Understanding the Factor Zoo

Impact of ESG and Momentum on Excess Returns in the Fama-French Factor Models

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Symbols

α_i	Intercept (Alpha) of stock i
β_i^{MKT}	MKT factor loading of stock i
β_i^{SMB}	SMB factor loading of stock i
β_i^{HML}	HML factor loading of stock i
β_i^{RMW}	RMW factor loading of stock i
β_i^{CMA}	CMA factor loading of stock i
β_i^{ESG}	ESG or ESG Residual factor loading of stock i
β_i^{MOM}	MOM factor loading of stock i
$\hat{\beta}_i^{MKT}$	Estimated MKT factor loading of stock i
$\hat{\beta}_i^{SMB}$	Estimated SMB factor loading of stock i
$\hat{\beta}_i^{HML}$	Estimated HML factor loading of stock i
$\hat{\beta}_i^{RMW}$	Estimated RMW factor loading of stock i
$\hat{\beta}_i^{CMA}$	Estimated CMA factor loading of stock i
$\hat{\beta}_i^{ESG}$	Estimated ESG or ESG Residual factor loading of stock i
$\hat{\beta}_i^{MOM}$	Estimated MOM factor loading of stock i
γ_m	Intercept (Alpha) of month m
$\overline{\gamma}$	Constant
γ_m^F	Monthly risk premium of each factor
γ_m^{MKT}	Monthly risk premium of Market Factor
γ_m^{SMB}	Monthly risk premium of Size Factor
γ_m^{HML}	Monthly risk premium of Value Factor
γ_m^{RMW}	Monthly risk premium of Profitability Factor
γ_m^{CMA}	Monthly risk premium of Investment Factor
γ_m^{ESG}	Monthly risk premium of ESG Factor
γ_m^{MOM}	Monthly risk premium of Momentum Factor
$\overline{\gamma}^{MKT}$	Average monthly risk premium of Market Factor
$\overline{\gamma}^{SMB}$	Average monthly risk premium of Size Factor
$\overline{\gamma}^{HML}$	Average monthly risk premium of Value Factor
$\overline{\gamma}^{RMW}$	Average monthly risk premium of Profitability Factor
$\overline{\gamma}^{CMA}$	Average monthly risk premium of Investment Factor
$\overline{\gamma}^{ESG}$	Average monthly risk premium of ESG Factor
$\overline{\gamma}^{MOM}$	Average monthly risk premium of Momentum Factor
$r_i - r^{RF}$	Excess return of stock i over the risk free rate
$r_{im} - r_m^{RF}$	Monthly excess return of stock i over the risk free rate
ω_m	Error term of month m
ε_i	Error term of stock i

Acronyms

Acronyms are linked the first time they appear in each chapter and subsection of each chapter. Subsequent uses of the acronym are not explicitly linked. A full list of acronyms and their definitions is provided below.

CAPM Capital Asset Pricing Model

NASDAQ National Association of Securities Dealers Automatic Quotation System

FF-5 (Fama-French Five Factor Model) The Fama/French 5 factors (2x3) are constructed using the 6 value-weight portfolios formed on size and book-to-market, the 6 value-weight portfolios formed on size and operating profitability, and the 6 value-weight portfolios formed on size and investment.

FF-3 (Fama-French Three Factor Model) The Fama/French factors are constructed using the 6 value-weight portfolios formed on size and book-to-market.

RFM-7 (Seven Risk Factor Model) containing the factors of the Fama-French Five Factor Model, the Momentum factor, and an ESG factor.

RFM-5 (Five Risk Factor Model) containing the factors of the Fama-French Three Factor Model, the Momentum factor, and an ESG factor.

MKT (Market Factor or Rm-Rf) is the excess return on the market, value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ that have a CRSP share code of 10 or 11 at the beginning of month t, good shares and price data at the beginning of t, and good return data for t minus the one-month Treasury bill rate.

SMB (Small Minus Big) is the average return on the nine small stock portfolios minus the average return on the nine big stock portfolios.

HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios.

RMW (Robust Minus Weak) is the average return on the two robust operating profitability portfolios minus the average return on the two weak operating profitability portfolios.

CMA (Conservative Minus Aggressive) is the average return on the two conservative investment portfolios minus the average return on the two aggressive investment portfolios.

MOM (Momentum) is constructed using six value-weight portfolios formed on size and prior (212) returns to construct Mom. The portfolios, which are formed monthly, are the intersections of 2 portfolios formed on size (market equity, ME) and 3 portfolios formed on prior (212) return. The monthly size breakpoint is the median NYSE market equity. The monthly prior (2-12) return breakpoints are the 30th and 70th NYSE percentiles. Mom is the average return on the two high prior return portfolios minus the average return on the two low prior return portfolios.

ESG (Bottom25 ESG minus Top25 ESG) is the average return of the Bottom25 ESG portfolio minus the average return of the Top25 ESG portfolio.

ESG Residual (ESG (R)) is the residuals plus the intercept from a regression of the ESG factor on the FF-5 factors plus the momentum factor.

Top25 ESG Portfolio consisting of the 25% of stocks with the highest ESG score.

Bottom25 ESG Portfolio consisting of the 25% of stocks with the lowest ESG score.

RF The one-month Treasury bill rate data through May 2024 are from Ibbotson Associates. Starting from October 2024, the one-month Treasury bill rate is from ICE BofA US 1-Month Treasury Bill Index.

NYSE New York Stock Exchange

AMEX American Stock Exchange

Introduction

According to Ang (2014), assets earn risk premiums as they are exposed to underlying factor risks that constitute different types of adverse economic conditions ("bad times") for which investors demand compensation. Factor risks, therefore, serve as the fundamental drivers of an asset's risk premium. Over the years, numerous theories have emerged to explain these factor risks. The foundational Capital Asset Pricing Model (CAPM), introduced in the 1960s by Treynor (n.d.), Sharpe (1964), Lintner (1965), and Mossin (1966), identified the market factor as the sole determinant of asset prices. This framework was later expanded by Fama & French (1993), who added the SMB and HML factors to account for size and value risk. Further refinements came with Fama & French (2015), who introduced the RMW and CMA factors, adding profitability and investment risk factors.

