returns regressed on the FF3 model are less impacted by the surprises in the macroeconomic announcements, (b) positive and statistically insignificant, (c) negative and statistically insignificant, and (d) negative and statistically significant, which would indicate that the impact of the announcements is less on the CAPM.

There is strong evidence to suggest that the FF3 model is relatively better at controlling for macroeconomic surprises than the CAPM. Out of the 575 possible values measuring the absolute difference in coefficients between FF3 and CAPM residuals, 58 are positive and statistically significant, while none of them are negative and statistically significant. Thus, there is overwhelming evidence to support the superiority of the FF3 model to the CAPM. Further, in a majority of the instances where the DIF variables are insignificant, the difference is still positive (370 versus 147).

The SUM statistic (see Eq. (11)), which provides broad insights into the relative performance of the two asset pricing models for each macroeconomic category are presented in Figs. 1–6. Using the results in Table 1 in conjunction with Figs. 1–6, the analysis below describes the relative ability of each model in controlling for the impact of announcements in the five broad macroeconomic categories on various size and BE/ME quintile portfolios.

4.1.1. Consumer demand

Overall, for the announcements related to consumer demand, there are 12 occasions where the FF3 model outperforms the CAPM. Within the consumer demand category, the FF3 model seems to best account for surprises in Retail Sales, since 11 out of the possible 25 DIF values for this announcement are positive and significant. There does not appear to be a significant difference in the ability of the FF3 model or the CAPM to control for surprises in Auto Sales, Business Inventories and Personal Income.

Fig. 1 reveals that, in controlling for consumer demand announcements, the superior performance of the FF3 model is most distinct for firms that are located in the first size and BE/ME quintiles. The *p*-values from Wald tests of the SUM statistics are also reported in the graph. First, all points on the graph lie in the first quadrant which suggests that, in general, across all size and BE/ME quintiles, the FF factors are better at representing consumer demand variables than the CAPM. Second, in comparing the two models, the plot for the size-based portfolios indicates that quintiles 1, 2, and 3 are statistically significant (p-values ≤ 0.09) in representing announcements relating to consumer demand. Third, the representation of consumer demand variables in BE/ME portfolios is an increasing function in quintiles two through five.

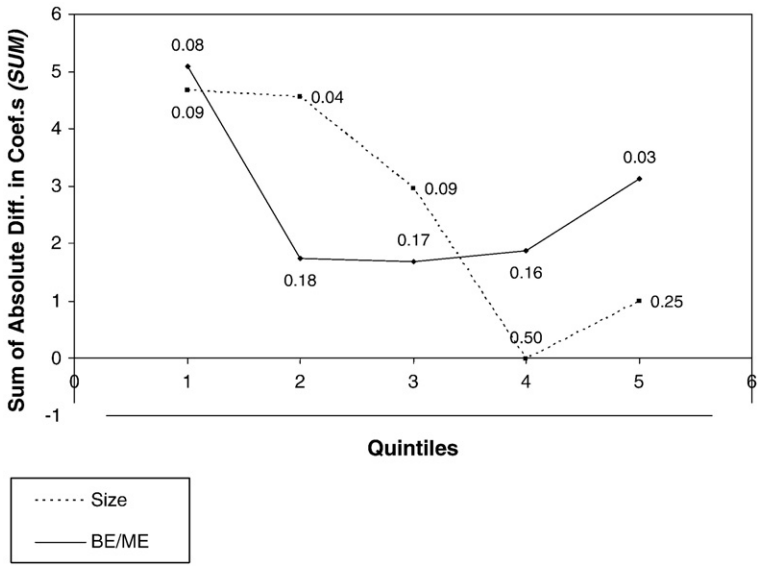

Fig. 1. FF3 vs. CAPM, Consumer Demand. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

4.1.2. Inflation

The relative merit of the FF3 model is most impressive in the context of considering inflation-related announcements. The information in Table 1 indicates that the performance of the FF3 model dominates the CAPM as it relates to inflation-related announcements. Observing the DIF variables for these announcements, we notice that the number of DIF variables that are positive and statistically significant far outweigh those that are negative and significant (22 versus 0, respectively). The superiority of the FF3 model is most evident when examining the entries for the Producer Price Index — of the 25 DIF variables for this announcement, 13 are positive and statistically significant, while 0 are negative and statistically significant. Therefore, we can safely conclude that the FF3 model represents a significant improvement over the CAPM in controlling for the pervasive risk associated with surprises in PPI specifically, and inflation in general.

