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ESG Integration in AP1 Systematic Equity Strategies

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Abstract

Responsible investing consists of buying more sustainable stocks, or green stocks, and selling the controversial ones. As a pension fund, and with the current climate regulations, it is a concern for Första AP-fonden to know if responsible investing is a plus value for financial aspects. Since our commissioner also has interests in factor strategies, rule-based systematic investment strategies, and possesses some, we will study and explain what are factor strategies. Financial benefits from responsible investing could be explained by savings made on carbon taxes, if a company has a strong environmental policy. On the other hand, factor strategies have proven to work well historically, like the Fama-French value strategy which performed more than decently during the 80s, growing up to around 10 times the initial budget. By using an optimization approach, that maximizes ESG and factor scores with equal importance, we observed that half of the factors had lower performance when combined with ESG. Moreover, the factor portfolios lost their initial characteristics after ESG integration. We concluded that quality was the most promising candidate for a potential new systematic strategy.

Sammanfattning

Hållbart värdeskapande kan definieras som ett sätt att skaffa en mer hållbar portfölj, genom att investera i hållbara företag, som bidrar till att använda naturresurser, humankapital och finansiellt kapital mer ansvarsfullt än andra. Som allmän pensionsfond med de pågående diskussionerna om klimatförändringar gör det intressant att undersöka om integration av ESG- (miljöansvar, socialt ansvarstagande, bolagstyrning) aspekter i investeringsbesluten kan bidra till att leverera en långsiktigt hög avkastning i linje med Första AP-fondens uppdrag. Dessutom är regelbaserade systematiska strategier (så kallade faktor strategier) av stort intresse för Första AP fonden. Hållbart värdeskapande skulle kunna förbättra dessa strategier genom att tillföra mer robust information än den som vanligtvis finns i de mest bolagens balansräkningar. Därför är det naturligt att undersöka effekterna av integrering av ESG i mest vanliga systematiska aktiestrategierna. Genom att lösa ett optimeringsproblem får vi portföljer som maximerar både ESG och traditionella riskfaktorer. Analysen har visat att efter ESG integreringen, förlorade faktorportföljerna delvis sina egenskaper. Det går att konstatera att Quality factor portfölj är den bästa kandidaten för ESG integrering.

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Any relative not cited here is not intentionally put aside, and has all my gratitude.

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Introduction

Problematization

Pension funds are essential to provide income for retired people, that's why in Sweden 16% of people's salary goes to the AP funds. During recent years, Swedish as well as international pension funds invested vastly into factor-based investment strategies. Factor-based investing gained popularity after the global financial crisis as a way to diversify more traditional investment portfolios that are usually heavily weighted in equity and fixed income. The number of assets under management of factor-based strategies has been evolving massively during recent years, shifting allocation away from bonds because of their decreasing returns. More recently, in the early 2000s, another investing trend has grown, called responsible investing. Besides, Swedish pension funds accord a certain importance to sustainability issues and ethics. Responsible investing can be explained as a more conscious, less greedy, way of investing. It is an investing opportunity that has not been missed by pension funds.

Factor-based strategies are focused on intrinsic characteristics of assets, so a portfolio having bonds and currencies can have the same characteristics as a stock portfolio. Asset managers are seeking strategies that move along factor-based strategies because of their past performance. In the widespread systematic strategies, the term "exposure" is quite often used, as a monitoring tool for performance. The more correlated a portfolio's returns are to factor portfolios' returns, the more exposure the portfolio has to the factor-based portfolio. Hence, pension funds are looking for factor exposure in their systematic portfolios. On the other hand, it has become critical to take into consideration environmental concerns as the current climate situation is alarming. Moreover, funds are bound to avoid controversial investments since the media backlash is unforgiving. Thus, it explains the necessity of pension funds to have "clean" investments.

As responsible investing takes more importance among investors, it becomes necessary to apply the ESG (Environmental, Social and Governance) approach to systematic investing strategies as well. Responsible investing has been renown for reducing risk, but at which extent? Would addition of responsible investing principles to factor-based strategies lead to decreases in performance and erosion of the underlying drivers of return?

In this project we will study effects of adding ESG as a parameter in the portfolio optimization process. The strategies we are focusing on are also known as Smart Beta. Smart Beta is a family of systematic strategies that aim to generate extra return by applying different weighting schemes than relevant benchmarks. It consists of studying different factor strategies within equity space such as classical Fama-French factor strategies (i.e. HML factor) as well as more price-driven anomalies such as Low Beta.

We will answer three questions in the theory part: "What is ESG investing and factor investing?","Why do investors chose these strategies?","How can we pair them?". Then, we will explain the model of factor scores and the method for adapting Fama-French-like factors with an ESG tilt, as well as the portfolio optimization used to construct portfolios following our factor strategies.

Research questions

RQ1: Does ESG enhance returns or reduce risk when integrated to factor strategies?

RQ2: How does ESG influence factor exposure when integrated to factor strategies?

Purpose

The purpose of the project is to adapt the factor ESG strategy to AP1's systematic strategies. The thesis thus follows the trend of ESG investing, and will help to get more sustainable portfolios.

Contribution to research

Our contribution to research is to add a new concrete utilization of ESG in factor strategies, applied to a specific portfolio. The thesis also aims at a better understanding of the purpose of ESG investing, for students or academics with an interest in finance.

The commissioner

The commissioner for this work is Första AP-fonden (AP1). Första AP-fonden is one of the five main Swedish pension funds. Those five take care of the regular pension money, i.e. the income from people who chose the default pension payment system. Första AP-fonden manages 330 billion SEK, and has a board directive to make long term 4% real annual return. Första AP-fonden will be named also AP1, AP1 fonden, further in the thesis.

1 Theory

1.1 Notations and definitions

1.1.1 Notations

- $|.|$: Absolute Value
- $nmax$: number of rebalancing periods
- N : total number of assets
- T : rebalancing period
- VaR : Value at Risk
- $\overline{w}_t$: vector of weights
- $w_{t,i}$: individual weight
- Σ : (depending on context) sum operator or covariance matrix

1.1.2 Mathematical definitions

- Value at Risk: Value at Risk is an indicator of risk, giving the necessary amount of capital to add in order to avoid loss with a certain probability. If V_0 is the initial value of our portfolio, and V_1 the future portfolio value at the desired time horizon, we set $X = V_1 - V_0$ the returns of our portfolio. For any probability value p, value at risk is defined as:

$$VaR_p(X) = \min m : \mathbb{P}(mR_0 + X \leq 0) \leq p$$

Where R_0 is the risk free rate at time 0.

Value at Risk can be rewritten in an explicit form. Let L be the loss function to our portfolio:

$$L = -\frac{X}{R_0}$$

Then:

$$\begin{aligned} VaR_p(X) &= \min m : \mathbb{P}(mR_0 - LR_0 \leq 0) \leq p \\ &= \min m : \mathbb{P}(L \geq m) \leq p \\ &= \min m : 1 - \mathbb{P}(L < m) \leq p \\ &= \min m : \mathbb{P}(L < m) \geq 1 - p \\ &= F_L^{-1}(1-p) \end{aligned}$$

Where F_L is the distribution function of L.

- Sharpe ratio: Expected returns minus risk free rate over standard deviation of returns.

$$SR = \frac{\mathbb{E}[r - r_f]}{\sigma}$$

- Turnover: Measure of the changes in holdings of a portfolio at time t.

$$turnover_t = \sum_i |w_{t,i} - w_{t-1,i}|$$

- Tracking error: Measure of the volatility that a strategy has when it deviates from the market.

$$TE = std(r - r_m)$$

- Max Drawdown: Difference between highest return point to lowest over the whole calculation period.
- Calmar Ratio: Average annual compounded returns divided by maximal drawdown, usual calculation window is 3 years.
- Business year/days: days excluding week ends, but including holidays. A business year is 264 business days.

1.1.3 Financial accounting definitions

In the following, we gather necessary definitions for financial terms.

- Market capitalization: Total value of the company. Evaluated by multiplying the number of shares times the share price.
- EBITDA: Earnings Before Interest Taxes Depreciation and Amortization, it is the net profit of a company, not taking into account any expenses dues to taxes and amortization.
- CAPEX: Capital Expenditures, money spent on material needs and investments.
- Earnings to price ratio: ratio of total earnings of a company divided by number of stocks multiplied by stock price. The lower this ratio is, the cheaper the company is. This has to be handled carefully, since it can predict some future growth (cheap stock, profitable company) or be low when the company is already on a downwards slope (cheap stock because of investors' lack of confidence).
- Book value (per share): total value of the company's assets minus total liabilities (divided by number of shares on the market).
- Book to market ratio: book value per share divided by market share price.
- Long-term debt to equity ratio: long-term debt divided by sum of all shares issued by the company. It indicates how much leverage the company has taken on. If it is too high, the company might have been too ambitious in its earnings prediction.
- Return on equity (ROE): net income divided by book value. It is a measure of the efficiency of the company, that is, how much profit is made compared to how much one shareholder invests.
- Asset growth: Current total assets minus total assets at the end of the previous year divided by current total assets.
- Exposure: When a strategy has exposure to a factor or the market, it means that its returns are correlated to a factor strategy's returns or the market's returns.

1.2 ESG

1.2.1 General concept

Investing under consideration of sustainability issues has become increasingly popular. More and more investors chose to invest responsibly, following a shifting trend from short term to more long term investing. The main focus of responsible investing nowadays is sustainability. However, the responsible investing trend was initiated by values-driven investing (Derwall, Koedijk, and Horst 2011). Values-driven investing stems from moral beliefs, and consisted mostly of avoiding investments like tobacco or weapon-spreading companies. The main aspect that could detract investors from values-investing could be seen as "a loss in financial performance in exchange for non-financial utility". Nonetheless, responsible investing can be implemented in different ways, and the goal is to avoid that loss. Principles regulating this kind of strategy have different names, among them Socially Responsible Investing, and then integration of Environmental, Societal and Governance (ESG). To quantify the concepts of ESG, companies are assessed in ESG ratings following the three different pillars. Environmental scores regroup for instance waste water management and CO2 emissions. Social scores are about the relation of the company to both external and internal stakeholders: product safety, workplace safety, proportion of female workers etc. Governance goes through all board characteristics, i.e. board independence, CEO remuneration, and governance score takes into account controversies about the company. It is important as a national pension fund to avoid controversial investments as much as possible.

The data for ESG ratings is collected from numerous sources: company disclosure, media, self-conducted company investigations. Then analysts can read the data and evaluate the accuracy of the information, by cross-reading different sources. Using disclosure as sole indicator of risk can be misleading, since companies with bad disclosure might make more efforts than companies with good disclosure. In fact, there are some cases of "greenwashing", companies overstating their sustainability efforts.

MSCI ratings divide the three pillars into key issues. For example, in environmental issues there is product carbon footprint, in social issues labor management, and governance issues include tax transparency. Of these key issues the most relevant ones, industry-wise, are selected and graded on a scale of 0 to 10. The industry relative score can be detailed this way: the key issues are focused on depending on the type of industry: i.e. for the automotive sector, product carbon footprint and product safety & quality, for the banking sector, tax transparency matters importantly. After grading the company's key issues, the scores are regrouped into a final industry relative grade, from CCC (laggards) to AAA (leaders). In this thesis, the focus will be on MSCI absolute scores, that is a numeric score obtained by summing the three pillar scores with a weighting specific to country and industry. MSCI final grade is just those scores that are ranked into quantiles.

1.2.2 Responsible Investment and Financial Analysis

Thereafter, some financial (and non-financial) consequences of ESG, and how ESG can be integrated into an investment process, will be exposed. Both predictive and real life examples will be given. For the commissioner, those examples are the best way to have a meaningful insight into the subject of ESG, and it is the most motivating aspect to incorporate ESG in their culture.

Environmental issues might lead to fines and thus market capitalization reductions. Moreover there are prices for carbon emissions, so companies will want to optimize CO2 emissions per sale. In the PRI academy courses (*PRI Academy — Principles for Responsible Investment* n.d.), it is shown in a discounted cash flow table that management of environmental issues can have a huge impact, by the example of a fictive mining company: the carbon permits and the water pricing can take up to 12.6% of the EBITDA. Also, in that case there are current controversies that led to lawsuits and potential factory closures. The decrease in EBITDA can be shrunk by improving company management systems and infrastructures, thus increasing the short term CAPEX. All these costs can be predicted by a very low environmental risk management score. The mining industry is an example of an industry with high environmental risk management impacts, because it has a major exposure to natural hazards, and many mining companies are located in countries with resource scarcity issues.

A strong example in social issues is supply chain scandals in certain industries (i.e. apparel). According to a report of Freshfields Bruckhaus Deringer (2013) ("Coping with a scandal" 2016), 53% of companies involved in supply chain scandals have not seen their share prices regain pre-crisis levels. As an investor, there must be a balance between wanting reward from risk and avoiding companies that could possibly never get back on track after controversial events (or could never get back on track because a mine has collapsed, after bad workplace safety management).

Corporate Governance focuses on how a company is managed, and how the board controls the management of a company to identify misbehaviors. In the case of Enron, an American commodities, energy and services firm, the board overlooked aggressive accounting tactics, which led to a bankruptcy (Bondarenko 2016). Again, the mining sector is a risky industry in this regard, because of corruption and geopolitical risk exposure in developing countries.

All the financial consequences of ESG constitute what we call ESG materiality. It is a subject investigated by many studies, since it is a tool to convince more investors to go sustainable. A study from Harvard (Khan, Serafeim, and Yoon 2015) states that many previous studies on ESG effects omitted to add a materiality filter. Most of those studies reached the conclusion that ESG did not affect financial performance. As a conclusion they showed that materiality is essential to create better performance. In the report of the Global Reporting Initiative and RobecoSAM (Brandt, Greenwald, and Müller 2015), focus is brought on two sectors: IT and banking, to describe materiality.

GRI Report GRI and RobecoSAM studied the views of reporting companies and investors on what is material among ESG issues (called "aspects" in the document). The report first gives two definitions of materiality, GRI defines it as "the threshold at which Aspects become sufficiently important that they should be reported", whereas RobecoSAM gives a broader view: "Financially material is any factor which might have a present or future impact on companies, value drivers, competitive position, and thus on long-term shareholder value creation".

1.2.3 ESG strategies

To obtain financial outperformance, ESG has to be subtly used. With a blind use of ESG ratings, it is likely that returns are detracted. For example, we can imagine that if a strategy excluded Apple for some reason concerning supply chain problems, it would decrease the market exposure of the portfolio, and miss an important opportunity in IT.

Two main strategies are screening and integration. Mathematically, screening corresponds to filtering and integration is more of a combined approach of ESG and a preexisting strategy.

Screening Screening (exclusion of companies from the investing universe) can be norms-based or based on product groups. Norms-based screening relies on conventions and international initiatives, investors will remove any company that does not follow for example fight against child labor. This strategy is popular because of its simplicity. In 2016, France had 2.6€ trillions assets under management in norms-based screening strategies (*European SRI study* 2016). Asset managers also use exclusion of certain products as a strategy, sales of excluded products that are deemed as unethical (*see figure 1*).