This paper extends the Fama & French (2015) multi-factor model by incorporating both a momentum and an ESG factor. Jegadeesh & Titman (1993) demonstrate that strategies that buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3- to 12-month holding periods. This finding is further supported by Figure 1, which depicts cumulative returns from 1963 to 2024 for the four factors introduced by Fama & French (1993) and Fama & French (2015) alongside a momentum factor using data obtained from Fama & French (2024) Data Library. Among these factors, the momentum strategy demonstrates the highest cumulative returns. Motivated by this robust performance, our analysis investigates how the momentum factor interacts with the five existing factors in the extended model.

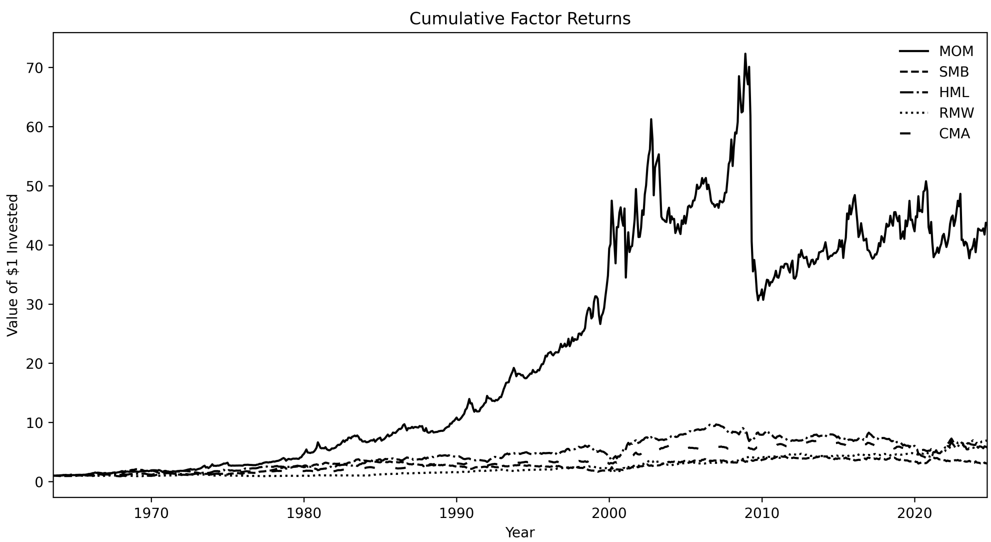

Figure 1: Returns to factor strategies since 1965

Recent research has increasingly explored carbon risk and sustainable investing, focusing on how these factors influence the cross-section of stock returns. Bolton & Kacperczyk (2021) found that firms with higher total carbon dioxide emissions tend to earn higher returns, even after controlling for size, book-to-market ratios, and other predictive variables. Similarly, Pastor et al. (2021) demonstrated that green assets exhibit negative CAPM alphas, while brown assets show positive alphas, indicating that portfolios composed of green assets earn lower expected returns. However, a systematic review by Kumar (2023), which examined studies using Fama-French factor models to assess an environmental, social, and governance (ESG) factor exposure, found no significant relationship between the alpha of globally and regionally diversified portfolios and ESG factors or sustainability attributes. Additionally, Roncalli et al. (2021) observed nuanced trends: brown firms slightly outperformed green firms from 2010 to 2012, but this pattern reversed between 2012 and 2016. After 2016, brown firms showed marginal excess performance over green firms, yet best-in-class green stocks consistently outperformed worst-in-class green stocks. These findings underscore the complex interplay between carbon emissions, ESG factors, and stock performance, suggesting that while higher emissions may sometimes correlate with higher returns, the broader implications for sustainable investing remain ambiguous. In this context, our analysis will explore how these dynamics interact with the momentum factor and other established components of the Fama-French multi-factor model.

We will integrate the Fama & French (2015) five-factor model FF-5 with a momentum and an ESG factor, employing a Fama & MacBeth (1973) regression to analyze the relation between excess returns of stocks and each factor while controlling for the other factors over the period from December 2009 until May 2024.

The next section outlines the methodology used to construct the ESG factor and details the Fama & MacBeth (1973) regression process. Thereafter the results are presented. Finally, we conclude our analysis and provide recommendations for further research.

Methodology

Constructing an ESG Factor

There are several ways to define a company's sustainability ranking, particularly regarding its ESG practices. This analysis utilizes the ESG score provided by Refinitiv (2022) to construct the ESG risk factor. Their database covers 85% of the global market cap (approx. 12,500 companies) with a history dating back to 2002. The ESG score is based on company-reported data, where failure to disclose highly material data points negatively impacts a company's score. Refinitiv (2022) calculates over 630 company-level ESG measures which are grouped into 10 categories that are aggregated into three pillar scores: Environmental, Social, and Governance. The overall ESG score is a weighted company score based on these pillar scores. Following corporate reporting cycles, the database is continuously updated, with the data being adjusted weekly and the ESG scores being recalculated accordingly. However, since companies publish their ESG reports annually, the same score is used every month until a new one becomes available.

1499 constituent stocks of the S&P 500 Index, S&P MidCap 400 Index, and S&P 600 Small Cap Index have been selected on October 31, 2024. Each month m, the stocks are sorted based on their ESG score. 25% of the stocks with the highest ESG score form the Top25 ESG portfolio and 25% of the stocks with the lowest ESG score form the Bottom25 ESG portfolio.

According to Fisher & Lorie (1970), a diversified portfolio requires 32 stocks to achieve a 95% reduction in firm-specific return variability, while 128 stocks are needed for a 99% reduction. Similarly, Campbell et al. (2001) concluded that at least 50 stocks are necessary to construct a diversified portfolio. In light of these findings, only those months where each portfolio comprised at least 50 stocks were considered. Due to the limited availability of historical ESG score data before December 2009, our study focuses on the period from December 2009 to May 2024. During this timeframe, the number of stocks in each portfolio ranged from 154 in December 2009 to 371 in May 2024.

