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Optimal Strategies for ESG Portfolios

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Abstract

In a previous paper (Alessandrini and Jondeau, 2020), we demonstrate that in the last decade, investing according to screening based on environmental, social, and governance (ESG) criteria would have allowed investors to considerably improve the ESG quality of their portfolio without deteriorating its financial performance. However, a drawback of such a screening process is that it possibly generates undesirable regional, sectoral, and risk factor exposures. In this paper, we propose an investment strategy that maximizes the ESG quality of the portfolio while maintaining regional, sectoral, and risk factor exposures within stated limits. We provide evidence that such a portfolio would have produced a risk-adjusted performance at least as high as the standard MSCI benchmark for a wide range of ESG criteria and regions over the 2007–2018 investment period.

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1 Introduction

Socially responsible investing (SRI) has long been perceived as a costly investment style. Indeed, this practice was essentially based on the exclusion of some industries that do not satisfy some social or environmental norms. Empirically, those industries that were screened out tended to perform better over time. Fabozzi et al. (2008), Hong and Kacperczyk (2009), and Luo and Balvers (2017) provide empirical evidence that so-called "sin stocks" (typically, firms from the alcohol, tobacco, gambling, and weapons industries) have enjoyed historically superior performance. At the firm level, the evidence is mixed. Some studies find that firms with stronger shareholder rights (Gompers et al., 2003) or firms with high employee satisfaction (Edmans, 2011) generate higher firm value.[1]

In the more recent period, new data have been made available to evaluate the nonfinancial performance of firms in terms of environmental, social, and governance (ESG) criteria. Strategies based on these criteria seem more valuable. Alessandrini and Jondeau (2020) find that in the 2007–2018 period, applying an ESG screening to an otherwise passive portfolio improves the portfolio ESG scores and yields unchanged or improved Sharpe ratios.[2] One possible explanation for this result is that the trend in favor of SRI leads to higher demand for high-scoring firms and a lower demand for low-scoring firms. In turn, this implies that improved performance might be due to a higher valuation being attached to companies with high ESG quality. Another complementary explanation is that the screening process exposes investors to some particular sources of risks. Alessandrini and Jondeau (2020) report that ESG screening leads to substantial regional tilts (in a multicountry portfolio) and to large sectoral tilts. In addition, ESG screening magnifies some exposures to conventional risk factors relative to standard benchmark portfolios. For instance, exposure to the size factor

[1] Gompers et al. (2003) consider a governance index that proxies for the level of shareholder rights and find that firms with stronger shareholder rights generate higher firm value. Edmans (2011) finds that firms with high employee satisfaction enjoy higher stock returns, by focusing on the 100 best companies to work for in America. In a recent analysis based on the findings of approximately 2,200 individual studies, Friede et al. (2015) find that roughly 90% of these studies obtain a nonnegative relation between the ESG criterion and corporate financial performance.

[2] In contrast, some recent studies find that ESG screening does not provide superior risk-adjusted performance. For instance, Auer and Schuhmacher (2016) report that portfolios containing the 5% best performing stocks according to a targeted ESG criterion do not generate a statistically significant gain in Sharpe ratio. In most cases, our main results do not contradict this evidence, as we only establish that the optimal portfolios are able to substantially increase ESG quality without deteriorating risk-adjusted performance.

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is often reduced, as larger firms usually benefit from higher ESG scores. ESG portfolios also lean toward more expensive stocks, therefore lowering exposure to the value factor.

Investors may be reluctant to adopt an ESG strategy if this strategy increases the exposure of their portfolio to all these (possibly undesirable) sources of risk. An important question is therefore whether one can build a portfolio with a higher ESG quality than the benchmark, with risk-adjusted performance that is at least as good as that of the benchmark and with bounded regional, sectoral, and risk factor exposures. Another way to approach this problem is to ask whether the improvement in the ESG profile is a consequence of the risk exposures, which would imply that improving ESG quality cannot be done without taking additional risks.

These are the questions we address in this paper. First, we precisely define the objective function of the investor. The investor maximizes the ESG score of the portfolio, while controlling for several important concerns: the portfolio weights should be close to those of the benchmark (low tracking error); the turnover should be as low as possible (low transaction costs); and the exposure to regional, sectoral, and risk factors should remain within certain limits. Then, we provide compelling empirical evidence that this optimization process results in portfolios with high ESG quality, high risk-adjusted performance, and bounded risk exposures.

This optimization process makes it possible to go one step further in terms of methodology with respect to simple screening. Most likely due to their simplicity, screening procedures, in the form of either negative exclusion or best-in-class approaches, are widely used in practice. In addition to introducing undesirable risk exposures, as highlighted by Alessandrini and Jondeau (2020), Blitz and Swinkels (2020) elaborate on several drawbacks and the lack of effectiveness of this approach. They conclude that engagement is a more relevant and effective way to deal with the ESG profile of a portfolio. Engagement, however, is costly and requires potentially significant resources to analyze each company. This becomes especially relevant for institutional investors holding large portfolios covering global markets. Another important drawback of the screening process is that it reduces the available universe and does not make full use of all the components and information available to produce an efficient portfolio. The framework presented in this article allows us to incorporate all the information

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in both the ESG scores and risk attributes of the companies to reach the optimal portfolio. It is therefore in the camp of what is often referred to as integration (Hayat and Orsagh, 2015) in the field of ESG investing.

Our analysis is based on MSCI ESG data for the scores and MSCI benchmark data for the investment universe. We use the same sample period (2007–2018) as in Alessandrini and Jondeau (2020). Worldwide, the sample of firms with an ESG score starts with more than 1,700 firms at the beginning of the period and covers approximately 7,000 firms at the end of the period. Every stock in the sample receives scores on the environmental (E), social (S), and corporate governance (G) criteria. Scores are available on a monthly basis, which is particularly relevant from the perspective of building dynamic portfolios. We demonstrate that our approach can be implemented and provides very good performance: The strategy substantially increases the targeted ESG score without deteriorating financial performance and keeps transaction costs, tracking error, and regional, sectoral, and risk factor exposures within stated limits. We apply the approach to a wide range of ESG criteria and regions and provide evidence that the optimized portfolio fulfills the various objectives.

Pedersen et al. (2019) provide a rationale for why the relation between scores and financial performance of firms may be positive or negative, even when a high score predicts higher future profits. On the one hand, the ESG score provides information about the firm's fundamental value. On the other hand, some investors may have a preference for the ESG quality of their portfolio. If the market is driven by investors only using the ESG score as an indicator of high future performance, high-ESG stocks should deliver high expected returns. In contrast, in a market driven by investors with ESG preferences, high-ESG stocks would deliver low expected returns. Interestingly, this model may explain why the results seem inconclusive over time or across regions or industries.

We identify two potential limits to our approach. First, implementing this strategy may be rather time consuming because it requires optimization over potentially several hundred weights. We partly address this issue by limiting the investment set to the 200 firms with the largest market capitalization.[3] Obviously, criteria other than size may be adopted, allowing

[3]For an asset manager, limiting the number of stocks included in the portfolio also reduces the operational cost of the strategy. The limit of 200 firms is, however, arbitrary and can be easily increased, provided some additional computing power.

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our approach to be combined with some smart beta strategies. Second, the question of the persistence in the high performance of the optimal portfolio remains open. As argued by Pedersen et al. (2019), if investors are increasingly motivated to invest in firms with high ESG quality, they are willing to accept a lower return for a higher ESG quality; therefore, stocks with high ESG scores should deliver lower expected returns.

The remainder of the paper is organized as follows. In Section 2, we provide a description of the data used and illustrate the effect of ESG screening on the characteristics of the portfolio in terms of regional, sectoral, and risk factor exposures. In Section 3, we describe our approach to building an ESG portfolio that does not suffer from these undesirable exposures. In Section 4, we provide evidence that the resulting portfolios benefit from high ESG scores and good risk-adjusted performance without suffering from these exposures. Section 5 concludes the paper.