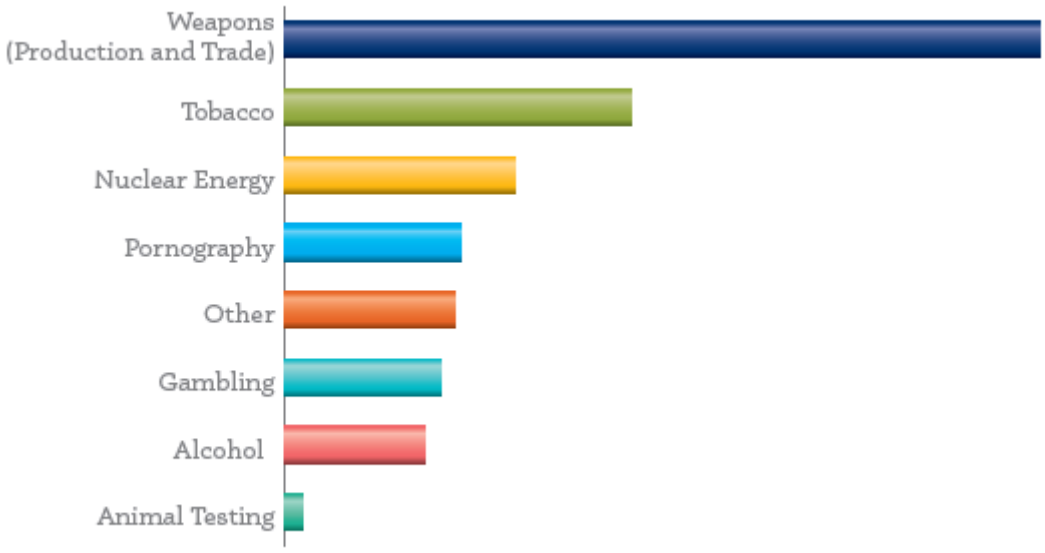
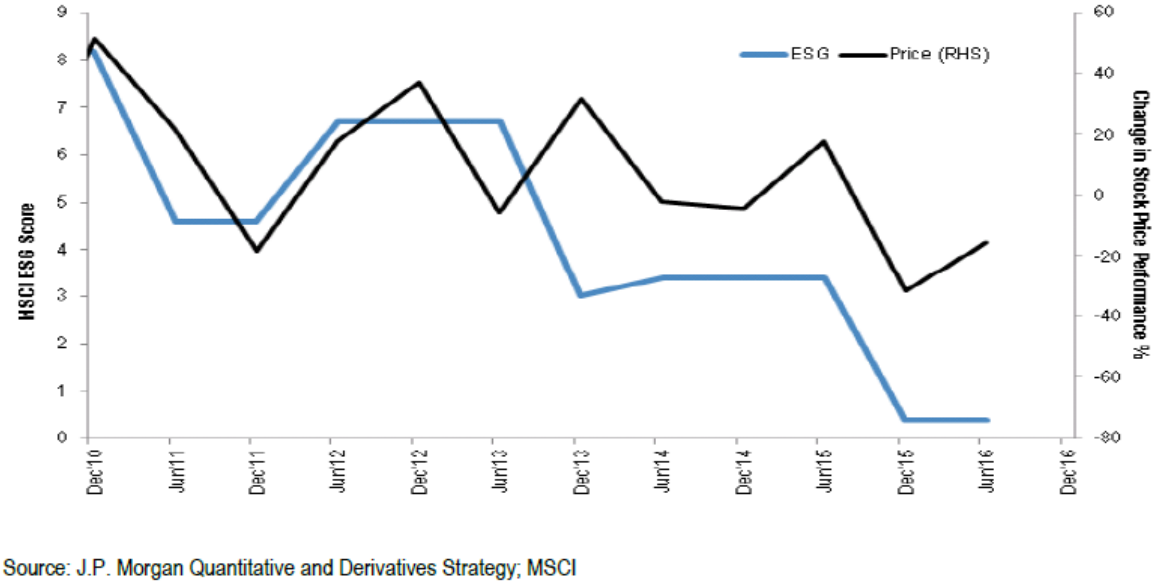


Figure 1: Top exclusion criteria in EU (from SRI study Eurosif, 2016)

Screening could also consist in taking out the last quintile or decile in the ESG ranking. The rationale of such a strategy can be explained in the major company scandals that could scare investors. It is important for investors to monitor ESG in order to avoid major losses. The Volkswagen "Dieselgate" scandal, when it was discovered that Volkswagen cheated on their emission test results, has resulted in serious stock price decrease (no bankruptcy here). It has also impacted the ESG score, as in the following figure[1][2].



Source: J.P. Morgan Quantitative and Derivatives Strategy; MSCI

Figure 2: Relation between stock price and ESG (Volkswagen case)

Pension funds are mostly using "sin stocks" exclusion (exclusion of product groups like nuclear weapons), but it is not to achieve better performance. As (Hong and Kacperczyk 2009) established, pension funds are more exposed to media coverage and national criticism, which pushes them more to avoid controversial investments.

ESG Integration However, there is a difference between taking away stocks and to tilt towards best companies with highest ESG score. ESG integration consists in taking into account ESG aspects directly into investment decisions, which might tilt an existing portfolio strategy towards better ESG characteristics. It is more adaptive than screening, since it just changes some parameters in a preexisting strategy. The strategies that will be mixed with ESG will be explained in the next section.

[1] Courtesy J.P. Morgan Chase & Co., Copyright 2016
[2] As of 14 December 2016

1.3 Factor Investing

1.3.1 General Concept

One of the key principles in portfolio construction is that diversification brings risk reduction. Diversification can be explained by the fact that if one stock goes down, another one might not. It is more or less effective depending on the correlation between the assets selected, that is why it has been proposed that diversification should be done by investing in varying asset classes. Asset classes are for example stocks, bonds, real estate and currencies. Using this as a way to differentiate assets and diversify is pretty simple. However, even when investors chose thoroughly the assets with respect to their type, the results were not really probing, because some asset classes had the same behavior. That is why research went deeper into asset characterization, thus factors were born. Those describe a certain asset behavior. Andrew Ang describes the parallel between asset class and aliment, factor and nutrient (Ang 2014). If one wants to have a nutritious diet, the nutrients should cover daily recommended intakes, like in salt, sugar, proteins, vitamins. To get a diversified (healthy) portfolio, we must categorize the risks. The goal of factor investing is to get better explained returns from risk premia (financial compensations for risk).

Another advantage of factor investing is well described in (Bender and Wang 2015). It is that it allows to have a rules-based, transparent strategy that is straightforward. On the other hand, it differs from actively managed portfolios, where the stocks are picked and managers are monitoring constantly when there are opportunities in the market.

Pension funds were reluctant to invest in equities because of their volatility. In fact, "[...] high equity volatility since 2000 has been a big turn-off for the $ 35 trillion global pension fund industry ", says Natsuko Wari in the Reuters article (Wari 2013), "not least because huge waves of retirement in many aging western countries are due over the next decade". She highlights a reality that concerns our commissioner, and the number of retirees is not going to decrease soon. Thus, the need for cheap alternatives to bonds is critical because of the low or even negative bond yields. Equity investing has the problem of high portfolio management fees whereas the factor strategy is a way to reduce management fees since it is systematic investing.

1.3.2 Risk premium

To understand the concept of risk premium, let us go back to one essential asset pricing model: Capital Asset Pricing Model (CAPM). It states that the return of an asset is equal to the average risk aversion times the risk. CAPM states that the best way to obtain returns is to have risky assets, that are volatile. That is, the most rewarding ones are the ones that go along with the market. The market is the universe of all the assets, it reflects the world's economy. The relation between an asset's expected returns and the market is explained like this:

$$\mathbb{E}[r_i] - r_f = \frac{COV(r_i, r_m)}{VAR(r_m)}(\mathbb{E}[r_m] - r_f)$$

According to the CAPM, the assets that bring the most diversification, that means have low covariance with the market or negative covariance, are not expected to give good returns because they have no market risk. This theory is the basis for any factor model. To go further into factor theory we will need to define the Beta:

$$\beta_i = \frac{COV(r_i, r_m)}{VAR(r_m)}$$

Beta is a measure of the co-movement between an asset and the market. Under the CAPM model, we can see that a portfolio with a high beta will have high expected returns. One problem of this is the lack of thoroughness in the empirical studies. The "market" portfolio is always subjective, so it is hard to validate any experience. Lots of studies took a benchmark from the main US indices (S&P 500, FT Russell 1000...), and we can question the relevance of that choice.

Moreover, even though if it is approved and used by most academics, the use of beta as a measure of risk has long been contested by investors, as stated in the Globe and Mail article : beta only measures volatility and not risk, the latter being something to avoid: "Volatility is good; risk is the possibility of a permanent loss of capital." (Athanassakos 2017). The article is about defaults of diversifying for the sake of diversifying, without having further thought laid in it, volatility is source of both upsides and downsides. Volatility can be interpreted as the source of risk premium, whereas risk of permanent loss means no long-term benefits. Idiosyncratic risk is what can be related to tail events, which are the events that happen in the tail of the returns' distribution, or low probability events.

1.3.3 Factor theory

Diversification is good to divest from idiosyncratic risk, the one underlined by (Athanassakos 2017). It is common sense that having 100% of holdings in one company is riskier than holding stocks in ten different companies. Nevertheless, it is useless to diversify without having good knowledge of the risk. In fact, diversification has its limits: its benefits diminish with the number of assets. Thus, after 100 stocks in the portfolio, adding one does not reduce risk as much as it did with a 10 stock-portfolio. Pension funds can be interested in factor strategies because it gives good diversification, and it is a systematic investing strategy that is easier to implement than active stock picking. Moreover, there are lower management fees because it is automated. Factor investing is a long-term investment strategy, which is the goal of any pension fund.

Factor theory came as an extension of CAPM, it brought more specific definitions of risk. The problem of CAPM was stated in (Fama and French 2004): "evidence mounts that much of the variation in expected return is unrelated to market beta". As for the market risk in CAPM, any other risk should also be rewarded with risk premium. The goal of "factorizing" is to find the risk bubbles that can represent other risks than market, in order to get better diversification. Factorizing risk allows to have more concentrated asset allocation and if the strategy is well managed, there is a possibility of finding balance in the risk premia/diversification trade-off. To come back to the nutrient analogy of every factor is a nutrient, and assets are aliments, then if someone eats bread, pasta and rice it will not be bringing extra energy than if only eating bread, it is just too much carbohydrates. That is diversification done badly, thus we want to select factors thoroughly. Because of the risk they carry, factor strategies go down when bad events happen. This can discourage many investors, but (Ang 2014) highlights good historical returns for Fama-French strategies.

Another source of arbitrage (excess returns) is market inefficiency. In fact, the CAPM model takes into account the efficient market hypothesis, which means that every investor has complete information about the market, and that the market responds immediately to any new available information. The inefficiency comes from the delay between what happens in the company and investors' decisions, also it comes from the investors not having a perfect knowledge of companies.

In statistics, factor analysis consists of describing a variable with a set of independent variables called factors, chosen solely on theoretical conjectures. In this context, factor analysis in finance consists of explaining an asset's returns with a set of independent risk factors. The goal of having a factor strategy is to have a rules-based allocation, and to have quantitative variables to base our allocation on. Fama and French were the first researchers to bring their factor model to the spotlight, they used the factor model to create a systematic portfolio. The mathematical model from Fama and French will be described in the next section, as it has been acclaimed by the investing community.

As a conclusion and transition, factor theory came from failures of the CAPM, and it is a widely approved source of excess returns. The strong advantage of having factorized risk is that it can be measured simply by accounting characteristics.

1.3.4 Fama-French and Factor investing

Robert Merton and Steven Ross (1983) discovered a way to decompose assets' returns, by noticing some market misconceptions. Then Fama and French (1992) concretized it with a regression model describing the relationship between movements in factor returns and the market returns. Since the market has often less information on small cap companies, it is likely that they are underpriced, and thus are good investments. This gave birth to size factor, or Small Minus Big. The other strategies are all stemming from other market misconceptions. Below, several factors will be described, and we will explain how the factor strategies produce better returns. We will see that constructing a factor strategy is straightforward and can be done in a systematic way, since it consists in ranking assets with certain characteristics and then allocate them in different portfolios.

Size factor (SMB) A size factor strategy buys small market capitalization companies and sells bigger companies. Profit comes from the gap between price of much wanted companies and their real performance, and the neglecting of the small ones. One possibility to get exposure to size factor, is to weight ones portfolio by inverse market capitalization, which will allocate more budget into the smaller companies. Size factor is a behavioral factor, because returns of size strategies rely on investors' bias, as written in (Berger and McCarthy 2016) "Less established companies [are] viewed as less desirable; investors overpay for large issuers".

Value factor (HML) A value factor strategy consists, in the Fama-French model, in going short Low book to market ratio stocks and going long High book to market stocks, the common name for the strategy is High Minus Low (HML). The investors' belief here is that the market capitalization does not truly represent the intrinsic value of a company measured by the value of company's assets. Another way of explaining value returns is mean reverting: stock prices that are under their average tend to go up (Berger and McCarthy 2016). Value is a wide characteristic that has different definitions according to different academics. For example, earnings to price is also usually used instead of Fama-French's book-to-price ratio. The risk premium, if we consider purely rational aspects, is coming from the strong correlation between value stocks. As we said previously, factor strategies are risky, and cannot, or should not be considered only as investor bias. The problem with behavioral theory is that it stumbles upon the long term reality: in fact, if value investing was only taking returns from behavioral biases, investors would on the long term erase the value premium, since attractive stocks would have become expensive again because of high demand.

Momentum factor (WML) Momentum is a factor that is really intuitive: if a stock went up, it will keep going, and if it went down, it will keep falling. The strategy is called past Winners Minus past Losers. To evaluate the momentum of a group of stocks, it is not the individual trend that matters but the cross-sectional current situation. In other words, we will compute performance over a period relative to the other stocks, regardless of absolute individual performance over the long-term. The risk of momentum strategies resides in stocks rebounding, like Bank of America during the 2008 crisis, since they are taken short when they go down. Since momentum is a "positive feedback" strategy (Ang 2014), it outclasses the other factor strategies during growth times.

In the strategies that AP1 fonden is interested in, the factors are not restricted only to these three, but those were selected for more clarity in the equation below. We will also cite two other factors:

Quality factor This factor is an indicator for stability of profits. It relies on accounting characteristics like long-term debt to equity ratio and return on assets. A company with high quality rating should also have low stock price standard deviation. Quality investors are seeking for reduced drawdowns and fairly priced companies.

Low volatility (LV) This factor is straightforward to implement, low volatility strategies hold low volatility stocks. Stocks with high volatility are often overpriced, thus it is reasonable to avoid them to get good risk-adjusted returns.