Figure 2 shows each portfolio's monthly average ESG score. A score of 100 represents the highest possible ESG rating, indicating exemplary ESG practices, while lower scores reflect weaker ESG performance. The Top25 ESG portfolio has an average ESG score of 72.5. In contrast, the Bottom25 ESG portfolio has an average ESG score of 23.28. In particular, the average ESG score of the Bottom25 ESG portfolio increased over time from 18.73 in December 2009 to 31.23 in May 2024. This is a 66.7% increase. The Top25 ESG portfolio, on the other hand, had only a slight increase in its average ESG score of 7.39% from 70.75 in December 2009 to 75.98 in May 2024. The larger increase in the Bottom25 ESG portfolio is likely due to increased market emphasis on sustainable and responsible business practices.

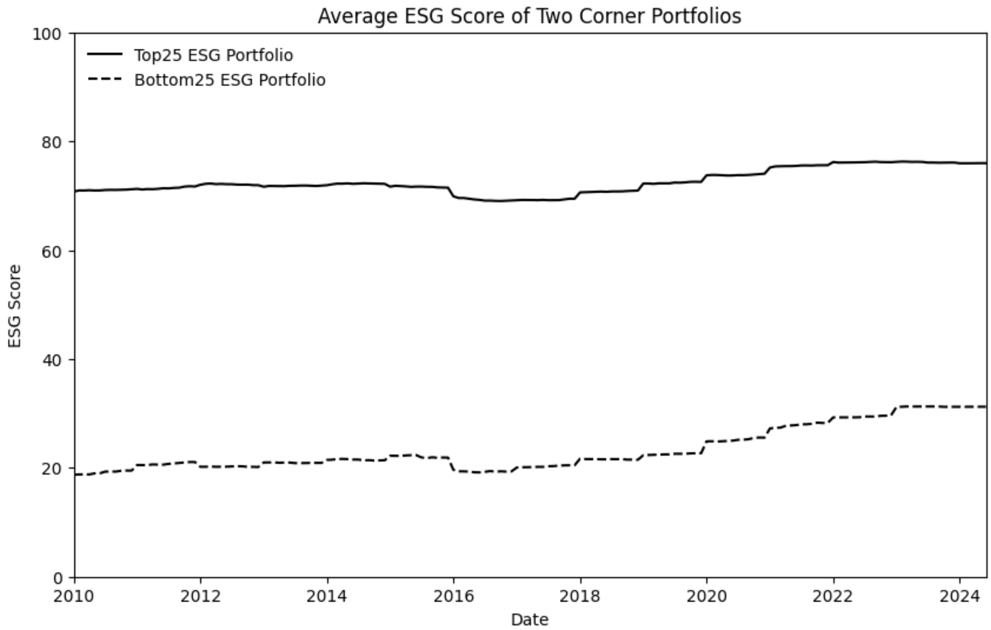

Figure 2: Average ESG score of two corner portfolios

The ESG factor is the difference between the average return of the Bottom25 ESG portfolio $r_{ESG\_Bottom25}$ and the average return of the Top25 ESG portfolio r_{ESG_Top25}.

$$ESG_m = 1/2(r_{ESG\_Bottom25,m} - r_{ESG\_Top25,m}) \tag{1}$$

As will be shown in a later chapter, the ESG factor exhibits a strong and significant positive Pearson correlation coefficient of 0.71 with SMB. This correlation suggests that, on average, companies with low ESG scores tend to have a smaller market capitalization. Consequently, in its original form, the ESG factor behaves similarly to the SMB factor, effectively serving as a proxy for size and providing limited additional information. To address this issue, the ESG factor is regressed on the FF-5 and the momentum factor.

$$\begin{aligned} E\hat{S}G_m = \alpha &+ \beta^{MKT} MKT_m + \beta^{SMB} SMB_m + \beta^{HML} HML_m \\ &+ \beta^{RMW} RMW_m + \beta^{CMA} CMA_m + \beta^{MOM} MOM_m + \varepsilon \end{aligned} \tag{2}$$

The sum of residuals plus the intercept from this regression form the ESG Residual risk factor *ESG_Residual*. This removes any information from the ESG factor contained in the other factors, allowing us to focus solely on the unique information it provides.

$$ESG\_Residual_m = \alpha + (ESG_m - \hat{ESG_m}) \tag{3}$$

Fama-MacBeth Regression

A Fama & MacBeth (1973) regression is conducted to assess if bearing factor risks is compensated with a risk premium.

First, each stock's excess return is regressed on the FF-5 factors, MOM, and the ESG factor (The ESG Residual factor separately) over the entire period from December 2009 to May 2024. This yields the estimated factor loadings.

$$\begin{aligned} r_i - r^{RF} = {} & \alpha_i + \beta_i^{MKT} MKT + \beta_i^{SMB} SMB + \beta_i^{HML} HML + \beta_i^{RMW} RMW + \beta_i^{CMA} CMA \\ & + \beta_i^{ESG} ESG + \beta_i^{MOM} MOM + \varepsilon_i \end{aligned} \tag{4}$$

Second, for each month, the monthly excess returns of all stocks are regressed on the estimated factor loadings obtained from the previous regression. By conducting this estimation monthly, the bias caused by autocorrelation and heteroscedasticity is reduced.

$$\begin{aligned} r_{im} - r_m^{RF} = {} & \gamma_m + \gamma_m^{MKT} \hat{\beta}_i^{MKT} + \gamma_m^{SMB} \hat{\beta}_i^{SMB} + \gamma_m^{HML} \hat{\beta}_i^{HML} + \gamma_m^{RMW} \hat{\beta}_i^{RMW} + \gamma_m^{CMA} \hat{\beta}_i^{CMA} \\ & + \gamma_m^{ESG} \hat{\beta}_i^{ESG} + \gamma_m^{MOM} \hat{\beta}_i^{MOM} + \omega_m \end{aligned} \tag{5}$$

The coefficients γ_m^{MKT}, γ_m^{SMB}, γ_m^{HML}, γ_m^{RMW}, γ_m^{CMA}, γ_m^{ESG}, and γ_m^{MOM} can be interpreted as the estimated monthly risk premiums for the respective risk factor. To calculate the average monthly risk premiums and obtain t-statistics, each monthly risk premium (represented as γ_m^F) is regressed on a constant.

$$\gamma_m^F = \overline{\gamma} + u_m \tag{6}$$

This yields the average monthly risk premium of each factor $\overline{\gamma}^{MKT}$, $\overline{\gamma}^{SMB}$, $\overline{\gamma}^{HML}$, $\overline{\gamma}^{RMW}$, $\overline{\gamma}^{CMA}$, $\overline{\gamma}^{ESG}$, $\overline{\gamma}^{MOM}$.