2 Preliminary Analysis

2.1 Data

The MSCI ESG database provides ESG scores for a large cross-section of firms over the period from January 2007 to December 2018. This database has been previously used by Bender et al. (2018), Dunn et al. (2018), Pollard et al. (2018), and Alessandrini and Jondeau (2020), among others. Each firm is evaluated according to its exposures or externalities in three complementary areas: (1) environmental, which includes climate change, natural resources, pollution and waste, and environmental opportunities; (2) social, which includes human capital, product liability, stakeholder opposition, and social opportunities; and (3) governance, which includes corporate governance and corporate behavior. For each region, a score (between 0 and 10, with 10 representing the best) summarizes the assessment of several key issues identified by MSCI. The weighted average (WA) score combines the E, S, and G scores. As these scores may suffer from industry biases, another score, called the industry-adjusted average (IAA) score, also combines the E, S, and G scores but accounts for the position of the firm relative to its peers within the industry. We also consider the

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Carbon score, a subcategory of the E score, as it is particularly relevant in the context of global warming.

The number of firms with MSCI-ESG scores increased from 1,700 in January 2007 to more than 7,000 in December 2018. To compare the performance of the ESG strategies to a well-established benchmark portfolio, we reduce the pool of firms to those belonging to MSCI standard indexes. We consider the All Country World Index (ACWI), which covers large- and mid-cap stocks across 23 developed markets and 24 emerging markets, as well as four large zones, the United States, Europe, the Pacific, and emerging countries. We use the corresponding MSCI indexes as regional benchmark portfolios.

As Figure 1 (Panel A) demonstrates, the coverage of firms belonging to the MSCI index with an ESG score substantially increased in developed markets from 2007 to 2012, from approximately 70% to more than 90%. After 2012, the coverage is above 90% for the three regions. In emerging countries, coverage has been limited: it was close to 20% until 2012 and has been close to 90% since 2013. The overall number of firms with an ESG score represents 54% of the number of firms in the MSCI ACWI in 2007 and 96% in 2018. Panel B also reveals that the coverage is even higher in terms of market capitalization. In the full sample, firms with an ESG score represent at least 90% of the market capitalization of the corresponding MSCI standard index in Europe and the Pacific and 95% in the United States. Even in emerging countries, coverage was between 40% and 60% until 2012 and has been near 90% since 2013.[4]

[Insert Figure 1 here]

2.2 Efficiency measure

A major challenge in comparing ESG portfolios to a standard benchmark is that we consider two separate dimensions, i.e., financial performance and ESG quality. This dual objective has been analyzed, for instance, by Pedersen et al. (2019) and Chen and Mussalli (2020). To

[4]To avoid issues with the lack of coverage before 2012, we also conducted our analysis for the period 2012–2018 with no alteration of the main results.

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evaluate a portfolio simultaneously with respect to financial performance and the ESG profile, we compute a so-called efficiency measure. This indicator combines financial performance through the excess return per unit of risk (Sharpe ratio) and ESG quality through the ESG score per unit of risk (ESG ratio). Formally, we define this indicator for a portfolio p as follows:

$$Eff_p = (1-\gamma)\left(\frac{\bar{R}_p - \bar{R}_f}{\sigma_p}\right) + \gamma\left(\frac{Score_p}{\sigma_p}\right) = (1-\gamma)\,SR_p + \gamma ESGR_p \tag{1}$$

where $\bar{R}_p$, σ_p, and $Score_p$ denote the average annualized return, the annualized volatility, and the average score of portfolio p, and $\bar{R}_f$ denotes the average risk-free rate. The measure is a weighted average of the Sharpe ratio and a second ratio, which relates the ESG profile of the portfolio to its volatility. Given that scores are roughly on the same scale as annual returns (expressed in percent), the two ratios are comparable in magnitude and can easily be combined to evaluate the overall profile of the portfolio.[5] In this paper, we set γ equal to 0.5. The equal weight attributed to the two components of the indicator is arbitrary and reflects the preferences of an investor, who cares as much about financial returns as ESG quality. We investigated other weights and other functional forms and obtained similar results. To compare any screening strategy to the benchmark, we also compute the efficiency measure of the benchmark according to each ESG criterion.

2.3 Screening

We now illustrate the impact of screening out firms with low scores on the properties of the portfolios. Table 1 reports the case in which the firms with the 50% lowest scores are excluded from the portfolio for various regions and ESG criteria. The resulting ESG portfolios are based on an equal weighting of the selected firms. We report the average score, the risk-adjusted performance, the regional exposures (when applicable), some relevant

[5] The scores computed by MSCI conveniently happen to be on a 0 to 10 scale, which makes them comparable to returns. Any other scale of scores, or even ratings, can be easily accommodated by simple rescaling. Chen and Mussalli (2020) use a comparable framework to combine ESG scores and financial returns.

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sectoral exposures, and exposures to the three Fama and French (1993) factors.[6] To save space, we do not report the efficiency measures of the benchmark but instead the gain in efficiency of the ESG portfolios relative to the benchmark.

We start with regional portfolios, as they are not exposed to regional risks. We compare the ESG quality and financial performance of the MSCI standard benchmark and the six portfolios built using ESG criteria (industry-adjusted average (IAA), weighted average (WA), E, S, G, and Carbon scores). For the MSCI benchmark, we cannot directly compute ESG quality because not all firms belonging to the index have an ESG score. As a consequence, we report for each criterion the corresponding score of the benchmark based on all firms belonging to this benchmark with a score.

[Insert Table 1 here]

We find that screening out firms with the 50% lowest scores allows investors to substantially increase the score of their portfolio. On average over the six criteria, the ex post score increases by 1.2 to 1.3 points in all regions. The improvement is the largest for the industry-adjusted average criterion and the smallest for the weighted average criterion. Improving the weighted average score is a difficult task because the three pillars (E, S, and G) may have different prescriptions in terms of screening. As emphasized in Alessandrini and Jondeau (2020), an increase in the ESG score does not necessarily result in a deterioration of the financial performance of the portfolio. On average over the six criteria, the Sharpe ratio of the ESG portfolio is above the Sharpe ratio of the benchmark in the United States, in Europe, and for the worldwide investment set. In fact, if we exclude screening based on the Carbon score in the Pacific and in emerging countries, the Sharpe ratio of the ESG portfolios is consistently higher than the Sharpe ratio of the benchmark portfolios.

We also note that the tracking error values are below 1.5% per year on average for ACWI, close to 2% for the United States, Europe, and the Pacific and below 5% for emerging countries. Annual turnover is very low for the benchmark, as it only accounts for firms that

[6] Regional, sectoral, and risk factor exposures reported in these tables are averages over the full sample. As we illustrate below, these averages may conceal much larger discrepancies over some subsamples. Our optimization approach will impose restrictions at each point in time.

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enter or exit the index and firms that start reporting ESG scores. For the United States, Europe, and the Pacific, average turnover increases from 5-10% for the benchmark to 60-70% for the ESG portfolios. For emerging countries, it increases from 12% for the benchmark to 100%. For the worldwide investment set, the annual turnover is close to 60%.[7]

As the table reveals, the gains in efficiency are substantial (usually close to or above 0.05) in the United States, Europe, and the Pacific and for the worldwide investment set, as both the Sharpe ratio and the ESG ratio increase when the ESG screening is used. In emerging countries, the gain in efficiency is lower on average because the ESG portfolios do not always benefit from a substantial increase in their Sharpe ratio values.

The relatively high risk-adjusted performance of ESG portfolios may be partly due to certain risk exposures. These portfolios exhibit large sectoral biases. In the first column of the table, we report the average weight of selected industries in the benchmark; in subsequent columns we report the weights of the ESG portfolio relative to the benchmark. We only report the most relevant industries to save space, so the positive and negative biases do not necessarily sum to 0. Some industries benefit from positive biases for most criteria and regions. In particular, information technology firms are substantially overweighted in all regions, particularly in the United States and emerging countries. Financials are severely underweighted in all regions but for different criteria: the underweighting is as large as 5.8% in Europe for the G score and as large as 9.6% in emerging countries for the E score. In developed markets, firms in the energy industry are underweighted when the screening is based on the E criterion, while they benefit from higher weights when the S score is considered. In contrast, in emerging countries, firms in the energy industry benefit from substantial overweighting on the E score. Telecommunication firms have a positive bias in Europe and emerging countries but a negative bias in the United States.

The table also reports the exposure of the ESG portfolios to the standard three Fama and French (1993) factors.[8] The market exposure is usually close to 1 suggesting that the

[7]Assuming a transaction fee equal to 10 basis points, an annual turnover of 100% would reduce the ex post annual return by approximately 20 bp per year.

[8]The three Fama-French factors include the market portfolio, the small-minus-big (SMB) factor, and the high-minus-low (HML) factor. For each region under consideration, we construct the factors using all the firms available in the MSCI-ESG database with the same methodology as described in Fama and French (1993).

