Norwegian School of Economics

Bergen, Spring, 2021

The Nature of Asset Pricing Anomalies

Characteristics versus Covariances of Factor Exposures

Alexandra Lapitskaya

Supervisor: Francisco Santos

Master thesis, MSc in Economics and Business Administration,

Finance

NORWEGIAN SCHOOL OF ECONOMICS

Contents

Acknowledgements

I would like to express sincere gratitude to my thesis supervisor, Professor Francisco Santos, for his constant support and availability throughout the thesis writing process. The knowledge gained during the courses taught by him, along with fruitful discussions and detailed feedback on my thesis work, have proven essential during the writing process. I would also like to thank my family and friends for their unconditional support during my studies and beyond.

Abstract

In this thesis, I test whether the return premia associated with firm characteristics such as value, size, operating profitability, investment, momentum, and equity status are driven by firm characteristics or exposure to risk factors (covariances) in the U.S. stock market. I find that the value, operating profitability, investment, and market risk (equity status) premia are associated with firm characteristics rather than covariances with corresponding risk factors. The firms with these characteristics earn a return premium irrespective of their risk factor loadings, and the factor loadings explain the returns only to the extent to which they proxy for corresponding characteristics. On the contrary, the size premium is mostly driven by the covariances with the SMB factor, as the premium is evident even after controlling for the size characteristic. For the momentum premium, the covariance structure of returns is unstable, and no convincing conclusions can be drawn with the methodology used in this thesis.

1. Introduction

Daniel & Titman (1997) suggest that the return premia associated with firm characteristics such as size or book-to-market ratio are driven by the characteristics themselves rather than risk factor exposures, as postulated by Fama & French (1993, 1996). In the characteristic model of Daniel & Titman (1997), the returns of the firms with similar characteristics covary not because the firms load on a specific risk factor associated with this characteristic, but because these firms have similar properties. In this case, the characteristics proxy for relative distress, and the firms with the characteristics of a distressed firm (e.g. high book-to-market ratio) earn a premium regardless of their loadings on the corresponding risk factor (i.e. HML). In contrast, the risk model of Fama & French (1993, 1996) requires compensation for the high loadings on the HML factor, regardless of the underlying book-to-market characteristic.

Daniel & Titman (1997) find that the return premia associated with value, size, and market risk follow the characteristic story: the factor loadings do not explain the premia beyond the extent to which they act as proxies for the corresponding characteristics. Davis et al. (2000) reject the characteristic story for the value premium in the extended sample of stock returns between July 1929 and June 1997 and conclude that Daniel & Titman's (1997) results for the value premium are specific to the tested period. However, they cannot reject the characteristic story for the market risk premium and conclude that the size premium in the U.S. stock market is not economically robust enough for the tests to distinguish between the two models.

In this thesis, I contribute to the existing debate on the nature of characteristic-based asset pricing anomalies by extending Daniel & Titman's (1997) methodology to a wider range of return premia. Many more anomalies have been brought to light in recent years, yet have not been studied in-depth. However, I limit my tests to the most conventionally powerful and accepted characteristic-based anomalies, such as operating profitability, investment, and prior return (momentum).

In addition, I reproduce Daniel & Titman's (1997) and Davis et al.'s (2000) tests for size, value, and market risk premia. The contribution is twofold: first, my sample is extended by the extra 20 years of monthly stock returns, which allows testing the persistence of the explanations offered earlier. Second, to test the six chosen characteristics, I need a factor model that incorporates factor proxies for all of them. For that, I use Fama & French's (2015) five-factor model and augment it with the momentum factor. It is interesting to see whether the choice of the factor model affects the conclusions in the risk versus characteristic debate.

To sum up, I test the nature of the size, value, market risk, operating profitability, investment, and momentum premia in the U.S. stock returns between July 1967[1] and December 2020. Following Daniel & Titman (1997), I isolate the effect of characteristics from that of factor loadings by performing a portfolio sort on firm characteristics and pre-formation factor loadings. In this way, the statistically and economically significant variation of returns within each characteristic portfolio is attributed to the variation in factor loadings that is unrelated to the tested characteristic; this should allow me to conclude that the factor model is valid. Alternatively, the lack of variation in returns after controlling for characteristics is suggestive of the characteristic model.

Following this logic, I examine the patterns of excess and abnormal returns of the portfolios sorted by characteristics and corresponding risk factor loadings. In addition, I form characteristic-balanced portfolios that load strongly on the tested risk factor, but are neutral in terms of the tested characteristic, and discuss the excess returns and alphas of these portfolios. I augment this discussion with the robustness tests: first, I confirm the existence of a stable covariance matrix of portfolio returns and significant variation in factor loadings across different factor loading portfolios; then, I exclude the sample period when the tested risk factors were performing poorly to ensure that either explanation is not falsely rejected because of the low factor-related return premium.

The results are disturbing for the traditional risk measures. I find that the return premia associated with value, operating profitability, investment, and market risk do not follow the conventional risk-based explanation. Once I control for the characteristic in question, there is almost no variation in excess returns associated with the corresponding risk factor loadings. Holding characteristics constant, the portfolios with low factor loadings generate higher excess returns than predicted by the risk model, while the portfolios of low-beta firms generate excess returns that are lower than what would be expected. The return premium associated with size is suggestive of the risk story. Finally, I find that momentum-sorted portfolio returns do not

[1] Although the data is available from July 1963, these four years are excluded due to the pre-formation factor loadings estimation methodology. This is discussed later in the thesis.

follow a stable covariance structure, which is why Daniel & Titman's (1997) methodology fails to distinguish between the risk and the factor models. The tests of the nature of momentum premium are therefore inconclusive.

My findings for the market risk premium are consistent with the results of Daniel & Titman (1997) and Davis et al. (2000) who also find that the market risk follows the characteristic story. This explanation is therefore robust to the sample period and risk model chosen for the tests. For the size premium, the results favor the risk story, which contradicts Daniel & Titman (1997). However, Daniel & Titman's (1997) tests are conducted in the period when the size effect is rather weak, which could undermine the validity of their results. For this particular reason, Davis et al. (2000) do not test the story behind the size premium at all.

My results for the value premium agree with the findings of Daniel & Titman (1997), who suggest that value follows the characteristic story, but disagree with the results of Davis et al. (2000). This lack of alignment occurs due to the two main reasons: first, the sample period differs due to data availability issues, and I am not able to include the period between 1929 and 1963 when the risk-based explanation for the value premium was particularly strong. Second, the results may be affected by the choice of a different, more powerful risk model. In my tests, I use the Fama & French five-factor model augmented with the momentum factor and show that this model is better suited to explain portfolio returns than the Fama & French three-factor model, used in Davis et al. (2000).

The findings of the characteristic-based nature of many major asset pricing anomalies have powerful implications for portfolio analysis and investment strategies, as they suggest that an investor can earn a high premium without loading on common risk factors. In addition, practitioners should be cautious when applying the factor models to measure performance or estimate the cost of capital whenever the return premia are driven by characteristics.

The rest of the thesis proceeds as follows. Section 2 discusses the relevant literature related to the premia in question and the characteristics versus covariances debate. Section 3 presents the data collection and cleaning process, along with the descriptive statistics of the factor portfolios, return patterns of characteristic portfolios, and the risk model tests. Section 4 describes the methodology used for the main empirical results. Section 5 discusses the empirical analysis of the characteristics versus covariances tests for value, size, profitability, investment, momentum, and market risk anomalies. Section 6 concludes.

2. Literature review

By now, there is substantial evidence that the cross-sectional differences in stock returns can be explained by a multitude of firm characteristics, as there is considerable variation in stock returns left unexplained by the conventional capital asset pricing model of Sharpe (1964) and Lintner (1965). The most notable and well-studied asset pricing anomalies[2] are the firm's size and book-to-market ratio, brought to light by Fama & French (1993) in their three-factor asset pricing model.

However, there is considerable debate around why these characteristics proxy for the differences in stock returns. Fama and French (1993, 1996) argue that firm characteristics are related to distress, and the distress is associated with loading on a separate risk factor, which is proxied for by the zero-cost portfolios formed on the characteristic (e.g. SMB and HML). Behavioral explanations for the persistence of characteristic-related return premia have been offered too[3]; these explanations, however, are not inconsistent with the multifactor models. Daniel & Titman (1997) is the first paper that poses the question of whether the pattern in returns of portfolios sorted by characteristics is indeed consistent with a factor model. Their research is centered around the value characteristic, as they question the existence of a separate risk factor associated with the book-to-market ratio and the existence of a risk premium on this factor[4].

The main challenge for Daniel & Titman (1997) was to come up with a methodology that allows distinguishing between the effect of factor loadings and the effect of characteristics since the two are highly correlated. They propose a clever way to deal with the problem, as they suggest that there are firms whose characteristics do not match their factor loadings. For example, a distressed firm in a growing industry will earn high returns under the characteristic model as the firm is weak. However, this firm will have a low loading on the distress risk

[2] I will often refer to the premia tested in this paper as anomalies, which they are in the CAPM world.

[3] See Lakonishok et al. (1994), Kothari et al. (1995).

[4] As mentioned earlier, Daniel & Titman (1997) also test the nature of size and market risk premia, but the focus of their paper is the value premium.

factor if such factor captures the covariation of returns within industries, and thus, the firm will have low-risk factor loadings and will earn low returns in the risk model.

As a result, to separate the effect of factor loadings and characteristics, Daniel & Titman (1997) perform a triple sort of firms into portfolios based on the firm's size and book-to-market ratio as proxies for characteristics and the pre-formation HML factor loadings as a proxy for risk, such that the variation in returns within each characteristic portfolio is attributed solely to the variation in factor loadings. They find that value follows the characteristic model because the co-movements in returns of distressed firms are associated with the book-to-market characteristic rather than the loadings on the HML risk factor: after controlling for characteristics, there is no discernible variation in returns associated with the variation in HML factor loadings. The characteristic model also holds for the size and market risk premia– a striking attack on Fama & French's (1993) risk-based explanation of asset pricing anomalies.

Davis et al. (2000) respond to Daniel & Titman's (1997) rejection of the risk model by applying their methodology in an extended sample period. They confirm that the risk model for the value premium does not hold in the 20-year period studied by Daniel & Titman (1997) (July 1973 to December 1993). However, they find that the risk story is valid in the extended sample of stock returns between July 1929 and June 1997, and conclude that Daniel & Titman's (1997) results for the value premium are specific to the tested period. Davis et al. (2000) do not test the size premium, as they argue that the size premium in the U.S. stock market is not economically significant enough for the tests to distinguish between the risk and the characteristic model. However, their conclusions for the market risk premium agree with the conclusions of Daniel & Titman (1997), as the market risk premium follows the characteristic model consistently in the extended sample period.

Daniel & Titman's (1997) tests have been extended outside of the U.S. stock market to test the out-of-sample validity of the characteristic model. Daniel et al. (2001) find that the value premium follows the characteristic story in Japan, while the results for size and value are inconclusive as neither model can be rejected. In Australia, Gharghori et al. (2006) fail to reject the risk model for the value, size, and market risk premia. In the U.K., however, the risk model is rejected for all three tested premia (Lee et al., 2007). In France, the results are inconclusive as neither the risk nor the characteristic model can be rejected (Lajili-Jarjir, 2007). Gebhardt et al. (2005) extend Daniel & Titman's (1997) methodology to the cross-section of corporate bond returns and find that default and term betas explain the returns even after controlling for bond characteristics (duration and ratings).

Overall, the out-of-sample tests of Daniel & Titman's (1997) characteristic model confirm the validity of the model in different stock markets and sample periods and for different asset classes and return premia. However, the story behind the various stock return premia lacks consistency, as the extent to which covariances determine stock returns varies in different data samples.

Since the 1990s, the number of asset pricing anomalies has only been growing and so has been the pressure to create a risk model that provides superior approximations for portfolio returns. With this in mind, Fama & French (2015) augment their three-factor asset pricing model with two additional factors – profitability and investment – and create a five-factor asset pricing model. They build their model on the evidence that firms with robust operating profitability outperform firms with weak operating profitability, and the firms with conservative investment strategies outperform firms with aggressive investment strategies. The effects of operating profitability and investment strategy are embodied within the dividend discount model and the conclusions of Miller and Modigliani (1961). Fama and French (2015) find that the five-factor model outperforms the three-factor model in its ability to describe the returns of portfolios sorted on size, book-to-market, profitability, and investment.

Another notable asset pricing anomaly is momentum. Jegadeesh & Titman (1993) find that the strategy that involves buying stocks that performed well in the past and selling stocks that performed poorly in the past generates positive abnormal returns in various holding periods. The persistence and economic significance of the momentum premium led to the creation of the four-factor model, in which Fama & French's market, size, and value factors are augmented with the momentum factor (Carhart, 1997).

Despite the persistence of more novel asset pricing anomalies, there is very little evidence on the characteristics versus covariances debate for momentum, profitability, and investment anomalies. Momentum investing has been studied by Grundy & Martin (2001), who find that the momentum premium has a characteristic-based nature. Perhaps the only recent paper directly concerned with testing the characteristics and the covariances stories for multiple return premia is Chordia et al. (2017), who run cross-sectional regressions of stock returns on the factor loadings and characteristics. They find that the firm characteristics reliably explain a larger fraction of stock return variation than factor loadings. Upon including all the characteristics in the regression, there is no evidence of a beta premium for the book-to-market and momentum factors, and scarce evidence of such for the profitability, investment, and size factors.

The methodological and theoretical approach of Chordia et al. (2017) is different from that of Daniel & Titman (1997), as they allow for both characteristics and risk factor loadings to jointly explain stock return variation, instead of allowing for only one explanation. Thus, there are no studies concerned with directly comparing the characteristic and the risk-based explanations for the momentum, investment, and operating profitability premia, using Daniel & Titman's (1997) methodology. In addition, the research on the nature of the size, value, and market risk premia in the U.S. stock market is not common after the early 2000s, meaning that there is no recent evidence on the persistence of the explanations offered by Daniel & Titman (1997) and Davis et al. (2000).

Therefore, the main goal of this thesis is to test the nature of size, value, market risk, profitability, investment, and momentum premia in the U.S. stock market using Daniel & Titman's (1997) approach for distinguishing between the risk and the characteristic models. There are several ways in which this thesis contributes to the existing research on the characteristic vs risk story in the cross-sectional variation of stock returns. First, I shed the light on the nature of profitability, investment, and momentum anomalies – the ones that have not been studied extensively in the U.S. stock market. Second, I test the applicability of Daniel & Titman's (1997) methodology to a more extensive version of the asset pricing model as well as to a wider range of anomalies. Finally, I am able to test the story for value, size, and market risk premia in the sample extended until December 2020, and see whether the conclusions of Daniel & Titman (1997) and Davis et al. (2000) hold in recent years.

3. Data description

In this section, I discuss the data collection and description and conduct preliminary tests that are essential for the main analysis. In Section 3.1, I discuss the data collection and variable construction and present the descriptive statistics of the most relevant variables. In the next three subsections, I present the results of the tests that need to be conducted to ensure the validity of Daniel & Titman's (1997) methodology in the chosen sample of stock returns and asset pricing anomalies. In Section 3.2, I present the descriptive statistics of the Fama & French factor portfolios and discuss whether the return premia on risk factors chosen for this study are economically and statistically significant enough for the tests to be conducted. In Section 3.3, I discuss return patterns of the portfolios sorted on the tested characteristics and document the existence of economically significant return premia associated with the firm characteristics. Finally, in Section 3.4, I test the Fama & French five-factor model augmented with momentum (the six-factor model), and conclude that it provides better approximations of portfolio returns than the Fama & French three- and five-factor models.

3.1 Data collection and variable construction

In this chapter, I discuss the data collection and variable construction, in which I closely follow the approach of Daniel and Titman (1997) and Davis et al. (2000). I retrieve the monthly stock return data from the Center for Research in Security Prices (CRSP) and the annual stock fundamentals data from CRSP/Compustat Merged, complementing it by the historical book equity data retrieved from French's data library. The sample covers the period between July 1963 and December 2020 and is the most extensive sample I could achieve given the availability of accounting data in CRSP/Compustat Merged. The sample used in this thesis includes common shares (CRSP share code of 10 or 11) of firms listed on NYSE, Nasdaq, or Amex (NYSE MKT).

The CRSP data is used to compute market equity, momentum, and, at a later stage, factor loadings and portfolio returns. The market equity of a firm is calculated as the number of shares outstanding (SHROUT) multiplied by stock price (PRC) and is computed monthly, and is required to be larger than 0. The market equity calculated in June of year *t* is used as market equity for year *t*. Momentum, or prior return, at the end of month *t*, is calculated at the cumulative return between month *t-11* and *t-1*, following the approach of Fama and French

(French, 2021). The stocks that do not have a price at the end of month *t-12* or a return for month *t-1* are excluded. The missing returns are replaced with the delisting returns, whenever available.