Fig. 2 plots the SUM statistics for firms in the various size and BE/ME. The benefit of the FF3 model is statistically significant (at *p*-values ≤ 10%) across all size quintiles with the exception of quintile 4. However, with regards to book value, the statistically significant advantage of the FF3 model is observed primarily for firms in the first, third, and fifth BE/ME quintile.

4.1.3. Interest rates

The results pertaining to interest rate announcements are markedly different from other macroeconomic announcements. Examining the summary information provided in Table 1, evidence suggests that the FF3 model does not have any significant edge

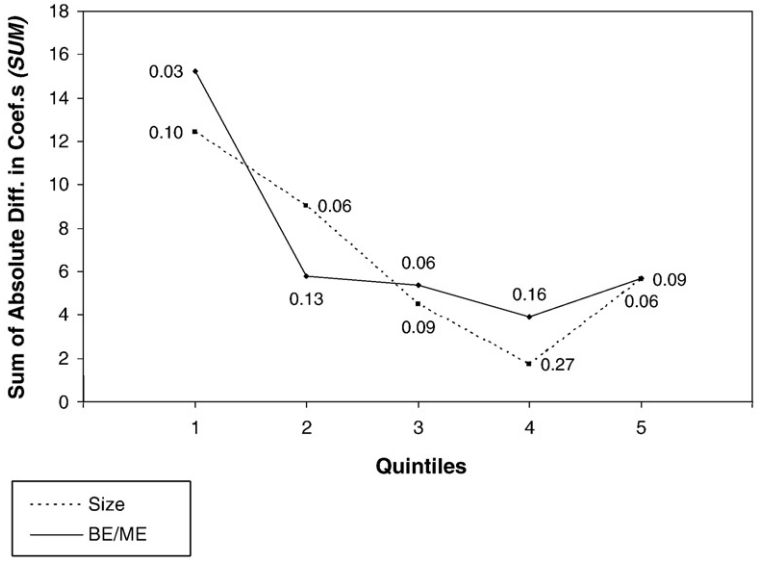

Fig. 2. FF3 vs. CAPM, Inflation. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

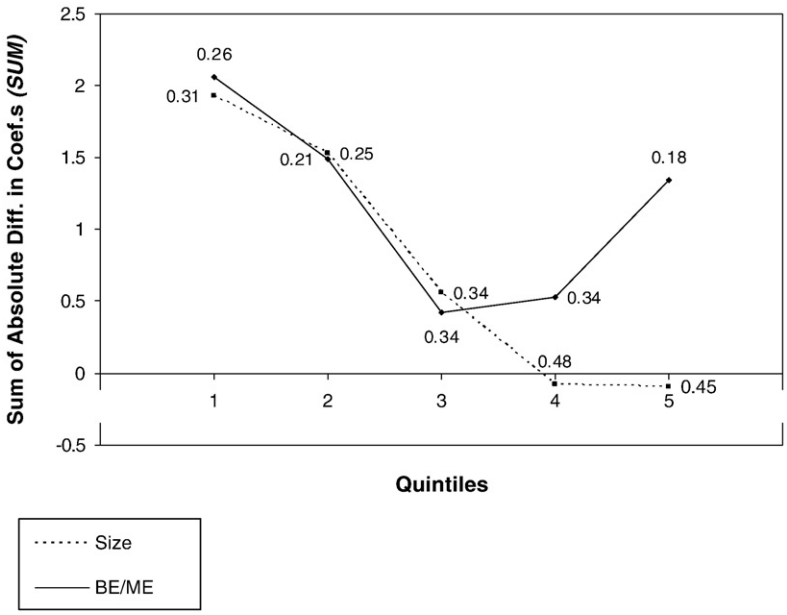

Fig. 3. FF3 vs. CAPM, Interest Rates. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

over the CAPM in controlling for surprises in these announcements. In other words, interest rate announcements are relatively controlled for by using either the FF3 model or the CAPM. It may however be worth noting that although all 50 coefficients are statistically insignificant, the number of positive coefficients still outweighs the number of negative coefficients by about 1.4 times.