Empircal Results

Summary Statistics

Table 1 provides summary statistics for the factor returns over the entire period from December 2019 to May 2024. Panel A shows average monthly returns (Mean), the standard deviations of monthly returns (Std. Dev.), and the t-statistic for the average returns of a t-test with the null hypothesis that the mean equals zero. Panel B provides the Pearson correlation coefficients among the factors analyzed.

Table 1: Summary Statistics

Summary statistics for monthly factor returns are shown between December 2009 and May 2024. Panel A of the table shows average monthly returns (Mean), the standard deviations of monthly returns (Std. Dev.), and the t-statistic (T-statistic) for the average returns of a t-test with the null hypothesis that the mean equals zero. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level. Panel B shows the Pearson correlation coefficients of the factors. ESG (R) refers to the ESG Residual factor.

Panel A: Averages, Std. Devs. , and T-Statistics for monthly returns

	Mkt-RF	SMB	HML	RMW	CMA	MOM	ESG	ESG (R)
Mean	1.08%***	-0.03%	-0.12%	0.30%**	0.04%	0.24%	0.45%***	0.47%***
Std. Dev.	4.41%	2.70%	3.28%	1.97%	2.11%	3.59%	1.68%	0.98%
T-Statistic	3.22	-0.15	-0.49	2.04	0.25	0.87	3.56	6.34

Panel B: Pearson Correlation Coefficients

	MKT	SMB	HML	RMW	CMA	MOM	ESG	ESG (R)
MKT		0.36	0.08	-0.09	-0.13	-0.32	0.30	0.00
SMB	0.36		0.28	-0.40	0.04	-0.29	0.71	0.00
HML	0.08	0.28		0.06	0.65	-0.28	-0.10	0.00
RMW	-0.09	-0.40	0.06		0.11	0.01	-0.47	0.00
CMA	-0.13	0.04	0.65	0.11		0.04	-0.29	0.00
MOM	-0.32	-0.29	-0.28	0.01	0.04		-0.06	0.00
ESG	0.30	0.71	-0.10	-0.47	-0.29	-0.06		0.58
ESG (R)	0.00	0.00	0.00	0.00	0.00	0.00	0.58	

On average, the market return over the risk-free rate is positive at 1.08% per month and statistically significant at the 1% level. MKT exhibits the highest positive correlation with SMB and ESG, indicating that small-cap stocks outperform large-cap stocks and low ESG score stocks outperform high ESG score stocks during periods of positive market excess returns.

The Size factor (SMB) demonstrates an insignificant average monthly return of -0.03%, which is lower than the values reported by Fama & French (2015). They documented an average SMB return ranging from 0.29% to 0.30% over the period from July 1963 to December 2013. However, the standard deviation of the SMB factor is only marginally lower than the values reported by Fama & French (2015), indicating comparable levels of risk while showing lower average returns. Consequently, the risk-return profile of SMB appears to have deteriorated between December 2009 and May 2024 relative to earlier periods. The SMB factor shows the highest correlation (0.71) with the ESG factor, a relation that is elaborated upon in the following section. RMW and SMB have a negative correlation coefficient of -0.40 which means that small stocks tend to be less profitable than big stocks. The interaction of size with the other factors will be addressed again in the next chapter.

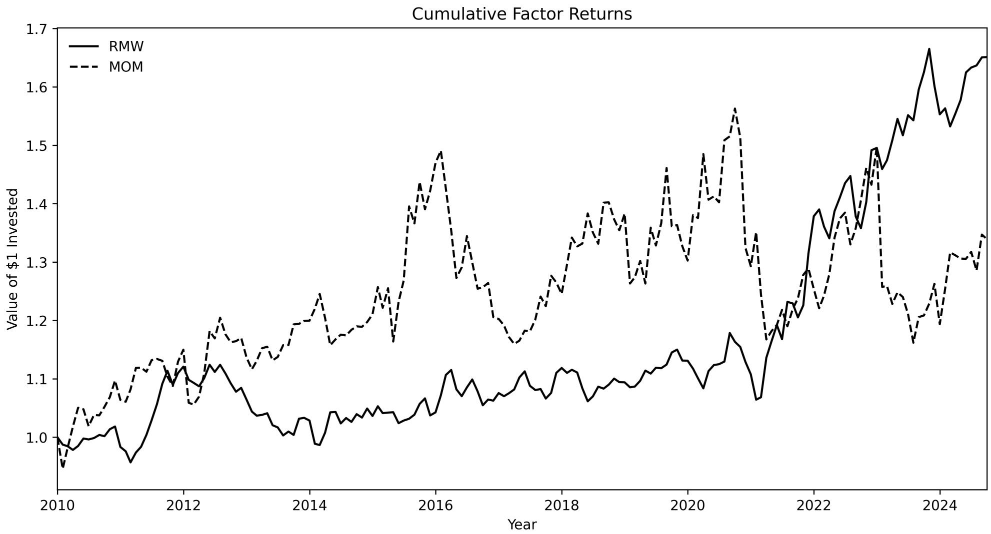

Figure 3: Cumulative factor strategy returns of RMW and momentum between 2010 and 2024

RMW has a positive and statistically significant average monthly return at the 5% level of 0.30%. As figure 3 shows, RMW does not exhibit statistically significant average returns from 2009 to 2021. However, after 2021, the average return of RMW increased significantly. A strategy that would have bought stocks with robust operating profitability and sold stocks with weak operating profitability would have performed much better in the period following 2021 compared to the preceding years. The Pearson correlation coefficient between RMW and HML presented in Panel B is 0.06. This result is similar to Fama & French (2015) who found a correlation of 0.04 between those two factors.

This suggests that the two factors are unrelated and constitute different measures of risk.