I use annual CRSP/Compustat Merged accounting data to compute the book-to-market, operating profitability, and investment ratios. To avoid the forward-looking bias, I match the returns between July of year *t* and June of year *t+1* with the accounting data released in calendar year *t-1*[5] [6].

To compute the book-to-market ratio in year *t*, I take the market equity in December of year *t-1* to avoid a bias in the results due to momentum. In the fiscal years ending in 1992 or earlier, the book equity is computed as shareholder equity, plus deferred taxes (when available), plus investment tax credit (when available), minus preferred stock (when available). Following the change in the treatment of deferred taxes (French, 2021), deferred taxes and investment tax credit are not included in the book equity calculations after 1992. For shareholder equity, I use the shareholder equity data in Compustat (SEQ) upon availability, or the common equity (CEQ) plus the carrying value of preferred stock (PSTK), or else the total assets (AT) minus the total liabilities (LT). For deferred taxes and investment tax credit, I use Compustat's deferred taxes and investment tax credit item (TXDITC) if available, or else investment tax credit and/or deferred tax items individually (ITCB and/or TXDB). For preferred stock, I use its redemption value (PSTKRV), or liquidating value (PSTKL), or carrying value (PSTK).

Additionally, for the firms that lack accounting data, I use the book equity values from Kenneth French's data library, whenever they are available. This dataset includes the hand-collected book equity values from Moody's Industrial, Public Utility, Transportation, and Bank and Finance Manuals, compiled by Davis et al. (2000). The observations with non-positive values of book equity are excluded from the tests.

Operating profitability is calculated as annual revenues (REVT) minus cost of goods sold (COGS), selling, general, and administrative expenses (XSGA), and interest expense (XINT)

---

[5] The data released between January and June of year *t* corresponds to the fiscal year ending in year *t-1*. The data released between July and December of year *t* corresponds to the fiscal year ending in year *t*.

[6] If there are several data entries in Compustat for a firm in a given fiscal year, I use the most recent information to calculate accounting ratios.

for each data point where at least one of the expense items is not missing. The operating profitability is further scaled by the sum of book equity, calculated as described earlier, and minority interest (MIB), whenever available, following Fama and French's revised method for computing operating profitability (French, 2021).

Investment in year *t* is calculated as the change in the book value of total assets (AT) between years *t-1* and *t*, divided by the total assets in year *t-1*.

The summary statistics of the relevant firm characteristics, after data processing and cleaning, can be found in Table I.

Table I. Descriptive statistics of firm characteristics

This table presents the summary statistics of the accounting and stock data that will be later used in the tests. The data is presented after the relevant cleaning steps have been conducted and includes the number of unique observations, mean values, standard deviations, and minimum and maximum values.

	N	Mean	SD	Min	Max
Book-to-market, yearly	226,446	0.877	1.08	0.00	81.30
Operating profitability, yearly	231,502	0.067	52.78	-22,614	9,423.75
Investment, yearly	211,887	0.179	1.85	-1	679.39
Market equity, yearly (June)	267,768	1,762	13,714	0.03	1,562,781
Market equity, monthly	3,218,608	1,761	13,894	0.01	2,255,969
Prior returns (2-12), monthly[7]	2,922,526	13.508	70.679	-100	9,857
Stock returns, monthly	3,211,876	1.131	18.32	-100	2,400

Finally, for the time-series regressions, I use factors and risk-free rates obtained from Kenneth French's data library. The data includes monthly market excess returns, SMB (small-minus-big), HML (high-minus-low), RMW (robust-minus-weak), CMA (conservative-minus-aggressive), and MOM (momentum) factors, as well as the monthly risk-free rate.

[7] Stock returns here and elsewhere are expressed in percentages.

3.2 Descriptive statistics of the factor portfolios

In this section, I discuss the performance of Fama and French's five factors and momentum in the entire sample period (between July 1963 and December 2020) and the three subperiods. One of the key requirements of Daniel & Titman (1997) is the existence of a significant premium associated with the tested factors. If the returns of the factor portfolios are low, there will be little variation in returns associated with the loadings on the corresponding risk factor, if the risk model holds. In this case, Daniel & Titman's methodology will not be appropriate to distinguish between the risk and the characteristic model, as the risk model could be falsely rejected.

Table II. Descriptive statistics of monthly factor portfolio returns

This table presents the average monthly returns of Fama & French's factor portfolios. The factor portfolios include market risk premium, SMB (small-minus-big), HML (high-minus-low), RMW (robust-minus-weak), CMA (conservative-minus-aggressive), and MOM (momentum). Test-statistic is in square brackets.

Factor	July 1963 – December 2020	July 1963 – June 1983	July 1983 – June 2003	July 2003 – December 2020
mktRP	0.57	0.31	0.57	0.85
	[3.34]	[1.09]	[1.92]	[2.88]
SMB	0.23	0.60	-0.06	0.13
	[2.00]	[2.93]	[-0.27]	[0.77]
HML	0.25	0.43	0.47	-0.21
	[2.30]	[2.58]	[2.30]	[-1.15]
RMW	0.25	0.03	0.50	0.21
	[3.01]	[0.28]	[2.67]	[1.88]
CMA	0.26	0.32	0.44	-0.03
	[3.38]	[2.47]	[2.93]	[-0.29]
MOM	0.64	0.93	0.82	0.09
	[3.97]	[3.99]	[2.79]	[0.30]

Table II shows the average size and *t*-statistic of the market risk premium, SMB, HML, RMW, CMA, and MOM. The first column shows the results in the entire sample period. I find that the most economically and statistically significant factors are the market risk premium and MOM (monthly returns of 0.57% and 0.64%, respectively). The other factors are very similar in terms of economic significance and about 2.5 times smaller than the market risk premium and MOM, although all of them are statistically significant[8].

The other three columns of Table II show the mean factor returns split into three roughly equal subperiods. I find that the factor performance varies across time. All the factors, except for the market risk premium, perform poorly in at least one of the subperiods, which weakens the overall mean return in the entire sample period. Some factors display performance that is inconsistent with the initial expectations. For example, the HML factor delivers a mean monthly return of -0.21% (*t*-statistic of -1.15) between July 2003 and December 2020. This means that in the last 17 years, the firms with high book-to-market ratios have been displaying lower returns than the firms with low book-to-market ratios, inconsistent with the earlier performance of the factor[9].

The periods of poor factor performance corrupt the average factor return in the entire sample period and decrease the power of Daniel & Titman's (1997) methodology to distinguish between the risk and the characteristic model. Therefore, I use the full sample period for the main analysis, but as a robustness test, I will exclude the "problematic" period when testing the characteristics with relatively low economic significance of a corresponding risk factor (SMB, HML, RMW, and CMA). For size, I will exclude the period between July 1983 and June 2003, when the SMB factor portfolio delivers a mean return of -0.06% (*t*-statistic of -0.27). For value, I will exclude the abovementioned period between July 2003 and December 2020. For operating profitability, I am going to exclude the period between July 1963 and June 1983, when the RMW's monthly return is 0.03% (*t*-statistic of 0.28). Finally, for investment, I will exclude the period between July 2003 and December 2020, when the mean return of the CMA factor portfolio is only -0.03% (*t*-statistic of -0.29). This will give the tests more power to differentiate between the risk and the characteristic model and will increase the validity of the results[10].

---

[8] Throughout the thesis, the statistical significance of the results is determined based on the 95% confidence level (unless noted otherwise).

[9] The recent decline in performance of value investment strategies is a well-documented phenomenon (e.g. Fama & French, 2021).

[10] Upon exclusion of the periods of poor factor performance, the mean monthly return on the SMB, HML, RMW, and CMA factor portfolios becomes 0.38%, 0.45%, 0.37%, and 0.38% respectively, all significant on the 99% confidence level.

Having shown the existence of risk premia, I examine the returns of characteristic-sorted portfolios to test for the existence of return premia associated with firm characteristics.

3.3 Return patterns of characteristic-sorted portfolios

Next, I examine the return patterns of the 25 portfolios sorted by size and each of the four tested characteristics (book-to-market, operating profitability, investment, and momentum). The results from this section serve as a formal test of the persistence of the asset pricing anomalies chosen for this study: I should see a clear difference in returns of the firms that are expected to generate high returns and those that are expected to generate low returns based on their characteristics.

Every June, I independently sort stocks into five size, value, profitability, and investment portfolios based on the breakpoints for the NYSE stocks. I separately combine the sort on size with the sorts on value, profitability, and investment to form three sets of 25 characteristic-sorted portfolios. As discussed in Section 3.1, to form portfolios at the end of June of year *t*, I use the market equity data for June of year *t* and the accounting data released in year *t-1*. The portfolios are held between July of year *t* and June of year *t+1* and are rebalanced annually. The characteristic-sorted portfolios for momentum are created based on the prior return and size breakpoints for NYSE firms in month *t-1*; the portfolios are held in month *t* and are rebalanced monthly (French, 2021). Finally, I compute the monthly value-weighted portfolio returns for each of the four sets of characteristic-sorted portfolios.

Table III presents the mean excess returns of the portfolios sorted by size and book-to-market (Panel A), operating profitability (Panel B), investment (Panel C), and momentum (Panel D). The results for book-to-market, operating profitability, and investment are closely aligned with the results of Fama & French (2015). In Panel A, the excess returns increase as size decreases and the book-to-market ratio increases. The mean monthly return difference between small firms with high book-to-market ratios and large firms with low book-to-market ratios is 0.43% (*t*-statistic of 2.42). In line with the earlier findings (Fama & French, 1993), the characteristic-return relationship is corrupted for the low book-to-market firms, as the small firms do not earn higher returns than the large firms.

Table III. Monthly excess returns of characteristic-sorted portfolios.

The table presents the monthly excess returns of portfolios sorted by market equity and book-to-market ratio (Panel A), market equity and operating profitability (Panel B), market equity and investment (Panel C), market equity and prior returns (Panel D). The portfolios are formed annually (Panels A, B, and C) or monthly (Panel D) from the breakpoints for NYSE firms. The sample covers the period between July 1963 and December 2020.

	Low	2	3	4	High
Panel A: Size-B/M portfolios					
Small	0.32	0.77	0.74	0.91	1.00
2	0.54	0.73	0.83	0.85	0.92
3	0.56	0.77	0.71	0.86	0.91
4	0.66	0.63	0.68	0.80	0.82
Big	0.57	0.53	0.56	0.49	0.60
Panel B: Size-OP portfolios					
Small	0.57	0.85	0.82	0.88	0.82
2	0.62	0.74	0.78	0.78	0.92
3	0.59	0.70	0.73	0.76	0.87
4	0.60	0.68	0.69	0.73	0.80
Big	0.37	0.40	0.54	0.54	0.63
Panel C: Size-Inv portfolios					
Small	0.88	0.93	0.92	0.85	0.41
2	0.80	0.87	0.88	0.87	0.57
3	0.83	0.86	0.77	0.78	0.63
4	0.71	0.73	0.73	0.76	0.67
Big	0.71	0.57	0.53	0.55	0.52
Panel D: Size-Mom portfolios					
Small	0.13	0.69	0.89	1.05	1.31
2	0.21	0.71	0.84	1.01	1.22
3	0.34	0.64	0.73	0.77	1.17
4	0.25	0.63	0.69	0.80	1.05
Big	0.24	0.51	0.46	0.59	0.83

Panel B of Table III shows that the portfolio returns increase as operating profitability increases and size decreases, while in Panel C, the returns increase as investment and size decrease. The difference in returns between small, highly profitable firms and large firms with low operating profitability is 0.45% (*t*-statistic of 2.52). The return difference between the portfolio of small firms with conservative investment strategies and large firms with aggressive investment strategies is 0.36% (*t*-statistic of 1.79). For the sorts on size and investment, Fama & French (2015) report the return difference of 0.59% for the period between July 1963 and December 2013, which suggests that the importance of the investment characteristic for the portfolio returns has deteriorated in recent years[11].

Finally, Panel D shows the returns of portfolios sorted by momentum and size – a test not covered by Fama & French (2015) since momentum is not included in their factor model. We can see that the momentum effect is even stronger than the effects of other anomalies shown in Panels A, B, and C. The difference in returns of small firms with high pre-formation returns and large firms with low pre-formation returns is 1.07% (*t*-statistic of 4.43). However, the portfolio of firms with the lowest pre-formation returns does not display the decrease in returns consistent with the increase in firm size. This is similar to the imperfections witnessed in Panel A for the size and book-to-market sort.

To summarize, these findings confirm that size, book-to-market, operating profitability, investment, and momentum are economically strong and persistent asset pricing anomalies in the period between July 1963 and December 2020. Therefore, testing the nature of these anomalies is a valuable contribution to the existing asset pricing literature. In the next section, I will test the factor model that incorporates the effect of all these firm characteristics against the Fama & French three- and five-factor models.

3.4 Risk model tests

This section presents formal tests of the six-factor risk model that I have chosen for this study, in comparison with the three- and five-factor models. Similar to Fama & French (2015), I utilize the 25 portfolios formed based on size and tested characteristic and run time-series regressions for each portfolio. The first set of regressions covers the Fama and French three factors (mktRP, SMB, and HML). The second set tests the Fama and French five-factor model (with mktRP, SMB, HML, RMW, and CMA). Finally, I test the five-factor model augmented

[11] This conclusion is supported by the poor performance of the CMA factor between July 2003 and December 2020, as discussed in Section 3.2.

with momentum (MOM). The key indicator for comparison of the performance of these models in the F-test of Gibbons, Ross & Shanken (1989) [the GRS test]. The null hypothesis of the GRS test is that alphas for all portfolios are equal to zero. I report the GRS value, the *p*-value, and the mean absolute alpha for each risk model tested in four sets of characteristic-sorted portfolios. The six-factor model will be an optimal choice for studying the nature of the risk pricing anomalies if it provides better approximations of portfolio returns than other risk models. If this is the case, the GRS F-statistic and mean absolute alpha should be lower for the six-factor model than for the other models it is compared to.

Table IV. The GRS test-statistic and average absolute alphas in the three-, five-, and six-factor models.

This table presents the GRS test-statistic, *p*-value, and average absolute alpha for Fama & French's three- and five-factor models, along with Fama & French's five-factor model, including momentum. The models are tested within four sets of 25 characteristic-sorted portfolios: size and value, size and operating profitability, size and investment, and size and prior return. The portfolios are formed annually (monthly for the size and momentum sort) using the breakpoints for NYSE stocks. The sample covers the period between July 1963 and December 2020.

	Fama & French's three-factor model			Fama & French's five-factor model			Fama & French's five-factor model + MOM		
	GRS	*p*-value	$A\|\alpha_i\|$	GRS	*p*-value	$A\|\alpha_i\|$	GRS	*p*-value	$A\|\alpha_i\|$
Size-B/M portfolios	3.19	0.000	0.091	2.64	0.000	0.087	2.22	0.000	0.073
Size-OP portfolios	1.94	0.004	0.088	1.59	0.035	0.063	1.32	0.136	0.051
Size-Inv portfolios	5.01	0.000	0.095	3.81	0.000	0.079	3.26	0.000	0.067
Size-Mom portfolios	5.02	0.000	0.301	4.41	0.000	0.262	3.56	0.000	0.109

Indeed, Table IV shows that the six-factor model has higher explanatory power than the three- and five-factor models in describing portfolio returns. In all the sets of characteristic-sorted portfolios, the six-factor model produces lower mean alphas and lower GRS F-statistic than the Fama and French models. The most considerable decrease in mean alpha is seen for the portfolios of firms sorted by market value and momentum (from 0.30% in the five-factor model to 0.11% in the six-factor model) since the addition of a characteristic-based risk factor yields the most significant improvements for the portfolios sorted on this characteristic.

Even though the six-factor model outperforms the alternative models, it is not free from problems. The null hypothesis of all alphas equal to zero is still rejected for 3 out of 4 portfolios, with the *p*-value is as low as 0.000. For the firms sorted on size and operating profitability, the GRS test fails to reject the null hypothesis at the 10% significance level – the result not achieved by the three- and five-factor model, for which the null is rejected at 0.1% and 1% significance levels, respectively.

Although the six-factor model is not perfect, it provides a better description of the portfolio returns than other conventional asset pricing models. Thus, this model specification will be used in the tests of the nature of selected asset pricing anomalies.