The graphs plotted in Fig. 3 confirm this finding. The figure indicates that the relative performance of the FF3 model and the CAPM for various firm sizes and BE/ME ratios are indeed quite similar to each other. Although statistically insignificant, it appears that the FF3 model outperforms the CAPM for small firms and firms at the extreme BE/ME quintiles.

4.1.4. Economic growth

The FF3 model outperforms the CAPM, by a factor of 7 to 1, in controlling for announcements related to economic growth. The most impressive performance is related to the announcement of Factory Orders; of the 25 DIF variables for this announcement, 6 are positive and statistically significant, while 0 are negative and statistically significant.

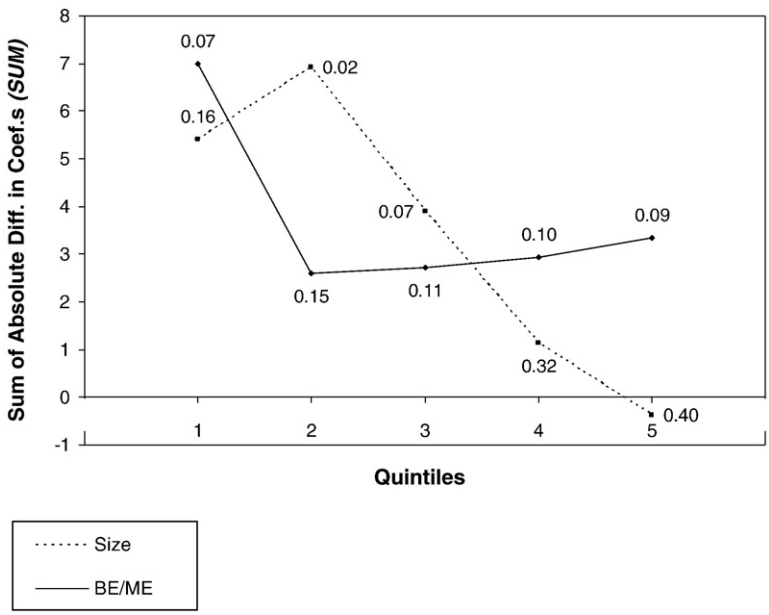

Fig. 4. FF3 vs. CAPM, Economic Growth. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

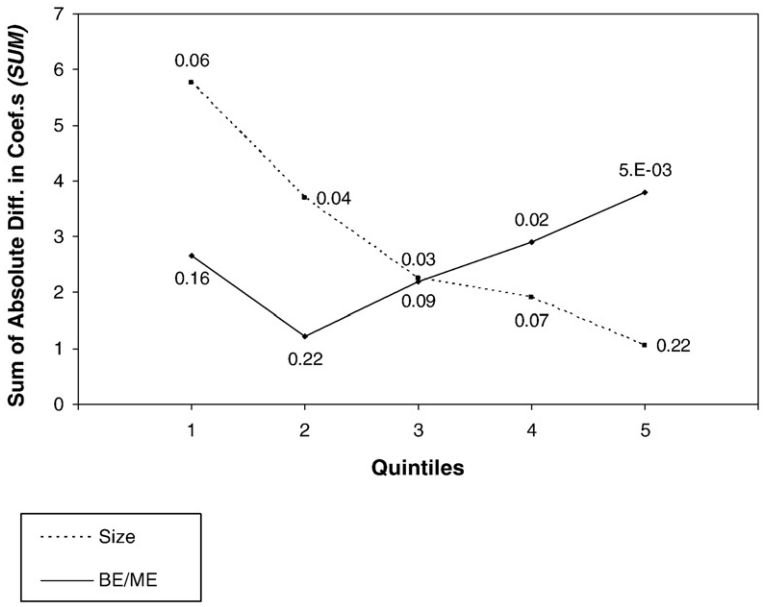

Fig. 5. FF3 vs. CAPM, Real Estate. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

Fig. 4 illustrates the superiority of the FF3 model in controlling for economic growth related announcements when compared to the CAPM. Specifically, the FF3 model outperforms the CAPM most dramatically for firms in the second and third size quintile (p-value ≤ 0.07). In terms of the BE/ME quintiles, the FF3 model outperforms the CAPM at p-values ≤ 0.10 for firms across quintiles 1, 4 and 5. Notably, the pattern of relationship pertaining to economic growth variables is somewhat similar to those relating to consumer demand for the size factor and inflation announcements for the BE/ME factor.