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screening does not imply a bias toward low-beta or high-beta firms. In contrast, we find that ESG portfolios tend to have a significant negative exposure to the SMB and HML factors in the United States and Europe and a positive exposure to the SMB and HML factors in the Pacific and emerging countries. In the United States and Europe (and ACWI), these numbers reflect the average biases toward larger and more expensive firms introduced by the screening procedure.

Finally, there is a strong regional bias when the allocation is performed for the worldwide investment set (Panel E). The portfolio based on screening out firms with low industry-adjusted average scores results in an underweighting of U.S. firms by 5.1% (from 45.9% to 40.7%) and an overweighting of European firms by 9.1% (from 25.5% to 34.7%). This is a considerable bias that can be explained by the higher scores obtained by European firms compared to U.S. firms on average. European markets experienced lower performance than U.S. markets over the sample period, which explains why financial performance of the ACWI portfolio is not as good as in the United States.

All these findings indicate that the ESG screening performs well at selecting firms with high ESG quality and financial performance in line with the benchmark. However, this screening is not innocuous with respect to the regional, sectoral, and risk factor exposures of the portfolios. Moreover, it is worth noting that the exposures reported in Table 1 are averaged over the 12-year sample. Some figures might conceal considerable fluctuations over time. Consequently, some ESG portfolios might end up being even more exposed at some points in time than what the average numbers indicate. Figures 2 to 4 show how the various risk exposures have evolved over time. The thick pink lines represent the exposure of the respective benchmark. At this stage, we can focus on the dotted blue lines, which represent the exposure of the 50% screening portfolios. To save space, we focus on ACWI, the United States, and Europe when the screening is based on the industry-adjusted average score. The shaded area in the plots corresponds to the range ±5% for regional exposures and ±2.5% for sectoral and risk factor exposures.

In Figure 2 (Panel A), we observe that the bias in favor of Europe versus the United States is quite consistent over time. In the second part of the sample, the U.S. underweighting is often much more severe than 5% on average, close to 10% in 2015–2016.

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[Insert Figures 2 to 4 here]

At the industry level, fluctuations might be even more pronounced. A good example is the exposure to the energy sector. The numbers in Table 1 seem to indicate that the sector ends up roughly in line with the benchmark (within the ±2.5% around the benchmark exposure to the energy sector). However, reality is very different depending on the period. In Europe, for instance, we can see in Figure 4 (Panel A) that the screening procedure results in a large overweighting of the sector in 2008–2010. The bias is then reversed and the sector is heavily underweighted from 2011 on. Other sectors also show similar patterns.

Finally, factor exposures also fluctuate significantly. In Figure 2 (Panel C), we can see how the size exposure differs from the benchmark and might go in different directions. The screening portfolio appears, as suggested by the average numbers, to invest more in large caps (and thus have a more negative exposure to the size factor) in the first part of the sample. This bias is, however, reversed toward the end of the sample.

These patterns therefore illustrate that there might be considerable fluctuations over time in the risk exposures of the portfolio. It is therefore important to constantly monitor the portfolio profile and ensure that, at each point in time, biases are somewhat under control.

3 Optimization Design

In this section, we describe our strategy to build portfolios with high ESG quality, adequate risk-adjusted performance and regional, sectoral, and risk factor exposures in line with the benchmark.

We denote by $R_{t+1} = (R_{1,t+1}, \cdots, R_{N_t,t+1})'$ the vector of stock returns at the end of month $t+1$ for the N_t firms available at the end of month t. The vector of weights of the optimal portfolio is determined in month t and denoted by $\alpha_t = (\alpha_{1,t}, \cdots, \alpha_{N_t,t})'$, with $\sum_{i=1}^{N_t} \alpha_{i,t} = 1$, and positivity restrictions $\alpha_{i,t} \geq 0$, $\forall i$. The ex post portfolio return is therefore $R_{p,t+1}(\alpha_t) = \sum_{i=1}^{N_t} \alpha_{i,t} R_{i,t+1}$. The constituents of the benchmark portfolio have weights $\tilde{\alpha}_t = (\tilde{\alpha}_{1,t}, \cdots, \tilde{\alpha}_{N_t,t})'$, and the ex post return is denoted by $R_{b,t+1}$. The ex ante

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score of the portfolio is defined as $S_{p,t}(\alpha_t) = \sum_{i=1}^{N} \alpha_{i,t} S_{i,t}$, where the scores $S_{i,t}$ are available at the end of month t.[9]

One difficulty in integrating ESG criteria into an allocation process is that ESG scores are not directly related to expected utility theory. Investors typically maximize the expected return of the portfolio, minimize its risk, or optimize a combination of the expected return and risk. ESG scores are not expressed in monetary terms and do not correspond to risk measures. Therefore, they can hardly be combined with expected return and risk measures in a theoretical way. In addition, one could argue that in designing an ESG portfolio, investors are ready to abandon part of the risk-adjusted performance of the portfolio to improve its ESG quality. In fact, (positive or negative) screening approaches, such as that implemented in the previous section, do not target the risk-adjusted performance at all.

There are alternative ways to simultaneously target multiple objectives. For instance, Chunhachinda et al. (1997) and Prakash et al. (2003) propose a polynomial goal programming approach to portfolio selection with several moment objectives. Jessen (2012) extends the standard mean-variance strategy with a minimum score restriction. She obtains a closed-form solution to this problem, with no other weight restrictions. Chen and Mussalli (2020) provide a framework for combining traditional alpha factors with ESG alpha and show the optimal weights of each respective factor to improve a measure of return that includes both financial performance and ESG profile. Pedersen et al. (2019) define a similar mean-variance-score optimization problem but show that this problem boils down to finding the portfolio with the highest Sharpe ratio for a given ESG score.

We consider a similar approach based on a simple objective function with a set of restrictions, but we adopt a different point of view. As we want to evaluate the consequences of improving the ESG quality on the financial performance of the portfolio, our main objective is to maximize the ESG score, while not departing too much from benchmark performance.[10] Specifically, we impose restrictions on three fundamental characteristics of the portfolio: the

[9] In fact, scores are not available in real time. To avoid possible look-ahead bias, we actually take scores from $t-1$. It should be noted that scores are relatively smoothed over time and the exact timing of the score has limited impact. We do not expect any material difference between using the ex ante scores and the predicted value of the scores for month $t+1$.

[10] This is typically the position taken by institutional investors, who care mostly about performance relative to a given benchmark, instead of absolute performance.

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tracking error, the transaction cost, and the risk exposures.[11] Restrictions are defined as follows.

1. We impose that the ex ante tracking error for month $t+1$ of the portfolio relative to the benchmark portfolio remain below $\overline{TE}$. The tracking error is defined relative to the benchmark, here the regional MSCI standard portfolio. The ex ante tracking error is computed as $TE_t(\alpha_t)^2 = \frac{1}{s_0}\sum_{\tau=t-s_0+1}^{t}(R_{p,\tau}(\alpha_t) - R_{b,\tau})^2$, where s_0 denotes the number of months used to compute the tracking error (we take $s_0 = 60$, corresponding to 5 years). Portfolio returns are computed using the last weight vector α_t.

2. We impose that the turnover for month $t+1$ remain below $\overline{T}$. The turnover of the portfolio is defined as $T_t(\alpha_t, \alpha_{t-1}) = \frac{1}{2}\sum_{i=1}^{N_t}|\alpha_{i,t} - \alpha_{i,t}^-|$, where $\alpha_{i,t}^- = \alpha_{i,t-1}(1+R_{i,t})/(1+R_{p,t}(\alpha_{t-1}))$ denotes the weight of stock i in the portfolio just before rebalancing. The transaction cost is defined as the percentage fee times twice the monthly turnover. It is paid at the beginning of month $t+1$, when the portfolio is rebalanced.