Factor	Characterization	Higher returns because
Value	High earnings to price	Mean reverting, underpriced stocks
Size	Small market capitalization	Investors neglect small companies, big companies overpriced
Momentum	Cross-sectional past returns	Positive feedback
Quality	Long-term debt to equity	Stable returns, endure bad times
Low volatility	Low volatility	Volatility stocks overpriced

Table 1: Factor descriptions

The factor model explained Fama and French used factor mimicking portfolios to concretize factors and put them in a realizable model. To explain factor mimicking portfolios, (Brightman et al. 2016) will be used, for three factors (size, value, and momentum). This article states the benefits that factor investing can have over stock picking (traditional investing method). We study an index i, with return r_i, and examine its behavior. The result expected is composed of expected returns from factor strategies and the market. The mathematical equation looks like this:

$$\mathbb{E}[r_i] = \alpha + \beta_{market}.\mathbb{E}[r_{market}] + \beta_{SMB}.\mathbb{E}[r_{SMB}] + \beta_{HML}.\mathbb{E}[r_{HML}] + \beta_{WML}.\mathbb{E}[r_{WML}]$$

In this equation the expected returns are decomposed into explanatory variables, which are the market expected returns, and factor portfolio expected returns. Alpha is the unexplained part of returns. We can check how much a factor contributes to returns of a portfolio by estimating the beta, which can be positive or negative. The contribution of a factor is called factor exposure of a strategy. In practice one mostly uses historical returns to estimate a behavior and compute factor exposures.
One problem of the factors is that they are theoretical quantities, we will need to use factor benchmarks as an objective measurement tool for validating our model.

Remark An index is a time series of daily stock values or any daily asset values.

1.3.5 Example of portfolio construction

We have seen how to characterize if one company is corresponding to one factor ("value" company for example). To construct a factor portfolio, it can be by going long companies with high factor characteristics and shorting the ones that are opposed to the factor definition. The strategies are equity-only because it is the most easily traded asset, and most of the literature focuses on it. As said before, the factor mimicking portfolios are arbitrary since factors are theoretical, and can have different definitions. Nevertheless, it is needed to establish a factor model that is usable in reality. There are reference factor portfolios considered as academic benchmarks. Since they are factor replicating indexes, they must be simply constructed with transparent rules. (Brightman et al. 2016) constructed its portfolio in the following way: First, they split the stocks into two market capitalization buckets, large and small cap. Then, in both halves we pick the 30% best stocks in factor score and 30% worst. Then we long the stocks with highest factor characteristics and short the low factor. For example, with value factor the strategy consists in ranking stocks by earnings to price ratio, then buying the high scored stocks in both small and large market capitalization universes, then we go short the companies that have the lowest earnings to price ratio. This is the concrete explanation of how an "academic" portfolio should be constructed.

The choice of factor benchmark will be the closest we can find to academic research, as a matter of fact, there are factor portfolios created specifically aiming to model the Fama-French factors, constructed in a similar way. Those academic portfolios are the most relevant to our research. Regardless of the long-short method chosen by Fama-French, we will concentrate on so called Smart Beta factor implementations since they are of greater relevance for pension funds' community.

Remark: Smart Beta is the denomination of factor strategies that are long-only, it is often used by asset managers.

1.3.6 Factor exposure

If we want to check factor exposure, we need first of all to create a factor portfolio and then we will compute its returns. To make it easier, we will use one factor, that is: value, as an example, because the methodology is the same for each factor.

To measure value exposure, the returns of a selected value strategy are computed. Most commonly, monthly returns are used. To get the value exposure of an index, we do a linear regression of the monthly index returns minus benchmark returns against the value returns. Since Fama-French strategies are long-short, it is leading to market neutrality (beta of 0 against market), hence we are computing active exposures (minus market). The coefficient of the regression is our exposure.

There are some parameters to watch out, as underlines AQR in a subsection of the same smart beta paper (Israel and Ross 2016). They describe how to get factor exposure and what must be confirmation parameters, and enumerate what are the common misbeliefs. Among the common mistakes, some statistical tests are not rigorous enough, others overlooked. For instance, a portfolio can have a value exposure of 0.4, but if the t statistic is insignificant then the exposure figure has no worth.

One motivation that has to be emphasized is the thoroughness of our portfolio construction regarding factor exposure. As (Bender and Wang 2015) state, "Passive managers hired to track a factor index cannot be held accountable if the factor underperforms since their objective is to track the index". Thus, if we want momentum exposure, we will reject solutions that improve the returns of a momentum portfolio, but changes it into value.

We learned that to get good returns, we need to take risk premia. But also to avoid idiosyncratic risk (possibly leading to permanent loss of capital). Can conventional company characteristics suffice to describe the real risk and future behavior? We can take the example of three companies: Bear Stearns, Merrill Lynch and Goldman Sachs. Three of them had top credit ratings (from AA- to A+), good turnover and seemed stable. Nevertheless, two of them crashed 2008 (Bear Stearns went bankrupt and Merrill Lynch got bought by Bank of America), one survived. If we look at their ESG scores, Bear Stearns had a D rating, Merrill Lynch B-, only Goldman Sachs had A-. Thus an ESG approach might have allowed to avoid in the worst case to invest in Bear Stearns, in the best case avoid the two bankrupt companies. This is an example of idiosyncratic risk controlled by ESG, it is interesting to have it as a complement in our factor based portfolio. In the next part, we will verify that ESG reduces risk and we will test if it can enhance risk adjusted returns.

1.4 Connection between ESG and Factor Investing

Since there is a growing interest in responsible investing and factor investing, it is interesting to look for strategies that can combine both. Furthermore, the mixed strategy has to be performing well or at least not much worse than a traditional one, and the companies invested in should have a good environmental and social impact, and be well managed. With that in mind, strategies that adapt factor strategies to ESG integration are to be studied. Two articles are the inspiration for the portfolio construction method employed in the thesis: (Trunow and Linder 2015) and (Bender, Sun, and Wang 2017). We will describe what is the motivation of the authors and how they combine ESG and factor investing.

Calvert strategy Calvert, an American investment firm, has developed an interest for ESG investing. They did a strategy having hybrid factors as weighting (Trunow and Linder 2015), mixing accounting metrics like in traditional factor strategies and ESG company ratings.

Calvert researchers underlined in this paper that there can be subjectivity biases in the different ESG data providers (Reuters, Sustainalytics, MSCI...), so they test the sensitivity to provider choice after the first sample test. Factor strategies are rule-based portfolio strategies, in which position sizes correspond to factor score. The portfolios that (Trunow and Linder 2015) highlight are constructed through three different methods. The first strategy is ESG exclusion, screening away worst-ranked stocks. The second strategy is pure ESG, rule based stock selection. In the context of the thesis, we will be more interested in strategies that integrate ESG into something else, thus we will be focusing on the third strategy. The third strategy integrates ESG in rule-based portfolio construction; it takes self-built factors or less popular ones, and allocates simply by combined ESG-factor score weight.

The factors used by Calvert are different from the ones in the Fama-French factor model. Three portfolios are studied. Each portfolio corresponds to a specific factor. First, the Altman z-score is a factor that is a combination of five financial characteristics, which can evaluate the probability of bankruptcy. Then the second factor strategy is a value strategy, with forward price-to-earnings ratio as factor. The last one is an accruals ratio strategy (which can be translated into quality of earnings). Accruals ratio is the difference between revenue and operating cash flow (profit from money invested in other companies or expenditures for services and products used by the company), divided by operating assets. A company that has more cash is more likely to be stable. All three strategies are integrating ESG by adding ESG Momentum to the criteria for stock selection. ESG Momentum is the trend followed by companies, that is, if a company's ESG rating has been going up or down. The portfolio takes a combination of the factor & ESG scores (by simply adding them), then screens out the bottom quintile based on ESG scores. The scores are done by quintiles, i.e. the companies ranked best are rated 1, the ones in the lowest quintile are rated 5. If a company has an average Altman z-score and a good ESG progression, let's say, a score of 3 in Altman z-score and 2 in ESG momentum, then the hybrid factor score is 2.5. New quintiles are done using the hybrid factor scores. In the Hybrid Factor portfolio with Altman z-score, the top quintile beats the bottom quintile by 2.98% in annual return, and there is also an improvement of the information ratio (similar to Sharpe ratio) of 0.64. Moreover, the difference in returns between top quintile and the market benchmark is 2%. For the second one, the difference between top and bottom quintile returns is 4.50%, and for the third, 4.88%. Since accruals ratio and Altman z-score strategies performed well with ESG momentum, we can assume that ESG can improve a quality factor strategy (speaking of the Fama French factor). Moreover we can foresee a relation between value factor and ESG, given the results from the second strategy.

The strategies are very simple to implement, and successful. Simply adding ESG score to factor score is a good way to get a new rule-based strategy, and it gives promising results. This kind of strategies is an interesting one because it uses hybrid factors, which could be one of the strategies we can use in the thesis. We need to investigate if the summing of ESG and Fama-French factor is relevant considering factor exposure, but we are not interested in Calvert's specific factors because they lack academic resources.

Merging ESG and factors strategy (Bender, Sun and Xing) This article is written by researchers from State Street Global Advisor. A goal of the three authors is to implement academic strategies to prove their advantages, and taking factor strategies up to date, with the responsible investing trend. Three strategies are presented, one will exclude worst-in-class ESG, one will use ESG as an independent factor, and the last uses ESG as a new definition of Quality in a multi-factor approach. The core of the strategies is a factor score maximizing function, with risk reduction. All of the three strategies enter in the category that we described in 1.3, that is, ESG strategies. They can be used to get a responsible investing portfolio. Since ESG screening is not part of our project, we will not focus on the first strategy cited. This paper differs from the previous one in their approach of the portfolio construction. The portfolio is created with a variation of mean-variance optimization, with factor exposure as maximizing parameter.

The idea takes its source from the works of (Grinold and Kahn 2000), who stated that if one uses a vector of stock characteristics as goal function in an optimization problem, the resulting portfolio will be the best representative portfolio of this characteristic (with lowest possible risk). The reason underlined by Bender for choosing an optimization based approach is the aptitude to balance different objectives, like returns and factor score for example. Below is described the portfolio construction method:

First they create a vector of factor scores by company, which gives factor score of each stock of the universe. The universe is the MSCI World stocks, and the MSCI World index is used as benchmark. The MSCI world index is the returns of a market capitalization weighted portfolio, composed of all components of MSCI World. The vector of factor scores will be called F_{factor} for each Smart Beta factor. To clarify, we can say that for a size portfolio, the vector F_{size} is the standardized market capitalization of each company, inverted (for instance, average market cap of the stock universe divided by company market cap). Then the asset allocation is tilted towards smaller companies, while keeping an eye on risk. The strategy is long-only. Bender et al. optimize the following problem:

Objective function	$f'w - \frac{\lambda}{2} w'\Sigma w$ where $f = 0.2 \times F_{value} + 0.2 \times F_{size} + 0.2 \times F_{quality}$ $+0.2 \times F_{momentum} + 0.2 \times F_{lowvol}$
Tracking error constraint	4%
Maximum weight	$w_{i,T} \leq 2\%$ for all positions, long-only portfolio
Active factor exposure	0.5 to 1.0 relative to MSCI World Index
Turnover constraint	25% quarterly turnover

Table 2: Optimization parameters for J.Bender et al.

Where w is the vector of weights, Σ is the correlation matrix of the stocks looking backwards from time of rebalancing, and λ is the risk aversion parameter. To compute active factor exposure, we need to subtract the MSCI World returns to the portfolio returns before running the regression against the factor portfolio returns. The exposure is calculated with State Street Global Advisor's own factor strategies.

The initial Smart Beta strategy that the authors are adopting is a multifactor approach, where they simultaneously maximize the five factor scores, with respect to constraints on tracking error and turnover constraints. The first ESG variation of the strategy we are interested in is one where the quality score is made of three metrics: return on assets, debt to equity ratio, and variance of earnings, plus a fourth one that is ESG score. The second strategy is to add ESG as a sixth factor in the optimization problem:

$$f = (F_{value} + F_{size} + F_{quality} + F_{momentum} + F_{lowvol} + F_{ESG})/6$$

The strategies have a little bit lower returns than the pure 5-factor strategy, but same Sharpe ratio. For active factor exposures, the lowest exposures are to low volatility, momentum and

value. Momentum exposures for pure factor, ESG as subcomponent, and ESG as sixth factor, are 0.51, 0.50 and 0.50 respectively. Low volatility exposures are 0.56, -0.55, 0.53. Value exposures are 0.57, 0.57, 0.53. The size exposure resulting from the three methods is very close to 1. Quality drops from 0.65, in the pure factor portfolio, to 0.64 in the "ESG as a subcomponent of quality" method, and to 0.56 in the last portfolio.

This article gives a good framework that we will follow for the optimization and rebalancing part. Nevertheless, the interest of our thesis is to check single factor exposure and to test stability of those exposures after ESG integration. Having ESG mixed with a factor is a good compromise between having the maximal ESG score and keeping factor exposure. The objective is to dig down each factor separately and to let ESG have a bigger proportion in the stock selection process. Thus we will choose this method to implement in our portfolio, but with simpler optimization problem and no exposure constraints.

The conclusion of this paper is that ESG integration is the best way to obtain good overall ESG score but it is detracting performance. As we will try to prove by experimenting it, having a lot of constraints in the portfolio might undermine portfolio performance.

Jennifer Bender published numerous papers on factor investing. According to her, factor strategies are good long term investing strategies, which need to have patience and to be able to endure underperformance periods. It is in compliance with Första AP-Fonden investment horizon.

The choice of method will depend on the specific needs of asset managers or asset owners. Since there are numerous constraints in state regulated funds, it seems wise to choose an optimization approach in order to take into account the constraints all at the same time. Our choice of method is the optimization method, but a single factor approach instead of multifactor approach, which could prevent us from seeing clear results of the influence of ESG for each factor. Moreover, the weighting scheme used to integrate ESG is not satisfying since it has no priority over factor exposure, thus can not influence factor exposure so much. Hence, we choose Calvert's weighting approach, which takes half ESG-half factor score.

2 Data and methodology

2.1 Data

We are using MSCI data which contains stock information for companies all around the world, since we want to avoid conclusions that could emerge from a small sample effect. The MSCI World data has 3007 unique companies listed .

MSCI also provided us with accounting data. Accounting data gives us all information on company performance and can be used to compute our factor scores. For volume data, the provider was Bloomberg. Volume data gathers the total daily traded amount of stocks, counted in local currency.

ESG data has been exclusively from MSCI since they offer at this day the most extensive database. For relevance purposes, the computations will start in 2007 since it is then that ESG data begins to cover a vast panel of companies. The MSCI ESG data does not include all of the companies of the MSCI World data.

Currency exchange rates are used to convert currencies into USD to compute volume data. Returns are computed in local currency.

The Fama-French academic portfolios are available on internet, as csv files, at this address: `http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`. Return data is daily or monthly. The Fama-French data does not include low volatility strategies.

Parameters

- Period of rebalancing: $T = 3 * 22 = 66$ business days (3 months)
- Total rebalancing periods: $n_{max} = 45$
- Start date: 02 January 2007
- End date: 02 May 2018
- Time span of the portfolio: 2948 business days

2.2 Portfolio

To measure the impact of ESG, we will need to construct first a reference factor portfolio then compare the factor ESG performance to the reference. Thus, we will first talk about pure factor portfolio construction.

2.2.1 Smart Beta factor portfolios

Factor	Characterization
Value	Logit of standardized earnings to price
Size	Logit of standardized inverse market capitalization
Momentum	Logit of standardized trailing 12-month-risk-adjusted return, excluding last month
Quality	Logit of standardized return on equity
Low volatility	1 - Logit of standardized 1 year volatility

Table 3: Factor characteristics

Trailing-12-month designates a characteristic that uses data on a certain backwards window. For example, if the momentum score is taken on March 2nd 2018, the beginning date for returns will be February 24th 2017, end date February 2nd 2017, and we will divide by the volatility on this period.