4.1.5. Real estate

The relative merit of the FF3 model is second most impressive after inflation in the context of considering real estate-related announcements. Of the 75 DIF variables for these announcements, 17 are positive and statistically significant, while none of them are negative and statistically significant. Furthermore, in considering the number of insignificant coefficients, which is indicative of the lack of a clear winner between the FF3 and the CAPM, we notice that only 75% of the possible coefficients associated with real estate-related announcements are insignificant. In comparison, the relative number of insignificant coefficients for consumer demand, inflation, interest rates, and economic growth are 90%, 85%, 100%, and 96%, respectively.

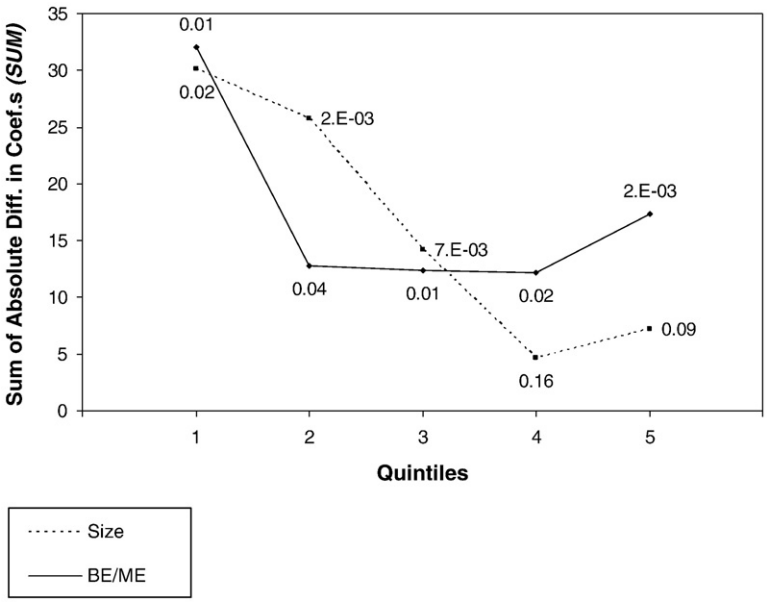

Fig. 6. FF3 vs. CAPM, All Announcements. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

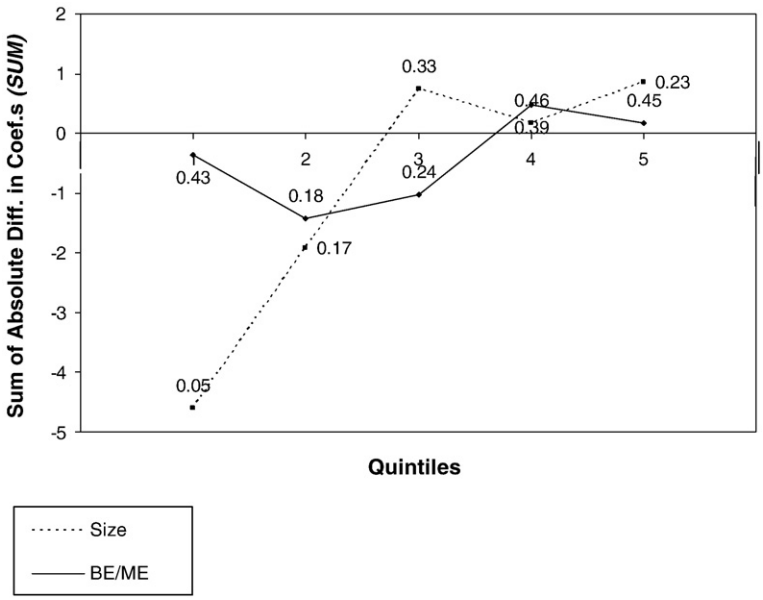

Fig. 7. HML vs. SMB, Consumer Demand. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

The graph plotted in Fig. 5 corroborates this finding. The FF3 model outperforms the CAPM in a statistically significant manner (p-values ≤ 0.07) for most size and BE/ME portfolios, with the exception of the largest firms (size quintile 5). The most significant gains of the FF are reported for smaller firms and firms with medium to high BE/ME ratios.

4.1.6. All announcements

The SUM statistics, calculated across all announcement categories present a synoptic view of the comparison between the two asset pricing models. The results indicate the superior performance of the FF model in representing various macroeconomic announcements across all of the size and BE/ME quintiles, except the 4th size quintile, and is most evident in the second size quintile and in the corner quintiles of BE/ME portfolios.