3. When the investment set covers several regions (such as ACWI), we compute in month t the weights of the firms belonging to each region involved in the benchmark portfolio. We denote by $\alpha_t^R = (\alpha_{1,t}^R, \cdots, \alpha_{R,t}^R)'$ the vector of regional weights in the optimal portfolio, with $\alpha_{r,t}^R = \sum_{i=1}^{N_t}\alpha_{i,t}1_{i\in r}$, where $1_{i\in r}$ means that firm i has its headquarters in region r. For the worldwide allocation, we consider $r \in \{$United States, Europe, the Pacific, emerging countries$\}$. Then, we impose that the optimal ESG portfolio have regional weights bounded by benchmark weights $\pm\,\theta^R\%$, i.e., $\alpha_t^R \in [\tilde{\alpha}_t^R - \theta^R; \tilde{\alpha}_t^R + \theta^R]$, where $\tilde{\alpha}_t^R = (\tilde{\alpha}_{1,t}^R, \cdots, \tilde{\alpha}_{R,t}^R)'$ denotes the vector of regional weights in the benchmark portfolio.

4. We compute in month t the weights of the firms belonging to each industry. We denote by $\alpha_t^S = (\alpha_{1,t}^S, \cdots, \alpha_{S,t}^S)'$ the vector of sectoral weights in the optimal portfolio, with $\alpha_{s,t}^S = \sum_{i=1}^{N_t}\alpha_{i,t}1_{i\in s}$, where $1_{i\in s}$ means that the main activity of firm i is in industry s. We consider the 11 industries from the Global Industry Classification Standard structure. Then, we impose that the optimal portfolio have sectoral weights bounded by

[11] As we do not introduce any target in terms of expected return, restricting transaction costs is a way to avoid a substantial rebalancing of the portfolio for a limited gain in terms of its score.

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the benchmark weights $\pm\,\theta^S\%$, i.e., $\alpha_t^S \in [\tilde{\alpha}_t^S - \theta^S; \tilde{\alpha}_t^S + \theta^S]$, where $\tilde{\alpha}_t^S = (\tilde{\alpha}_{1,t}^S, \cdots, \tilde{\alpha}_{S,t}^S)'$ denotes the vector of sectoral weights in the benchmark portfolio.

5. We compute in month t the ex ante exposures of the optimal portfolio to risk factors. We denote by β_t and $\tilde{\beta}_t$ the vector of ex ante exposures of the optimal portfolio and the benchmark portfolio, respectively. These exposures to risk factors are defined as $\beta_t^f = \sum_{i=1}^{N_t} \alpha_{i,t}\beta_{i,t}^f$, $f \in \{Market, SMB, HML\}$. $\tilde{\beta}_t^f$ is defined accordingly. Individual risk exposures $\beta_{i,t}$ and $\tilde{\beta}_{i,t}$ are computed over subsamples of five years (with a minimum of three years of nonmissing returns). Then, we impose that the expected exposures of the portfolio to the risk factors remain bounded by the benchmark exposures $\pm\theta^F$, i.e., $\beta_t = [\tilde{\beta}_t - \theta^F; \tilde{\beta}_t + \theta^F]$.

6. Finally, we impose that the optimal weights remain within the bounds $[\theta^L; \theta^U]$ to avoid overexposures to some stocks. As we consider long-only portfolios, we set $\theta^L = 0$.

The optimization program is therefore:

$$\max_{\{\alpha_t\}} \quad S_{p,t}(\alpha_t) \tag{2}$$

$$s.t. \quad TE_t(\alpha_t) < \overline{TE} \tag{3}$$

$$T_t(\alpha_t, \alpha_{t-1}) < \overline{T} \tag{4}$$

$$\alpha_{r,t}^R \in [\tilde{\alpha}_{r,t}^R - \theta^R; \tilde{\alpha}_{r,t}^R + \theta^R] \quad \text{for region } r = 1, \cdots, R \tag{5}$$

$$\alpha_{s,t}^S \in [\tilde{\alpha}_{s,t}^S - \theta^S; \tilde{\alpha}_{s,t}^S + \theta^S] \quad \text{for sector } s = 1, \cdots, S \tag{6}$$

$$\beta_t^f \in [\tilde{\beta}_t^f - \theta^F; \tilde{\beta}_t^f + \theta^F] \qquad \text{for factor } f \in \{Market, SMB, HML\} \tag{7}$$

$$\alpha_{i,t} \in [\theta^L; \theta^U] \quad \text{for } i = 1, \cdots, N_t \tag{8}$$

$$\sum_{i=1}^{N_t} \alpha_{i,t} = 1. \tag{9}$$

Clearly, other constraints might be added, such as restrictions on the exposure to additional risk factors or constraints on the portfolio value-at-risk or expected shortfall.

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4 Empirical Results

4.1 Design

The average number of stocks that belong to the MSCI standard benchmark portfolio with an ESG score is equal to 1927, 519, 421, 430, and 410 for ACWI, the United States, Europe, the Pacific, and emerging countries, respectively (with minimum values equal to 1295, 425, 364, 316, and 85, respectively).[12] Given this large number of stocks, the optimization over our sample (12 years of monthly allocations) is relatively time consuming. To reduce the computational burden, we include in the investment set the 200 firms with the largest market capitalization in a given region.[13] Then, for this subset of firms, we solve the optimization program (2)–(9). On average over all regions and all criteria, the optimization takes less than 10 minutes per month.[14]

Numerical restrictions are set as follows: The ex ante tracking error should be below $\overline{TE} = 2.5\%$ per year.[15] The portfolio turnover should be below $\overline{T} = 100\%$ per year.[16] For the worldwide investment set, the regional structure of the portfolio should be within $\pm 5\%$ of the regional structure of the benchmark ($\theta^R = 5\%$). The sectoral structure of the portfolio should be within $\pm 2.5\%$ of the sectoral structure of the benchmark ($\theta^S = 2.5\%$). The risk factor exposures of the portfolio should be within $\pm 5\%$ of the risk factor exposures of the benchmark ($\theta^F = 5\%$). Finally, all the individual weights should be below $\theta^U = 5\%$.

[12] The coverage of emerging countries is relatively low until the beginning of 2012. The average number of firms ranges between 85 and 190 between January 2007 and July 2012 and then exceeds 450 from January 2013 onward.

[13] For the United States, Europe, and the Pacific, this broadly corresponds to eliminating 50% of the firms. Therefore, the total number of firms considered in the investment set is relatively close to the number of firms considered for screening out the firms with the 50% lowest scores. However, in the optimal approach, firms are not selected on the basis of their score but rather on their size. In addition to making the portfolio easier to implement, this procedure has the advantage of focusing on the most liquid stocks, reducing any potential slippage in the portfolio. Moreover, their weights are determined in an optimal way, whereas firms are equally weighted in the screening approach. For emerging countries, until December 2012, given the limited number of available firms, we select the 50% largest firms to be part of the investment set.

[14] We also experimented with fewer firms to further reduce the computational burden. However, in this case, it was sometimes impossible to simultaneously satisfy the regional, sectoral, and risk exposures.

[15] Ex post, the tracking error may differ from its ex ante value. In contrast, turnover is determined ex ante, so that the investor has good control over the ex post annual transaction cost.

[16] The chosen value of 100% per year might seem large, especially with respect to benchmark turnover level of less than 10%. However, the effect on final performance remains limited. For a transaction fee of 10 bp, the impact would be approximately 0.2% per year.

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All these values are somewhat arbitrary but reasonable. In general, selecting more restrictive values for the regional, sectoral, or risk factor exposures would result in some tension on the tracking error and/or the turnover. Ultimately, the average score of the optimal portfolio would be reduced accordingly.

4.2 Regions

We start our analysis by considering the four large regions, the United States, Europe, the Pacific, and emerging countries. For each region, we determine the monthly optimal portfolio based on each of the six ESG criteria listed above. Table 2 reports details on the ESG quality and financial performance of the optimal portfolios over the 2007–2018 period. Because the focus on a given ESG criterion may have an impact on the score of the other criteria, we report the scores for all six criteria. The first column of the table corresponds to the characteristics of the value-weighted portfolio based on all firms belonging to the MSCI index with an ESG score.

To help read the table, we start with the optimal portfolio based on the IAA score for the United States (Panel A). The score is increased from 5.05 for the benchmark to 8.55 for the optimal portfolio, which reflects a considerable improvement. The rebalancing needed to obtain this score results in a turnover of 95.4% per year on average. The ex post tracking error relative to the benchmark is limited to 2.64% per year on average and close to the ex ante limit of 2.5%. The ex post return is similar to that of the benchmark return, while the volatility is slightly higher. This results in a slightly lower Sharpe ratio (0.48 instead of 0.49). Therefore, targeting the IAA score would imply a limited loss in terms of risk-adjusted performance.