4. Methodology

This section describes the methodology used to test whether the return premia associated with firm characteristics are driven by firm characteristics or exposure to risk factors. In Section 4.1, I describe the approach used to sort firms into portfolios and discuss the summary statistics of these portfolios. In Section 4.2, I discuss the tests conducted for portfolios sorted on two firm characteristics and corresponding risk factor loadings. Finally, in Section 4.3, I describe the tests that will be conducted for the characteristic-balanced portfolios.

4.1 Portfolio formation

In this section, I discuss my approach to portfolio formation, which is closely aligned with that of Daniel & Titman (1997) and Davis et al. (2000). To test whether the difference in returns of firms with different characteristics can be reliably explained by the difference in loadings on the corresponding factor, I need to isolate the effect of factor loadings from the effect of characteristics, since the two are highly correlated (Daniel & Titman, 1997). For this, in line with Daniel & Titman (1997) and Davis et al. (2000), I allocate firms into portfolios based on their characteristics and factor loadings.

I start by sorting stocks into three portfolios based on their market equity, constructing the 33rd and 67th percentile breakpoints from NYSE stocks. The breakpoints are computed monthly for the momentum tests and annually for the tests for other anomalies. For the monthly breakpoints, I use market equity in month *t*; for the annual breakpoints, the market equity in June of year *t* is used.

Afterwards, I independently sort stocks into three portfolios based on the tested characteristic (value, operating profitability, investment, or momentum), using the NYSE breakpoints. For value, operating profitability, and investment, the breakpoints are constructed annually, using the accounting data released in year *t-1*. For momentum, I construct monthly breakpoints; the breakpoints at the end of month *t* use prior return between *t-11* and *t-1*.

Finally, I combine the sort on size with the sort on the tested characteristic to form nine characteristic-sorted portfolios for each tested anomaly. For size, I use value as the second dimension in characteristic sort. For the market risk premium, I sort the firms based on their size and book-to-market ratios[12]. Having a two-dimensional sort instead of only sorting on the tested characteristic helps balance the portfolios and reduces noise in the results; size, which is widely used in Fama & French's portfolio sorts and factor portfolio construction, is an obvious choice for the second sorting variable.

Afterwards, I form factor-loading sorted portfolios. Since the ex-post risk factor loadings are not known at the time of portfolio formation, I use the pre-formation betas as an approximation for the post-formation betas. To compute them, I run the following time-series regression for each of the stocks in the nine characteristic-sorted portfolios, using Fama & French's (2015) risk factors as independent variables[13].

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

Following the approach of Davis et al. (2000), I run these regressions in the rolling window of 60 months, covering the returns between months *t-66* and *t-6*, where month *t* is the portfolio formation month. In line with Davis et al. (2000), I only keep those pre-formation coefficients that rely on at least 36 months of pre-formation stock returns. This increases the precision of beta estimates but limits the sample period. As a result, the earliest portfolio formation date in the sample that starts in July 1963 is June 1967.

Based on the pre-formation factor loadings, I allocate firms into three factor-loading portfolios, formed based on the 33rd and 67th percentile breakpoints, in line with Davis et al. (2000). However, contrary to Daniel and Titman (1997), I form portfolios based on the factor loading breakpoints that are independent of the characteristic sort. The conditional breakpoints allow for a more even distribution of firms into factor-loading portfolios, which can improve portfolio diversification. However, the use of independent breakpoints makes the firms in the same factor-loading tercile comparable in terms of pre- and post-formation betas. This allows me to conduct an additional test of the characteristic model, not covered in Daniel & Titman

[12] The characteristic associated with the market risk factor is the equity status – the premium earned by a stock by simply being a stock (and thus, riskier than a bond). Since all the tested securities are stocks, I cannot sort on this characteristic, and instead, I rely on other characteristics such as size and book-to-market ratio to create characteristic-balanced portfolios.

[13] Daniel & Titman (1997) use adjusted risk factors to estimate the pre-formation betas. In June of year *t*, they take the portfolio weights in Fama and French's (1993) risk factors and apply these weights to form factors between months *t-42* and *t-6*. These factors, used in the time-series regressions, utilize constant weights that do not evolve with market values. In my analysis, I use standard Fama & French (2015) variable-weighted versions of SMB, HML, RMW, CMA, and MOM, since Davis et al. (2000) report that the choice of the factor formation approach has no significant effect on the results.

(1997). With the independent breakpoints, I can calculate the risk-balanced portfolio return – the return to a portfolio that is balanced in terms of the respective factor loadings and secondary sorting characteristics, and because of this, directly associated only with the tested characteristic. This is a valuable addition to the tests of the nature of the premia, which is why I choose to keep the factor loading breakpoints independent.

As with the characteristic sort, the breakpoints for the factor loadings are constructed monthly for momentum and annually for all other risk factors. Daniel and Titman (1997) form five factor-loading portfolios instead of three, as in Davis et al. (2000), which results in a more granular sort. However, I find that this approach often leads to too few firms in portfolios, and occasionally no firms in a given portfolio at all. This problem persists throughout the entire sample period, yet is greatly reduced if I limit the number of factor-loading portfolios to three. Therefore, I choose Davis et al.'s (2000) approach in my study.

Combining the factor-loading and characteristic-based sort, I form 27 portfolios for each of the tested return premia. For size, value, operating profitability, and investment, the portfolios are held between July of year *t* and June of year *t+1*. For momentum, the portfolios are formed in month *t* and held in month *t+1*.

Since characteristics are highly correlated with the corresponding factors loadings, and sometimes with other characteristics, this may result in problems with the number of firms in the portfolios that rely on this correlation to be sufficiently low. Panel A of Table A1 in Appendix A shows the average number of firms in each of the 27 portfolios that are formed for the six tested anomalies individually. Panel B presents the description of poorly diversified portfolios (fewer than 5 firms in a portfolio).

In the sorts for profitability, investment, momentum, and market risk premium, nearly all the portfolios have a sufficiently large number of stocks allocated to them each month. The average number of firms in any portfolio is higher than 30 and there are no portfolios for which the diversification is insufficient in at least 1% of the holding months.

The average number of firms in portfolios for value tests is generally high, although, in the portfolio of large firms with high book-to-market and low HML loadings, the average number of firms is only 18. This portfolio also has fewer than five firms in one-fifth of all the holding months; however, there is always at least one firm in the portfolio in a given month. This portfolio is problematic because of the correlations between size and value as well as value and HML. Size and value are correlated since both characteristics rely on market equity; value and HML are correlated naturally such that large book-to-market firms are likely to load strongly on the HML factor.

The biggest problem is the sort for the size premium. Size and SMB are very strongly correlated, as the portfolios of small firms rarely load strongly on the SMB factor. Thus, the portfolios of small firms with high SMB betas suffer from a lack of diversification, and this problem is the strongest for the large and medium book-to-market firms, as both portfolios have less than 5 firms allocated to them in approximately half of the holding months. Moreover, in 32% (6%) of the holding months, there are no firms allocated to the large (medium) book-to-market, small size, high SMB beta portfolio. This problem will be addressed in Section 5.2 as a robustness test of the main results for the size premium.

In the next section, I will discuss the tests conducted within each of the sets of 27 characteristic- and beta-sorted portfolios.

4.2 The tests for characteristic- and beta-sorted portfolios

To test whether the difference in portfolio returns is driven by the differences in a tested characteristic or pre-formation factor loadings, I compute the average value-weighted buy-and-hold monthly excess returns for each of the 27 portfolios. For the risk story to hold, the excess returns should increase with the increase in ex-ante factor loadings and the portfolio of high factor-loading firms should outperform the portfolio of low factor-loading firms within each characteristic portfolio. Since firms in each of the characteristic portfolios are similar in terms of the tested characteristic, the difference in returns of the beta-sorted portfolios should be driven by the difference in betas solely, isolated from the effect of characteristics. In addition, I examine the returns on the combined factor loading portfolio level, as I equally weight the returns of all the portfolios within the same factor loading tercile.

If there is no reliable increase in returns stemming from an increase in factor loadings, yet the returns are different with respect to the characteristic sort within each factor loading portfolio, then the anomaly follows the characteristic story. In this case, the returns are driven by the difference in characteristics, while the difference in factor loadings has no significant effect on portfolio returns.

I continue by running the following set of time-series regressions for each characteristic- and risk-sorted portfolio utilizing 642 monthly return observations.

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

I report and examine the abnormal returns from these regressions for each characteristic- and beta-sorted portfolio. Under the risk model that is well-suited to explain the cross-sectional differences in stock returns, the alphas in each of the 27 portfolios should be indistinguishable from 0. Under the characteristic model, however, the high (low) factor loading portfolios perform worse (better) than predicted by the model. This suggests that we should be able to witness positive abnormal returns in the low factor-loading portfolios and negative returns in the high factor-loading portfolios if the characteristic model is true.

The next section examines the tests conducted for the characteristic-balanced portfolios for each asset pricing anomaly.

4.3 The tests for characteristic-balanced portfolios

Within each characteristic portfolio, I also test the returns of a strategy that invests one dollar into stocks with high pre-formation factor loadings and sells one dollar of stocks with low pre-formation factor loadings. As a result, such a strategy does not load on the tested characteristics and size[14]. In this way, I form nine zero-investment characteristic-balanced portfolios, compute their mean monthly excess returns, and use the returns as dependent variables in the time-series regressions on the six risk factors.

For the risk story to hold, we would expect the excess return of this strategy to be positive, since, under the risk story, portfolios with high factor loadings outperform portfolios with low factor loadings. If the characteristic model holds, we should see that the excess returns of this strategy are equal to zero, since the characteristics within each of the nine portfolios are similar, and the factor loadings are not driving the differences in returns in the characteristic world.

[14] In the tests for size and market risk premium, the characteristic-balanced portfolios do not load on size and value characteristics.

Another important set of results to examine are the abnormal returns in the time-series regressions for each characteristic-balanced portfolio. In the risk world, given that the Fama and French five-factor model with momentum provides a reasonable approximation for the portfolio returns, we should witness alphas that are indistinguishable from 0. However, if the characteristic model holds, the abnormal returns should be negative, because firms with high (low) factor loadings perform worse (better) than predicted by the risk model, and thus, generate negative (positive) alphas, and the characteristic-balanced portfolios are constructed by buying underperforming high-beta firms and selling outperforming low-beta firms.

In addition, these regression results allow me to validate the two crucial assumptions required to distinguish between the risk model and the characteristic model. First, there should be a stable covariance structure of returns such that the pre-formation factor loadings are a good predictor of the post-formation factor loadings. Second, there should be a substantial variation in the average factor loadings across different factor loading portfolios, which will allow me to differentiate between the effect of characteristics and factor loadings (Daniel & Titman, 1997)[15].

Both of these requirements can be validated by examining the post-formation loadings on the tested factor. If the pre-formation factor loadings are a good proxy for the post-formation factor loadings and they vary considerably across different factor loading portfolios, then, within each of the nine characteristic-balanced portfolios, I should be able to witness positive and both economically and statistically significant loadings on the tested factor. This will mean that the portfolio with high (low) pre-formation factor loadings has high (low) post-formation factor loadings, and the dispersion in post-formation factor loadings is high enough to produce a statistically significant beta in a characteristic-balanced portfolio.

Having described the methodology used for the analysis of the nature of various asset pricing anomalies, I proceed with the empirical analysis section, where I separately discuss the results of tests for the value, size, operating profitability, investment, momentum, and market risk premia.

[15] The third requirement of Daniel & Titman (1997) is the existence of an economically significant risk premium associated with the tested factor, as discussed in Section 3.2.

5. Empirical analysis

This section presents the results of the tests of characteristics versus covariances nature of the value (Section 5.1), size (Section 5.2), operating profitability (Section 5.3), investment (Section 5.4), momentum (Section 5.5), and market risk (Section 5.6) premia.

5.1 The value premium

In this section, I discuss the test results for the value anomaly and check whether the evidence favors the characteristic story or else the risk story. I start by examining the excess returns of the HML beta, market equity, and book-to-market ratio sorted portfolios and the excess returns of characteristic-balanced portfolios. Similarly, I examine the abnormal returns from the six-factor time series regressions in the risk and characteristic sorted portfolios and within the characteristic-balanced portfolios. Following this discussion and preliminary conclusions, I examine the post-formation HML factor loadings as a check for the validity of portfolio sort. Finally, I compare my results with the findings of Davis et al. (2000) and interpret the differences.

Table V shows the excess and abnormal returns of the portfolios sorted by market equity, book-to-market ratio, and pre-formation HML loadings. It also shows the excess returns and alphas of the characteristic-balanced portfolio strategy that buys firms with high HML factor loadings and sells firms with low HML factor loadings.

I start by examining the returns of the 27 characteristic- and beta-sorted portfolios. For the risk story to hold, we should see a monotonic increase in excess returns within each characteristic portfolio as the pre-formation factor loadings increase. Panel A shows that this is not the case for the value premium. Firms with high pre-formation HML loadings outperform the firms with low factor loadings in 4 out of 9 characteristic portfolios. However, the *t*-statistic on the excess returns of the characteristic-balanced portfolios shows that this difference in returns is not statistically significant in any of the portfolios[16].

[16] The excess returns (alphas) in the characteristic-balanced are equivalent to the difference in excess returns (alphas) between high- and low-factor loading firms within each characteristic-sorted portfolios. This occurs because the characteristic-balanced strategy weighs equally on the buy and on the sell side.

Table V. Mean monthly excess and abnormal returns of characteristic- and HML-beta-sorted portfolios and characteristic-balanced portfolios

The portfolios are formed annually based on market equity in June of year t, the book-to-market ratio in year t-1, and pre-formation HML factor loadings calculated from the returns between month t-66 and t-6. The book-to-market equity is calculated as the ratio of book equity released in year t-1 to the market equity in December of year t-1. For the pre-formation HML factor loadings, at least 36 months of return observations should be available. The pre-formation HML betas and the post-formation abnormal portfolio returns are calculated from the following time-series regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

'HML factor-loading portfolio R_e' covers the excess returns in the 27 portfolios sorted by size, book-to-market, and pre-formation HML factor loadings. 'HML factor-loading portfolio α' covers the abnormal returns from the abovementioned set of time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high HML factor loadings and sells firms with low HML factor loadings within each characteristic-sorted portfolio. The portfolio size and book-to-market ranking is specified within each of the rows. 'BM portfolios 3-1' presents the returns of the strategy that buys high book-to-market firms and sells low book-to-market firms within each size and HML beta portfolio. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The data in this table covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		HML factor-loading portfolio R_e			HML factor-loading portfolio α			Characteristic-balanced portfolio	
Size	BM	1	2	3	1	2	3	R_e	α
1	1	0.51	0.67	0.44	-0.05 [-0.64]	0.02 [0.20]	-0.33 [-4.18]	-0.07 [-0.66]	-0.28 [-2.95]
1	2	0.85	0.81	0.79	0.13 [2.02]	0.00 [0.06]	0.00 [0.09]	-0.06 [-0.61]	-0.13 [-1.47]
1	3	1.04	0.86	0.86	0.22 [3.09]	0.04 [0.69]	-0.03 [-0.62]	-0.19 [-1.90]	-0.25 [-2.84]
1	3-1	0.54 [4.10]	0.20 [1.59]	0.42 [3.24]					
2	1	0.64	0.61	0.59	0.12 [1.69]	-0.14 [-2.25]	-0.17 [-2.09]	-0.05 [-0.38]	-0.29 [-2.85]
2	2	0.68	0.74	0.72	-0.04 [-0.54]	-0.06 [-0.99]	-0.10 [-1.33]	0.04 [0.38]	-0.05 [-0.48]
2	3	0.95	0.85	0.86	0.16 [1.44]	0.02 [0.28]	-0.02 [-0.25]	-0.10 [-0.63]	-0.18 [-1.28]
2	3-1	0.32 [2.22]	0.24 [2.37]	0.27 [2.23]					
3	1	0.54	0.55	0.65	0.09 [1.80]	-0.03 [-0.69]	0.11 [1.12]	0.11 [0.93]	0.01 [0.12]
3	2	0.58	0.55	0.58	-0.06 [-0.63]	-0.14 [-1.97]	-0.15 [-1.69]	0.00 [0.00]	-0.09 [-0.62]
3	3	0.60	0.53	0.68	-0.08 [-0.48]	-0.20 [-2.36]	-0.05 [-0.62]	0.08 [0.43]	0.03 [0.13]
3	3-1	0.05 [0.30]	-0.03 [-0.21]	0.03 [0.18]					
Combined portfolio		0.71	0.68	0.68	0.05 [1.38]	-0.05 [-1.83]	-0.08 [-2.30]	-0.02 [-0.57]	-0.14 [-3.26]

On the combined portfolio level, where I equally weigh the monthly returns of all characteristic-sorted portfolios, the returns of all three factor-loading portfolios are not significantly different. The average monthly return of the high factor loading portfolios is 0.68%, while in the low factor loading portfolios it is 0.71%. The resulting return of the combined characteristic-balanced portfolio is -0.02% (*t*-statistic of -0.57). This pattern in excess returns is more in line with the characteristic story, which exposits that there should not be any increase in returns with an increase in factor loadings because characteristics determine the excess returns.