4.2. Attribution analysis — SMB versus HML

Figs. 7–12 plot the SUM statistics that indicate the relative performance of the two-factor HML model versus that of the two-factor SMB model. In interpreting Figs. 7–12, it is important to note that a plot above zero for a particular quintile means that the

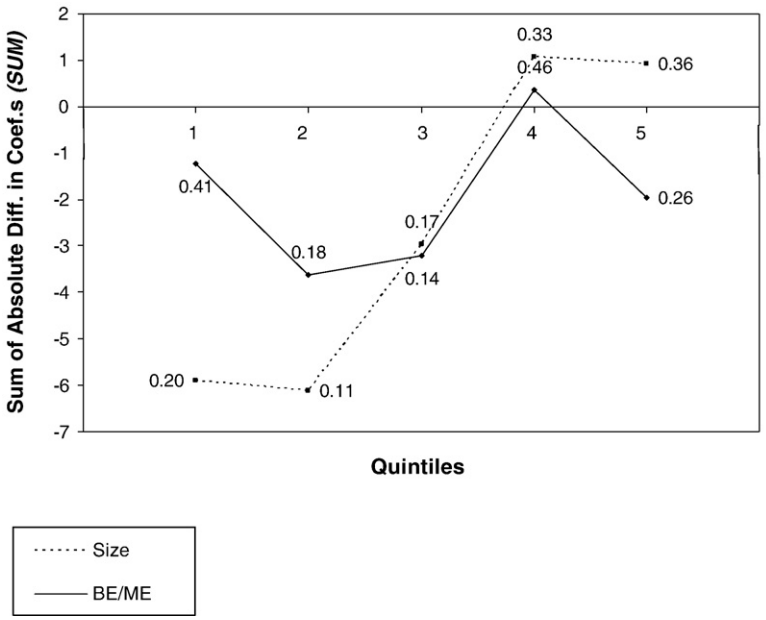

Fig. 8. HML vs. SMB, Inflation. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

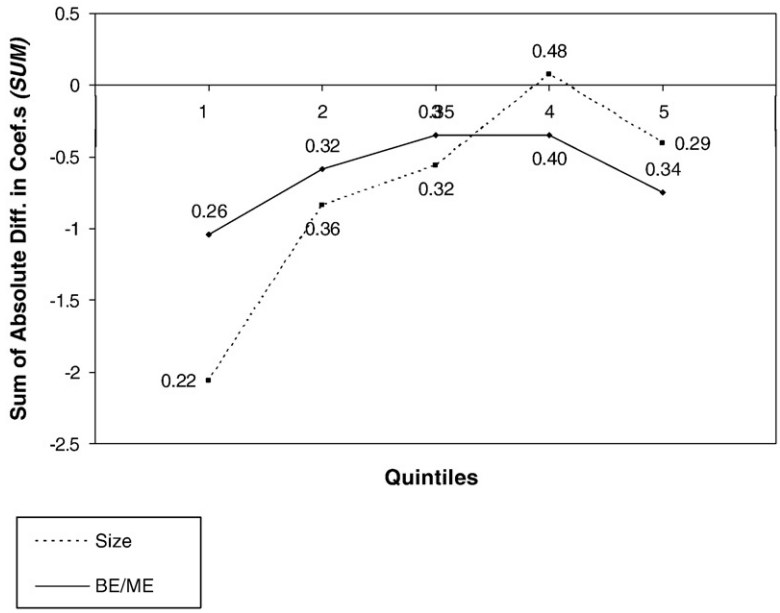

Fig. 9. HML vs. SMB, Interest Rates. The number next to the data point represents the p-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

two-factor HML model is better than the associated two-factor SMB model, and a plot below zero indicates that the two-factor SMB model is better at controlling for the macroeconomic announcements than the two-factor HML model for stocks in that particular size or BE/ME quintile. A comparative analysis of Figs. 7–11, and in particular the plots containing all macroeconomic announcements in Fig. 12, indicates that there is very little difference in performance between the two models. This implies that both factors (SMB and HML), in isolation, equally account for macroeconomic announcements; even though the combination of the two factors in the three-factor model synergistically perform better than either one of the two-factor models.