For each step where there is stock selection, data availability is verified. Thus we will exclude all companies that do not have enough historical accounting data, price data, traded volume data and companies that do not have ESG ratings. The remaining companies at the time of rebalancing constitute the universe for the benchmark and the portfolio.

We will construct a value portfolio with an initial budget B_0 with an arbitrary value of 30 billion SEK. The first allocation will be done this way:
Start with getting earnings to price, by inverting price to earnings ratio. Then standardize by region and sector, in order to make companies within different sectors comparable as well as mitigate issues that may arise from different accounting standards:

$$Z = \frac{x - \mu(region, sector)}{\sigma(region, sector)}$$

With μ the mean over region and sector and σ the standard deviation.
For momentum and low volatility, there is smaller and less significant region and sector bias. Thus, we compute z-scores (not to be confused with Altman z-score) on the whole filtered universe instead of doing it by sector and region:

$$Z = \frac{x - \mu_{all}}{\sigma_{all}}$$

Then the logit function is applied, to get the final factor score F. It allows to put even more weight on the best ranked companies. We also want to avoid negative values in the optimization, for computational simplicity.

$$F = \frac{1}{1 + \exp(-Z)}$$

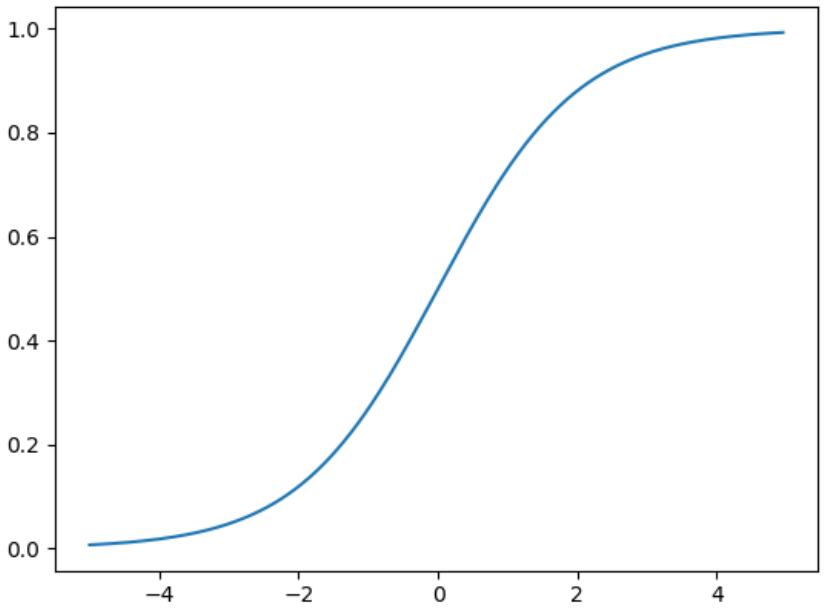


Figure 3: Logit function

We then rank the companies by factor score and take the 50 first ones, equally weighted to get a simple but relevant initial portfolio. The initial allocation is described below:

$$\overline{w}_0 = (w_{0,i}) = 0.2, 1 \leq i \leq 50$$

$$B_0 = B_0 * \sum_{i=1}^{50} w_{0,i}$$

The rebalancing is done using a mean-variance approach, with factor score maximizing function instead of mean. To meet board directives, the tracking error constraint will make up for variance reduction (see table below). We rebalance quarterly.

We begin with filtering companies with available accounting and ESG data. Then we solve the optimization problem on the remaining companies.

Objective function	$F'_{value,T}\overline{w}_T$
Tracking error	$(\overline{w}_T - \overline{w}_{benchmark})^T \Sigma (\overline{w}_T - \overline{w}_{benchmark}) \leq 3\%$ [a]
Maximum weight	$w_{i,T} \leq 2\%$ for all positions
No shorting	$w_{i,T} \geq 0$ for all positions
Yearly turnover constraint	Sum of changes in the portfolio must not exceed 100% of the budget
Traded volume constraint	Change of holdings in a company must not exceed 10% of the monthly volume traded by the company

[a] Since the size strategy is to tilt the portfolio towards lower market capitalization companies, which is the opposite of how the benchmark portfolio is constructed, we loosen the tracking error constraint from 3% to 5% in the size strategy in order to improve the size effect.

Table 4: Optimization parameters

Traded volume constraint: When a company's traded volume is low, that means that brokers will take high fees and it will make stocks harder to sell and to buy. This is done in order for asset buyers not to influence the price of the stocks they are buying themselves.

The benchmark is inspired of MSCI World index, constructed with market cap weighted allocation.

$$w_{i,benchmark} = \frac{MC(USD)_i}{\sum_j MC(USD)_j}$$

MC(USD): Market capitalization of the company

Remark The sum and the indexing are restricted to the filtered universe at the moment of the rebalancing, and not the whole universe of stocks at time T. On average, the benchmark is composed of around 1000 companies. (See Appendix)

The tracking error constraint is a constraint that forces the portfolio to not diverge too much from the benchmark. It is used to replace the risk minimizing term, or in other words to set the risk reference to the benchmark instead of a risk free asset. We estimate the forward tracking error by using historical covariance looking 6 months backwards. However, due to estimation error and instability of the covariance matrix, the realized tracking error goes over 3%. That issue is a very common issue and is encountered by practitioners regularly. In (Bender, Sun, and Wang 2017), they calibrate tracking error ex-post to get exact values of the tracking error, which is not the main subject of our study.

The yearly turnover constraint breaks down in 25% quarterly turnover constraint, it can be calculated this way:

$$\sum_{i=1}^{N} abs(w_{nT,i} - w_{(n-1)T,i}) \leq 0.25 \sum_{i=1}^{N} w_{(n-1)T,i}, \forall n \in [1, n_{max}]$$

Remark 2 To avoid a conflict between size factor weighting and market cap weighting, which is caused by the tracking error constraint for size, we decide to test a loosened tracking error constraint. Having two contradictory objectives could lead to picking random stocks, thus we would draw conclusions on sample effects and not the desired effect. If the size portfolio with 3% tracking error constraint has enough factor exposure nevertheless, the rest of the calculations will only be done with 3% tracking error constraint, else we will put aside the 3% constraint to focus on the loosened constraint.

2.2.2 ESG + factor, ESG only

In the ESG integrated portfolios, the method has been rigorously the same as before, expect for the F-score step. The integration method is inspired by Calvert investments, in the sense that we simply add factor score and ESG score with equal weights:

$$F_{integrated} = (F_{factor} + F_{ESG})/2$$

ESG score is MSCI weighted sum of the three pillars (environmental score, social score, governance score). Since MSCI scores are already sector standardized, the z-score is taken on the whole filtered universe, like for low volatility and momentum. Factor scores that relied on accounting data were strongly dependent on region standards, but in the case of MSCI ESG scores, the rating is done only by MSCI, thus there is no need to standardize by region.

ESG only portfolio is constructed using the same method as for pure factor portfolios, with F_{ESG}-maximizing optimization problem.

3 Results

3.1 Performance and ESG scores

To validate results on the influence of ESG, a portfolio performance of all the strategies with and without ESG is analyzed. Returns, volatility and tracking error are expressed per annum. All ESG scores are the average over the whole sample period. To compute value at risk, we use the historical distribution of daily losses. The level of value at risk is 3% and looks backwards to 1 year. Thus, to compute value at risk we take the 97th percentile of the distribution of historical daily losses over 1 year. Value at risk is expressed as relative value.

Index	Returns	Volatility	Sharpe ratio	Tracking error	VaR	Max drawdown pc	Calmar ratio
benchmark	0.0481867	0.160713	0.292543	0	0.0123398	-51.5506	0.262692
esg only	0.0604762	0.164974	0.330444	0.0361533	0.0117234	-53.8075	0.429868
lowvol	0.0613571	0.143805	0.431731	0.0375383	0.0105375	-45.9872	0.482186
lowvol esg	0.043877	0.151597	0.295007	0.0353209	0.00980421	-52.9567	0.257563
momentum	0.0736323	0.159222	0.419263	0.0395188	0.0135812	-51.4943	0.557952
momentum esg	0.0521953	0.164621	0.303426	0.0342796	0.0127149	-55.9223	0.441144
quality	0.056007	0.157716	0.315103	0.034302	0.0105057	-51.8997	0.243933
quality esg	0.0664445	0.157204	0.382252	0.0354377	0.011311	-50.4404	0.373666
size	0.0664966	0.14633	0.486864	0.0743845	0.00895448	-39.7512	0.627301
size 3%	0.0693943	0.150711	0.430075	0.0505276	0.0105216	-47.8363	0.676692
size esg	0.046621	0.169345	0.335604	0.0691119	0.0112359	-57.3882	0.257899
size esg 3%	0.0637841	0.163347	0.349845	0.0468286	0.0102979	-54.6719	0.277653
value	0.0576776	0.166849	0.350584	0.0385534	0.0112729	-52.0605	0.0929981
value esg	0.0537475	0.165016	0.338283	0.0359542	0.0123365	-57.5969	0.272555

Figure 4: Performance of factor portfolios, ESG and non-ESG

The ESG only portfolio performs average, regarding all the characteristics. It still beats the benchmark, except for volatility and maximal drawdown.

We will take a look at the pure factor strategies, then compare them with the ESG integrated ones. Among the factor strategies, two of them stand out for their poor results, and two of them for their very high returns.
Quality has the lowest Sharpe Ratio, still higher than the benchmark. A low Calmar ratio is also noticeable. Value has similar weaknesses, with a little bit higher Sharpe ratio.
Size and momentum have both very high annual returns (momentum the highest), and Sharpe ratios bigger than 0.4. Nevertheless, only pure size has outstanding characteristics. The favorable aspects of the size portfolio are the low drawdown and low volatility. Without having especially high returns, the low volatility portfolio is also among the best performing portfolios, resulting from the desired characteristic that is a reduced volatility. In fact, the volatility of the LV portfolio is the lowest, leading to a Sharpe ratio that comes second right after size, as well as a high Calmar ratio.

For the tracking error constraint, regarding size, we see that tightening the constraint does not have a drastic influence on financial aspects. The effects of tracking error reduction are smaller when it comes to size combined with ESG. Even though the returns from the size port-

folio with 3% tracking error are higher, the portfolio with loosened tracking error is the one really standing out and beating momentum by far. In fact, the size portfolio with 5% tracking error constraint has a low volatility of 14.6%, the highest Sharpe ratio, and lowest value at risk and maximal drawdown.

From these first results, it appears that ESG does not reduce volatility. In fact, it even increases volatility for all five factor portfolios. This comes naturally from the high volatility of ESG only portfolio.
For quality, the tracking error has been reduced. There is also a significant improvement in returns and Sharpe ratio in the ESG integrated portfolio.
Size and momentum have drastically reduced returns. The lowest maximal drawdown from size becomes the highest for size ESG. Low volatility sees its returns decreased by 1.7%, and volatility increased by 0.7%.

Below is the average ESG scores over time of all the portfolios[3]:

Index	Average E score	Average S score	Average G score	Average ESG score	Returns
benchmark	5.95902	5.11498	5.60778	5.34724	0.0481867
esg only	7.21873	6.68578	6.57027	6.87135	0.0604762
lowvol	5.82834	4.95629	5.66775	5.22507	0.0613571
lowvol esg	6.12679	5.6336	6.17117	5.83764	0.043877
momentum	5.235	4.70652	5.50154	4.85816	0.0736323
momentum esg	6.0787	5.62301	6.10212	5.79686	0.0521953
quality	5.61487	4.86088	5.73194	5.13852	0.056007
quality esg	7.11569	6.41291	6.69326	6.63051	0.0664445
size	4.93991	4.87592	5.45391	4.87689	0.0664966
size 3%	4.95254	4.75347	5.46685	4.8102	0.0693943
size esg	5.86052	5.52705	5.96693	5.63725	0.046621
size esg 3%	5.85213	5.49584	5.97302	5.62373	0.0637841
value	5.09563	4.45374	5.36552	4.71085	0.0576776
value esg	7.07181	6.45208	6.72134	6.70128	0.0537475

Figure 5: ESG scores of factor portfolios, ESG and non-ESG

All factor strategies with ESG integration have a higher ESG score by a point, except for size and low volatility. Quality ESG and value ESG have outstanding high ESG score, with scores higher than 6.6 and higher governance score than in the ESG only portfolio. Size, momentum and value are the only portfolios that have an ESG score under 5. It is noticeable that ESG integration led to an increase of 2 points for the value strategy.

[3]Reproduced by permission of MSCI ESG Research LLC

3.2 Exposure

We will also test if integrating ESG has any effect on deteriorating factor exposure or changing return profile of classical factor strategies. The results are presented under the following format: Exposure(p-value, adj. R^2). Exposures are computed with the help of univariate regressions.

Two new factors are used instead of our "Return on Equity Quality" factor: Conservative Minus Aggressive (CMA) and Robust Minus Weak (RMW). RMW uses the Operating Profitability ratio, it is the revenues minus all expenditures (CAPEX + cost of products sold), divided by the book value. Robust companies have high OP ratio because the expenditures are lower, as opposed to weak companies that invest a lot of capital into operating. Conservative minus aggressive strategy is one where the asset growth characteristic is used, a company that has big changes in its total assets will be shorted, whereas a company that has a lower shift is preferred for this specific quality method. A macroeconomic explanation for CMA (Cooper and Priestley 2011) is that "Aggressive" companies are expanding during a global growth time, and their additional assets are expandable, which means it is flexible to the downward part of the economical cycle. Conservative companies are more risky since they are less flexible, hence the risk premium. The reader must keep in mind that in factor investing, one usually looks for not only good companies, but even for companies "bad" enough that they can be shortened so that the risk premia can be even more attractive. That is why aggressive companies, which by common sense are fast-growing and promising companies, are not in the model. The CMA factor strategy from Fama-French has a really interesting profile in bad times (see Appendix).