These conclusions are supported when examining the return pattern within each of the nine size and HML factor-loading sorted portfolios. If the risk model is true, the variation in returns related to the variation in book-to-market ratios should be captured by the loadings on the HML risk factor, and we should not see any significant differences in returns between firms with high and low book-to-market ratios. As evident in Table V, this is not the case for value. In eight out of nine factor-loading and size sorted portfolios, high book-to-market firms outperform low book-to-market firms, and in five out of nine portfolios, these risk-balanced returns are statistically significant. Although imperfect, the evidence so far favors the characteristic story.

I also examine the abnormal returns of the triple-sorted and characteristic-balanced portfolios. To recall, for the risk model to hold, I would expect alphas to be equal to zero. For the results to be in line with the characteristic model, alphas in low (high) factor-loading portfolios should be positive (negative). As a result, the alphas in characteristic-balanced portfolios should be negative. Because it is characteristics and not factor loadings that determine the excess portfolio returns and given that all the firms in each characteristic-sorted portfolio are similar in terms of book-to-market ratios, the high factor loading portfolios should generate lower returns than predicted by the risk model, and the low factor loading portfolios should generate higher returns.

The pattern in abnormal returns is also suggestive of the characteristic story. I find that the abnormal returns are positive and statistically significant in two low factor-loading portfolios, and negative in three medium factor-loading portfolios and two low factor-loading portfolios. The positive (negative) alphas in low (high) factor loading portfolios are well in line with the predictions of the characteristic model. As a result, the alphas are negative and statistically significant in three out of nine characteristic-balanced portfolios, which contradicts the predictions of the risk model. The alpha for all characteristic-sorted portfolios combined equals -0.14% with a t-statistic of -3.26, which is economically and statistically significant and therefore, in line with the characteristic model.

Table VI. Regression results in the size and book-to-market balanced portfolios

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

This table presents the excess returns and the time-series regression results in the nine characteristic-balanced portfolios and the combined portfolio that equally weights the nine portfolios. The characteristic-balanced portfolios buy the firms with high pre-formation HML factor loadings and sell those with low pre-formation HML factor loadings within each size and book-to-market sorted portfolio. The sample covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Characteristic-balanced portfolio							
Size	BM	R_e	α	β	s	h	r	c	m
1	1	-0.07 [-0.66]	-0.28 [-2.95]	-0.02 [-0.98]	0.01 [0.41]	0.16 [3.69]	0.31 [6.85]	0.20 [3.00]	0.07 [3.31]
1	2	-0.06 [-0.61]	-0.13 [-1.47]	-0.09 [-4.63]	-0.02 [-0.76]	0.32 [7.88]	0.39 [9.66]	-0.12 [-2.01]	-0.03 [-1.71]
1	3	-0.19 [-1.90]	-0.25 [-2.84]	-0.02 [-1.11]	-0.16 [-5.08]	0.36 [8.52]	0.25 [6.03]	-0.15 [-2.31]	-0.01 [-0.31]
2	1	-0.05 [-0.38]	-0.29 [-2.85]	0.01 [0.39]	-0.03 [-0.73]	0.42 [8.96]	0.62 [13.00]	-0.04 [-0.60]	-0.02 [-0.82]
2	2	0.04 [0.38]	-0.05 [-0.48]	-0.06 [-2.45]	0.01 [0.34]	0.43 [8.72]	0.42 [8.63]	-0.30 [-4.07]	-0.01 [-0.21]
2	3	-0.10 [-0.63]	-0.18 [-1.28]	-0.04 [-1.16]	-0.17 [-3.38]	0.48 [7.21]	0.37 [5.48]	-0.26 [-2.63]	0.00 [0.11]
3	1	0.11 [0.93]	0.01 [0.12]	0.05 [1.89]	-0.00 [-0.11]	0.22 [4.01]	0.19 [3.44]	-0.07 [-0.82]	-0.03 [-1.25]
3	2	0.00 [0.00]	-0.09 [-0.62]	-0.04 [-0.20]	0.00 [0.03]	0.39 [5.92]	0.22 [3.33]	-0.24 [-2.45]	0.02 [0.50]
3	3	0.08 [0.43]	0.03 [0.13]	0.04 [0.81]	-0.11 [-1.72]	0.69 [7.56]	0.33 [3.57]	-0.60 [-4.43]	-0.03 [-0.73]
Combined portfolio		-0.02 [-0.57]	-0.14 [-3.26]	-0.02 [-1.65]	-0.05 [-3.56]	0.39 [19.70]	0.34 [17.50]	-0.18 [-6.01]	-0.00 [-0.45]

As a robustness check, I examine the post-formation HML factor loadings in the characteristic-balanced portfolios. The pre-formation factor loadings used to sort firms in the portfolios may turn out to be poor proxies of the post-formation factor loadings. In this case, I will not be able to conclude which story prevails for the value premium, because the sort on the factor loadings will be invalid. If the firms with high pre-formation HML betas no longer load heavily on the HML factor, the portfolio of high pre-formation factor-loading firms is no longer expected to earn higher excess returns. In case the pre-formation betas are a good predictor of the post-formation betas, I should witness positive loadings on HML within each of the nine portfolios. These loadings should also be statistically and economically significant, which will indicate that there is a dispersion in the factor loadings that is high enough to result in differences in excess portfolio returns.

The HML factor loadings in Table VI confirm that the pre-formation betas are a good predictor of the post-formation betas. The HML betas are positive and statistically significant in all 9 portfolios, with the magnitude ranging from 0.16 to 0.69. The average HML beta in the combined portfolio is 0.39 (*t*-statistic of 19.70). Given an average HML return of 0.25%, and holding other things equal, the difference in monthly returns of high and low factor-loading firms in the combined portfolio should be equal to 0.10%, which is significant enough to be evident in the results if the risk story was true.

However, my conclusions could be false if the results are affected by the poor performance of the HML factor in certain years. To recall, Table II shows that the HML factor portfolio earned a negative 0.21% return between July 2003 and December 2020. In this period, the firms that load strongly on HML are expected to generate lower returns than the firms with low HML factor-loadings. If the risk story holds, this will drive down the returns of high beta firms and decrease the returns of low beta firms in the entire sample, which undermines the validity of my earlier results.

To account for this, I re-run the tests behind the results in Table V for the period when the value factor was strong (between July 1967 and June 2003). The results (reported in Appendix B, Table B1) are quite similar to the results in the entire sample period, as they indicate that the risk model does not hold in the reduced sample either. The combined characteristic-balanced portfolio return is -0.05% with a *t*-statistic of -0.89, while the abnormal return is -0.22% with a *t*-statistic of -4.13. Therefore, the results from the robustness tests in this section confirm the validity of my earlier conclusions about the nature of the value premium.

It makes sense to discuss the results in light of the earlier research on the value anomaly. My findings are largely in line with the results of Daniel & Titman (1997) who reject the risk story in the sample covering U.S. stocks between July 1973 to December 1993. However, my conclusions contradict the findings of Davis et al. (2000) who find strong evidence in support of the risk story for the value premium. The most obvious reason for this contradiction is the differences in the sample period. Due to the lack of accounting data, the RMW and CMA factors cannot be estimated before 1963, and I am unable to utilize the six-factor model in the period not covered by CRSP/Compustat Merged. Davis et al. (2000) report that the risk story is especially strong between 1929 and 1963, as the combined characteristic-balanced portfolio earns an excess return of 0.19%. Daniel & Titman (1997) and Davis et al. (2000) confirm that the risk story does not hold between 1973 and 1997; my results support these conclusions and suggest that the poor performance of the risk-based explanation persists in the later years. Another, more hypothetical reason for the differences with Davis et al. (2000) [and minor discrepancies with Daniel & Titman (1997)] is the choice of a different risk model for the tests. The inclusion of RMW, CMA, and MOM factors drives the differences in the pre-formation and post-formation factor loadings along with abnormal returns. As the portfolio sort is impacted by the differences in pre-formation HML betas, the average portfolio returns could differ too, although it is hard to say if and why the differences would be material[17].

To summarize, the results of these tests reject the risk model for the value anomaly and fail to reject the characteristic model. This means that the returns of firms with similar book-to-market ratios covary not because the firms load in the same way on the HML risk factor, but because of the similarity in firm properties. I proceed by examining the results for the size premium.

5.2 The size premium

In this section, I discuss the test results for the size premium in a similar way as for the value premium. I start by looking at the excess returns of the triple-sorted and characteristic-balanced portfolios, following by a similar analysis for the abnormal returns in the time-series regressions. I also examine the post-formation SMB factor loadings along with the results in

[17] The differences with Davis et al. (2000) are not driven by the minor changes in the methodology made for this thesis (utilizing value-weighted versions of the risk factors and constructing the factor-loading breakpoints using an independent portfolio sort). Once I limit the data sample to 1929 – 1999 and use the three-factor model in the tests, my results are well aligned with the findings of Davis et al. (2000).

the sample period when SMB is robust, and conclude with the discussion of my results in light of the findings of Daniel & Titman (1997) and Davis et al. (2000).

Table VII presents the excess returns and alphas to the 27 portfolios sorted by market equity, book-to-market ratio, and SMB pre-formation factor loadings as well as the excess returns and alphas for the nine characteristic-balanced portfolios. The pattern in excess returns provides evidence that favors the risk story over the characteristic story. The firms with high SMB factor loadings outperform firms with low SMB factor loadings in 8 out of 9 characteristic-sorted portfolios, yet in only one portfolio (large firms with medium book-to-market) this difference in returns is statistically significant[18]. In the combined portfolio, firms with high SMB factor loadings (excess return of 0.75%) outperform firms with low factor loadings (0.66%). The resulting excess return of the combined characteristic-balanced portfolio is 0.09% (*t*-statistic of 1.60). Since this return is not statistically significant[19], the evidence so far is not sufficient to reject the characteristic model.

However, the weakness of the characteristic story in the case of size anomaly is evident when examining the returns of book-to-market and SMB-sorted portfolios. Within these portfolios, the difference in returns of large firms and small firms is expected to be negative and statistically significant, if the characteristic model holds. This difference is negative in six out of nine portfolios, and statistically significant only in one portfolio (large book-to-market firms with low SMB factor loadings). This evidence is frustratingly weak for the characteristic story, which is clear if I compare these results with a similar set of results for value, where I have concluded that the characteristic story holds. For the value anomaly, the excess return had a correct sign in eight out of nine portfolios and was statistically significant in five out of nine portfolios. The results for the size anomaly do not have the same economic and statistical significance.

---

[18] In some portfolios, the average characteristic-balanced return is not the same as the difference between the returns of high and low SMB beta firms. This occurs because occasionally there are no firms in the high SMB beta portfolio in a given month, as discussed in Section 4.1. Whenever such a portfolio is missing altogether, the characteristic-balanced return is not calculated, leading to discrepancies on average.

[19] Davis et al. (2000) utilize a one-tailored test for determining the statistical significance of the characteristic-balanced portfolio returns. They argue that the only alternative to the null hypothesis is a positive excess return as predicted by the risk model. In a one-sided test, this return of the combined size-balanced portfolio is statistically significant on approximately 95% confidence level.

Table VII. Mean monthly excess and abnormal returns of characteristic- and SMB-beta-sorted portfolios and characteristic-balanced portfolios

The portfolios are formed annually based on market equity in June of year t, book-to-market equity in year t-1, and pre-formation SMB factor loadings calculated from the returns between month t-66 and t-6. The book-to-market equity is calculated as the ratio of book equity released in year t-1 to the market equity in December of year t-1. For the pre-formation SMB factor loadings, at least 36 months of return observations should be available. The pre-formation SMB betas and the post-formation abnormal portfolio returns are calculated from the following set of time-series regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

'SMB factor-loading portfolio R_e' covers the excess returns of the 27 portfolios sorted by size, book-to-market, and pre-formation SMB factor loadings. 'SMB factor-loading portfolio α' covers the abnormal returns from the time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high SMB factor loadings and sells firms with low SMB factor loadings within each characteristic-sorted portfolio. The portfolio size and book-to-market ranking is specified within each of the rows. Size portfolios 3-1 present the returns of the strategy that buys large firms and sells small firms within each book-to-market and SMB factor-loading portfolio. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The data in this table covers the period between July 1967 and December 2020. Test-statistic is in square brackets

Characteristic portfolio		SMB factor-loading portfolio R_e			SMB factor-loading portfolio α			Characteristic-balanced portfolio	
BM	Size	1	2	3	1	2	3	R_e	α
1	1	0.50	0.62	0.51	-0.12 [-1.28]	-0.06 [-0.73]	-0.11 [-1.58]	0.01 [0.05]	0.01 [0.08]
1	2	0.69	0.68	0.49	0.05 [0.69]	-0.05 [-0.88]	-0.16 [-1.96]	-0.19 [-1.74]	-0.21 [-1.97]
1	3	0.55	0.61	0.68	0.04 [1.13]	0.02 [0.30]	0.22 [1.49]	0.13 [0.68]	0.18 [1.16]
1	3-1	0.05 [0.29]	-0.01 [-0.04]	0.18 [0.93]					
2	1	0.76	0.85	0.80	0.09 [1.32]	0.03 [0.58]	0.02 [0.37]	0.04 [0.35]	-0.07 [-0.71]
2	2	0.65	0.77	0.75	-0.08 [-1.27]	-0.05 [-0.88]	-0.12 [-1.24]	0.10 [0.75]	-0.03 [-0.28]
2	3	0.53	0.72	1.02	-0.13 [-2.16]	-0.10 [-1.19]	0.20 [0.92]	0.47 [2.03]	0.35 [1.51]
2	3-1	-0.23 [-1.70]	-0.13 [-1.03]	0.14 [0.58]					
3	1	0.89	0.84	0.97	0.11 [1.66]	-0.01 [-0.26]	0.05 [0.76]	0.08 [0.81]	-0.06 [-0.68]
3	2	0.83	0.93	0.86	0.07 [0.97]	0.03 [0.35]	-0.12 [-1.00]	0.03 [0.22]	-0.19 [-1.34]
3	3	0.53	0.82	0.65	-0.15 [-2.42]	-0.11 [-0.90]	-0.19 [-0.63]	0.17 [0.52]	0.01 [0.03]
3	3-1	-0.36 [-2.50]	-0.02 [-0.16]	-0.36 [-1.17]					
Combined portfolio		0.66	0.76	0.75	-0.01 [-0.43]	-0.03 [-1.08]	-0.02 [-0.47]	0.09 [1.60]	-0.00 [-0.03]

Table VII also shows the abnormal returns of the triple-sorted and characteristic-balanced portfolios. On the combined portfolio level, the alphas are zero in all three factor-loading portfolios, which is consistent with the risk story. In the 27 risk- and characteristic-sorted portfolios, I find two statistically significant negative alphas in low factor-loading firms and one such alpha in high factor-loading firms. Although finding a negative alpha in high factor-loading portfolios is a good sign for the characteristic model, finding negative alphas in low factor-loading portfolios clearly contradicts the characteristic model, which would expect low-beta firms to generate higher returns than predicted by the factor model and thus, produce positive abnormal returns.

In the nine characteristic-balanced portfolios, the alphas are indistinguishable from 0 in all but one portfolio (medium-sized firms with low book-to-market ratios). This is also the only portfolio where the high SMB-beta firms produce lower returns than the low SMB-beta firms. But most importantly, on the combined portfolio level, the abnormal return is -0.00% (*t*-statistic of -0.03), textbook-consistent with the risk model.

The alpha that is nearly perfectly consistent with the risk model suggests that the excess return witnessed in the combined characteristic-balanced portfolio is also well aligned with the predictions of the six-factor model. Thus, the lack of statistical significance of the excess return does not indicate the weakness of the risk story for the size premium; it is rather the weakness of the size premium itself.

The results displayed in Table VII provide much stronger evidence in favor of the risk model than that of the characteristic model. As a follow-up test, I discuss the robustness checks of the earlier results.

As with the value premium, I examine the post-formation loadings on the relevant risk factor, shown in Table VIII. I find that the assumption of a stable covariance matrix of returns is valid, and the factor loadings vary substantially. The loadings on the SMB factor are positive and statistically significant in all nine portfolios, and the SMB beta in the combined portfolio is 0.35 with a *t*-statistic of 19.91. Given an average SMB portfolio return of 0.23%, the firms that load highly on SMB should produce a return that is 0.08% higher than the return of low factor loading firms, ignoring the effect of other factors. To recall, the excess return observed in the combined characteristic-balanced portfolio is 0.09%, highly consistent with these expectations.