Further comparative analysis reveals that the HML two-factor model does better than the SMB two-factor model for those firms that are large and carry high BE/ME ratios (i.e., quintile 5 firms). On the other hand, the two-factor version of the SMB factor is better for firms in the smallest size and low BE/ME ratios (i.e., quintile 1 firms). Thus, there is some evidence that the benefits of the FF3 model can be attributed either to SMB or HML depending on the size and BE/ME of the firm.

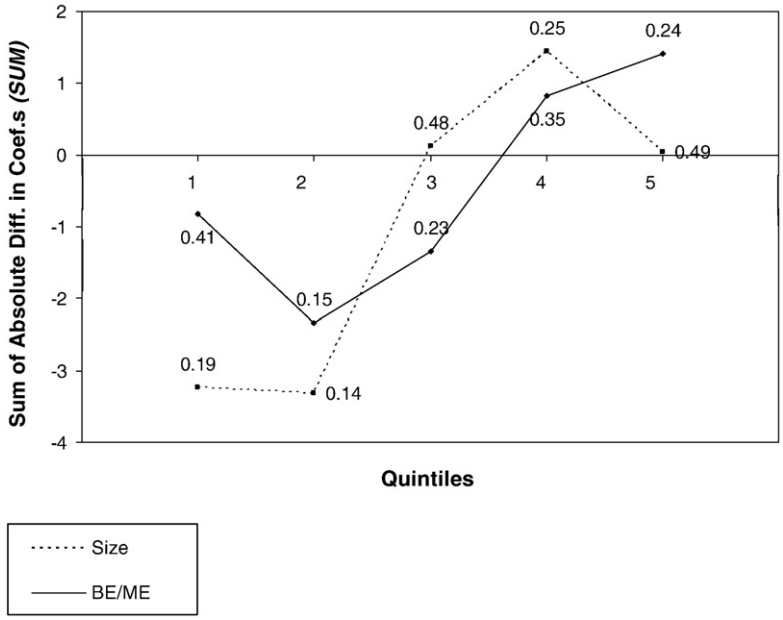

Fig. 10. HML vs. SMB, Economic Growth. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

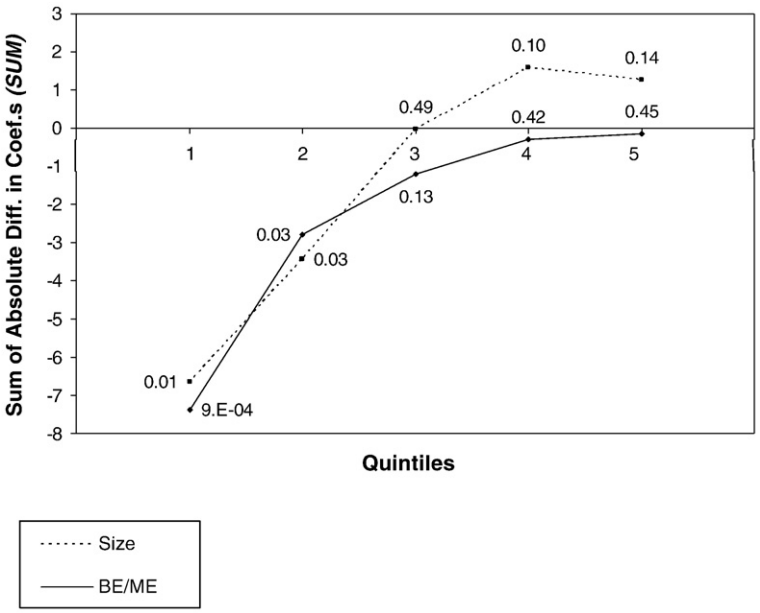

Fig. 11. HML vs. SMB, Real Estate. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

An examination of Fig. 7 reveals that the HML and SMB models each appear to equally control for consumer demand announcements, as 5 out of the 10 possible BE/ME and size quintiles lie below zero.

The plots in Fig. 8 indicate that, in general, for inflation-related announcements, SMB factor is relatively more important than HML factors in accounting for the FF model's performance. Note only the larger size portfolios (quintiles 4 and 5) falls above zero, suggesting that HML performs better for firms in these quintiles. In contrast, SMB performs better than the HML model for all other firms.