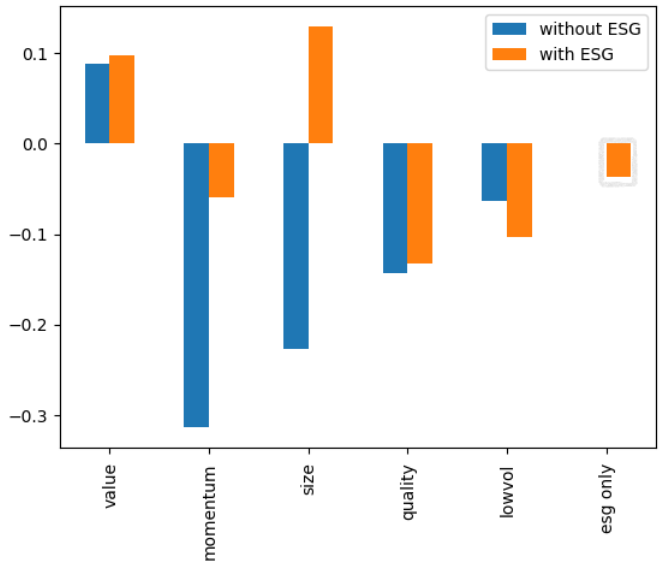
Index	WML	SMB	HML	CMA	RMW	Mkt-RF
benchmark	-0.4916 (0.0,0.1308)	-1.2712 (0.0,0.1523)	0.685 (0.0,0.058)	-1.5986 (0.0,0.1899)	-1.5943 (0.0,0.1418)	0.8958 (0.0,0.9449)
esg only	-0.0298 (0.01,0.0109)	0.0785 (0.0,0.0134)	-0.0365 (0.11,0.0027)	-0.043 (0.15,0.0019)	0.0774 (0.02,0.007)	0.0133 (0.07,0.0037)
lowvol	0.0286 (0.03,0.0063)	0.1088 (0.0,0.0183)	-0.0639 (0.02,0.0075)	0.3358 (0.0,0.1486)	0.3923 (0.0,0.1527)	-0.138 (0.0,0.3975)
lowvol esg	0.0123 (0.24,0.0006)	0.1724 (0.0,0.0775)	-0.1034 (0.0,0.0364)	0.0919 (0.0,0.016)	0.1986 (0.0,0.0606)	-0.0505 (0.0,0.0825)
momentum	0.1552 (0.0,0.2376)	0.1594 (0.0,0.0422)	-0.3128 (0.0,0.2242)	-0.1701 (0.0,0.0376)	0.2556 (0.0,0.0652)	-0.0084 (0.35,-0.000…
momentum esg	0.0277 (0.01,0.0109)	0.1442 (0.0,0.0577)	-0.0592 (0.0,0.0117)	-0.1271 (0.0,0.0347)	0.0063 (0.84,-0.001…	0.039 (0.0,0.0522)
quality	0.0166 (0.11,0.0026)	0.1123 (0.0,0.032)	-0.1432 (0.0,0.0715)	-0.0855 (0.0,0.0137)	0.2154 (0.0,0.0717)	-0.0107 (0.13,0.0021)
quality esg	0.0148 (0.14,0.002)	0.068 (0.0,0.0119)	-0.1325 (0.0,0.0672)	-0.0022 (0.93,-0.001…	0.2594 (0.0,0.1153)	-0.0284 (0.0,0.0276)
size	0.1795 (0.0,0.0979)	0.4253 (0.0,0.0955)	-0.227 (0.0,0.0353)	0.3627 (0.0,0.0539)	0.4193 (0.0,0.0543)	-0.1044 (0.0,0.0707)
size 3%	0.0452 (0.01,0.0114)	0.325 (0.0,0.1155)	-0.067 (0.05,0.005)	0.053 (0.23,0.0008)	0.1689 (0.0,0.0171)	-0.0327 (0.0,0.013)
size esg	-0.0843 (0.0,0.0265)	0.2183 (0.0,0.0311)	0.1295 (0.0,0.0137)	-0.0923 (0.1,0.0029)	-0.0741 (0.25,0.0005)	0.0303 (0.03,0.0061)
size esg 3%	-0.0691 (0.0,0.0477)	0.1711 (0.0,0.0509)	0.136 (0.0,0.0428)	-0.0776 (0.02,0.0068)	-0.1301 (0.0,0.0163)	0.0484 (0.0,0.0504)
value	-0.0305 (0.01,0.0084)	0.1351 (0.0,0.0329)	0.0875 (0.0,0.0177)	-0.0077 (0.82,-0.001…	-0.0195 (0.62,-0.001…	0.027 (0.0,0.0154)
value esg	-0.0786 (0.0,0.0937)	0.0021 (0.93,-0.001…	0.0972 (0.0,0.0322)	-0.0063 (0.82,-0.001…	-0.0228 (0.49,-0.000…	0.0251 (0.0,0.0192)

Figure 6: Exposure of factor portfolios, ESG and non-ESG

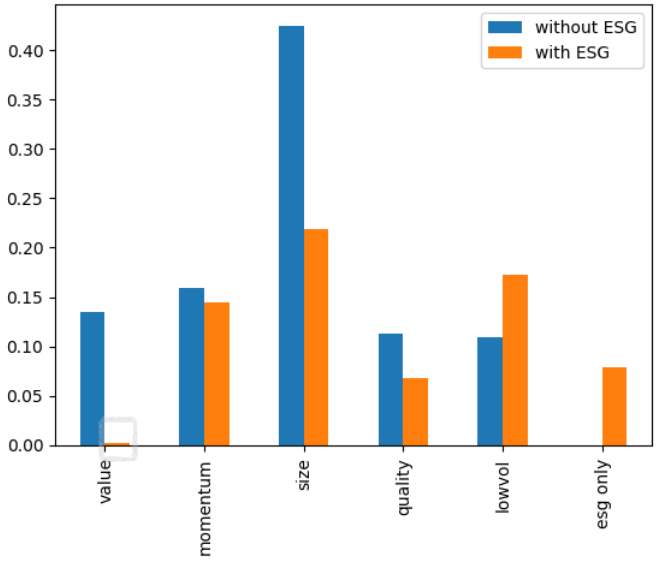
Among the expected results for exposure, we see that pure momentum and pure size portfolios have high exposure to their corresponding Fama-French factors. Since the pure size portfolio has much lower and less significant exposures when constrained to 3% tracking error than the one with 5% tracking error constraint (named simply "size"), we will only focus of the latter (this applies also the size ESG).

Quality has more exposure to RMW than to the CMA quality from Fama-French. Exposure to the market is not significant, with p-value of 0.13.

Below, more graphical displays of all exposures are displayed, to make the influence of ESG on each factor exposure clearer. The blue bars are pure factor portfolios, orange ones are ESG integrated factor portfolios. In light gray rectangles are the exposures with p-values higher than 0.6.



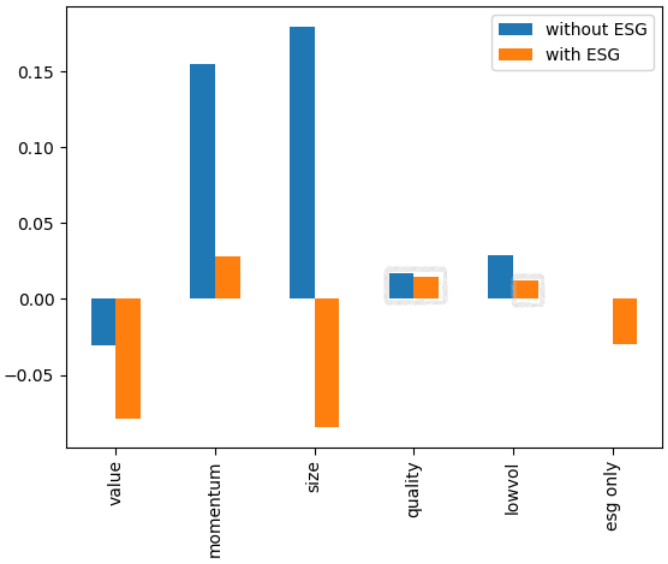
(a) HML



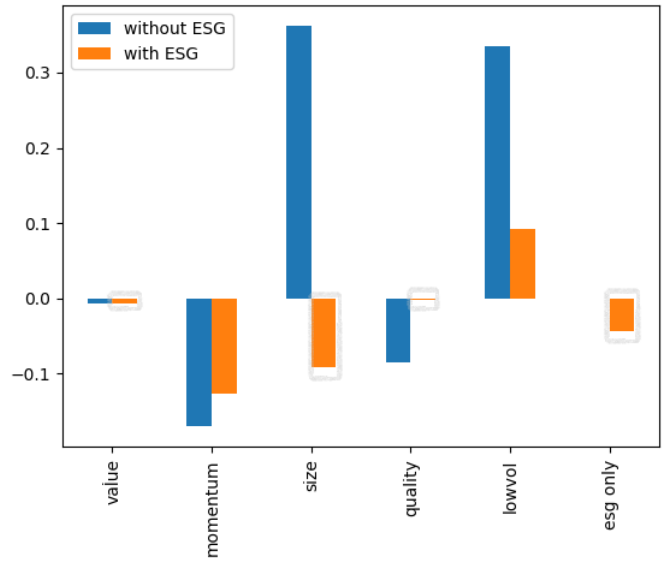
(b) SMB

Figure 7: Exposure of factor portfolios, ESG and non-ESG, to Fama-French HML and SMB factors

We observe that the SMB (size) exposure is diminished by ESG integration for four out of five strategies, even though exposure is still present in the factor ESG portfolios, except value ESG. HML (Fama-French's value) exposure is completely eroded for size and momentum portfolios, going from -31.3% to -5.9% for momentum, from -22.7% to 12.9% for size, both at significant levels. HML exposure is conserved for value, low volatility and quality portfolios.



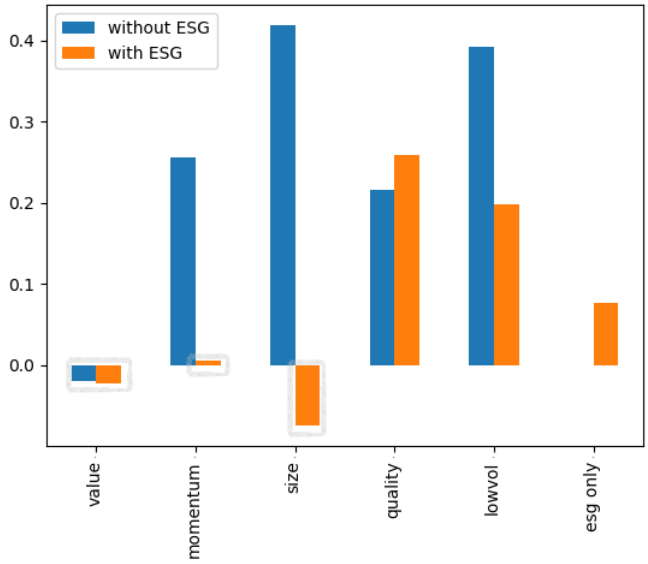
(a) WML



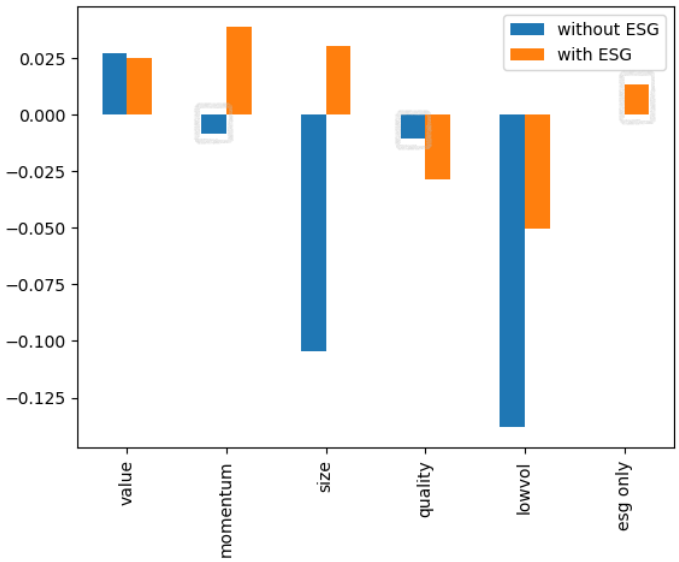
(b) CMA

Figure 8: Exposure of factor portfolios, ESG and non-ESG, to Fama-French WML and CMA factors

We can see again that momentum and size have strong reaction to ESG integration, with drop of more than 10% in exposure to WML factor, which leads for momentum to lose completely WML exposure. For size, a 40% drop in CMA exposure can be noticed. The low volatility portfolio has returns strongly correlated to Fama French CMA strategy, it is the only portfolio that keeps positive CMA exposure after ESG integration.



(a) RMW



(b) Mkt-RF

Figure 9: Exposure of factor portfolios, ESG and non-ESG, to Fama-French RMW factor and the market (Mkt-RF)

Again, size and momentum have their exposures reverted. Low volatility drops exposure to both RMW and the market after ESG integration.

Remark The portfolio exposure are computed on active returns, that is, returns minus returns of the benchmark, since Fama French strategies are long-short and market neutral.

4 Analysis

4.1 Performance and ESG scores

For the low volatility and size strategies, we can assume that high ESG scoring companies had really bad factor scores. Thus the optimization at each rebalancing could have resulted in picking size companies or low volatility companies with low ESG score instead of high ESG with negative factor scores. This is a possible explanation for the low increase in average ESG scores for these two portfolios after ESG integration. The result for low volatility goes along with the results from ESG as a subcomponent of quality from (Bender, Sun, and Wang 2017), where the LV factor exposure did not change a lot.

The governance score is a strong contribution in both ESG score and stability of earnings, hence the positive relation between quality and ESG. Value gets acceptable returns after ESG integration, since it only lowers the Sharpe ratio of 0.02, but the increase in ESG score is promising. On the other hand, the three other factor portfolios lose 2% of annual returns with ESG integration.

Keeping in mind the fact that the ESG integration method is to have 50/50 weight in factor score and ESG score, and the fairly good performance of the pure ESG portfolio, ESG integration should not be detracting performance in the factor strategies with factors positively correlated to ESG. Thus it is safe to assume that momentum and size have a negative correlation with ESG. In the case of low volatility the decrease in returns is smaller, and value at risk is reduced.

The improvement for the quality portfolio can confirm what both Calvert and State Street Global Advisors (Bender, Sun, and Wang 2017) stated, that ESG goes well with the quality factor. Even without filtering the last quintile of companies ranked by ESG rating, the improvement of 2% in annual returns is attractive. Moreover, the significant improvement in ESG score of the portfolio, which brings it almost as high as the ESG only portfolio, is another argument favoring the ESG + Quality strategy.

4.2 Exposure

The first result to highlight is the benchmark exposure to Fama-French market benchmark, which is 89,58% with very high significance. This means that our choice of benchmark goes along with the Fama-French benchmark. The benchmark could have moved even closer to the market if there was no volume constraint. In fact, one can check the benchmark size (see Appendix), which is around 1000 stocks, against more than 5000 for Fama-French.

For our self-made quality portfolio, it is noticeable that the quality characteristic is similar to the Robust Minus Weak construction rule. This can be explained by the fact that return on equity is a ratio that is lower with higher expenditures, like operating profitability. Since (Bender, Sun, and Wang 2017) also use return on equity (return on assets), they have a positive correlation between ESG and their quality factor.

The active exposure of size to the market is strongly negative, as expected, since the benchmark has a market capitalization weighting, as opposed to size portfolios. As opposed to (Bender, Sun, and Wang 2017), we did not put a factor exposure constraint, because the focus was put on ESG, and to highlight the erosion of exposure in the case ESG would affect it. Regarding that, we can note the consequent changes in factor exposure due to ESG integration: size loses its Fama-French SMB exposure, and momentum its WML exposure, when ESG is integrated. This implies a loss of their core characteristic, and proves that ESG does in fact erode factor exposure for size and momentum. If we lose the exposure to those factors, and Calvert did not, it is also because of the single factor approach used. In fact, in all of Calvert strategies the weight of ESG score is considerably low compared to 0.5 in our case (in the ESG as 6th factor approach, it is of a sixth).