Table VIII. Regression results in the size- and book-to-market balanced portfolios

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

This table presents the excess returns and the time-series regression results in the nine characteristic-balanced portfolios and the combined portfolio that equally weights the nine portfolios. The characteristic-balanced portfolios buy the firms with high pre-formation SMB factor loadings and sell those with low pre-formation SMB factor loadings within each size and book-to-market sorted portfolio. The sample covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Characteristic-balanced portfolio							
BM	Size	R_e	α	β	s	h	r	c	m
1	1	0.01	0.01	0.07	0.19	-0.03	-0.12	-0.15	0.01
		[0.05]	[0.08]	[2.57]	[4.98]	[-0.58]	[-2.29]	[-1.90]	[0.37]
1	2	-0.19	-0.21	0.15	0.16	-0.12	0.09	-0.19	-0.07
		[-1.74]	[-1.97]	[6.07]	[4.39]	[-2.36]	[1.77]	[-2.64]	[-2.67]
1	3	0.13	0.18	0.25	0.50	-0.16	-0.29	-0.50	-0.05
		[0.68]	[1.16]	[6.72]	[9.12]	[-2.18]	[-3.88]	[-4.45]	[-1.24]
2	1	0.04	-0.07	0.17	0.35	-0.09	-0.12	-0.03	0.03
		[0.35]	[-0.71]	[7.10]	[10.38]	[-2.07]	[-2.68]	[-0.43]	[1.16]
2	2	0.10	-0.03	0.20	0.44	-0.04	-0.08	-0.19	0.04
		[0.75]	[-0.27]	[7.66]	[11.82]	[-0.69]	[-1.62]	[-2.51]	[1.40]
2	3	0.47	0.35	0.28	0.29	-0.04	-0.28	-0.08	-0.01
		[2.03]	[1.51]	[5.19]	[3.75]	[-0.41]	[-2.63]	[-0.52]	[-0.12]
3	1	0.08	-0.06	0.15	0.35	-0.07	0.09	-0.04	0.01
		[0.81]	[-0.68]	[6.68]	[10.87]	[-1.70]	[2.07]	[-0.56]	[0.36]
3	2	0.03	-0.19	0.25	0.37	0.08	0.17	-0.16	-0.01
		[0.22]	[-1.34]	[7.58]	[7.72]	[1.28]	[2.62]	[-1.70]	[-0.39]
3	3	0.17	0.01	0.15	0.62	-0.38	0.14	0.06	-0.07
		[0.52]	[0.03]	[1.94]	[5.60]	[-2.47]	[0.96]	[0.28]	[-0.97]
Combined portfolio		0.09	-0.00	0.18	0.35	-0.08	-0.05	-0.15	-0.01
		[1.60]	[-0.03]	[14.97]	[19.91]	[-3.47]	[-2.26]	[-4.15]	[-0.84f]

The main problem for the tests for size is that the size characteristic and SMB factor loadings are highly correlated. As a result, there are few firms in the portfolios which rely on the correlation to be imperfect (see Appendix A, Table A1), and in some portfolio formation years, these portfolios have no firms. This is a problem for portfolio 2-3-3 (large firms with high SMB factor loadings and medium book to market ratio) and portfolio 3-3-3 (large firms with high SMB factor loadings and high book to market ratio). The former portfolio has firms allocated to it in 606 out of 642 tested months, while the latter has firms only in 438 out of

642 months. This is not surprising: it is expected that large firms are more likely to have low SMB factor loadings and low book-to-market ratios due to the negative correlation between the two characteristics. Nonetheless, the problem undermines the conclusions from this set of results.

In addition, the SMB factor, along with others, is not doing consistently well in the entire sample period. Between July 1983 and June 2003, the SMB factor portfolio produces a monthly return of -0.06% (*t*-statistic of -0.27), the sign of which is inconsistent with the expectations that the small firms outperform the large firms.

I combine the solution to these two problems in one single test. First, I remove the problematic period for the SMB factor from the sample; therefore, the sample in this additional test extends from July 1967 to June 1983 and from July 2003 to December 2020. In addition, I construct the SMB factor loading breakpoints that are conditional on the characteristic-sorted portfolio. To recall, the portfolios in the main test are constructed using breakpoints that are the same for each characteristic-balanced portfolio. With conditional breakpoints, there are always firms in each portfolio each month, and the diversification of portfolios is improved. However, it is not possible to compare the returns of firms within the same factor loading portfolio to test the effect of characteristics, since the mean factor loadings may differ substantially across characteristic-sorted portfolios.

The results of this test are presented in Appendix B, Table B2. I find that the evidence from the robustness tests that control for the imperfections in the main tests is still more consistent with the risk story. The combined characteristic-balanced portfolio return is 0.14% with a *t*-statistic of 2.76, which is both economically and statistically in line with the risk. However, the abnormal return of this portfolio is -0.09% with a *t*-statistic of -1.96 – consistent with the characteristic story.

Two main reasons lead me to conclude that the risk story is more pronounced than the characteristic story for the size premium. First, the size of the excess return (in absolute terms) indicates the extent to which the characteristic model underpredicts the returns, while the size of the abnormal return is suggestive of the extent to which the risk model overpredicts the returns. Juxtaposing the two, we can see that the characteristic model underpredicts the returns more significantly (by 0.14 p.p.) than the risk model overpredicts them (by 0.09 p.p.). Therefore, the risk story outperforms the characteristic story.

Second, the SMB beta-return relationship holds well for the portfolios of medium and high book-to-market firms, as shown in Appendix B, Table B2. In these portfolios, firms with high SMB betas always outperform firms with low SMB betas, and the characteristic-balanced return ranges from 0.10% to 0.28%. The portfolios of low book-to-market firms, however, have very low characteristic-balanced returns and high alphas and are driving the evidence in favor of the characteristic story. In Table III, I have shown that the size-return relationship does not hold for the low book-to-market firms – the large firms outperform the small firms, contrary to the other portfolios. It is therefore not surprising that the portfolios of low book-to-market firms show almost no SMB beta-return relationship, and it is likely that this result is not due to the weakness of the risk story for the size premium, but rather due to this anomaly within the size anomaly.

The evidence for the size premium in Daniel & Titman (1997) is also somewhat mixed – they show the characteristic-balanced portfolios exhibit both a positive excess return and a negative alpha[20]; however, the evidence is more in line with the characteristic story. This is not surprising as half of the sample period of Daniel & Titman (1997) lies within the period that I excluded in the robustness tests due to the weak performance of the SMB factor. For this particular reason, Davis et al. (2000) do not test the size premium in their paper, as the lack of robustness of the tested risk factor may lead to wrong conclusions about the nature of the premium.

To conclude, the evidence from this section suggests that the size premium follows the risk story, as the returns of the portfolios vary not with respect to the size characteristic, but due to the variations in factor loadings. The evidence in favor of the characteristic story, although present, is incomplete and weaker than that in favor of the risk story. I continue the discussion of empirical results by testing the operating profitability premium.

[20] The alpha in the combined characteristic-balanced portfolio is significant at the 10% level; the *t*-statistic of the excess return is not reported.

5.3 The operating profitability premium

This section examines the results of tests of the nature of the operating profitability premium. Table IX shows the monthly excess and abnormal returns of the 27 portfolios sorted by size, operating profitability, and pre-formation loadings on the RMW factor, as well as the excess and abnormal returns of the nine characteristic-balanced portfolios.

The returns of the 27 characteristic- and beta-sorted portfolios provide evidence that is inconsistent with the risk story, as the returns do not display a gradual increase as the pre-formation factor loadings increase. By examining the returns of the nine characteristic-balanced portfolios, I find that only two out of nine portfolios exhibit a positive excess return, as the returns of firms with high factor loadings are higher than those of firms with low factor loadings. However, these characteristic-balanced excess returns are not statistically significant. The returns of the combined portfolio are also consistent with the characteristic model, as all low factor loading stocks combined produce an excess return (0.67%) that is not statistically significantly different from the return of high factor loading stocks (0.64%). The resulting combined characteristic-balanced return is -0.03% (*t*-statistic of -0.78).

The return variation with respect to the operating profitability characteristic is more substantial. In all nine size and RMW-beta sorted portfolios, firms with high operating profitability outperform the firms with low operating profitability; in five out of nine portfolios, this difference in returns is statistically significant.

I proceed with examining the abnormal returns of the 27 portfolios and the nine characteristic-balanced portfolios. Only one alpha is statistically significant in the individual portfolios. It is in a portfolio of low factor-loading stocks and is negative, which is inconsistent with both the risk and the characteristic model. The fact that all other 26 alphas are equal to zero is suggestive of the risk model. However, in a combined portfolio the alphas are more consistent with the characteristic model. Although statistically insignificant, they gradually decrease as the RMW factor loadings increase. The combined alpha for low RMW factor loading firms is 0.03 (*t*-statistic of 0.75), while for high RMW factor loading firms the abnormal return is -0.06 (*t*-statistic of -1.89). As a result, the abnormal return of the combined characteristic-balanced portfolio is negative and statistically significant (-0.09% with a *t*-statistic of -2.30). In the nine individual characteristic-balanced portfolios, I witness negative alphas in seven portfolios, although only one of them is statistically significant.

Table IX. Mean monthly excess and abnormal returns of characteristic- and RMW-beta-sorted portfolios and characteristic-balanced portfolios

The portfolios are formed annually based on market equity in June of year t, operating profitability released in year t-1, and pre-formation RMW factor loadings calculated from the returns between month t-66 and t-6. For the pre-formation RMW factor loadings, at least 36 months of return observations should be available. The pre-formation RMW betas and the post-formation abnormal portfolio returns are calculated from the following set of time-series regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

'RMW factor-loading portfolio R_e' covers the excess returns of the 27 portfolios sorted by size, book-to-market, and pre-formation HML factor loadings. 'RMW factor-loading portfolio α' covers the abnormal returns from the abovementioned set of time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high RMW factor loadings and sells firms with low RMW factor loadings within each characteristic-sorted portfolio. The portfolio size and operating profitability ranking are specified within each of the rows. Op Prof portfolios 3-1 present the returns of the strategy that buys highly profitable firms and sells unprofitable firms within each size and RMW factor-loading portfolio. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The data in this table covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		RMW factor-loading portfolio R_e			RMW factor-loading portfolio α			Characteristic-balanced portfolio	
Size	Op Prof	1	2	3	1	2	3	R_e	α
1	1	0.62	0.70	0.69	0.00 [0.07]	-0.08 [-1.42]	-0.10 [-1.63]	0.06 [0.69]	-0.10 [-1.31]
1	2	0.76	0.84	0.85	-0.01 [0.23]	0.06 [0.97]	-0.01 [-0.19]	0.09 [1.02]	0.00 [0.04]
1	3	0.82	0.89	0.84	-0.06 [-0.70]	0.05 [0.75]	-0.06 [-0.86]	0.02 [0.19]	-0.00 [-0.01]
1	3-1	0.19 [1.52]	0.19 [2.18]	0.15 [1.49]					
2	1	0.66	0.62	0.55	0.17 [1.87]	-0.08 [-1.32]	-0.11 [-1.33]	-0.11 [-0.83]	-0.28 [-2.25]
2	2	0.78	0.67	0.73	0.05 [0.67]	-0.08 [-1.35]	-0.07 [-1.20]	-0.05 [-0.59]	-0.13 [-1.33]
2	3	0.70	0.83	0.80	-0.19 [-2.18]	-0.00 [-0.01]	-0.08 [-1.23]	0.10 [1.04]	0.11 [1.08]
2	3-1	0.04 [0.28]	0.22 [2.39]	0.25 [2.29]					
3	1	0.53	0.33	0.31	0.13 [1.53]	-0.12 [-1.59]	-0.06 [-0.54]	-0.22 [-1.45]	-0.19 [-1.26]
3	2	0.66	0.52	0.39	0.15 [1.72]	-0.06 [-1.12]	-0.10 [-1.22]	-0.26 [-1.95]	-0.25 [-1.78]
3	3	0.53	0.61	0.63	0.01 [0.07]	-0.00 [-0.05]	0.03 [0.53]	0.10 [0.85]	0.03 [0.23]
3	3-1	0.00 [0.01]	0.28 [2.63]	0.32 [2.14]					
Combined portfolio		0.67	0.67	0.64	0.03 [0.75]	-0.04 [-1.26]	-0.06 [-1.89]	-0.03 [-0.78]	-0.09 [-2.30]

Finally, I find that within the combined characteristic-balanced portfolio, the risk model overpredicts the return by 9 percentage points (the alpha of -0.09%), while the characteristic model overpredicts the return by 3 percentage points (the excess return of -0.03%). Thus, the characteristic model wins when juxtaposed against the risk model.

As a robustness test, I examine the RMW factor loadings in the characteristic-balanced portfolios. Again, the post-formation factor loadings are consistent with the pre-formation factor loadings, as the RMW betas are statistically significant in all portfolios and economically strong in most of them. Notably, however, the effect of large positive RMW factor loadings is often outweighed by the effect of the loadings on other factors. For example, the portfolios of large firms with low and medium operating profitability have an expected return of -0.02% due to their large negative loadings on the market risk factor and HML. This undermines the conclusions that can be drawn from examining the individual portfolios, since the positive excess return that would be visible if the risk model holds is not expected in the first place. Nonetheless, the secondary factor loadings in the combined portfolio do not have such a large impact on the results as within the individual portfolios. Therefore, the conclusions drawn on the overall level are still valid.

Finally, I also test the results in the period when RMW is strong, thus excluding the period before July 1983 when RMW return is as low as 0.03% (*t*-statistic of 0.28). The results, shown in Appendix B, Table B3, add little value to the tests of the nature of the operating profitability premium. Although the excess return of the combined characteristic-balanced portfolio is 0.00% (*t*-statistic of 0.04), very clearly in line with the characteristic model, the abnormal return is very low too (-0.02% with a *t*-statistic of -0.48). The main reason for this disappointing excess return prediction of the risk model is the negative loadings on the market risk factor, SMB, and MOM as well as the relatively low positive loadings on the RMW factor. As a result, the excess returns of characteristic-balanced portfolios are lower than they would be in the absence of the effect of other factors and characteristics.

To conclude this section, the operating profitability premium follows the characteristic story, as there is no evidence of statistically and economically significant difference in excess returns with respect to the difference in the RMW factor loadings. However, the power of these tests to distinguish between the risk and characteristic models is weaker than in the case of value and size premia, as the returns of RMW beta-sorted portfolios are often impacted by the loadings on other factors. In the next section, I will discuss the results for the investment premium.

Table X. Regression results in the size and operating profitability balanced portfolios

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

This table presents the excess returns and the time-series regression results in the nine characteristic-balanced portfolios and the combined portfolio that equally weights the nine portfolios. The characteristic-balanced portfolios buy the firms with high pre-formation RMW factor loadings and sell those with low pre-formation RMW factor loadings within each size and operating profitability sorted portfolio. The sample covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Characteristic-balanced portfolio							
Size	Op Prof	R_e	α	β	s	h	r	c	m
1	1	0.06 [0.69]	-0.10 [-1.31]	-0.01 [-0.72]	-0.08 [-2.98]	0.29 [7.77]	0.47 [12.71]	-0.06 [-1.07]	0.02 [1.19]
1	2	0.09 [1.02]	0.00 [0.04]	0.01 [0.43]	-0.01 [-0.28]	0.16 [4.00]	0.20 [4.96]	0.04 [0.71]	-0.04 [-1.92]
1	3	0.02 [0.19]	-0.00 [-0.01]	-0.05 [-1.93]	0.03 [0.76]	0.12 [2.46]	0.30 [6.02]	0.05 [0.72]	-0.13 [-5.31]
2	1	-0.11 [-0.83]	-0.28 [-2.25]	-0.03 [-1.09]	0.08 [2.01]	0.28 [4.94]	0.49 [8.41]	0.00 [0.03]	-0.04 [-1.40]
2	2	-0.05 [-0.59]	-0.13 [-1.33]	0.00 [0.16]	0.07 [2.14]	0.01 [0.21]	0.18 [4.07]	0.12 [1.85]	-0.05 [-2.05]
2	3	0.10 [1.04]	0.11 [1.08]	-0.05 [-2.09]	-0.01 [-0.20]	0.03 [0.57]	0.12 [2.51]	-0.01 [-0.12]	-0.02 [-0.97]
3	1	-0.22 [-1.45]	-0.19 [-1.26]	-0.08 [-2.12]	0.27 [5.14]	-0.26 [-3.55]	0.25 [3.42]	0.08 [0.76]	-0.09 [-2.53]
3	2	-0.26 [-1.95]	-0.25 [-1.78]	-0.15 [-4.41]	0.12 [2.62]	-0.18 [-2.75]	0.32 [4.88]	0.18 [1.81]	-0.08 [-2.48]
3	3	0.10 [0.85]	0.03 [0.23]	-0.03 [-1.08]	-0.14 [-3.28]	0.04 [0.64]	0.33 [5.79]	0.04 [0.45]	0.02 [0.63]
Combined portfolio		-0.03 [-0.78]	-0.09 [-2.30]	-0.04 [-4.64]	0.04 [2.88]	0.05 [2.98]	0.29 [16.07]	0.05 [1.82]	-0.05 [-4.99]

5.4 The investment premium

In this section, I test the risk and the characteristic models for the investment anomaly. Within the excess returns of the 27 risk- and characteristic-sorted portfolios, I find a return pattern that is inconsistent with the risk model. Not only do the returns not increase with an increase in the pre-formation factor loadings, but within seven out of nine characteristic-sorted portfolios, the portfolio of firms with high CMA loadings generates a lower mean excess return than the portfolio of low-factor loading firms. In one of the characteristic-balanced portfolios, the mean excess return is statistically significantly negative. This evidence goes against the risk model.