The plots for interest-rate related announcements, as shown in Fig. 9, are particularly interesting. Earlier, it was demonstrated that it was not possible to distinguish the performance of the FF3 model from the CAPM for announcements relating to interest rates. What the attribution analysis further contributes to this discussion is that the two-factor SMB model performs relatively better than the two-factor HML model in the FF3 framework. The SMB two- factor model is most effective in capturing macroeconomic announcements for those firms that are in quintile 1 of the size and BE/ME portfolios.

Finally, in accounting for the variables related to economic growth and the real estate market, Figs. 10 and 11 reaffirm the importance of HML factor in the large size and high BE/ME quintiles and the SMB factor in the small size and low BE/ME quintiles.

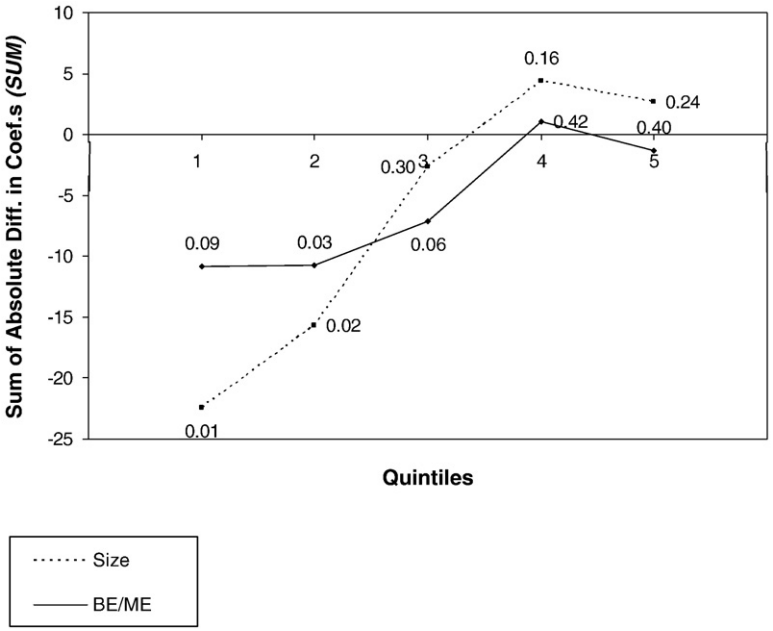

Fig. 12. HML vs. SMB, All Announcements. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

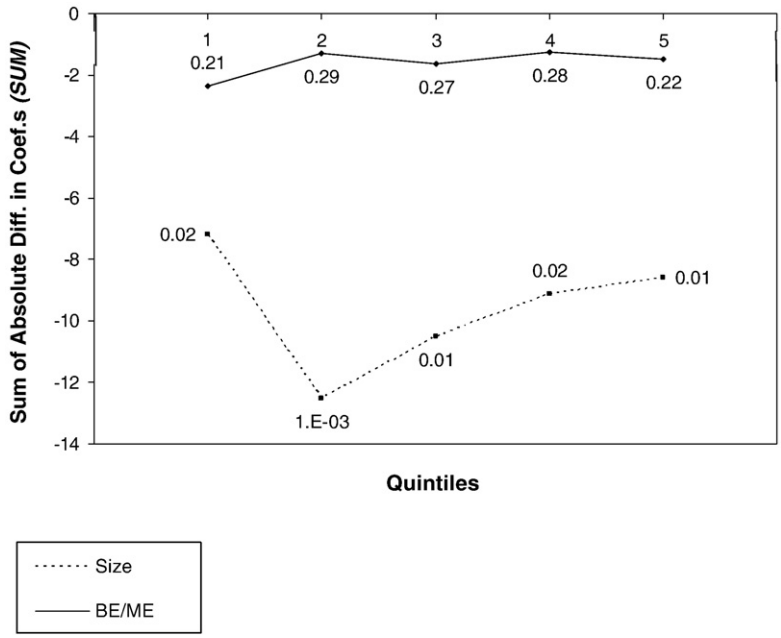

Fig. 13. FF3 vs. FF5, All Announcements. The number next to the data point represents the *p*-score from a one-tailed Wald Coefficient test as per Eqs. (12) and (13).