Figure 5 illustrates the balance between risk-adjusted performance and ESG quality through the efficiency measure. The plots indicate the total efficiency measure and the contribution breakdown from both the performance and the ESG parts, for the benchmark, the 50% screening portfolio, and the optimal portfolio. In total, for the United States, the efficiency measure of the optimal portfolio is improved with respect to both the benchmark and the screening portfolio. With respect to the benchmark and the 50% screening strategy, the

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small decline in the Sharpe ratio is more than compensated by the substantial improvement in ESG quality, resulting in a large increase in the efficiency measure.

[Insert Table 2 and Figure 5 here]

If we now contemplate the individual scores, we note that an investor targeting the E criterion would have been able to increase the score of the portfolio from 5.74 to 8.36, while also increasing its Sharpe ratio to 0.5. Even compared to the 50% screening strategy, the score increases substantially, while the Sharpe ratio is only slightly reduced, resulting in a very similar efficiency.

Targeting the S and G criteria provides similar results. On the one hand, the score increases considerably compared to the benchmark (from 4.8 to 7.12 for the S score and from 5.45 to 7.67 for the G score). On the other hand, the Sharpe ratio of the optimal portfolio remains close to the Sharpe ratio of the benchmark. In addition, the score improvement relative to the 50% screening strategy is quite large for Sharpe ratio values in the same ballpark.

Importantly, all these improvements are obtained while also controlling for the sector and risk factor exposures. It is worth mentioning that sectoral restrictions are imposed ex ante and are usually satisfied ex post.[17] For risk factor exposures, restrictions are imposed in real time and are based on the (ex ante) exposures of the portfolio constituents estimated over the last five years before the month of investment. The ex post exposures reported in the table are based on the time series of portfolio return. They may be different from the ex ante exposures and may not satisfy the restrictions imposed at the optimization stage.[18]

To illustrate how risk factor restrictions are imposed, we consider the case of the United States: The benchmark portfolio has, on average over the sample, ex ante exposures equal

[17] In principle, firms do not change their main industry. However, it is possible that for an industry with an ex ante weight close to its maximum limit, selected firms perform better than the rest of the portfolio, so that ex post the weight of this industry will marginally exceed its limit.

[18] The ex ante exposures of the benchmark portfolios are constructed as follows. For a given region, we consider the composition of the portfolio at the end of month t. We compute the exposures of each of the constituents to the risk factors using the last five years of data. Then, we compute the weighted exposure of the benchmark portfolio at the end of month t, $\tilde{\beta}_t$. We compute the ex ante exposures of the optimal portfolio in the same way, using past data only. For each risk factor f, the ex ante exposure of the optimal portfolio has to be chosen between $\tilde{\beta}_t^f - \theta^F$ and $\tilde{\beta}_t^f + \theta^F$. These restrictions are imposed on the individual weights of the optimal portfolio in the optimization process.

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to 0.952, 0.023, and 0.016 for the market, SMB, and HML factors, respectively. The ex ante exposures of the optimal portfolio based on the IAA score are on average equal to 0.957, 0.018, and 0.003 respectively, and they satisfy the ex ante restrictions for each month of the sample. Ex post, the (reported) exposures of the benchmark are equal to 0.986, −0.023, and 0.007. Those of the optimal portfolio are equal to 0.977, 0.024, and −0.052. For the United States, the optimal portfolios satisfy all the ex ante restrictions on risk factor exposures. In addition, as Figure 3 (Panel B) demonstrates, the ex post exposures for the market, SMB, and HML factors (black lines) all remain in the shaded area, which represents the ±2.5% around the benchmark risk factor exposures.

More generally, by imposing the weight restrictions at each rebalancing, we ensure that the exposures do not fluctuate too far from the benchmark exposures over time. Returning to Figures 2 to 4, we can see that the exposures remain under control. The shaded areas represent the allocations that are permitted by the restrictions, i.e., ±5% for the regions and ±2.5% for the sectors and the risk factors around the benchmark allocation. The black line is the effective weight of the optimal portfolio. If we again consider the case of the United States (Figure 3, Panel A), we observe that the optimization avoids the energy sector from being severely underweighted in the middle of the sample or the information technology sector from being extremely overweighted in the second part of the sample. Figure 3 (Panel B) demonstrates how the optimization allows the size exposure to remain much closer to the benchmark at each point in time.

Turning to Europe, Table 2 (Panel B) reveals that for all criteria the maximization of ESG quality is achieved together with a substantial improvement in the financial performance of the portfolio. For instance, for the industry-adjusted average criterion, the score is increased from 6.79 for the benchmark to 9.56, while the Sharpe ratio doubles from 0.13 to 0.26. As seen from Figure 5, the efficiency measure increases substantially, from 0.24 to 0.37. This improvement is also remarkable with respect to the 50% screening portfolio, which achieves an efficiency measure of 0.33. Contrary to the U.S. case, the improvement comes from both financial performance and ESG quality. When turning to different ESG criteria, similar twin improvements are obtained for all criteria, resulting in considerable efficiency gains, even larger than those in the United States.

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As for the United States, the good performance delivered by ESG portfolios in Europe does not result from sectoral or risk factor exposures. As Figure 4 (Panel A) reveals, all sector weights are within the stated limits for each month of the sample, and the ex post exposures to the Fama-French risk factors are almost all insignificantly different from the benchmark exposures.

For the Pacific (Table 2 Panel C), maximizing the ESG scores also results in higher Sharpe ratios. For the IAA criterion, the score increases from 5.71 to 8.98, while the Sharpe ratio increases from 0.18 to 0.27. Importantly, the MSCI benchmark has a positive exposure to SMB and HML factors, as do the optimal portfolios, as illustrated in the table. These results allow us to emphasize how flexible the approach is in the targeted factor exposure. It does not seek a zero exposure but rather an exposure that is sufficiently close to that of the benchmark. In the Pacific, and contrary to the United States and Europe, the exposure of the benchmark to the size factor is positive and significant. Our allocation targets and is able to deliver a similar level.

For emerging countries, targeting the IAA score results in an increase in the score from 4.47 to 6.65 and in the Sharpe ratio from 0.23 to 0.33 relative to the benchmark. Similar twin performances are obtained for all criteria except the Carbon score. As for the Pacific, as the benchmark portfolio exhibits positive exposures to the SMB and HML factors, so do the optimal portfolios.

It should be noted that the improved ESG quality and the higher financial performance of the optimal portfolio are obtained at the cost of higher tracking error and turnover with respect to the screening approach. On average over the six ESG criteria, the tracking error of the optimal portfolio is 2.7% per year (versus 1.85% for the 50% screening strategy) in the United States and 2.71% per year (versus 2.2%) in Europe. The turnover also increases to 94% per year (versus 65.9%) in the United States and 95.9% per year (versus 64.1%) in Europe. In emerging markets, the tracking error is lower for the optimal portfolio than for the 50% screening strategy and the turnover is similar on average. We consider in Section 4.5 an alternative optimization criterion based on turnover minimization to investigate this issue.

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The allocation based on the Carbon criterion exhibits some interesting patterns. First, the increase in the score is usually large, with average scores above 9.15 in the United States, Europe, and the Pacific. Moreover, in these three regions the optimal portfolio delivers a high Sharpe ratio relative to the other criteria. Finally, the tracking error and the turnover are usually lower than those obtained with the other criteria. These good results are partly explained by the fact that Carbon scores are usually high for a large fraction of the firms in these regions (64.5% of European firms have a Carbon score above 9 on average from 2013 on), so that improving the Carbon score can be attained at a relatively low cost in these regions. In contrast, firms in emerging countries have relatively low Carbon scores on average, particularly before 2013. As a consequence, the score increase, the Sharpe ratio, and the gain in efficiency are the lowest for this criterion.

4.3 Worldwide Investment Set

Maximizing the score of the portfolio for the worldwide investment set raises the additional issue of regional exposures. In Panels E and F of Table 2, we analyze the impact of imposing regional restrictions on the ESG quality and the financial performance of the optimal portfolios. These restrictions are likely to have an impact on the allocation because the score of large firms in Europe is on average higher than the score of large U.S. firms.

When no regional restriction is imposed on the optimization process (Panel E), we obtain as expected that a large fraction of the optimal portfolio is invested in European firms, while U.S. firms are severely underweighted. The most substantial impact is obtained with the industry-adjusted average criterion: the weights of the U.S. and European firms are equal to 29.8% and 43.8% on average, while in the benchmark portfolio, these values are equal to 47.5% and 26%, respectively. This happens to be very consistent over time, as seen from the red line in Figure 2 (Panel A). For the E and S criteria, average weights are less affected but nevertheless remain higher than those of the benchmark portfolio.