Novy-Marz (2013) analyzed the relation between book-to-market ratio and profitability. He found that companies with higher profitability have higher returns on average. Similarly, companies with higher book-to-market ratios have higher returns. Looking at portfolio characteristics, he also observed a negative correlation between profitability and book-to-market ratio between July 1963 and December 2010 suggesting that the performance of a value strategy can be improved by controlling for profitability and vice versa. A univariate sort on book-to-market, as he points out, results in "*a value portfolio polluted with unprofitable stocks and a growth portfolio polluted with profitable stocks. [...] a profitability strategy that avoids holding stocks that are profitable but fully priced, and avoids selling stocks that are unprofitable but nevertheless cheap, should outperform conventional profitability strategies*". Since value and profitability strategies are negatively correlated, a value investor can reduce portfolio volatility and capture the profitability premium without taking on additional risk. However, the low correlation between HML and RMW found here suggests that there is no relation between value and high-profitability stocks. A key methodological difference may explain this mismatch: Fama & French (2015) measure profitability using operating profitability, while Novy-Marz (2013) relies on gross profitability. Operating profitability is calculated as revenue minus cost of goods sold, minus selling, general, and administrative expenses, minus interest expenses, divided by book equity. Gross profitability on the other hand is simply defined as revenue minus cost of goods sold divided by total assets. Novy-Marz (2013) argue that the "*farther down the income statement one goes, the more polluted profitability measures become, and the less related they are to true economic profitability*", justifying their choice of a simpler profitability measure.

CMA has an average monthly return of 0.04%, which is not statistically different from zero. CMA and HML exhibit a high correlation of 0.65, closely aligning with the correlation of 0.71 reported by Fama & French (2015). They argue that this result arises because high book-to-market value companies tend to be low-investment firms. HML is long on high book-to-market value firms and CMA buys low investment firms explaining the high correlation coefficient. Consequently, an investor will find lower diversification benefits when combining a value strategy with a conservative strategy as the two factors' returns tend to move together.

The average HML return is close to zero but slightly negative at -0.12%. It is not statistically significant at any conventional significance level. Fama & French (2015) describe HML as a redundant factor for explaining average returns in the US stock market from 1963 to 2013. They regress HML on the other FF-5 factors and find that the returns of HML are largely absorbed by RMW and CMA. This reflects the tendency of high book-to-market value firms to invest conservatively. However, contradicting the by Novy-Marz (2013) observed negative correlation between profitability and book-to-market, Fama & French (2015) find a positive slope of RMW. This implies that value stocks move similarly to profitable stocks after controlling for the other factors despite their tendency to be unprofitable when considered in isolation.

The momentum factor has an average return of 0.24% which surpasses the average returns of most other factors. However, the return is not significant. Figure 3 suggests that this lack of significance is likely due to the larger return variation during the considered period. Hence, a momentum strategy would have yielded both positive and negative returns. The negative correlation between MOM and HML (-0.28) could be explained by the recent outperformance of growth stocks over value stocks. While the momentum strategy captures the excess return of recent winners (i.e. growth stocks) over recent losers (i.e. value stocks), the value strategy reflects the excess returns of value stocks over growth stocks, leading to an inverse relation when growth stocks have higher returns. Momentum is also negatively correlated with the market, SMB, and ESG factors. RMW and CMA have both a correlation coefficient close to zero and are therefore uncorrelated with a momentum strategy. Hence, implementing a momentum strategy would yield diversification benefits as an investor can capture the momentum risk premium without taking on additional risk.

The ESG factor exhibits an average monthly return of 0.45%, which is statistically significant at the 1% level. This indicates that, in the absence of controlling for other factors, companies with low ESG scores outperform those with high ESG scores by an average of 0.45% per month. Similarly to SMB, the ESG factor negatively correlates with RMW (-0.47) driven by the high correlation between SMB and ESG mentioned earlier. The ESG factor is also negatively correlated with CMA (-0.29) which might be because companies with higher ESG scores emphasize sustainability and long-term stability aligning themselves with conservative firms that reinvest less aggressively. Those are sold in the ESG factor and bought in the CMA factor resulting in a negative correlation coefficient.

The ESG Residual factor (ESG (R)) has an average monthly return of 0.47% which is statistically significant at the 1% level. The return represents the intercept of the regression of the ESG factor on all other risk factors. The residuals are on average zero. The statistically significant intercept suggests that after controlling for the other risk factors, other drivers explain the excess returns of a portfolio consisting of companies with low ESG scores over a portfolio composed of companies with high ESG scores.

Market Capitalization Patterns in ESG Portfolios

Panel B of table 1 reports a Pearson correlation coefficient between ESG and SMB of 0.71. This strong positive correlation can be attributed to a significant market capitalization imbalance between the Top25 ESG portfolio and the Bottom25 ESG portfolio. Figure 4 plots market capitalization multiples (i.e. MCap Top25 ESG portfolio divided by MCap Bottom25 ESG portfolio) of the Top25 ESG portfolio over the Bottom25 ESG portfolio (left Y-Axis) against the size of each portfolio (right Y-Axis). The plot shows that the Top25 ESG portfolio always has at least 4.22 times more market capitalization than the Bottom25 ESG portfolio. However, the largest difference was found in December 2018 when the Top25 portfolio had 15.74 times more market capitalization than the Bottom25 portfolio.