On the combined portfolio level, firms with low factor loadings produce a higher excess return than the firms with high factor loadings (0.72% and 0.64%, respectively). As a result, the return of all the characteristic-balanced portfolios combined is negative and statistically significant (-0.07% with a *t*-statistic of 2.09). The economic and statistical significance of this result is striking: although this evidence rejects the risk model, the large negative return of the combined characteristic-balanced portfolio is not predicted by the characteristic model either.

I also examine the returns sorted by CMA factor loadings and the size characteristic to see if the pattern is consistent with the characteristic model. In all the nine sorts of this kind, firms with aggressive investment strategies generate lower excess returns than firms with conservative investment strategies. In three out of nine portfolios, the difference in returns between the firms with aggressive and conservative investment strategies is statistically significant. This suggests that the effect of the investment characteristic is not fully captured by the risk loadings, indicative of the characteristic story.

Finally, I examine the abnormal returns in the six-factor regressions, both for the 27 individual portfolios and for the nine characteristic balanced portfolios. The alphas in the individual portfolios are strongly suggestive of the characteristic story. I find two statistically significant positive alphas among firms with low factor loadings, and three statistically significant negative alphas among firms with high factor loadings – well aligned with the predictions of the characteristic model. In addition, there is a negative alpha in the low factor loading firms in portfolio 1-3 (small firms with aggressive investment strategies). On the combined level, there is a clear monotonic relationship between alphas and factor loadings, as the abnormal returns decrease as the factor loadings decrease. The alpha for all high CMA loading firms combined is negative and statistically significant (-0.08%, *t*-statistic of -2.55).

Table XI. Mean monthly excess and abnormal returns of characteristic- and CMA-beta-sorted portfolios and characteristic-balanced portfolios

The portfolios are formed annually based on market equity in June of year t, investment data released in year t-1, and pre-formation CMA factor loadings calculated from the returns between month t-66 and t-6. For the pre-formation CMA factor loadings, at least 36 months of return observations should be available. The pre-formation CMA betas and the post-formation abnormal portfolio returns are calculated from the following set of time-series regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

'CMA factor-loading portfolio R_e' covers the excess returns of the 27 portfolios sorted by size, investment, and pre-formation HML factor loadings. 'CMA factor-loading portfolio α' covers the abnormal returns from the abovementioned set of time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high CMA factor loadings and sells firms with low CMA factor loadings within each characteristic-sorted portfolio. The portfolio size and investment ranking is specified within each of the rows. Inv portfolios 3-1 present the returns of the strategy that buys high book-to-market firms and sells low book-to-market firms within each size and CMA factor-loading portfolio. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The data in this table covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		CMA factor-loading portfolio R_e			CMA factor-loading portfolio α			Characteristic-balanced portfolio	
Size	Inv	1	2	3	1	2	3	R_e	α
1	1	0.87	0.82	0.88	0.07 [1.11]	-0.03 [-0.53]	0.07 [1.11]	0.01 [0.09]	-0.00 [-0.01]
1	2	0.85	0.89	0.88	0.05 [0.80]	0.08 [1.52]	0.08 [1.23]	0.03 [0.36]	0.02 [0.28]
1	3	0.50	0.70	0.49	-0.23 [-3.78]	-0.07 [-1.06]	-0.18 [-2.86]	-0.00 [-0.05]	0.05 [0.53]
1	3-1	-0.37 [-4.13]	-0.12 [-1.49]	-0.38 [-4.27]					
2	1	0.74	0.86	0.68	0.00 [0.04]	-0.00 [-0.00]	-0.12 [-1.51]	-0.06 [-0.57]	-0.12 [-1.05]
2	2	0.80	0.74	0.74	0.08 [1.23]	-0.03 [-0.47]	-0.05 [-0.74]	-0.06 [-0.64]	-0.13 [-1.41]
2	3	0.61	0.68	0.59	-0.07 [-0.93]	-0.09 [-1.49]	-0.04 [-0.57]	-0.02 [-0.21]	0.03 [0.33]
2	3-1	-0.13 [-1.31]	-0.18 [-2.19]	-0.09 [-0.87]					
3	1	0.85	0.69	0.55	0.21 [2.10]	0.00 [0.05]	-0.29 [-3.47]	-0.30 [-2.05]	-0.48 [-3.21]
3	2	0.64	0.56	0.47	0.03 [0.33]	-0.04 [-0.72]	-0.18 [-2.60]	-0.17 [-1.52]	-0.20 [-1.79]
3	3	0.59	0.52	0.50	0.32 [3.94]	-0.00 [-0.06]	-0.06 [-0.73]	-0.09 [-0.65]	-0.38 [-2.97]
3	3-1	-0.26 [-1.80]	-0.17 [-1.57]	-0.04 [-0.37]					
Combined portfolio		0.72	0.72	0.64	0.05 [1.51]	-0.02 [-0.66]	-0.08 [-2.55]	-0.07 [-2.09]	-0.14 [-3.69]

Similar conclusions can be derived from the abnormal returns of the nine characteristic-balanced portfolios: six out of nine alphas are negative, two of them are statistically significant. On the combined characteristic-balanced portfolio level, the alpha is both economically and statistically strong (-0.14%, *t*-statistic of -3.69). Overall, the evidence in Table XI is strongly supportive of the characteristic model, although the negative return of the combined characteristic-balanced portfolio should be studied further.

As an additional test, I examine the post-formation loadings on the CMA factor in the characteristic-balanced portfolios, presented in Table XII. In all portfolios, the loadings on CMA are positive and statistically and economically significant. Although the loadings are somewhat low for small firms (CMA betas ranging from 0.14 to 0.20), they are still consistent with the requirement of a stable covariance structure of stock returns. Moreover, the CMA beta in the combined portfolio is economically and statistically solid (0.28 with a *t*-statistic of 10.79). Therefore, the tests conducted and described above are valid.

The loadings on other risk factors in the characteristic-balanced portfolios shed light on the strikingly large negative return of the combined characteristic-balanced portfolio. Most of the characteristic-balanced portfolios exhibit large negative loadings on the HML factor, which is also evident in the combined portfolio (HML loading of -0.13, *t*-statistic of -7.30). As there is no evidence of the risk story for investment premium, there should be no differences in returns that are related to the differences in CMA factor loadings, uncorrelated with the differences in the characteristic. Thus, the expected return of the characteristic-balanced portfolios is zero, but only given that the portfolios are balanced in terms of other characteristics and factor loadings that determine the expected returns. However, the negative effect of HML factor loadings[21] lowers the return of the characteristic-balanced portfolio significantly, leading to a statistically strong negative excess return of the combined portfolio. Therefore, the negative characteristic-balanced return occurs due to the problems with the methodological approach rather than due to the weakness of the characteristic model per se.

[21] In Section 5.1, we have established that the return premium associated with high book-to-market firms is related to the value characteristic rather than the HML factor loadings. Nonetheless, the book-to-market ratio and the HML betas are highly correlated, so the betas in Table XII also act as proxies for the corresponding characteristics.

Table XII. Regression results in the size and investment balanced portfolios

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

This table presents the excess returns and the time-series regression results in the nine characteristic-balanced portfolios and the combined portfolio that equally weights the nine portfolios. The characteristic-balanced portfolios buy the firms with high pre-formation CMA factor loadings and sell those with low pre-formation CMA factor loadings within each size and investment sorted portfolio. The sample covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Characteristic-balanced portfolio							
Size	Inv	R_e	α	β	s	h	r	c	m
1	1	0.01 [0.09]	-0.00 [-0.03]	0.01 [0.70]	-0.04 [-1.22]	-0.10 [-2.31]	-0.12 [-2.87]	0.14 [2.31]	0.04 [1.75]
1	2	0.03 [0.36]	0.03 [0.30]	-0.01 [-0.29]	-0.01 [-0.17]	-0.13 [-3.22]	-0.06 [-1.50]	0.17 [2.71]	0.01 [0.63]
1	3	-0.00 [-0.05]	0.05 [0.62]	-0.03 [-1.65]	-0.04 [-1.26]	-0.13 [-3.24]	-0.19 [-4.69]	0.20 [3.42]	-0.01 [-0.74]
2	1	-0.06 [-0.57]	-0.12 [-1.06]	-0.01 [-0.21]	0.08 [2.11]	-0.12 [-2.24]	-0.06 [-1.11]	0.20 [2.53]	0.05 [2.05]
2	2	-0.06 [-0.64]	-0.14 [-1.43]	0.02 [0.75]	-0.07 [-2.02]	-0.13 [-2.94]	0.09 [2.05]	0.23 [3.37]	0.04 [1.67]
2	3	-0.02 [-0.21]	0.03 [0.27]	-0.04 [-1.82]	0.03 [1.03]	-0.31 [-7.10]	-0.07 [-1.66]	0.30 [4.53]	-0.03 [-1.37]
3	1	-0.30 [-2.05]	-0.50 [-3.32]	-0.05 [-1.47]	0.05 [1.01]	-0.02 [-0.33]	0.42 [5.88]	0.32 [2.98]	0.03 [0.88]
3	2	-0.17 [-1.52]	-0.20 [-1.77]	-0.06 [-2.34]	-0.03 [-0.67]	-0.13 [-2.39]	0.20 [3.66]	0.23 [2.87]	-0.02 [-0.77]
3	3	-0.09 [-0.65]	-0.37 [-2.96]	-0.06 [-1.97]	0.16 [3.79]	-0.07 [-1.17]	0.33 [5.54]	0.74 [8.34]	0.01 [0.31]
Combined portfolio		-0.07 [-2.09]	-0.14 [-3.69]	-0.03 [-2.91]	0.02 [1.39]	-0.13 [-7.30]	0.06 [3.41]	0.28 [10.79]	0.01 [1.47]

As a final robustness check, I reproduce Table XI for the period when the CMA factor is strong and the tests should be more powerful. This involves excluding the period between July 2003 and December 2020, as the CMA factor has been very weak in recent years (-0.03%, *t*-statistic of -0.29). The results, reported in Appendix B, Table B4, support the characteristic model and are free from problems occurring in the extended sample period. The combined characteristic-balanced portfolio return is -0.01% (*t*-statistic of -0.28), closely aligned with the zero-return expectations of the characteristic model. The abnormal return of the same portfolio is -0.16% (*t*-statistic of -3.30), also suggestive of the characteristic mode.

To conclude, the pattern in returns of investment characteristic and risk-sorted portfolios is inconsistent with the risk model and in line with the characteristic model. The portfolios of firms with high CMA factor loadings do not earn higher returns than their low CMA-beta counterparts when accounting for the investment strategy characteristic. As a result, I reject the risk model for the investment anomaly and fail to reject the characteristic model. In Section 5.5, I discuss the results for the momentum premium.

5.5 The momentum premium

Table XII shows the results of the momentum tests. From the first glance, the results are odd from both the risk and the characteristic standpoint. On the combined characteristic-balanced portfolio level, the mean excess return is negative and strong (-0.15%, *t*-statistic of -3.64), indicating that firms with high loadings on the momentum factor generate significantly lower returns than firms that do not load strongly on the momentum factor. However, the abnormal return is only -0.05% (*t*-statistic of -1.37), suggesting that the firms that load strongly on momentum are *expected* to generate lower returns than the firms with the low MOM factor loadings in the six-factor model. Given that the MOM factor is the most economically solid factor among all six tested, this should not be the case.

The reason for these unconventional results can be found in Panel B of Table XII. We can see that the dispersion in post-formation MOM factor loadings is very low. Out of the nine characteristic-balanced portfolios, only four have statistically significant positive loadings on the MOM factor. Even for these portfolios, the economic significance of the factor loadings is very low – the highest MOM beta is only 0.10. In the combined portfolio, the MOM beta is as low as 0.06 (*t*-statistic of 5.84)[22].

[22] This problem persists even when I exclude the period of poor MOM factor performance – from July 2003 to December 2020.

Table XIII. Mean monthly excess and abnormal returns of characteristic- and MOM-beta-sorted portfolios and excess returns and regression results in characteristic-balanced portfolios

Panel A presents the mean monthly excess and abnormal returns of characteristic- and HML-beta-sorted portfolios and characteristic-balanced portfolios. Panel B presents the regression results in characteristic-balanced portfolios. The portfolios are formed monthly based on market equity in June of year t, prior returns between months t-12 and t-2, and pre-formation HML factor loadings calculated from the returns between months t-66 and t-6. For the pre-formation MOM factor loadings, at least 36 months of return observations should be available. In Panel A, 'MOM factor-loading portfolio R_e' covers the excess returns of the 27 portfolios sorted by size, prior return, and pre-formation MOM factor loadings. 'MOM factor-loading portfolio α' covers the abnormal returns from the abovementioned set of time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high MOM factor loadings and sells firms with low MOM factor loadings within each characteristic-sorted portfolio. The portfolio size and book-to-market ranking is specified within each of the rows. Mom portfolios 3-1 present the returns of the strategy that buys high book-to-market firms and sells low book-to-market firms within each size and MOM factor-loading portfolio. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The pre-formation MOM factor loadings, as well as abnormal returns (Panel A) and abnormal returns and factor loadings (Panel B), are estimated from the following set of regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

The data in this table covers the period between July 1967 and December 2020. t-statistic is in square brackets.