The gain in ESG quality relative to the benchmark is considerable, on average 2.4 points. The improvement is particularly large for the IAA criterion with an increase in the average score from 5.57 to 9.11. Importantly, even if the risk-adjusted performance of the European market is clearly below that of the U.S. market over the period, the optimal portfolio gen-

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erates a risk-adjusted performance that is higher than that of the benchmark. In addition, the Sharpe ratio of the optimal portfolio is almost always higher than the Sharpe ratio of the corresponding 50% screening strategy. Consequently, the gain in efficiency is substantial, from 0.33 to 0.45.

Imposing regional restrictions results in a reallocation of the optimal portfolio in favor of U.S. firms (Panel F). However, the impact on the ESG quality and the risk-adjusted performance of the portfolio is marginal. The ESG score and the Sharpe ratio are of the same order as those obtained when no regional restriction is imposed and the efficiency of the portfolio is similar. In fact, the main consequence of imposing regional restrictions is that it reduces the tracking error of the portfolio relative to the benchmark portfolio by keeping the regional weights within the ±5% bounds (see also the black lines in Figure 2 Panel A). The table also reveals that risk factor exposures are not altered when regional weights are restricted: Optimal portfolios have negative exposures to the SMB factor, consistent with the exposures of the benchmark portfolio. Exposures of the benchmark and optimal portfolios to the HML factor are essentially insignificantly different from 0 (see Figure 2 Panel C).

Overall, in our sample period, imposing regional restrictions would have been harmless for portfolio construction due to the superior performance of U.S. firms.

4.4 Subsample Analysis

We next perform a subsample analysis of the portfolio allocation. Segmenting our sample in different periods is relevant for three reasons. First, the full period includes very different market environments. In developed markets, the first half of the sample was severely impacted by the financial crisis and is characterized by high volatility and most often muted financial performance. In contrast, the second part of the sample benefited from better market conditions. Subsample analysis will therefore allow us to assess whether the ability of score maximization to maintain good financial performance is persistent across market regimes. Second, as discussed above, ESG coverage increases considerably around 2012–2013, and it could be that the lower quality of the data in the first part of the sample had an impact on the overall results. Third, ESG investing has gained popularity over the more

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recent years. It may be argued that increasing interest in ESG investing has translated into good companies attracting more capital and therefore benefiting from higher valuations.

We consider two subperiods, 2007–2012 and 2013–2018, which correspond to two subsamples of six years each but also account for the improvement in the data quality. Notably, the coverage of emerging countries increased considerably in 2012. Clearly, these periods also correspond to different market conditions. In developed countries, the average return of the benchmark is much higher in the second subsample. In contrast, emerging markets experienced much better performance in the first half of the sample. In all regions, volatility is much higher in the first period.

In Table 3, we report some relevant statistics to evaluate the ESG quality and the financial performance of the various portfolios. The row corresponding to the score represents the targeted score for the ESG portfolio and the IAA score for the benchmark. Interestingly, the table reveals that in all regions the IAA score of the benchmark is lower on average in the second half of the sample. This result is notably due to the S score, which was reduced by approximately 0.2-0.8 point in all regions.

Figures 6 and 7 help visualize the changes in the efficiency measure and its components through the two subsamples. As the first half of the sample experienced high volatility, the Sharpe ratio and the ESG ratio are both low in all regions. As a consequence, the efficiency measures are relatively low in all regions and for all scores. Nevertheless, the efficiency measures of the optimal portfolio benefit from an improvement in both the Sharpe ratio and ESG quality compared to the benchmark portfolio and the 50% screening portfolio.

The second subsample is characterized by a relatively low volatility in developed markets and large gains in the Sharpe ratios of the optimal portfolios. Therefore, we observe more substantial gains in efficiency in all countries, reflecting both the higher scores and the relatively higher Share ratios of the optimal portfolios.

In sum, thus far, there is no sign of a reduction in the ESG quality and financial performance of the ESG portfolios relative to those delivered by the benchmark portfolio.

[Insert Table 3 and Figures 6 and 7 here]

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4.5 Change in the optimization criterion

In principle, the optimization problem could be stated in various ways, potentially targeting a different objective. From a practical perspective, it would make sense to ensure that the portfolio is not too costly to trade and would not suffer from the inclusion of transaction costs. To address this issue, instead of directly maximizing the score of the portfolio, we also consider the case in which the investor minimizes the turnover (or the transaction cost) due to rebalancing while targeting a minimum increase in the targeted score of 2 points at each period in time. As the investor is assumed to have an assigned benchmark (through the tracking error limit), minimizing the turnover is another way to maximize the ex post return or alpha of the portfolio. It is worth noting that increasing the score by 2 points is a difficult task for some criteria. In most countries, except for the IAA score, the score maximization objective is usually unable to reach such a target while maintaining turnover below 100%.

The results are reported in Table 4 for the main regions. We find that for most regions and criteria, the optimization is able to improve by 2 points the score of the benchmark.[19] The case of the United States with the IAA score (Panel A) highlights the merits of this different approach. As targeted, the score is improved by 2 points. With respect to score maximization, the improvement in the score is less impressive, although the Sharpe ratio remains roughly similar. As a result, the gain in efficiency is also more limited. However, turnover decreases considerably from 95% to approximately 15%, which would impact the net performance less and at the same time make the portfolio easier to manage. We also observe a lower tracking error compared to the score maximization case. Similar reductions in turnover are achieved for Europe and the Pacific.

Other results show, however, some exceptions: The increase in the weighted average score ranges between 1.6 and 1.9 points (for emerging countries and the United States, respectively), thus missing the objective of 2 points. As mentioned before, the difficulty mainly comes from the incompatibility in the targeted criteria (investing in some firms to improve the E score would result in a decrease in the S or G score). In all cases, the increase

[19]The average score that is reported in the table is often slightly below the targeted value because of the initial adjustment of the portfolio weights.

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in the weighted average score requires high turnover (between 148% and 175% per year across regions), reflecting the necessity to rebalance the portfolio to a large extent.

We note that increasing the Carbon score is a difficult task in all regions because the score of the benchmark is already high. For instance, in Europe, it only increases from 7.9 to 9.4. More generally, increasing the Carbon score requires high turnover for all regions.

In all regions, the financial performance of the optimal portfolio is lower than the performance obtained by maximizing the score, although it is usually higher than the performance of the benchmark. In most cases, the lower Sharpe ratio is due to an insufficient increase in the targeted score. For instance, in the United States, maximizing the E score results in a higher Sharpe ratio than minimizing the turnover with a minimum increase of 2 points of the E score: The first portfolio exhibits an E score of 8.36 for a Sharpe ratio of 0.5, while the second portfolio has an E score of 7.73 for a Sharpe ratio of 0.42. This evidence suggests that targeting firms with higher E scores is also beneficial for financial performance. We observe similar results for the E and Carbon scores in other developed countries.

Overall, these results suggest that some scores can be improved at a relatively low cost in terms of turnover or the Sharpe ratio. Typically, the IAA, E, and S scores can be substantially increased with no decrease in the Sharpe ratio and limited transaction costs. Improving the G score by at least 2 points implies both a (slight) decrease in the Sharpe ratio and a turnover above 100%.

[Insert Table 4 here]

5 Conclusion

In building an ESG portfolio, two main difficulties arise. First, improving the ESG quality of a portfolio should not occur at the expense of lower financial performance. Second, it also should not imply some exposures to undesirable risk factors. In this paper, we demonstrate that these two goals can be achieved by designing an optimization program that targets these different objectives. Maximizing the portfolio score while maintaining the tracking error, the turnover, and the regional, sectoral, and risk factor exposures within stated limits

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would have allowed investors to generate a substantially higher score with no deterioration in the risk-adjusted performance of the portfolio, while controlling for the risk exposures. This main result holds for the four main regions and the worldwide investment set, for the main ESG criteria, and for different sample periods (2007–2018, 2007–2012, and 2013–2018). ESG quality and financial performance are usually improved relative to a pure screening approach.