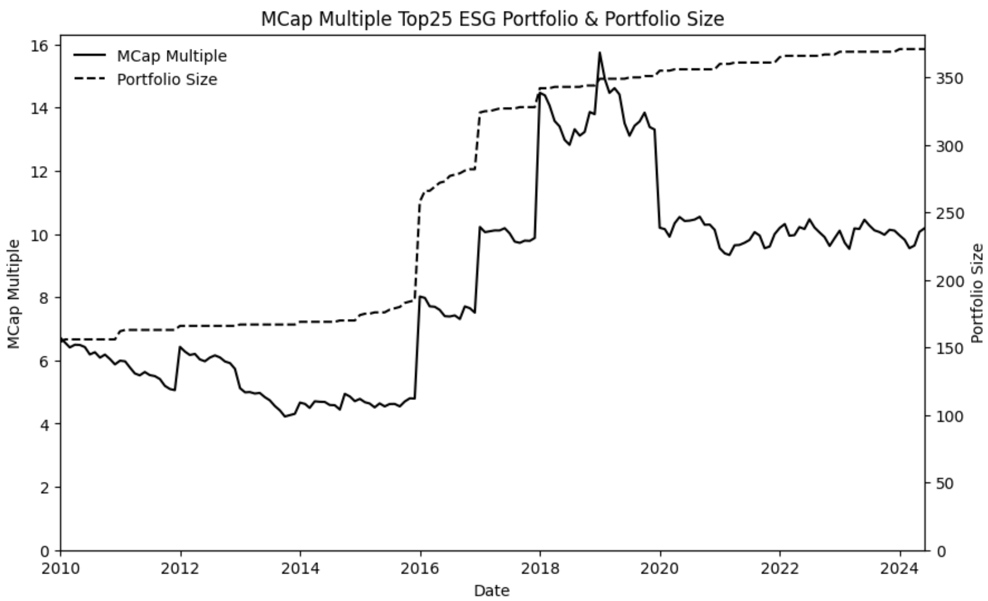

Figure 4: MCap multiple Top25 ESG portfolio and portfolio size

Although the difference in market capitalization varies, five significant changes could be observed over time. They always occurred in December (12/2011, 12/2015, 12/2016, 12/2017, and 12/2019) as in this month, the ESG scores for most companies are updated. An increase in portfolio size accompanies all changes in market capitalization. The portfolio size increases as more ESG scores become available for more companies. The change in portfolio size in December 2015 and December 2016 are particularly noticeable. In those months, the number of stocks with available ESG scores increased by 291 from 742 to 1033 and 167 from 1129 to 1296, respectively.

Every change before 2019 led to an imbalanced increase in the Top25 portfolio market capitalization compared to the Bottom25 portfolio except for the change in December 2019. Here, the Bottom25 portfolio market capitalization increased more strongly resulting in a drop of the market capitalization multiple from 13.3 to 10.2.

In general, a strong imbalance in market capitalization can be observed between companies with a high ESG score and a low ESG score. Research by Wealth & Management (2024) highlights that while ESG ratings have increased significantly across market capitalization categories, larger firms tend to achieve higher ESG scores, largely due to their superior resources and increased stakeholder pressure (See figure 5).

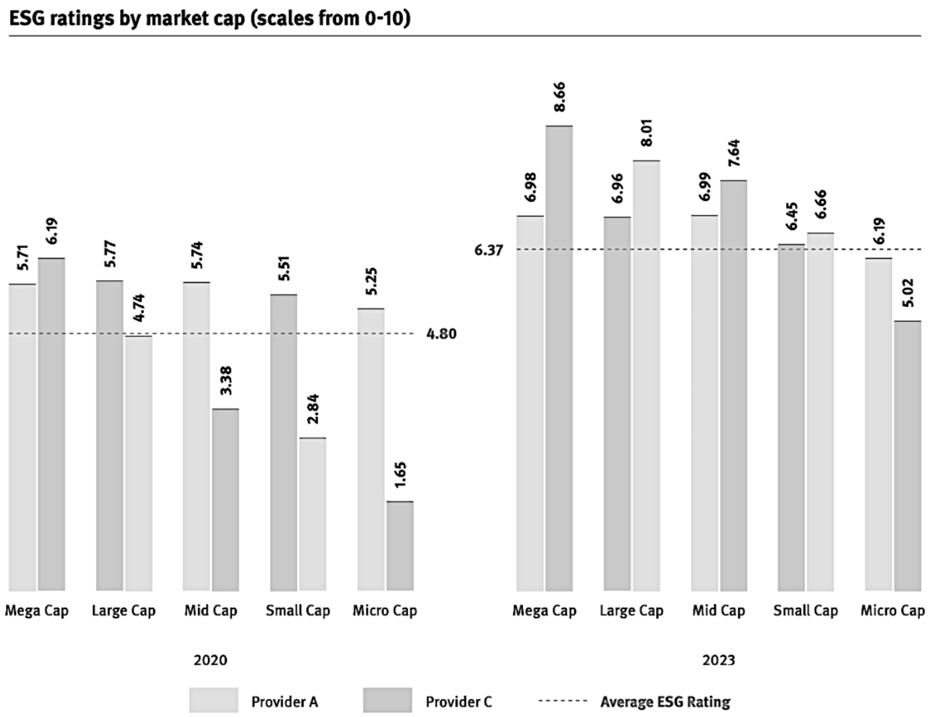

Figure 5: ESG ratings by market cap from *Wealth & Management (2024)*

Similarly, Martínez & Navas (2024) found that larger firms typically achieve better ESG scores for related reasons. Department (2023) further confirms this positive correlation between market capitalization and ESG performance.

As outlined, we address this and any other potential correlation between the ESG factor and other factors by calculating the ESG Residual factor as the sum of the intercept plus the residuals from a regression of ESG on the other factors. Table 2 presents the results. The alpha is positive, albeit small (0.0047), and significant indicating that the average monthly excess return of the ESG strategy returns are not fully explained by its exposure to the other factors. Consistent with expectations, the SMB factor exhibits the strongest explanatory power for the excess returns.

RMW, CMA, and MOM also have significant coefficients although the MOM is relatively small at 0.07. Including HML does not appear to enhance the explanation of the ESG factor returns after controlling for RMW and CMA. However, omitting RMW and CMA from the regression results in a negative and statistically significant coefficient for HML. This finding aligns with the conclusions of Fama & French (2015), who describe HML as a redundant factor, stating that "*the average HML return is captured by the exposures of HML to other factors*." Overall, the factors account for approximately 60% of the variance in the ESG factor.

Table 2: ESG Residual Regression Results

Shows the results from a regression of the ESG factor on the five Fama & French (2015) factors plus a momentum factor. Coef. is the coefficient. T-Stat. is the heteroskedasticity robust t-statistic. R^2 is the adjusted R-squared of the regression. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level.