Panel A. Mean monthly excess and abnormal returns of characteristic- and MOM-beta-sorted portfolios and characteristic-balanced portfolios

Characteristic portfolio		MOM factor-loading portfolio R_e			MOM factor-loading portfolio α			Characteristic-balanced portfolio	
Size	Mom	1	2	3	1	2	3	R_e	α
1	1	0.50	0.64	0.36	-0.09 [-1.03]	0.10 [1.44]	-0.11 [-1.56]	-0.14 [-1.51]	-0.03 [-0.31]
1	2	1.02	0.89	0.89	0.16 [2.64]	0.10 [1.62]	0.07 [1.03]	-0.13 [-1.52]	-0.09 [-1.08]
1	3	1.36	1.21	1.08	0.35 [4.84]	0.26 [4.06]	0.14 [1.95]	-0.28 [-3.10]	-0.21 [-2.27]
1	3-1	0.86 [5.02]	0.57 [3.89]	0.72 [4.54]					
2	1	0.57	0.67	0.35	0.01 [0.08]	0.24 [3.13]	-0.05 [-0.55]	-0.22 [-1.74]	-0.06 [-0.43]
2	2	0.84	0.84	0.65	0.06 [0.77]	0.07 [1.14]	-0.12 [-1.59]	-0.19 [-1.78]	-0.18 [-1.73]
2	3	1.04	1.01	0.94	-0.01 [-0.10]	0.07 [1.16]	0.03 [0.37]	-0.10 [-0.99]	0.03 [0.33]
2	3-1	0.47 [2.55]	0.34 [2.05]	0.59 [3.37]					
3	1	0.48	0.46	0.50	0.17 [1.43]	0.17 [1.99]	0.34 [3.18]	0.02 [0.14]	0.17 [1.00]
3	2	0.56	0.56	0.35	-0.01 [-0.10]	-0.05 [-0.75]	-0.15 [-1.64]	-0.20 [-1.41]	-0.14 [-0.99]

3	3	0.78	0.78	0.70	-0.08 [-0.87]	-0.07 [-1.15]	-0.07 [-0.88]	-0.07 [-0.57]	0.01 [0.06]
3	3-1	0.30 [1.43]	0.32 [1.68]	0.20 [1.03]					
Combined portfolio		0.79	0.78	0.65	0.06 [1.52]	0.10 [2.74]	0.01 [0.21]	-0.15 [-3.64]	-0.05 [-1.37]

Panel B. Regression results in characteristic-balanced portfolios

Characteristic portfolio		Characteristic-balanced portfolio							
Size	Mom	R_e	α	β	s	h	r	c	m
1	1	-0.14 [-1.53]	-0.03 [-0.31]	-0.13 [-6.11]	-0.10 [-3.25]	-0.19 [-4.50]	0.05 [1.07]	-0.08 [-1.29]	0.06 [3.06]
1	2	-0.14 [-1.63]	-0.09 [-1.08]	-0.07 [-3.47]	-0.07 [-2.53]	-0.08 [-1.94]	0.13 [3.20]	-0.05 [-0.83]	0.03 [1.59]
1	3	-0.27 [-3.09]	-0.21 [-2.27]	-0.09 [-4.12]	-0.02 [-0.61]	-0.09 [-2.11]	0.06 [1.42]	-0.11 [-1.65]	0.04 [1.67]
2	1	-0.23 [-1.81]	-0.06 [-0.43]	-0.09 [-3.07]	-0.12 [-2.76]	-0.05 [-0.91]	0.06 [0.94]	-0.43 [-4.83]	0.05 [1.62]
2	2	-0.19 [-1.82]	-0.18 [-1.73]	-0.09 [-3.42]	-0.09 [-2.38]	-0.12 [-2.39]	0.19 [3.89]	-0.08 [-1.11]	0.10 [3.98]
2	3	-0.10 [-0.96]	0.03 [0.33]	-0.11 [-4.40]	-0.04 [-1.16]	-0.17 [-3.65]	0.08 [1.76]	-0.13 [-1.85]	-0.01 [-0.46]
3	1	0.01 [0.08]	0.17 [1.00]	-0.12 [-3.04]	-0.05 [-0.92]	-0.48 [-6.11]	0.29 [3.58]	-0.19 [-1.58]	0.05 [1.21]
3	2	-0.21 [-1.45]	-0.14 [-0.99]	-0.07 [-1.95]	-0.12 [-2.60]	-0.35 [-5.32]	0.20 [3.02]	-0.10 [-1.02]	0.10 [2.92]
3	3	-0.08 [-0.58]	0.01 [0.06]	-0.05 [-1.75]	-0.13 [-2.88]	-0.23 [-3.93]	0.17 [2.76]	-0.22 [-2.50]	0.08 [2.66]
Combined portfolio		-0.15 [-3.74]	-0.06 [-1.47]	-0.09 [-9.58]	-0.08 [-6.06]	-0.20 [-10.54]	0.14 [7.22]	-0.15 [-5.54]	0.05 [5.84]

This unsatisfactory outcome is not the result of low pre-formation variation in factor loadings. The lowest pre-formation MOM beta in the characteristic-balanced portfolios is 0.95 – nearly 16 times the size of the post-formation beta in the combined portfolio. Therefore, the main problem is that the pre-formation factor loadings are a poor predictor of the post-formation factor loadings for the momentum anomaly, and one of the crucial assumptions for the validity of the tests – the stable covariance structure of returns – is violated. The pre-formation MOM factor loadings are not a good predictor of the post-formation factor loadings, which leads to low MOM factor loadings in the characteristic-balanced portfolios. As a result, the MOM factor has a very limited effect on the portfolio returns, and an economically solid difference in returns between factor-loading portfolios is not expected in the model. In this case, the characteristic-balanced portfolios load strongly on all other factors, and for all of the factors (except for RMW), the factor loadings are negative. The joint effect of other factor loadings outweighs the effect of MOM factor loadings, which is the reason for the negative excess return of characteristic-balanced portfolios.

Therefore, the methodology of Daniel & Titman (1997) cannot be applied to testing the momentum characteristic because the pre-formation factor loadings are not a good predictor of the post-formation factor loadings. Thus, no convincing conclusions can be drawn from this set of tests. In my tests, I use Fama & French’s version of momentum, where the portfolios are formed on the basis of returns between month *t-11* and *t-1* and held for one month. Jegadeesh & Titman (1993) present a variety of versions of momentum, with the formation and holding periods ranging between 3 and 12 months. It is possible that another approach to calculating the momentum premium would yield a more stable covariance structure of portfolio returns, allowing the researchers to test the nature of the premium using Daniel & Titman’s methodology. This, however, is outside the scope of this thesis.

The next section explores the results for the market risk premium.

5.6 The market risk premium

Finally, I test the story behind the market risk premium by examining the excess and abnormal returns of portfolios formed based on size and value characteristics as well as the market risk premium, and returns of characteristic-balanced portfolios. In general, there is no evidence of a monotonic relationship between risk and returns, suggestive of the characteristic story. Although firms that load strongly on the market factor outperform firms with low factor loadings in six out of nine characteristic-balanced portfolios, this difference in returns is never statistically significant. In the combined portfolio, the excess return difference between high and low factor loading firms is only 0.06% (*t*-statistic of 1.22) – too low to confirm the risk story and in line with the characteristic story.

Table XIV. Mean monthly excess and abnormal returns of characteristic- and market risk-beta-sorted portfolios and characteristic-balanced portfolios

The portfolios are formed annually based on market equity in June of year t, book-to-market equity in year t-1, and pre-formation market risk factor loadings calculated from the returns between month t-66 and t-6. The book-to-market equity is calculated as the ratio of book equity released in year t-1 to the market equity in December of year t-1. For the pre-formation market factor loadings, at least 36 months of return observations should be available. The pre-formation market betas and the post-formation abnormal portfolio returns are calculated from the following set of time-series regressions:

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

'Mkt factor-loading portfolio R_e' covers the excess returns of the 27 portfolios sorted by size, book-to-market, and pre-formation Mkt factor loadings. 'Mkt factor-loading portfolio α' covers the abnormal returns from the abovementioned set of time-series regressions in the 27 triple-sorted portfolios. 'Characteristic-balanced portfolio' presents the excess and abnormal returns of the strategy that buys firms with high market risk factor loadings and sells firms with low market risk factor loadings within each characteristic-sorted portfolio. The portfolio size and book-to-market ranking is specified within each of the rows. The combined portfolio presents the equally-weighted average of the results in each of the nine characteristic-sorted portfolios. The data in this table covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Mkt factor-loading portfolio R_e			Mkt factor-loading portfolio α			Characteristic-balanced portfolio	
BM	Size	1	2	3	1	2	3	R_e	α
1	1	0.45	0.66	0.53	-0.17 [-2.02]	0.03 [0.45]	-0.11 [-1.31]	0.07 [0.61]	0.06 [0.53]
1	2	0.61	0.71	0.60	-0.00 [-0.02]	0.02 [0.35]	-0.07 [-0.95]	-0.01 [-0.09]	-0.07 [-0.65]
1	3	0.57	0.59	0.50	0.15 [1.73]	0.07 [1.51]	-0.13 [-1.86]	-0.08 [-0.56]	-0.29 [-2.10]
2	1	0.72	0.87	0.86	0.06 [1.01]	0.07 [1.26]	0.00 [0.02]	0.15 [1.24]	-0.06 [-0.65]
2	2	0.67	0.73	0.72	-0.00 [-0.04]	-0.05 [-0.86]	-0.15 [-2.06]	0.06 [0.49]	-0.15 [-1.52]
2	3	0.59	0.54	0.62	-0.04 [-0.39]	-0.16 [-2.29]	-0.12 [-1.46]	0.03 [0.20]	-0.08 [-0.52]
3	1	0.91	0.92	0.85	0.19 [3.29]	0.07 [1.34]	-0.13 [-2.09]	-0.06 [-0.52]	-0.32 [-3.69]
3	2	0.74	0.84	0.91	0.06 [0.69]	0.04 [0.62]	-0.09 [-1.11]	0.17 [1.12]	-0.15 [-1.20]
3	3	0.50	0.63	0.67	0.02 [0.17]	-0.08 [-0.99]	-0.17 [-1.87]	0.17 [0.95]	-0.19 [-1.13]
Combined portfolio		0.64	0.72	0.69	0.03 [0.76]	0.00 [0.04]	-0.11 [-2.97]	0.06 [1.22]	-0.14 [-3.31]

The main predictions of the characteristic model are also supported in the abnormal returns of the characteristic- and factor-loading sorted portfolios. Among the 27 alphas, there is a positive alpha among the low factor loading portfolios, and two negative alphas in the high factor loading portfolios, all three significant on the 5% significance level. This evidence is in line with the characteristic story. In addition, there are statistically significant negative alphas in portfolios 1-1-1 (small firms with low book-to-market ratio and low market beta) and 2-3-2 (medium firms with large book-to-market ratio and medium market beta), not suggestive of either risk or characteristic story. In the combined portfolio, alphas monotonically increase with an increase in the market factor loadings, with a statistically significant negative alpha for all the high market factor loading firms combined (-0.11% with a *t*-statistic of -2.97). All but one alpha in the nine characteristic-balanced portfolios are negative, and two of them are statistically significant. Not surprisingly, the alpha in the combined characteristic balanced portfolio is also economically and statistically strong (-0.14%, *t*-statistic of -3.31). All in all, the evidence for the market risk premium is clearly consistent with the characteristic model[23].

The evidence in Table XV indicates the validity of the pre-formation factor loading sort. Market betas in all the characteristic-balanced portfolios are both economically and statistically significant. The market beta in the combined portfolio is 0.29 (*t*-statistic of 29.35). The strong market factor loadings, combined with a highly economically significant market risk premium of 0.57% suggest that these tests have sufficient power to distinguish between the risk and the characteristic model.

To conclude, the risk model does not hold for the market risk premium and can be rejected in favor of the characteristic model. It means that the stock earns a premium not because of its loadings on the market risk factor, but because of simply being a stock. The results discussed in this section are in line with Daniel & Titman (1997) and Davis et al. (2000) who also test the story behind the market risk premium and reject the risk model. This suggests that the characteristic-based explanation for the market risk premium is persistent in the U.S. stock market, and is robust against the choice of the sample period and the risk model.

[23] The risk-balanced returns (i.e. the returns of the portfolios that are neutral in terms of tested factor loadings and secondary characteristics) are not calculated for the market risk premium, because there is no discernible characteristic associated with the premium, and therefore, such a test is redundant.

Table XV. Regression results in the size and book-to-market balanced portfolios

$$r_i - r_f = \alpha_i + \beta_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + e_{it}$$

This table presents the excess returns and the time-series regression results in the nine characteristic-balanced portfolios and the combined portfolio that equally weights the nine portfolios. The characteristic-balanced portfolios buy the firms with high pre-formation market risk factor loadings and sell those with low pre-formation market risk factor loadings within each size and book-to-market sorted portfolio. The sample covers the period between July 1967 and December 2020. Test-statistic is in square brackets.

Characteristic portfolio		Characteristic-balanced portfolio							
BM	Size	R_e	α	β	s	h	r	c	m
1	1	0.07 [0.61]	0.06 [0.53]	0.16 [5.68]	0.13 [3.30]	-0.32 [-5.93]	-0.26 [-4.82]	0.23 [2.85]	-0.03 [-1.15]
1	2	-0.01 [-0.09]	-0.07 [-0.65]	0.23 [9.32]	0.19 [5.42]	-0.05 [-1.00]	-0.16 [-3.42]	0.07 [1.03]	-0.12 [-5.03]
1	3	-0.08 [-0.56]	-0.29 [-2.10]	0.19 [5.70]	0.15 [3.17]	0.12 [1.80]	0.18 [2.76]	0.20 [2.13]	-0.09 [-2.80]
2	1	0.15 [1.24]	-0.06 [-0.65]	0.27 [12.35]	0.33 [10.54]	-0.21 [-4.85]	-0.17 [-3.91]	0.27 [4.15]	0.01 [0.66]
2	2	0.06 [0.49]	-0.15 [-1.52]	0.31 [13.39]	0.28 [8.40]	0.04 [0.88]	0.10 [2.08]	-0.04 [-0.59]	-0.07 [-3.17]
2	3	0.03 [0.20]	-0.08 [-0.52]	0.33 [9.76]	0.13 [2.71]	0.10 [1.42]	-0.03 [-0.51]	-0.13 [-1.29]	-0.14 [-4.05]
3	1	-0.06 [-0.52]	-0.32 [-3.69]	0.36 [17.60]	0.27 [9.15]	-0.00 [-0.12]	-0.06 [-1.51]	0.17 [2.72]	-0.04 [-1.99]
3	2	0.17 [1.12]	-0.15 [-1.20]	0.38 [12.50]	0.34 [7.67]	-0.09 [-1.48]	0.15 [2.53]	0.23 [2.52]	-0.07 [-2.30]
3	3	0.17 [0.95]	-0.19 [-1.13]	0.39 [9.67]	0.37 [6.37]	0.04 [0.50]	0.11 [1.35]	0.16 [1.37]	-0.01 [-0.34]
Combined portfolio		0.06 [1.22]	-0.14 [-3.31]	0.29 [29.35]	0.24 [17.09]	-0.04 [-2.18]	-0.02 [-0.90]	0.13 [4.42]	-0.06 [-6.36]

6. Conclusion

The main goal of this thesis is to shed light on the characteristics versus covariances debate in a variety of asset pricing anomalies. The anomalies chosen for this study are value, size, market risk premium (equity status), operating profitability, investment, and momentum. The research on the nature of operating profitability, investment, and momentum remains scarce, which makes it valuable to test the characteristic and risk stories for these anomalies. Size, value, and market risk premium, although studied earlier, still present an interesting subject for discussion, since I provide evidence on whether the conclusions of earlier studies hold if the sample is extended until December 2020.

First, I test the validity of several requirements that are crucial to drawing valid conclusions from my tests. I show that the premium associated with the SMB, HML, RMW, CMA, MOM, and market risk factors is statistically and economically robust in the sample period between July 1963 and December 2020. However, the factor performance varies and, in some periods, all factors except for the market risk premium perform much poorer than in others. I also show the existence of an economically and statistically significant premium associated with the tested characteristics. Finally, I show that the six-factor model (Fama & French's five-factor model plus momentum) provides a reasonable approximation of portfolio returns, and presents an improvement from the three- and five-factor models.

Once I ensure that the abovementioned requirements are fulfilled, I proceed to the main tests of the characteristic and risk models. For each anomaly, I form portfolios based on characteristics and factor loadings and discuss the monthly excess and abnormal returns of these portfolios. I also form characteristic-balanced portfolios which load heavily on the factor associated with the tested characteristic but are neutral characteristic-wise. I complement this with a set of robustness tests, in which I check the covariance structure of returns and confirm the validity of the main results in the period when the associated risk factor is strong.

I find that such anomalies as value, operating profitability, investment, and market risk premium follow the characteristic story: after controlling for characteristics, there is no premium associated with the risk factor loadings. On the contrary, size follows the risk story, as there is a premium in stock returns of the characteristic-neutral portfolios. Finally, momentum fails the robustness tests for the stable covariance structure of stock returns. The dispersion in post-formation MOM factor loadings is therefore too low for the tests to distinguish between the two models.

The results of this thesis have both practical and theoretical implications. The results show that it is possible to create an investment strategy that will earn a positive abnormal return without loading on conventional risk factors. This is true for the anomalies that are driven by characteristics rather than covariances. For these anomalies, researchers and practitioners should be cautious when applying the factor models to measure performance or estimate the cost of capital.

There are several ways in which the discussion presented in this thesis can be extended or improved. First of all, the underlying reasons for why some premia are driven by characteristics and others by covariances are not the topic of this thesis. However, it could be interesting to examine the differences in the nature of these anomalies that result in different return premia drivers. Additionally, it could be discussed why the story behind some of the anomalies (for example, the value premium) varies over time.

Ideally, the portfolios formed based on the characteristics and factor loadings should be neutral in terms of secondary factors that could be driving the portfolio returns. My results show that this is not always the case: the characteristic-balanced portfolios often load on the risk factors that are not accounted for in the portfolio sort (for example, the value- and HML-sorted portfolios load strongly on the RMW factor). This is less of a problem in the original study by Daniel & Titman (1997) because their tested risk model only incorporates three risk factors (market risk premium, size, and value), two of which are always accounted for in the portfolio sort. The more complex the risk model is, the more of an issue the effect of other factors becomes. This problem cannot be solved by adding more dimensions to the portfolio sort without hurting portfolio diversification. Therefore, it is valuable to find ways to address this problem, which may involve relying on a methodology different from that of Daniel & Titman (1997).

Finally, the conclusions may change once a more powerful factor model is used as a proxy for the risk story. Although, as I show earlier, the six-factor model outperforms the three- and five-factor models, the availability of a more robust model specification may change the conclusions about the nature of the tested anomalies.