These results suggest that ESG investing is fundamentally different from screening out sin stocks, an approach that has been found to produce negative performance (Fabozzi et al., 2008; Hong and Kacperczyk, 2009). A possible interpretation of this apparent inconsistency is that high ESG scores are actually good predictors of higher firm performance in a way that is not fully incorporated into market prices. This point has been made by Pedersen et al. (2019), who describe a model in which some investors use only the information provided by ESG scores about future performance and some other investors have a preference for firms with high ESG scores. When the market is dominated by the first type of investors, a portfolio of firms with high ESG scores can generate higher financial performance. Our results indicate that financial markets may have been driven by this type of investor over our sample period.

One important question that remains open is whether the recent massive trend toward ESG integration will reduce the financial performance of portfolios based on ESG criteria. Our subsample analysis suggests that in the last six years investing in a portfolio with high ESG quality would not have resulted in lower financial performance compared to the first six years of our sample.

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Table 1: Characteristics of Portfolios Based on ESG Screening

	MSCI bench.	IAA score	WA score	E score	S score	G score	Carbon score
Panel A: United States							
Performance							
Annual. return (%)	7.94	8.31	8.28	8.66	7.62	8.37	8.63
Annual. std dev. (%)	14.77	14.05	14.30	14.18	14.31	14.56	14.54
Annual. Sharpe ratio	0.49	0.54	0.53	0.56	0.48	0.53	0.54
Annual. tracking error (%)	0.00	1.86	1.92	1.73	1.88	2.04	1.66
Annual. turnover (%)	6.25	56.61	63.21	61.28	68.93	77.48	67.65
Benchmark score	–	5.05	5.05	5.74	4.79	5.45	6.98
Average score	–	6.62	5.91	6.93	5.91	6.94	8.13
Efficiency measure	–	0.51	0.47	0.52	0.45	0.50	0.55
SR gain in Efficiency	–	0.03	0.02	0.04	0.00	0.02	0.03
ESG gain in Efficiency	–	0.06	0.04	0.05	0.04	0.05	0.04
Sectoral exposures							
Health Care	13.48	-0.76	-1.11	2.52	-2.96	-1.19	2.03
Financials	13.80	-3.57	-2.88	-0.18	-1.05	-2.61	0.93
Information Technology	17.16	6.95	9.05	3.95	8.69	3.12	3.03
Energy	9.42	-2.17	-3.91	-5.16	2.00	-2.96	-5.36
Telecommunication	8.04	-1.86	-2.94	0.57	-2.81	-3.78	-1.09
Ex post risk factor exposures							
Market	0.981*	0.965*	0.975*	0.962*	0.968*	0.981*	0.982*
SMB	-0.041*	-0.142*	-0.111*	-0.126*	-0.098*	-0.079*	-0.112*
HML	0.014*	-0.062*	-0.074*	0.020	-0.035	-0.053*	0.032
Panel B: Europe							
Performance							
Annual. return (%)	3.30	4.42	4.57	4.17	3.90	4.46	3.71
Annual. std dev. (%)	19.32	18.23	18.54	18.56	18.97	17.84	18.80
Annual. Sharpe ratio	0.13	0.20	0.21	0.19	0.17	0.21	0.16
Annual. tracking error (%)	0.00	2.25	2.43	1.92	2.65	2.43	1.62
Annual. turnover (%)	6.87	59.73	61.17	61.63	66.90	68.15	67.25
Benchmark score	–	6.79	5.80	6.42	5.52	6.13	7.89
Average score	–	8.32	6.74	7.57	6.77	7.53	8.88
Efficiency measure	–	0.33	0.29	0.30	0.26	0.32	0.32
SR gain in Efficiency	–	0.03	0.04	0.03	0.02	0.04	0.01
ESG gain in Efficiency	–	0.05	0.03	0.04	0.04	0.05	0.03
Sectoral exposures							
Health Care	12.76	-1.39	-4.92	2.16	-6.28	-3.28	2.36
Financials	20.62	-4.58	-4.13	1.91	-0.75	-5.85	2.71
Information Technology	4.38	2.11	2.68	0.73	2.48	2.37	0.69
Energy	8.04	-0.96	-0.71	-1.52	0.89	-2.93	-2.04
Telecommunication	6.86	3.04	3.05	1.99	3.29	4.58	-0.90
Ex post risk factor exposures							
Market	0.977*	0.972*	0.983*	0.965*	0.962*	0.954*	0.978*
SMB	-0.047*	-0.153*	-0.130*	-0.128*	-0.133*	-0.080*	-0.119*
HML	-0.001	-0.082*	-0.080*	-0.006	0.070*	-0.122*	-0.009

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Table 1 (Continued)

	MSCI bench.	IAA score	WA score	E score	S score	G score	Carbon score
Panel C: Pacific							
Performance							
Annual. return (%)	3.55	3.42	3.42	3.43	3.95	3.95	3.36
Annual. std dev. (%)	15.86	15.37	15.43	15.16	16.01	15.76	15.21
Annual. Sharpe ratio	0.18	0.18	0.18	0.18	0.20	0.21	0.17
Annual. tracking error (%)	0.00	2.29	2.43	2.76	2.06	2.69	2.86
Annual. turnover (%)	5.32	59.86	61.60	60.07	67.77	75.05	65.04
Benchmark score	–	5.71	5.34	5.80	5.20	5.45	7.25
Average score	–	7.34	6.16	7.13	6.25	6.79	8.62
Efficiency measure	–	0.33	0.29	0.32	0.30	0.32	0.37
SR gain in Efficiency	–	0.00	0.00	0.00	0.01	0.01	0.00
ESG gain in Efficiency	–	0.06	0.03	0.05	0.03	0.04	0.05
Sectoral exposures							
Health Care	5.50	0.37	-0.87	2.07	-1.06	-0.74	1.46
Financials	21.60	-0.61	-0.61	-3.05	1.18	-0.17	0.31
Information Technology	6.67	2.11	2.11	1.50	1.42	1.99	0.54
Energy	2.60	0.36	0.36	-0.58	0.69	0.01	-1.35
Telecommunication	7.41	0.46	0.46	2.43	3.19	-1.87	-1.09
Ex post risk factor exposures							
Market	1.017*	0.980*	0.975*	0.958*	1.026*	0.990*	0.974*
SMB	0.025	-0.016	0.094	0.072	-0.021	0.092	-0.010
HML	0.045*	0.086*	0.086*	0.095*	0.117*	0.041	0.198*
Panel D: Emerging countries							
Performance							
Annual. return (%)	5.79	6.53	6.71	5.80	6.93	4.65	3.44
Annual. std dev. (%)	22.14	22.17	22.02	22.50	21.94	21.71	23.64
Annual. Sharpe ratio	0.23	0.26	0.27	0.23	0.28	0.18	0.12
Annual. tracking error (%)	0.00	4.13	4.33	3.98	4.25	4.69	6.97
Annual. turnover (%)	11.63	84.82	87.85	89.71	92.18	95.44	115.51
Benchmark score	–	4.47	4.68	4.84	4.63	4.79	5.53
Average score	–	6.08	5.55	6.15	5.77	6.12	7.05
Efficiency measure	–	0.27	0.26	0.25	0.27	0.23	0.21
SR gain in Efficiency	–	0.02	0.02	0.00	0.03	-0.02	-0.06
ESG gain in Efficiency	–	0.04	0.02	0.03	0.03	0.03	0.02
Sectoral exposures							
Health Care	1.68	-0.57	-0.90	-0.48	-0.08	-1.29	-1.19
Financials	26.66	-3.33	-3.86	-9.57	-0.12	-0.24	-13.19
Information Technology	14.81	6.65	8.67	8.04	5.59	1.42	3.14
Energy	11.17	3.24	2.10	3.44	1.20	1.04	11.40
Telecommunication	7.37	-0.05	0.09	2.19	0.85	0.62	0.83
Ex post risk factor exposures							
Market	0.990*	0.946*	0.938*	0.957*	0.941*	0.929*	0.942*
SMB	0.382*	0.254*	0.271*	0.290*	0.217*	0.268*	0.319*
HML	0.159*	0.174*	0.170*	0.194*	0.178*	0.140*	0.329*

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Table 1 (Continued)