The fact that SMB does better for smaller firms, while HML does better for large BE/ME firms could be attributed to the inherent nature of the firms themselves. Small-sized firms and firms that have high BE/ME are extremely sensitive to variations in economic conditions. Bernanke and Gertler (1989) indicate that during a recession investors are likely to switch from high-risk small firms towards large firms that are collateralized and hence safer. Furthermore, small firms and the value of their collateral are significantly affected by worsening credit market factors as measured by high interest rates, inflation and economic slowdown (Perez-Quiros and Timmermann, 2000). Similarly, Fama and French among others find high BE/ME firms to have low profitability and greater uncertainty of earnings which makes it riskier.

4.3. The relative merit of the FF three-factor model augmented by credit variables

In this section we examine whether an augmented five-factor (FF5) model is better than the FF3 model, and whether quality and term structure factors subsume the efficacy of the conventional FF factors.

The comparative analysis of the FF5 and FF3 models in responding to all macroeconomic announcements are presented in Fig. 13. This figure is fashioned after the previous set of graphs that compared the FF3 model to the CAPM, and the two-factor SMB to the two-factor HML models. In Fig. 13, a plot above zero indicates that the FF3 model is more effective than the augmented FF5 model in capturing underlying macroeconomic announcements. On the other hand, a plot below zero suggests that FF5 is superior to FF3 in controlling for macroeconomic announcements. All plots on the graph are below zero, which indicates that, in general, across all size and BE/ME quintiles the FF5 model is superior to the FF3 model. However, the superior performance of the FF5 model is statistically significant only for the size-related portfolios.

Upon comparing the magnitude of the absolute difference in coefficients of the FF5 versus FF3 models and the FF3 model versus the CAPM, the marginal improvement of the FF5 relative to the FF3 model is not as great as the improvement of the FF3 model over the CAPM. A review of the individual announcements (not reported) indicates that the relevance of the credit variables in the augmented FF5 model diminish as the size and BE/ME quintiles increase.

5. Conclusions

The empirical success of the three-factor Fama and French (FF3) model has challenged researchers to explain the economic underpinnings of the model. Prior literature relating SMB and HML to macroeconomic fundamentals have generally focused on a limited set of state variables. This study conducts a comprehensive comparison of the impact of surprises in 23 different types of macroeconomic variables within an augmented CAPM and an augmented FF3 model. In this approach, the merits of the FF3 model are demonstrated whenever surprises in the 23 different types of macroeconomic announcements have smaller average impact on returns examined in an FF3 model versus those under the CAPM. The analysis is carried out using the returns of 25 different portfolios which form the intersection of the universe of stocks, divided into size and book-value-to-market-value quintiles. Thus, we show for which types of portfolios, and for which types of macroeconomic variables, the FF3 model outperforms the CAPM in modeling asset returns.

Overall, in 58 out of 575 possible instances of comparison (about 10 percent), the FF3 model performs significantly better than CAPM in controlling for unanticipated changes in macroeconomic variables. This is most evident for firms belonging in the second size quintile and the two extreme BE/ME quintiles. On the other hand, there is no instance where the CAPM bests the FF3 model. The FF3 model seems to be superior to the CAPM in controlling for macroeconomic announcements related to inflation, the real estate sector, consumer demand and economic growth. For announcements related to interest rates, there was no clear indication of the superiority of either one of the two models. The individual announcements that are most closely related with the FF3 model include Personal Consumption, Retail Sales, CPI, PPI, Factory Orders, Construction Spending, Housing Starts, and New Home Sales.

In addition, we compare the performance of a two-factor SMB model with that of a two- factor HML model. In general, the SMB model does better for small firms and firms with low BE/ME; whereas, the HML model does better for firms that are large in terms of size and firms that carry high BE/ME. The results generally indicate that HML and SMB are both equally important in reflecting the various macroeconomic announcements.

Lastly, we draw a comparison between a five-factor (FF5) model that incorporates quality and term spread variables with the FF3 model. The results indicate that the FF5 model is superior to the FF3 at controlling for the influence of macroeconomic announcements, especially for the size-related portfolios. However, this relative superiority of the FF5 model is not near the magnitude of the superiority of the FF3 over the CAPM.

The evidence presented here establishes the manner in which the FF three-factor model controls for the underlying economic fundamentals that theoretically should drive asset returns. Several possibilities for extension remain to be explored. First, extending our analysis to foreign capital markets would enhance the robustness of the results. Second, it would be interesting to assess the role of other factors such as momentum in the analysis. Finally, establishing the significance of these results to different business and monetary policy conditions would also be worthy of examination. These issues are left for future research.

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