Low volatility has strong exposure to Conservative Minus Aggressive factor and Robust Minus Weak, which goes along with its definition. In fact, low volatility is a defensive strategy, and CMA portfolio has short positions in companies that have big changes in total assets, likewise companies that have high expenditures are expected to have volatile returns thus are neither LV nor RMW. Low volatility with ESG has eroded exposure to the factors that could correspond best to strategies seeking for stable returns, CMA and RMW. Moreover, the market exposure have dropped consequently. However, momentum, value, and size exposures have stayed close to their initial value. The exposure to the WML factor was very low and changed to very low and non significant, which is acceptable. For the two other factors, ESG integration amplified the exposures. Even with decreased performance, the goal of our thesis was mainly to check if we could keep factor exposure in the factor strategies. Thus low volatility is suited for ESG integration.

Value has very stable exposure except for Fama-French's size factor, but since size is moving opposite of the benchmark, we can assume that losing size exposure lets the portfolio have less tracking error. Regarding our self-made quality, it also conserves exposures to Fama-French factors. Consequently, ESG integration does affect exposure for the value and quality strategies, but to a level that is well acceptable. The book-to-market ratio is high for companies that have high book value, thus low liabilities or high asset value. As companies with good governance and no environmental issues have to invest less money in fixing their emissions or have less fines due to controversial actions, ESG can be linked to less liabilities. This could be an explanation for the positive relation between value and ESG.

By adding the changes of SMB and WML exposure for value + ESG, and the little changes to quality, we can arrive to the conclusion that ESG integration changes drastically factor exposure, even if the change is little less for positively related strategies. The level of tolerance to factor exposure changes will determine whether or not an investor will want to use this strategy for value and quality.

4.3 Robustness analysis for exposure

We try to make changes in the covariance matrix time horizon ranging from 6 months to 3 years. The covariance matrix has an impact on the tracking error constraint, which is the main parameter that impacts the portfolio behavior. Below are heat maps for exposures, with only exposure levels with p-value bigger than 0.06.

Index	WML	SMB	HML	CMA	RMW	Mkt-RF
esg only	-0.029824	0.0784851	nan	nan	0.0774448	nan
lowvol	0.0286272	0.108784	-0.0638916	0.3358	0.392254	-0.137991
lowvol esg	nan	0.17241	-0.103434	0.0919425	0.198647	-0.0505284
momentum	0.155173	0.159381	-0.312825	-0.170062	0.255624	nan
momentum esg	0.0277053	0.144153	-0.0592392	-0.127115	nan	0.0390272
quality	nan	0.112289	-0.1432	-0.0855039	0.215447	nan
quality esg	nan	0.0680495	-0.132527	nan	0.259424	-0.0283853
size	0.179497	0.42528	-0.226995	0.362692	0.419329	-0.10435
size esg	-0.0744801	0.20394	0.122867	-0.0747679	-0.0961008	0.0370807
value	-0.0304724	0.135111	0.0875438	nan	nan	0.0270012
value esg	-0.0785987	nan	0.0972113	nan	nan	0.0250981
benchmark	-0.491634	-1.27119	0.685026	-1.59858	-1.5943	0.89581

Figure 10: Exposure of portfolios, covariance horizon = 6 months

Index	WML	SMB	HML	CMA	RMW	Mkt-RF
esg only	-0.0510366	0.115642	nan	-0.197375	0.158378	nan
lowvol	0.070119	0.151119	-0.0673051	0.349497	0.365307	-0.126015
lowvol esg	nan	0.144564	-0.101449	0.0859434	0.162242	-0.044218
momentum	0.200678	0.179779	-0.3969	-0.182672	0.362085	-0.0187697
momentum esg	0.0285612	0.154382	-0.0687236	-0.132015	nan	0.035435
quality	0.0225647	0.106433	-0.132966	nan	0.210504	-0.0150397
quality esg	nan	0.0693422	-0.114285	nan	0.247953	-0.0265407
size	0.0702691	0.425008	nan	0.154859	0.273782	-0.0625434
size esg	nan	0.213863	0.107303	-0.176432	nan	0.0270123
value	-0.0586066	0.115175	0.105766	nan	nan	0.033394
value esg	-0.0998948	nan	0.129022	nan	nan	0.027688

Figure 11: Exposure of portfolios, covariance horizon = 2 years

Index	WML	SMB	HML	CMA	RMW	Mkt-RF
esg only	-0.0401476	0.0594978	nan	-0.0652788	nan	0.0269046
lowvol	0.0893378	0.177574	-0.0852369	0.388768	0.382734	-0.136239
lowvol esg	nan	0.156536	-0.116389	0.0923791	0.151231	-0.0413281
momentum	0.205356	0.180188	-0.41733	-0.204785	0.368961	nan
momentum esg	0.0276529	0.114391	-0.0738671	-0.144239	nan	0.0423051
quality	0.0213412	0.0898947	-0.130009	nan	0.229978	-0.0181464
quality esg	0.0185116	0.0677811	-0.120075	nan	0.232133	-0.0196563
size	0.0807401	0.418693	nan	0.196803	0.241803	-0.0577317
size esg	-0.0899648	0.208576	0.152803	-0.0742768	-0.124293	0.0395993
value	-0.0675681	0.101556	0.116905	nan	nan	0.034968
value esg	-0.109585	nan	0.138424	nan	-0.0863159	0.0388059

Figure 12: Exposure of portfolios, covariance horizon = 3 years

Size portfolio is the most affected by changes in the covariance matrix since it is the most bounded by tracking error. A noticeable change is the drop in CMA and RMW exposures after covariance matrix time horizon going up to 2 and 3 years, while exposure was at a high of 36% and 41% before.

Overall, the absolute values can change a bit, but relative values are not that much affected. That is why the heat map remains almost unchanged and it proves the robustness of the method.

4.4 ESG only portfolio

We noticed that ESG reverted or lowered factor exposures a lot for the worst cases, amplified factor exposures in the favorable cases in ESG integration. How is that related to the performance and exposure of the ESG only portfolio? A straightforward explanation could be given if the ESG portfolio had positive exposure to Fama-French's value and quality (RMW) factors, and negative exposure to size and momentum. Then, for most stocks, the equally weighted sum of pure factor score and ESG score would be higher or equal to the pure factor score, in the favorable case, and very low in the unfavorable case. This would be leading to good factor portfolios if ESG was positively linked to the factor, else portfolios with no exposure or exposure to the wrong factors. Nevertheless, the Fama-French factor exposures of the ESG only portfolio are unsatisfying if we want to explain the results from ESG integration only by looking at the ESG only portfolio.

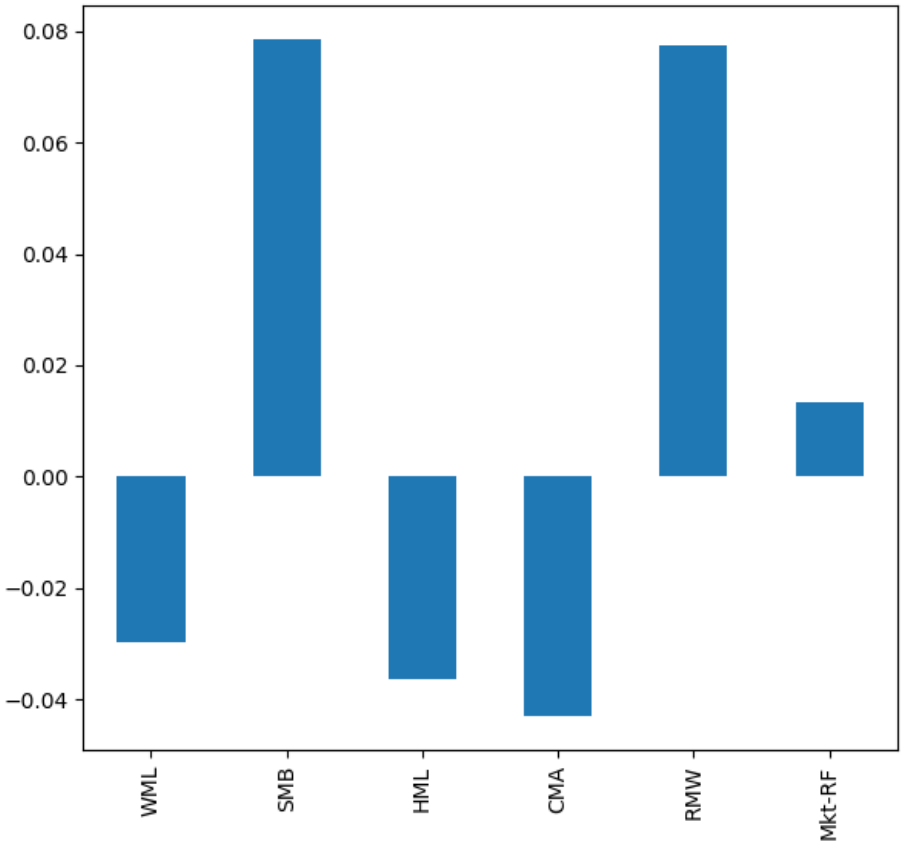


Figure 13: Exposure of esg only portfolio, covariance horizon = 6 months

The exposures to HML and CMA are not significant (p-values of respectively 0.11 and 0.13) so we can not draw a conclusion on how can ESG integration affect value and quality or low volatility strategies just by looking at Fama-French exposure. Otherwise, the exposure to Robust Minus Weak factor is low and positive for the ESG only portfolio, and ESG integration improved our quality portfolio's exposure to RMW. The negative exposure of ESG only portfolio to CMA could explain the detracting of exposure after ESG integration in our portfolios, especially for low volatility, if we have a high tolerance for significance.

Another interesting result is the exposure to our own factors:

Index	Value	Size	Quality	Momentum	Lowvol
esg only	0.0029 (0.94,-0.001…	0.0818 (0.0,0.0289)	0.1422 (0.0,0.0169)	0.08 (0.02,0.0074)	0.1007 (0.0,0.013)
lowvol	-0.079 (0.07,0.0039)	0.1731 (0.0,0.0929)	0.166 (0.0,0.0158)	-0.0012 (0.98,-0.001…	1.0 (0.0,1.0)
lowvol esg	0.0405 (0.24,0.0006)	0.1657 (0.0,0.1347)	0.2945 (0.0,0.085)	0.1774 (0.0,0.047)	0.3523 (0.0,0.194)
momentum	-0.0385 (0.37,-0.000…	0.1162 (0.0,0.0418)	0.3406 (0.0,0.0735)	1.0 (0.0,1.0)	-0.0012 (0.98,-0.001…
momentum esg	0.1279 (0.0,0.023)	0.1018 (0.0,0.0535)	0.257 (0.0,0.0691)	0.3664 (0.0,0.2207)	-0.1168 (0.0,0.0214)
quality	0.137 (0.0,0.0248)	0.0931 (0.0,0.0415)	1.0 (0.0,1.0)	0.2204 (0.0,0.0735)	0.1052 (0.0,0.0158)
quality esg	-0.0277 (0.4,-0.0005)	0.1119 (0.0,0.0668)	0.4904 (0.0,0.263)	0.1611 (0.0,0.0425)	0.2242 (0.0,0.0856)
size	0.3774 (0.0,0.0388)	1.0 (0.0,1.0)	0.4627 (0.0,0.0415)	0.3736 (0.0,0.0418)	0.5457 (0.0,0.0929)
size esg	0.2455 (0.0,0.0203)	0.1608 (0.0,0.0315)	0.1474 (0.07,0.0039)	0.0383 (0.56,-0.001…	-0.0708 (0.27,0.0003)
value	1.0 (0.0,1.0)	0.1071 (0.0,0.0388)	0.1933 (0.0,0.0248)	-0.0352 (0.37,-0.000…	-0.0706 (0.07,0.0039)
value esg	0.2732 (0.0,0.1043)	0.0492 (0.01,0.0104)	0.1164 (0.0,0.0119)	-0.1342 (0.0,0.0263)	0.0378 (0.25,0.0006)

Figure 14: Exposure of the factor portfolios to the self-created factor strategies

The ESG only portfolio has exposure to all factors except value, and highest exposure to low volatility. It is thus not obvious that ESG having exposure to our strategies would help ESG integration, since the exposures of our own strategies to our own factors change a lot. We can see that all ESG adapted strategies have strong exposure to the factor they are supposed to have exposure to, except size. For quality and momentum portfolios, exposure to value is reverted when portfolios have ESG integration, leading to differences in exposure of 16%, for quality, and for momentum we get an exposure of 12.8% with significance whilst it had no significant exposure before. Exposures to momentum also undergo big changes after ESG integration, for all strategies except quality.

Additionally, we can observe the previous conclusions we reached about size. Since they are among the portfolios that have the most shifts in exposure after ESG integration (four out of five factor exposures drop by at least 30% for size), we can confirm that this factor is not compatible with ESG integration. However, quality has exceptional stability to ESG integration, especially quality ESG has conserved 49% of quality exposure, and exposure to two of four other factors stays stable (change of 2% size exposure, 6% momentum exposure). Value, momentum and low volatility are only relatively stable. Three out of five factor exposures are conserved for these portfolios after ESG integration.

5 Conclusion

In this report, we have investigated the influence of ESG in factor strategies. The following questions were asked: Does ESG enhance returns or reduce risk when integrated to factor strategies? How does ESG affect factor exposure when integrated to Smart Beta strategies? The answers brought by the thesis differ depending on the factor strategy.

As in the articles cited in the Theory part, it has been confirmed that ESG integrated to quality improved its returns. With tracking error constraints and a market cap based benchmark, the ESG + factor portfolios tend to have higher volatility. Value and low volatility are stable and the strategies with ESG integrated show similar results than pure factor strategies, with a notable decrease in returns for low volatility. Size and momentum strategies were deeply modified when associated with ESG. Factor exposure was completely reversed for the two factor strategies. In fact, the correlation between academic portfolio returns and our momentum or size portfolio sometimes went from positive to negative.

In the ESG weighting in the portfolio construction, our method is similar to Calvert's. The ESG score has a consequent weight in the optimization problem. The framework for optimization from (Bender, Sun, and Wang 2017) guided the main lines of our tests for ESG portfolios. Given that the constraints were less restraining than (Bender, Sun, and Wang 2017), changes in ESG scores and factor exposures were tremendous after ESG integration.

An asset manager, or asset owner, is thus encouraged to use ESG as a way to improve quality strategies returns. Having a good ESG rated portfolio is a proof of a certain non-financial interest, thus can increase trust from values-driven investors. Given factor exposure considerations, ESG score requirements, or tolerance to financial performance reduction, an investor will or will not choose to implement value ESG and low volatility ESG portfolios that we built for this thesis. ESG considerations put aside, the pure momentum and pure size strategies have high returns for a reasonable level of volatility, thus are interesting systematic strategies to implement. The returns over time can be seen in the appendix.

To give a concise answer to our two questions, our conclusion is that ESG increases risk when integrated to factor strategies, but decreases returns for momentum, size and low volatility. ESG erodes exposure to Fama French factors a lot.

The constructed portfolios are on the whole universe of stocks, and we experimented the same construction method for the universe excluding USA, which gives the results that can be seen in the last part of the appendix.