$R^2_{adj} = 0.6$	Alpha	Mkt-RF	SMB	HML	RMW	CMA	MOM
Coef.	0.0047***	0.02	0.44***	-0.05	-0.13***	-0.19***	0.07***
T-Stat.	5.571	0.991	9.272	-1.402	-2.827	-2.780	2.320

Figure 6 shows the cumulative factor returns for the ESG factor and the ESG Residual factor. An investor who would have bought stocks with a low ESG score and sold stocks with a high ESG score would have doubled his initial investment during the considered period. By the other factors unexplained cumulated excess returns performed even better than the ESG factor although it needs to be mentioned that the ESG Residual does not constitute a tradable strategy as it contains Alpha which cannot be traded. The ESG Residual factor also exhibited significantly lower volatility compared to the ESG factor due to small residuals.

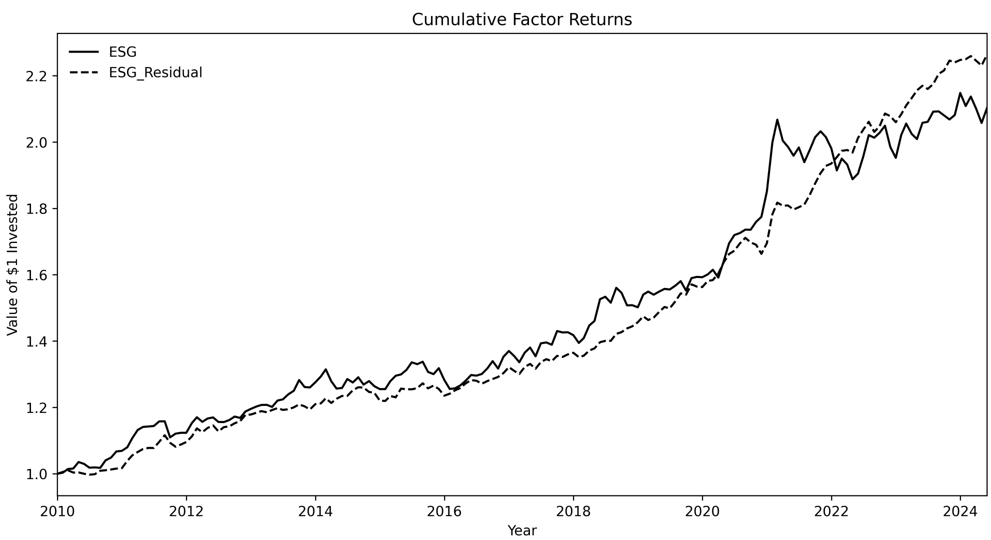

Figure 6: Cumulative factor strategy returns of ESG and ESG Residual between 2010 and 2024

Fama-MacBeth Regression

Table 3 presents the results of the Fama & MacBeth (1973) regression with different specifications. The analysis was implemented with seven factors (RFM-7) and with five factors (RFM-5). RFM-7 uses the factors of the FF-5 model, the momentum factor, and the ESG factors. RFM-5 uses the factors of the FF-3 model, the momentum, and ESG factors. The left (right) section of the table shows the results when using the ESG factor (ESG Residual factor). Panel A (B) shows the results between December 2009 and May 2024 (December 2009 and December 2019). Panel B does not include the COVID-19 pandemic and the years since to show the possible impacts it had on risk premiums.

Panel A of table 3 shows a statistically significant average Alpha $\overline{\gamma}$ ranging between 0.65% and 0.72%, depending on the model specification. This suggests that there is a consistent residual return over all months that cannot be explained by the factor loadings. These unobserved effects were even larger prior to the COVID-19 pandemic with a monthly average Alpha between 1.00% and 1.07%. The average monthly market risk premium ranges from 0.36% to 0.41% for the pre-pandemic period but lacks statistical significance. This suggests that bearing market factor risk was not compensated during the period from December 2009 to December 2019. However, the rapid recovery of the market following the market crash in 2020 appears to have revived the market risk premium. Over the entire period, the average risk premium ranged from 0.76% to 0.81%.

The monthly risk premium of SMB is positive between 0.27% and 0.34% but never statistically significant. Consequently, there is no evidence to confirm that investors are compensated for bearing size risk. This finding aligns with Alquist et al. (2018) who concluded that there is "*neither strong empirical evidence nor robust theoretical support for a prominent size premium*". However, Blitz & Hanauer (2021*b*) suggests that "*size can add a lot of value by serving as a catalyst that helps to unlock the full potential of other factors, such as value and momentum*". Similarly Alquist et al. (2018) note that other factors work better in small caps, as these may yield higher returns within that segment.

The risk premiums of the value, profitability, and investment factors are notably negative. However, only the value and investment premiums are statistically significant at the 5% and 10% level over the entire considered period. Both factors exhibit significance at 5% level before the COVID-19 pandemic. As demonstrated in a previous chapter, HML and CMA are positively correlated, leading to similar risk premiums. However, the value premium is more negative than the investment premium. Despite Fama & French

(2015) suggesting that HML becomes redundant in explaining returns, its negative risk premium persists even after controlling for RMW and CMA and this result remains robust across different time periods. Blitz & Hanauer (2021*a*) highlights that in "*recent years, the value premium has failed to materialize since the Global Financial Crisis. With value stocks severely lagging growth stocks in the late 2010s and early 2020s, the factor is being questioned*." The observed negative risk premium for HML aligns with these findings. Figure 3 implied that the standalone RMW factor had large positive returns after 2021. However, after controlling for the other factors, the results of the Fama & MacBeth (1973) regression show an even smaller risk premium of -0.21% over the entire period compared to -0.13% for the period before the COVID-19 pandemic. The observed positive returns after 2021 are therefore not reflected in the risk premiums and are likely related to the interaction of RMW with other factors.

Unsurprisingly, over the entire period, the momentum risk premium is positive and statistically significant at the 10% level. However, prior to the COVID-19 pandemic, the risk premium was considerably higher, with at least an average premium of 0.85% per month compared to up to 0.64% over the entire period. This indicates that momentum strategies have underperformed in recent years relative to their historical average. Nonetheless, a momentum strategy has still been well-compensated, delivering a relatively large monthly risk premium. As discussed in an earlier chapter, the results in table 1 suggest that momentum strategies provide diversification benefits due to their negative correlation with most other factors. Consequently, investors could have captured the observed momentum risk premium while simultaneously reducing portfolio volatility.