References

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of Finance, 52*(1), 57-82.

Chordia, T., Goyal, A., & Shanken, J. A. (2017). Cross-sectional asset pricing with individual stocks: betas versus characteristics. *Available at SSRN 2549578.*

Daniel, K., & Titman, S. (1997). Evidence on the characteristics of cross sectional variation in stock returns. *The Journal of Finance,* 1-33.

Daniel, K., Titman, S., & Wei, K. J. (2001). Explaining the cross-section of stock returns in Japan: Factors or characteristics? *The Journal of Finance, 56*(2), 743-766.

Davis, J. L., Fama, E. F., & French, K. R. (2000). Characteristics, covariances, and average returns: 1929 to 1997. *The Journal of Finance*, *55*(1), 389-406.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *The Journal of Financial Economics*, 3-56.

Fama, E. F., & French, K. R. (1996). Multifactor explanations of asset pricing anomalies. *The Journal of Finance*, 55-84.

Fama, E. F., & French, K. R. (2015). A five-factor asset pricing model. *The Journal of Financial Economics*, *116*(1), 1-22.

Fama, E. F., & French, K. R. (2021). The value premium. *The Review of Asset Pricing Studies, 11*(1), 105-121.

French, K. R. (2021, May 1). *Kenneth R. French - Data Library*. Retrieved from Kenneth R. French: https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Gebhardt, W. R., Hvidkjaer, S., & Swaminathan, B. (2005). The cross-section of expected corporate bond returns: Betas or characteristics?. *Journal of Financial Economics, 75*(1), 85-114.

Gharghori, P., Chan, H., & Faff, R. (2006). Factors or characteristics? That is the question. *Pacific Accounting Review.*

Gibbons, M. R., Ross, S. A., & Shanken, J. (1989). A test of the efficiency of a given portfolio. *Econometrica: Journal of the Econometric Society*, 1121-1152.

Grundy, B. D., & Martin, J. S. M. (2001). Understanding the nature of the risks and the source of the rewards to momentum investing. *The Review of Financial Studies, 14*(1), 29-78.

Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance, 48*(1), 65-91.

Kelly, B. T., Pruitt, S., & Su, Y. (2019). Characteristics are covariances: A unified model of risk and return. *The Journal of Financial Economics*, *134*(3), 501-524.

Kothari, S. P., Shanken, J., & Sloan, R. G. (1995). Another look at the cross-section of expected stock returns. *The Journal of Finance, 50*(1), 185-224.

Lakonishok, J., Shleifer, A., & Vishny, R. W. (1994). Contrarian investment, extrapolation, and risk. *The Journal of Finance, 49*(5), 1541-1578.

Lajili-Jarjir, S. (2007). Explaining the cross-section of stock returns in France: Characteristics or risk factors? *European Journal of Finance, 13*(2), 145-158.

Lee, E., Liu, W., & Strong, N. (2007). UK evidence on the characteristics versus covariance debate. *European Financial Management, 13*(4), 742-756.

Lewellen, J. (1999). The time series relations among expected return, risk, and book to market. *The Journal of Financial Economics, 54*, 5–43.

Lintner, J. (1965). Security prices, risk, and maximal gains from diversification. *The Journal of Finance*, *20*(4), 587-615.

Miller, M. H., & Modigliani, F. (1961). Dividend policy, growth, and the valuation of shares. *The Journal of Business, 34*(4), 411-433.

Sharpe, W. F. (1964). Capital asset prices: a theory of market equilibrium under conditions of risk. *The Journal of Finance*, *19*(3), 425-442.

Appendices

Appendix A

Table A1. The average number of firms in portfolios and a summary of poorly diversified portfolios.

Panel A presents the average number of firms in each portfolio in each post-formation month. Columns ‘Size’, ‘Value’, ‘OP’, ‘Inv’, ‘Mom’, and ‘Mkt’ refer to each of the tested anomalies. Columns ‘1st dim’, 2nd dim’ and ‘FL’ refer to the dimensions on which the firms were sorted into portfolios (characteristics and factor loadings). ‘1st dim’ is the first dimension for the characteristic sort, which is the book-to-market ratio for the size anomaly and size for all other anomalies. ‘2nd dim’ refers to the second dimension for the characteristic sort, which is size for the size anomaly, operating profitability for the operating profitability anomaly, investment for the investment anomaly, prior return for the momentum anomaly, and book-to-market ratio for the book-to-market and market risk premia. ‘FL’ refers to the sort on pre-formation factor loadings: SMB for size, HML for value, RMW for operating profitability, CMA for investment, MOM for momentum, and Mkt for the market risk premium. Panel B presents the description of poorly diversified portfolios. ‘Anomaly’ refers to the premium tested, ‘Portfolio’ describes the characteristics of the portfolio within ‘Anomaly’ that is suffering from diversification problems. ‘Share of poorly diversified portfolios’ refers to the percentage of months in which there are fewer than 5 firms in ‘Portfolio’. ‘Share of missing portfolios’ refers to the percentage of months in which there are 0 firms in ‘Portfolio’. The sample covers the period between July 1967 and December 2020.

Panel A. The average number of firms in portfolios

1st dim	2nd dim	FL	Size	Value	OP	Inv	Mom	Mkt
1	1	1	154	287	562	351	453	218
1	1	2	175	157	373	278	318	171
1	1	3	316	197	429	388	402	252
1	2	1	77	209	158	188	184	231
1	2	2	107	199	209	214	212	191
1	2	3	90	198	195	197	200	183
1	3	1	178	327	138	276	301	450
1	3	2	81	361	136	222	256	346
1	3	3	30	428	167	285	300	318
2	1	1	155	111	79	52	62	59
2	1	2	215	95	71	64	69	103
2	1	3	238	63	60	57	65	110
2	2	1	85	60	54	65	63	55
2	2	2	101	96	97	92	95	98
2	2	3	59	80	89	62	75	84
2	3	1	116	32	50	100	86	41
2	3	2	45	60	79	101	97	63
2	3	3	12	70	95	82	89	58
3	1	1	317	114	54	34	40	52
3	1	2	395	118	46	60	60	131
3	1	3	415	51	24	42	49	99

3	2	1	67	43	48	54	54	33
3	2	2	64	77	87	93	97	74
3	2	3	38	51	52	59	61	61
3	3	1	82	18	45	72	61	27
3	3	2	21	45	109	87	94	45
3	3	3	7	46	86	55	75	37

Panel B. The summary of poorly diversified portfolios

Anomaly	Portfolio	Share of poorly diversified portfolios	Share of missing portfolios
Size	Large book-to-market, small size, high SMB betas	50.5%	31.8%
Size	Medium book-to-market, small size, high SMB betas	48.4%	5.6%
Value	Large size, large book-to-market, low HML betas	21.0%	0.0%
Size	Low book-to-market, small size, high SMB betas	12.1%	0.0%
Size	High book-to-market, medium size, high SMB betas	5.0%	0.0%
Value	Large size, large book-to-market, high SMB betas	1.2%	0.0%

Appendix B

Table B1. Mean monthly excess and abnormal returns in characteristic- and HML-beta-sorted portfolios and characteristic-balanced portfolios

The results in this table are equivalent to the results in Table V, except that the period covered is July 1967 to June 2003.

Characteristic portfolio		HML factor-loading portfolio R_e			HML factor-loading portfolio α			Characteristic-balanced portfolio	
Size	BM	1	2	3	1	2	3	R_e	α
1	1	0.26	0.49	0.16	-0.07 [-0.68]	-0.06 [-0.65]	-0.51 [-5.05]	-0.10 [-0.80]	-0.45 [-3.78]
1	2	0.82	0.76	0.69	0.16 [1.90]	-0.01 [-0.13]	-0.08 [-1.15]	-0.13 [-1.03]	-0.24 [-2.23]
1	3	1.10	0.92	0.86	0.31 [3.48]	0.11 [1.81]	-0.06 [-0.98]	-0.24 [-2.00]	-0.37 [-3.57]
1	3-1	0.84 [5.00]	0.43 [2.73]	0.70 [4.26]					
2	1	0.40	0.49	0.43	0.12 [1.29]	-0.19 [-2.21]	-0.23 [-2.26]	0.03 [0.18]	-0.35 [-2.76]
2	2	0.64	0.61	0.59	-0.01 [-0.06]	-0.18 [-2.55]	-0.19 [-2.09]	-0.05 [-0.35]	-0.18 [-1.30]
2	3	1.01	0.83	0.82	0.27 [1.86]	0.00 [0.06]	-0.03 [-0.35]	-0.19 [-1.00]	-0.31 [-1.66]
2	3-1	0.62 [3.36]	0.35 [2.70]	0.39 [2.66]					
3	1	0.37	0.39	0.44	0.16 [2.59]	-0.04 [-0.65]	0.07 [0.57]	0.08 [0.57]	-0.09 [-0.63]
3	2	0.44	0.55	0.46	-0.15 [-1.06]	-0.13 [-1.51]	-0.21 [-1.83]	0.02 [0.13]	-0.06 [-0.35]
3	3	0.53	0.59	0.67	-0.17 [-0.82]	-0.17 [-1.58]	-0.11 [-1.08]	0.14 [0.58]	0.06 [0.23]
3	3-1	0.16 [0.66]	0.21 [1.26]	0.22 [1.15]					
Combined portfolio		0.62	0.63	0.57	0.07 [1.31]	-0.07 [-1.85]	-0.15 [-3.28]	-0.05 [-0.89]	-0.22 [-4.13]

Table B2. Mean monthly excess and abnormal returns in characteristic- and SMB-beta-sorted portfolios and characteristic-balanced portfolios

The results in this table are equivalent to the results in Table VII, except that the period covered is July 1967 to June 1983 and July 2003 to December 2020. In addition, the breakpoints used for the SMB factor-loading sort are not independent, but conditional, and vary across the characteristic-sorted portfolios.

Characteristic portfolio		SMB factor-loading portfolio R_e			SMB factor-loading portfolio α			Characteristic-balanced portfolio	
BM	Size	1	2	3	1	2	3	R_e	α
1	1	0.79	0.81	0.77	0.03 [0.27]	-0.01 [-0.16]	-0.18 [-1.62]	-0.03 [-0.19]	-0.21 [-1.44]
1	2	0.68	0.80	0.68	0.05 [0.72]	0.06 [0.76]	-0.11 [-1.25]	0.00 [0.03]	-0.16 [-1.55]
1	3	0.49	0.58	0.56	0.06 [1.01]	0.07 [1.01]	-0.03 [-0.39]	0.07 [0.50]	-0.09 [-0.78]
2	1	0.82	0.89	0.92	0.11 [1.62]	0.04 [0.55]	0.00 [0.01]	0.10 [0.68]	-0.11 [-0.86]
2	2	0.64	0.84	0.89	0.04 [0.56]	0.12 [1.66]	0.01 [0.15]	0.25 [1.83]	-0.03 [-0.29]
2	3	0.47	0.44	0.65	-0.01 [-0.10]	-0.16 [-1.84]	-0.08 [-0.86]	0.18 [1.09]	-0.07 [-0.47]
3	1	0.83	0.87	1.11	0.03 [0.40]	-0.06 [-0.98]	0.05 [0.55]	0.28 [2.07]	0.02 [0.15]
3	2	0.83	0.79	1.01	0.10 [1.20]	0.01 [0.11]	0.02 [0.24]	0.18 [1.14]	-0.08 [-0.58]
3	3	0.47	0.62	0.66	0.01 [0.10]	0.03 [0.37]	-0.05 [-0.38]	0.19 [1.04]	-0.06 [-0.33]
Combined portfolio		0.67	0.74	0.81	0.05 [1.16]	0.01 [0.28]	-0.04 [-0.95]	0.14 [2.76]	-0.09 [-1.96]

Table B3. Mean monthly excess and abnormal returns in characteristic- and RMW-beta-sorted portfolios and characteristic-balanced portfolios

The results in this table are equivalent to the results in Table IX, except that the period covered is July 1983 to December 2020.

Characteristic portfolio		RMW factor-loading portfolio R_e			RMW factor-loading portfolio α			Characteristic-balanced portfolio	
Size	Op Prof	1	2	3	1	2	3	R_e	α
1	1	0.55	0.62	0.60	0.03 [0.36]	-0.05 [-0.87]	-0.09 [-1.28]	0.05 [0.43]	-0.11 [-1.21]
1	2	0.73	0.84	0.82	-0.02 [-0.63]	0.08 [1.11]	0.00 [0.04]	0.09 [0.88]	0.05 [0.52]
1	3	0.84	0.93	0.84	-0.02 [-0.19]	0.11 [1.50]	-0.03 [-0.41]	0.00 [0.03]	-0.01 [-0.11]
1	3-1	0.29 [1.77]	0.31 [2.82]	0.24 [1.96]					
2	1	0.65	0.64	0.48	0.12 [1.04]	-0.09 [-1.15]	-0.17 [-1.80]	-0.17 [-1.09]	-0.29 [-2.04]
2	2	0.85	0.74	0.82	0.00 [0.03]	-0.06 [-0.89]	-0.02 [-0.34]	-0.04 [-0.35]	-0.03 [-0.24]
2	3	0.74	0.94	0.85	-0.27 [-2.46]	0.01 [0.17]	-0.11 [-1.39]	0.11 [0.92]	0.16 [1.30]
2	3-1	0.09 [0.46]	0.30 [2.77]	0.37 [2.82]					
3	1	0.62	0.40	0.47	0.05 [0.45]	-0.09 [-1.03]	0.05 [0.38]	-0.14 [-0.79]	0.01 [0.03]
3	2	0.72	0.69	0.54	0.03 [0.35]	-0.05 [-0.80]	-0.06 [-0.64]	-0.18 [-1.12]	-0.10 [-0.61]
3	3	0.61	0.78	0.91	-0.08 [-0.85]	-0.00 [-0.05]	0.08 [1.18]	0.29 [2.11]	0.16 [1.23]
3	3-1	-0.00 [-0.03]	0.38 [3.21]	0.43 [2.30]					
Combined portfolio		0.70	0.73	0.70	-0.02 [-0.51]	-0.01 [-0.46]	-0.04 [-1.00]	0.00 [0.04]	-0.02 [-0.38]

Table B4. Mean monthly excess and abnormal returns in characteristic- and CMA-beta-sorted portfolios and characteristic-balanced portfolios

The results in this table are equivalent to the results in Table XI, except that the period covered is July 1967 to June 2003.

Characteristic portfolio		CMA factor-loading portfolio R_e			CMA factor-loading portfolio α			Characteristic-balanced portfolio	
Size	Inv	1	2	3	1	2	3	R_e	α
1	1	0.75	0.76	0.85	0.04 [0.49]	-0.04 [-0.66]	0.12 [1.53]	0.10 [0.94]	0.08 [0.76]
1	2	0.80	0.88	0.93	0.04 [0.48]	0.06 [0.88]	0.16 [2.00]	0.13 [1.17]	0.12 [1.09]
1	3	0.32	0.58	0.34	-0.31 [-3.95]	-0.16 [-2.14]	-0.23 [-2.82]	0.02 [0.22]	0.08 [0.77]
1	3-1	-0.43 [-3.81]	-0.19 [-1.89]	-0.51 [-4.59]					
2	1	0.67	0.78	0.67	0.05 [0.49]	-0.07 [-0.86]	-0.06 [-0.59]	0.00 [0.02]	-0.11 [-0.77]
2	2	0.70	0.63	0.68	0.11 [1.24]	-0.12 [-1.74]	-0.09 [-1.01]	-0.02 [-0.17]	-0.20 [-1.63]
2	3	0.39	0.53	0.43	-0.12 [-1.28]	-0.19 [-2.25]	-0.11 [-1.10]	0.03 [0.29]	0.01 [0.09]
2	3-1	-0.27 [-2.17]	-0.25 [-2.23]	-0.24 [-1.89]					
3	1	0.73	0.66	0.48	0.25 [2.00]	0.01 [0.16]	-0.40 [-3.54]	-0.25 [-1.29]	-0.65 [-3.35]
3	2	0.56	0.44	0.41	0.09 [0.91]	-0.07 [-1.06]	-0.21 [-2.48]	-0.15 [-1.13]	-0.30 [-2.14]
3	3	0.34	0.40	0.37	0.39 [3.79]	0.04 [0.60]	-0.05 [-0.52]	0.03 [0.16]	-0.44 [-2.69]
3	3-1	-0.38 [-2.09]	-0.26 [-1.82]	-0.11 [-0.65]					
Combined portfolio		0.59	0.63	0.57	0.06 [1.33]	-0.06 [-1.63]	-0.10 [-2.20]	-0.01 [-0.28]	-0.16 [-3.30]