6 Further development

6.1 Weighting of ESG and factor scores

The results proved that a 50/50 weighting for ESG and factor score dramatically modified the portfolio optimization. Since there is a strong interest in having high ESG rated companies in the portfolio, it seems reasonable. However, for momentum or size, if one wants to keep exposures to his/her factor after integrating ESG, the 50/50 weighting is unadapted. A 80% factor score weight might be more adapted for a more factor-oriented portfolio, for example.

6.2 The current situation of factor strategies

Historically, value strategies have been very popular among investors, but returns of value portfolios have been less and less impressive approaching the 21st century. Having that in mind, it is with precaution that momentum and size factors have to be studied, since it could still be a temporary effect. As for value, for which investors have expectations to rebound, it can also be the opposite happening to size and momentum, that could run out of steam. In fact, one can easily imagine that profitable investment strategies become more and more popular, thus increasing the price of the specific assets that have good factor scores, and dampening the size and momentum effects.

6.3 Regulations

In this thesis, the results depend strongly on constraints, especially tracking error. One can try to construct portfolios with same optimization problems without tracking error, but then it would be unrealistic to believe it would be accepted by institutional investors. When it comes to ESG, nowadays exclusion of stocks is the most common framework for many pension funds, depending on the country's law. This could also be implemented in future strategies.

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Appendix

Size of filtered universe

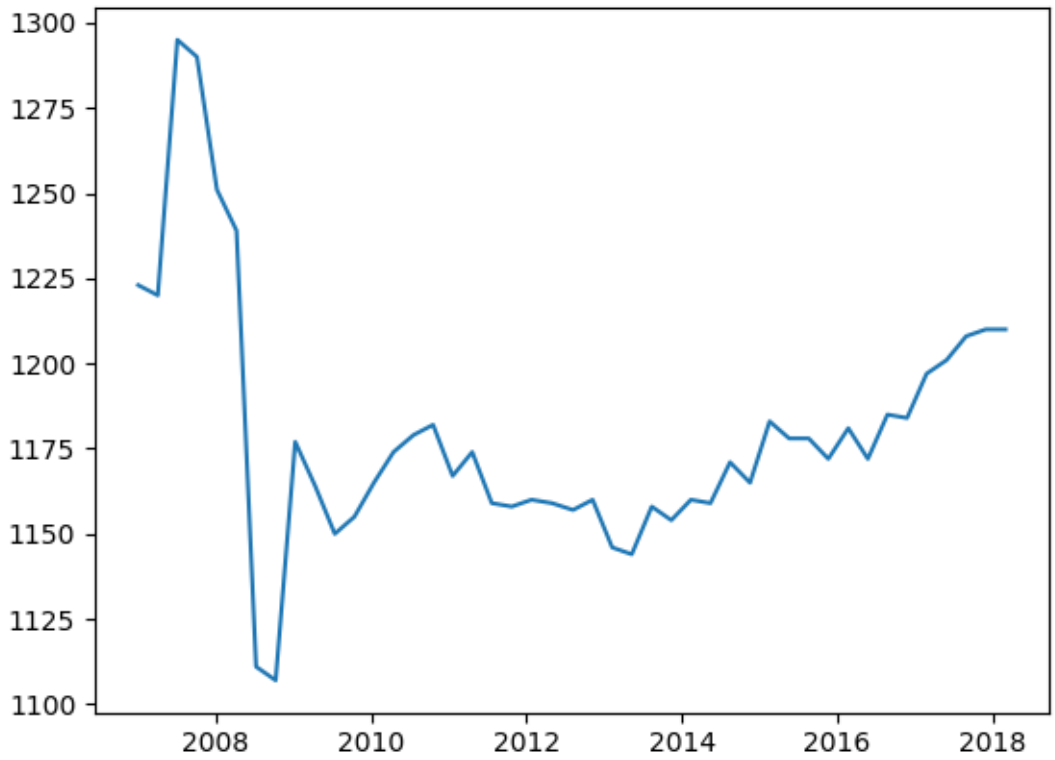

Figure 15: Number of stocks in the benchmark at each rebalancing

Comparisons over time

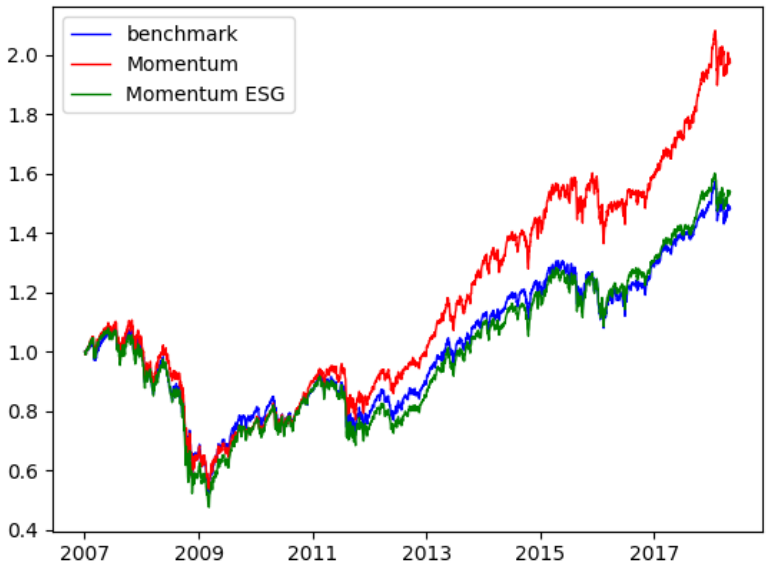

Figure 16: Cumulated returns of momentum portfolios, with benchmark as reference

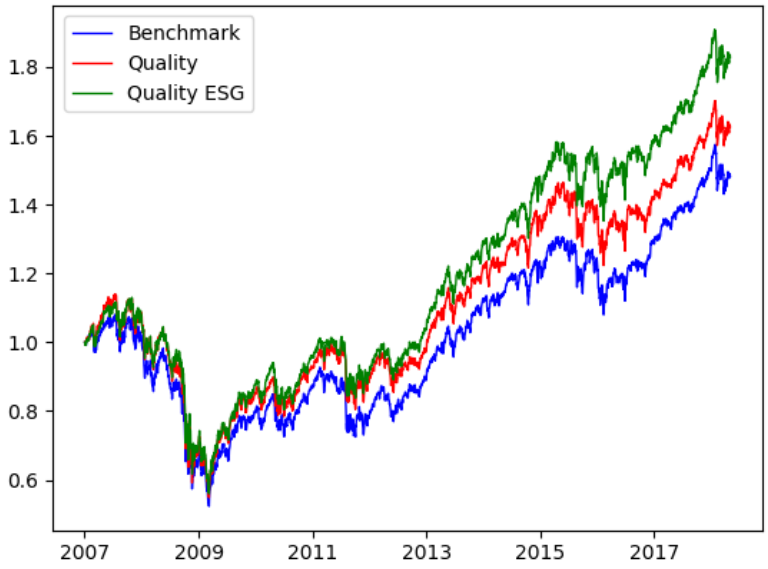

Figure 17: Cumulated returns of quality portfolios, with benchmark as reference

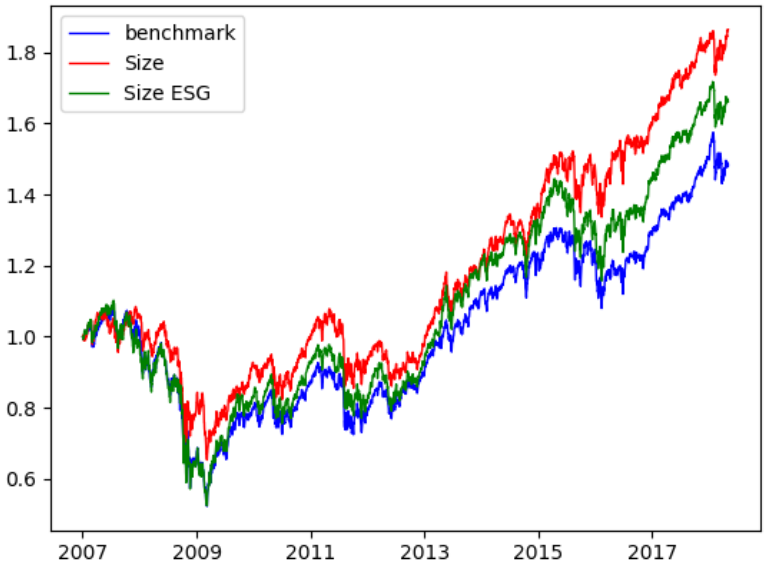

Figure 18: Cumulated returns of size portfolios, with benchmark as reference

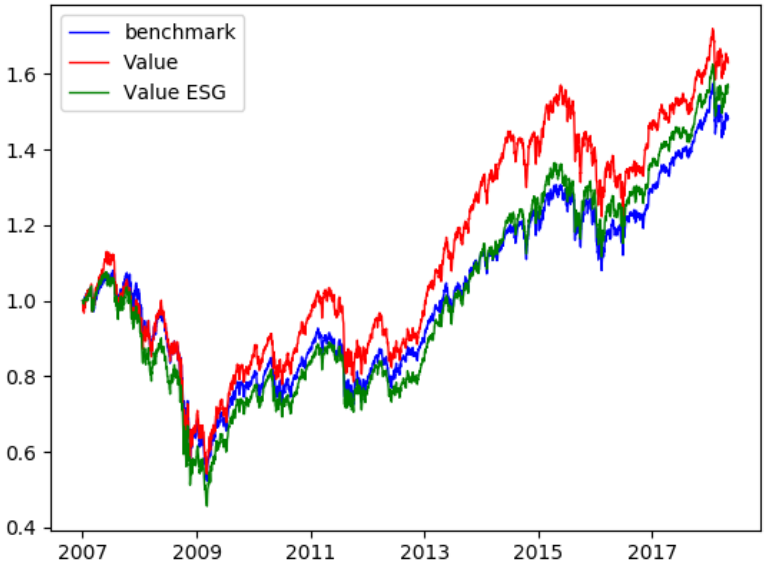

Figure 19: Cumulated returns of value portfolios, with benchmark as reference

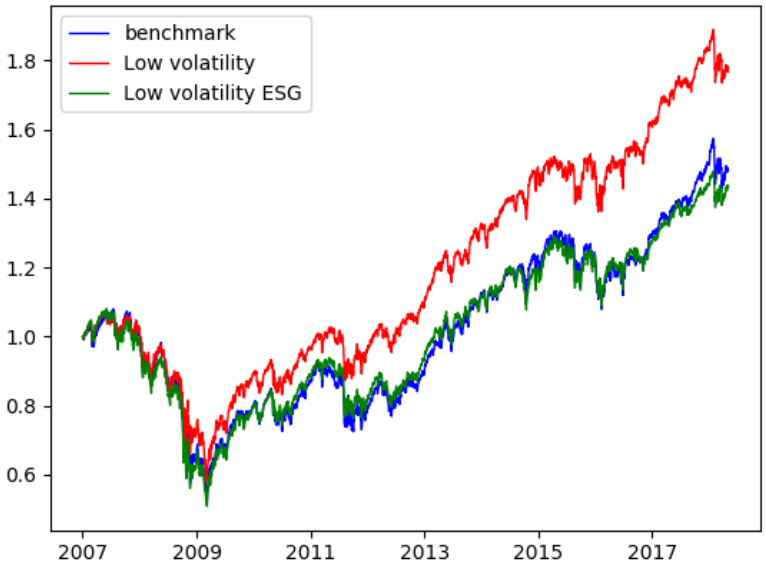

Figure 20: Cumulated returns of low volatility portfolios, with benchmark as reference

Figure 21: 5 best performing portfolio returns, with benchmark as reference

Fama French CMA strategy : a strange factor strategy

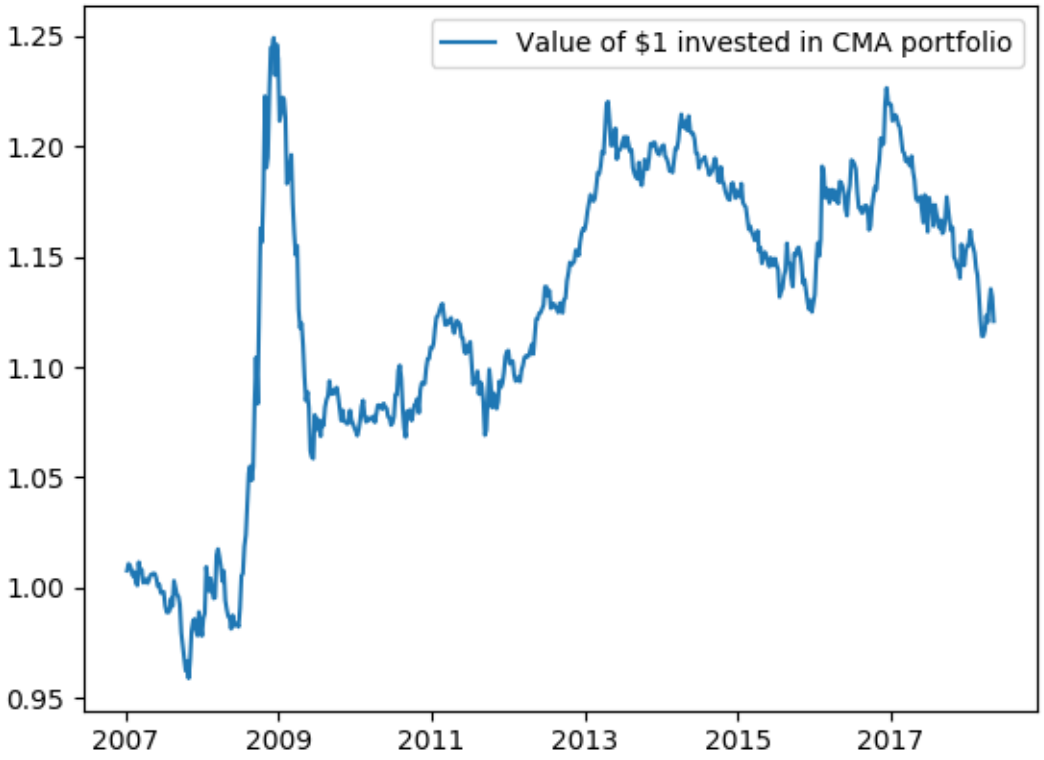

Figure 22: CMA strategy returns

The principle of a factor strategy, as underlined by (Bender and Wang 2015), is that when an investor endures bad times, it should be rewarded in the long term by a risk premium. In this case, the strategy has low returns under stabilizing periods, and very high returns in crises. It is interesting to see such a profile, since it very different from all other factor strategies.