The left section of Table 3 shows that investors have been compensated for bearing ESG risk, with an average monthly risk premium of 0.4%, which is statistically significant at the 5% level. Without controlling for profitability and investment factors, the ESG risk premium is slightly lower at 0.37% and significant only at the 10% level. Prior to the COVID-19 pandemic, the ESG risk premium was 0.32% under RFM-7 and 0.33% under RFM-5, slightly lower than over the full period. This suggests that as awareness of ESG risks increased more in recent years, the compensation for bearing these risks may have been lower during earlier years of the considered period. In contrast, the ESG Residual risk premium, shown in the right section of table 3, is much smaller and not statistically significant at conventional significance levels. During the period from December 2009 to December 2019, the average monthly risk premium was near zero and highly insignificant. When removing any information from the ESG factor contained in the other factors, there appears to be no systematic compensation for bearing ESG risk. Thus, the constructed ESG factor primarily serves as a proxy for other risk factors and does not seem to be a standalone risk factor.

Table 3: Results Fama & MacBeth (1973) Regression

$\overline{\gamma}$, $\overline{\gamma}^{MKT}$, $\overline{\gamma}^{SMB}$, $\overline{\gamma}^{HML}$, $\overline{\gamma}^{RMW}$, $\overline{\gamma}^{CMA}$, $\overline{\gamma}^{MOM}$, $\overline{\gamma}^{ESG}$ and $\overline{\gamma}^{ESG(R)}$ are the average monthly risk premiums based on a Fama & MacBeth (1973) regression. Panel A (B) shows the results for the period between December 2009 and May 2024 (December 2009 and December 2019). The table shows the results for RFM-7 and RFM-5 models separately. Heteroscedasticity and autocorrelation-adjusted t-statistics are shown in parenthesis. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level.

	ESG		*ESG Residual*	
Panel A: Time Period between December 2009 - May 2024				
	RFM-7	RFM-5	RFM-7	RFM-5
$\overline{\gamma}$	0.72%***	0.69%***	0.72%***	0.65%***
	(3.57)	(3.37)	(3.57)	(3.19)
$\overline{\gamma}^{MKT}$	0.76%*	0.79%**	0.76%*	0.81%**
	(1.93)	(1.97)	(1.93)	(2.06)
$\overline{\gamma}^{SMB}$	0.27%	0.27%	0.27%	0.28%
	(1.19)	(1.14)	(1.19)	(1.23)
$\overline{\gamma}^{HML}$	-0.55%**	-0.56%**	-0.55%**	-0.55%**
	(-1.99)	(-2.01)	(-1.99)	(-2.01)
$\overline{\gamma}^{RMW}$	-0.21%		-0.21%	
	(-1.13)		(-1.13)	
$\overline{\gamma}^{CMA}$	-0.36%*		-0.36%*	
	(-1.74)		(-1.74)	
$\overline{\gamma}^{MOM}$	0.64%*	0.59%*	0.64%*	0.62%*
	(1.92)	(1.75)	(1.92)	(1.85)
$\overline{\gamma}^{ESG/ESG(R)}$	0.40%**	0.37%*	0.10%	0.07%
	(2.43)	(1.91)	(0.92)	(0.58)
Panal B: Time Period between December 2009 - December 2019				
	RFM-7	RFM-5	RFM-7	RFM-5
$\overline{\gamma}$	1.07%***	1.03%***	1.07%***	1.00%***
	(5.91)	(5.45)	(5.91)	(5.24)
$\overline{\gamma}^{MKT}$	0.36%	0.39%	0.36%	0.41%
	(0.92)	(1.00)	(0.92)	(1.06)
$\overline{\gamma}^{SMB}$	0.31%	0.33%	0.31%	0.34%
	(1.39)	(1.46)	(1.39)	(1.49)
$\overline{\gamma}^{HML}$	-0.53%**	-0.54%**	-0.53%**	-0.54%**
	(-2.40)	(-2.43)	(-2.4)	(-2.43)
$\overline{\gamma}^{RMW}$	-0.13%		-0.13%	
	(-0.89)		(-0.89)	
$\overline{\gamma}^{CMA}$	-0.35%**		-0.35%**	
	(-2.35)		(-2.35)	
$\overline{\gamma}^{MOM}$	0.87%***	0.86%***	0.87%***	0.85%***
	(2.72)	(2.68)	(2.72)	(2.65)
$\overline{\gamma}^{ESG/ESG(R)}$	0.32%**	0.33%**	0.01%	-0.01%
	(2.30)	(2.30)	(0.08)	(-0.07)

Conclusion & Outlook

The ESG factor might not yet warrant inclusion as a standalone component in the FF-3 or FF-5 models, as it effectively serves as a proxy for the size factor and provides limited unique explanatory power. The ESG Residual reveals the unique risk premium associated with ESG, indicating that one is not compensated for bearing ESG risk and confirming the inefficiency of including ESG in factor models. Momentum remains a robust factor with a significant risk premium and negative correlations with most other factors, offering diversification benefits. HML demonstrates its declining relevance in explaining excess returns within the multi-factor models. As Fama & French (2015) show, this is primarily due to its redundancy when accounting for the effects of profitability and investment factors. The size factor lacks a discernible risk premium, corroborating recent findings by Blitz & Hanauer (2021*a*), questioning its standalone validity but acknowledging its potential in enhancing other factor strategies, particularly within small caps.

Future research may integrate multivariate portfolio analysis to refine the configuration of an ESG factor. This may include evaluating the effects of adopting a value-weighted rather than an equally weighted strategy or maintaining a fixed number of stocks within the portfolio throughout the analysis period. Additionally, future studies could investigate the dynamic interactions between ESG factors and other factors not considered in our analysis. Researchers should also account for potential biases arising from different ESG scoring methodologies, as these may influence portfolio composition and observed returns. Finally, exploring the individual components — E, S, and G — that comprise the ESG score could offer insights into whether they independently represent priced risk factors.

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