Results ex-USA

Size of filtered universe

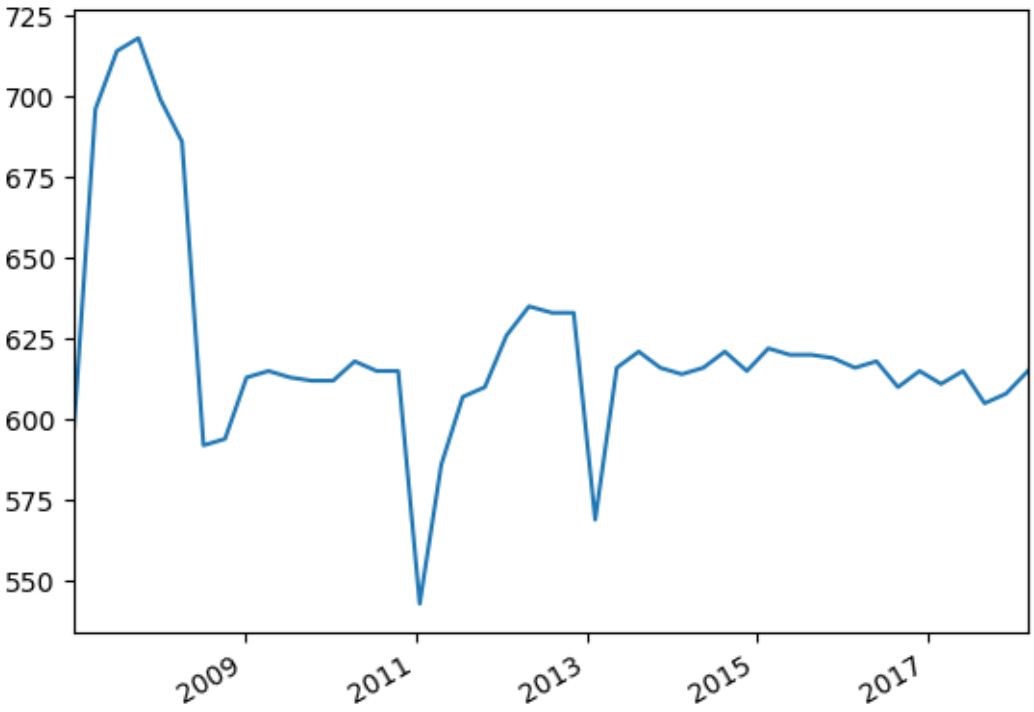

Figure 23: Number of stocks in the benchmark at each rebalancing, with USA stocks excluded

Comparisons over time

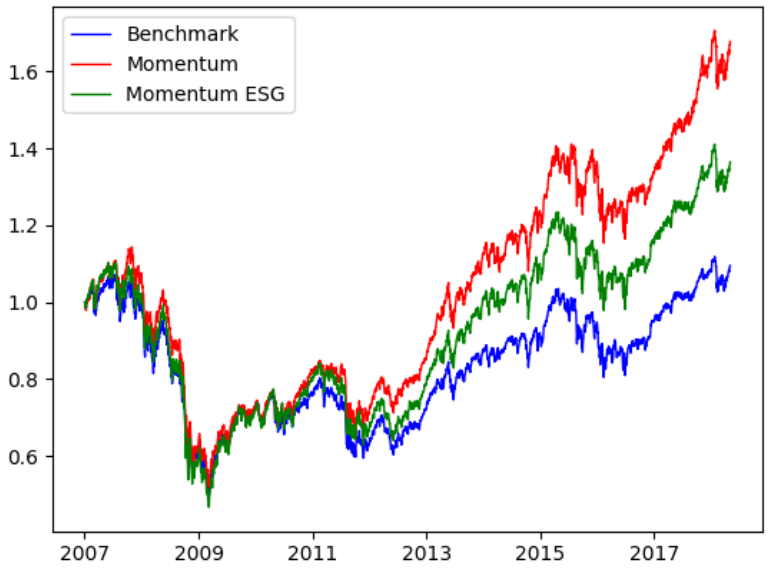

Figure 24: Cumulated returns of momentum portfolios ex USA, with benchmark as reference

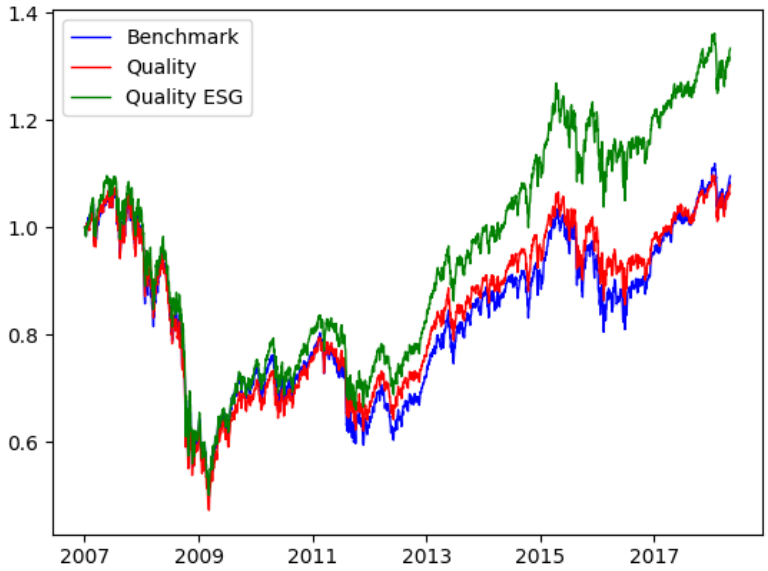

Figure 25: Cumulated returns of quality portfolios ex USA, with benchmark as reference

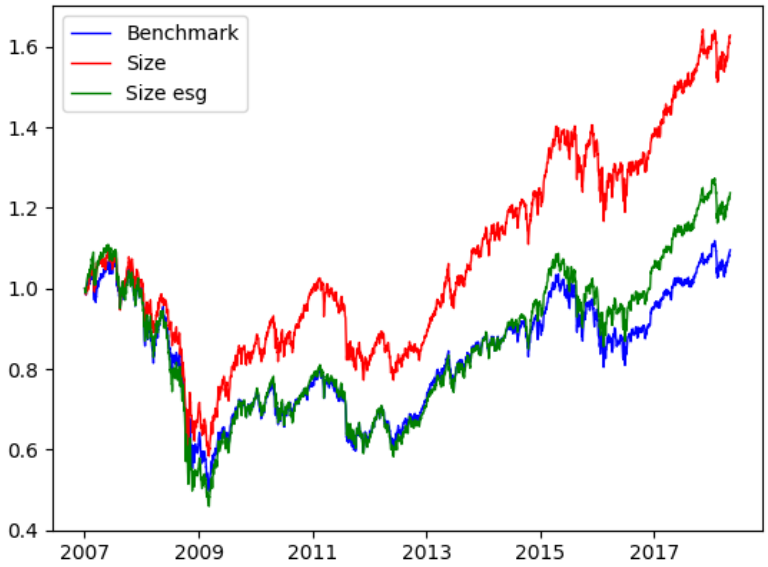

Figure 26: Cumulated returns of size portfolios ex USA, with benchmark as reference

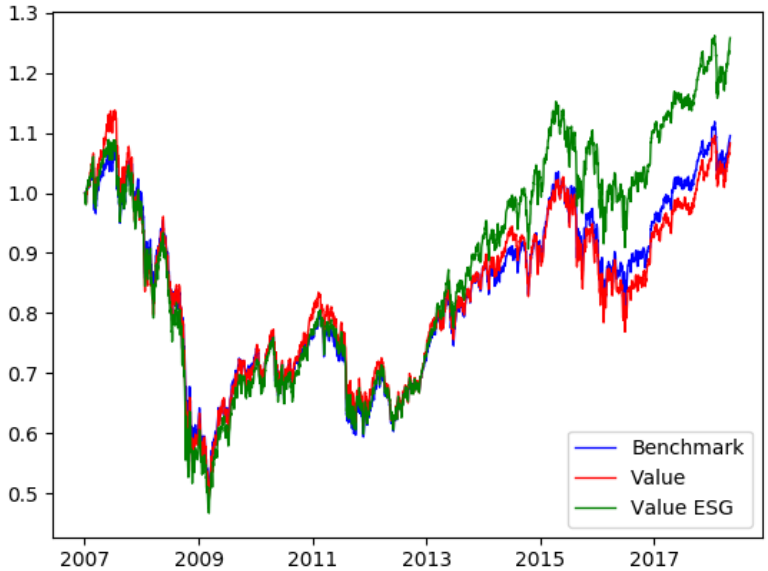

Figure 27: Cumulated returns of value portfolios ex USA, with benchmark as reference

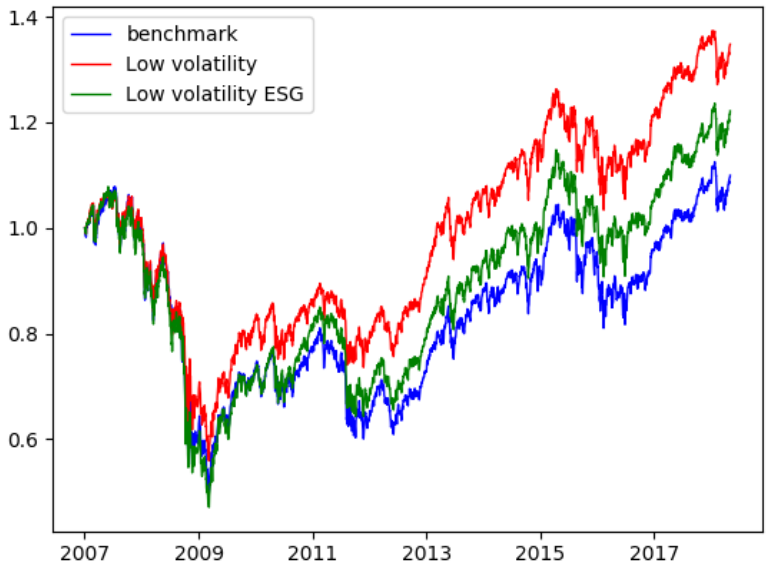

Figure 28: Cumulated returns of low volatility portfolios ex USA, with benchmark as reference

Index	Returns	Volatility	Sharpe Ratio	Tracking Error	VaR	Max drawdown pct	Calmar Ratio
benchmark	0.0215887	0.163731	0.137861	0	2.80364e+08	-53.672	0.0984667
esg only	0.0407852	0.166264	0.221662	0.0479059	3.17078e+08	-54.9517	0.287503
lowvol	0.0376112	0.147268	0.249084	0.0355796	2.24647e+08	-47.7755	0.136855
lowvol esg	0.0309206	0.160946	0.201739	0.0359288	3.51409e+08	-56.3371	0.131442
momentum	0.0592824	0.160329	0.312673	0.0379244	3.21381e+08	-54.6436	0.374969
momentum esg	0.0421581	0.168792	0.240302	0.0377941	3.09397e+08	-57.6911	0.189459
quality	0.0189515	0.15616	0.133488	0.0380108	2.80902e+08	-55.9571	0.0479799
quality esg	0.0388247	0.161551	0.230059	0.0349891	2.86749e+08	-54.3294	0.135699
size	0.054796	0.14901	0.339562	0.0649018	3.12887e+08	-47.0444	0.327823
size esg	0.0330358	0.166881	0.208565	0.0430255	2.91794e+08	-58.5822	0.233634
value	0.0212412	0.167836	0.145961	0.0339381	3.00284e+08	-56.6711	0.0908284
value esg	0.0352048	0.170881	0.221997	0.0302705	3.13759e+08	-57.1109	0.166768

Figure 29: Performance of portfolios ex-USA

Index	Average E score	Average S score	Average G score	Average ESG score	Returns
benchmark	6.11259	5.44018	5.84047	5.62264	0.0215887
esg only	7.11446	6.58817	6.65759	6.77566	0.0407852
lowvol	5.9775	5.35739	5.92206	5.54193	0.0376112
lowvol esg	6.16112	5.719	6.22827	5.89409	0.0309206
momentum	5.52377	5.03319	5.62728	5.18118	0.0592824
momentum esg	6.15466	5.7063	6.15946	5.86926	0.0421581
quality	5.69475	5.16791	5.97565	5.37071	0.0189515
quality esg	7.03069	6.49163	6.82175	6.6683	0.0388247
size	4.91413	4.91896	5.41134	4.89654	0.054796
size esg	6.07424	5.7184	6.09883	5.83766	0.0330358
value	5.26001	4.94967	5.52155	5.06998	0.0212412
value esg	6.97454	6.43338	6.70478	6.63712	0.0352048

Figure 30: ESG scores of portfolios ex-USA

Index	WML	SMB	HML	CMA	RMW	Mkt-RF
benchmark	-0.4787 (-9.02,0.119…	-1.1195 (-8.76,0.113…	0.7301 (6.43,0.0637)	-1.6462 (-11.99,0.19…	-1.4889 (-9.0,0.119)	0.8768 (63.62,0.872…
esg only	-0.0128 (-1.27,0.001)	-0.0133 (-0.55,-0.00…	-0.0283 (-1.35,0.001…	-0.0595 (-2.19,0.006…	0.0584 (1.86,0.0041)	0.0213 (3.13,0.0146)
lowvol	0.014 (1.18,0.0007)	0.0228 (0.8,-0.0006)	-0.0891 (-3.66,0.020…	0.2236 (7.28,0.0806)	0.304 (8.74,0.1129)	-0.1107 (-16.55,0.31…
lowvol esg	-0.0338 (-3.38,0.017…	0.0582 (2.41,0.0081)	-0.0196 (-0.94,-0.00…	0.0288 (1.05,0.0002)	0.0294 (0.93,-0.000…	-0.0089 (-1.3,0.0012)
momentum	0.1215 (10.95,0.167…	0.1418 (4.96,0.0383)	-0.2658 (-11.68,0.18…	-0.1494 (-4.62,0.033…	0.1704 (4.57,0.0325)	-0.0028 (-0.34,-0.00…
momentum esg	-0.0341 (-3.15,0.014…	0.0642 (2.46,0.0085)	0.0729 (3.25,0.0159)	-0.0942 (-3.22,0.015…	-0.1019 (-3.02,0.013…	0.0408 (5.63,0.0494)
quality	0.0086 (0.81,-0.000…	0.0978 (3.86,0.0229)	-0.1054 (-4.84,0.036…	-0.0077 (-0.27,-0.00…	0.162 (4.96,0.0384)	-0.0406 (-5.72,0.050…
quality esg	0.022 (2.18,0.0063)	0.063 (2.62,0.0098)	-0.1273 (-6.27,0.060…	0.0105 (0.38,-0.001…	0.2058 (6.78,0.0707)	-0.0327 (-4.84,0.036…
size	0.0972 (5.19,0.042)	0.3803 (8.8,0.1144)	-0.1786 (-4.57,0.032…	0.1481 (2.88,0.0122)	0.3007 (5.15,0.0413)	-0.0802 (-6.35,0.062…
size esg	-0.0969 (-8.19,0.100…	0.1309 (4.44,0.0307)	0.1039 (4.06,0.0256)	-0.1385 (-4.16,0.026…	-0.1495 (-3.89,0.023…	0.0402 (4.82,0.0362)
value	-0.0507 (-4.73,0.034…	0.0958 (3.7,0.021)	0.1086 (4.89,0.0373)	-0.0065 (-0.22,-0.00…	-0.0693 (-2.05,0.005…	0.0276 (3.76,0.0217)
value esg	-0.0399 (-4.11,0.026…	-0.0006 (-0.02,-0.00…	0.0606 (2.99,0.0132)	0.0525 (1.98,0.0049)	-0.0495 (-1.62,0.002…	0.0275 (4.15,0.0267)

Figure 31: Factor exposures to Fama French factors, portfolios ex-USA

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