	MSCI bench.	IAA score	WA score	E score	S score	G score	Carbon score
Panel E: ACWI							
Performance							
Annual. return (%)	5.70	5.63	5.78	6.33	5.51	5.62	5.94
Annual. std dev. (%)	16.12	15.62	15.69	15.51	15.87	15.77	15.63
Annual. Sharpe ratio	0.31	0.31	0.32	0.36	0.30	0.31	0.33
Annual. tracking error (%)	0.00	1.43	1.40	1.44	1.42	1.42	1.68
Annual. turnover (%)	7.12	60.91	63.48	61.70	68.98	74.24	67.93
Benchmark score	–	5.57	5.26	5.82	5.05	5.60	7.18
Average score	–	7.16	6.14	6.98	6.23	7.01	8.41
Efficiency measure	–	0.39	0.36	0.41	0.35	0.38	0.44
SR gain in Efficiency	–	0.00	0.01	0.03	0.00	0.00	0.01
ESG gain in Efficiency	–	0.06	0.03	0.04	0.04	0.05	0.05
Regional exposures							
United States	45.87	-5.13	-4.55	-0.52	-3.95	-3.68	0.19
Europe	25.54	9.14	7.61	6.26	5.15	7.42	7.11
Pacific	13.02	0.58	1.32	-0.02	1.66	-0.33	0.78
Sectoral exposures							
Health Care	10.50	0.01	-1.63	2.17	-2.99	-1.10	2.79
Financials	18.54	-2.51	-2.04	-0.94	0.41	-1.85	0.41
Information Technology	11.44	3.56	5.23	2.71	4.51	1.41	1.28
Energy	8.95	-1.23	-1.91	-2.96	1.42	-1.69	2.18
Telecommunication	7.64	-0.29	-0.77	0.97	0.04	-1.90	-0.71
Ex post risk factor exposures							
Market	0.989*	0.966*	0.968*	0.961*	0.973*	0.978*	0.968*
SMB	-0.067*	-0.130*	-0.120*	-0.161*	-0.121*	-0.136*	-0.181*
HML	-0.009	0.009	0.013	0.027	0.068	-0.021	0.034

Note: The table reports summary statistics on portfolios based on the 50% ESG screening based on the industry-adjusted average (IAA), weighted average (WA), environmental (E), social (S), governance (G), and Carbon scores. Statistics are: the annualized average return, volatility, Sharpe ratio, tracking error (relative to the standard MSCI benchmark of the respective region), and turnover; the average benchmark and portfolio scores; the efficiency measure with the contribution of the Sharpe ratio and the ESG ratio to the efficiency gain relative to the benchmark; the regional exposures (when relevant), some relevant sectoral exposures, and the three risk factor exposures. Column 1 corresponds to the MSCI benchmark for the region considered. * denotes significance at the 5% confidence level.

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Table 2: Characteristics of Portfolios Based on Score Maximization

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel A: United States							
Annual. Return (%)	7.94	7.95	8.65	8.27	8.05	8.41	8.68
Annual. volatility (%)	14.81	14.99	15.12	15.25	14.85	15.53	14.85
Annual. Sharpe ratio	0.49	0.48	0.52	0.50	0.49	0.50	0.54
Annual. tracking error (%)	–	2.64	2.66	2.78	2.62	2.97	2.52
Annual. turnover (%)	9.38	95.44	96.09	96.97	100.31	100.05	75.28
Industry-adjusted score	5.05	8.55	8.14	6.79	7.34	6.46	6.58
Weighted score	5.05	6.67	6.80	6.11	6.31	5.81	5.73
E score	5.74	7.11	7.42	8.36	6.35	6.27	6.69
S score	4.79	6.35	6.40	5.27	7.12	5.25	5.34
G score	5.45	6.63	6.68	6.07	6.07	7.67	5.94
Carbon score	6.98	8.16	8.04	8.21	7.55	7.41	9.15
Efficiency measure	0.41	0.53	0.49	0.52	0.49	0.49	0.58
SR Gain in Efficiency	–	0.00	0.02	0.00	0.00	0.00	0.02
ESG Gain in Efficiency	–	0.11	0.05	0.08	0.08	0.06	0.07
Ex post risk factor exposures							
Market	0.986*	0.977*	0.979*	0.983*	0.964*	1.011*	0.960*
SMB	-0.023*	0.024	0.051	0.032	0.025	0.011	0.022
HML	0.007	-0.052	-0.040	0.038	-0.005	-0.028	0.038
Panel B: Europe							
Annual. Return (%)	3.30	5.80	6.06	4.78	5.93	5.74	5.62
Annual. volatility (%)	19.34	19.60	19.47	19.19	19.75	19.30	19.28
Annual. Sharpe ratio	0.13	0.26	0.27	0.21	0.26	0.26	0.25
Annual. tracking error (%)	–	2.59	2.88	2.54	2.74	2.92	2.61
Annual. turnover (%)	9.82	96.91	99.12	100.41	99.68	99.40	79.94
Industry-adjusted score	6.79	9.56	9.22	8.09	8.78	8.36	7.53
Weighted score	5.80	7.17	7.40	6.73	7.06	6.73	6.22
E score	6.42	7.51	7.76	8.62	6.95	6.89	6.91
S score	5.52	6.93	7.17	6.08	7.78	6.20	5.86
G score	6.13	7.40	7.50	6.63	6.84	8.33	6.45
Carbon score	7.89	8.14	8.35	8.47	7.93	8.02	9.43
Efficiency measure	0.24	0.37	0.33	0.33	0.33	0.35	0.37
SR Gain in Efficiency	–	0.06	0.07	0.04	0.07	0.06	0.06
ESG Gain in Efficiency	–	0.07	0.04	0.06	0.05	0.06	0.04
Ex post risk factor exposures							
Market	0.992*	0.996*	0.993*	0.975*	0.999*	0.990*	0.981*
SMB	-0.047*	-0.003	0.015	0.040	0.000	0.051	-0.031
HML	0.016	-0.002	-0.029	-0.016	0.013	-0.068*	0.006

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Table 2 (Continued)

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel C: Pacific							
Annual. Return (%)	3.55	4.86	4.53	4.62	4.31	4.50	5.30
Annual. volatility (%)	15.90	15.56	15.70	16.01	15.83	15.72	15.93
Annual. Sharpe ratio	0.18	0.27	0.24	0.24	0.23	0.24	0.29
Annual. tracking error (%)	–	2.81	2.81	2.80	3.00	2.88	2.70
Annual. turnover (%)	8.85	98.45	98.39	98.50	99.97	97.74	88.58
Industry-adjusted score	5.71	8.98	8.58	7.63	7.87	7.31	7.25
Weighted score	5.34	6.84	7.00	6.49	6.61	6.21	6.15
E score	5.80	7.24	7.46	8.15	6.56	6.35	6.85
S score	5.20	6.76	6.91	5.83	7.44	5.74	5.85
G score	5.45	6.54	6.59	6.09	6.02	7.55	6.02
Carbon score	7.25	8.22	8.24	8.28	7.60	7.70	9.30
Efficiency measure	0.27	0.42	0.34	0.38	0.35	0.36	0.44
SR Gain in Efficiency	–	0.04	0.03	0.03	0.02	0.03	0.05
ESG Gain in Efficiency	–	0.11	0.05	0.07	0.07	0.07	0.06
Ex post risk factor exposures							
Market	1.016*	0.972*	0.974*	0.996*	0.987*	0.979*	1.001*
SMB	0.051*	0.140*	0.226*	0.192*	0.189*	0.159*	0.134*
HML	0.051*	0.040	0.033	0.029	0.074*	0.042	0.095*
Panel D: Emerging countries							
Annual. Return (%)	5.79	7.87	8.29	7.02	8.10	6.50	5.79
Annual. volatility (%)	22.14	21.79	21.99	22.16	21.74	21.59	22.63
Annual. Sharpe ratio	0.23	0.33	0.34	0.28	0.34	0.27	0.22
Annual. tracking error (%)	–	3.50	3.38	3.82	3.27	3.26	4.14
Annual. turnover (%)	27.63	101.30	101.87	102.61	102.86	102.63	107.67
Industry-adjusted score	4.47	6.65	6.39	5.75	5.90	5.56	5.11
Weighted score	4.68	5.64	5.75	5.40	5.46	5.24	5.03
E score	4.84	5.75	5.89	6.53	5.24	5.27	5.38
S score	4.63	5.61	5.70	5.03	6.10	5.04	4.80
G score	4.79	5.69	5.71	5.17	5.32	6.39	5.00
Carbon score	5.53	4.26	4.39	4.29	4.22	4.10	6.76
Efficiency measure	0.22	0.32	0.30	0.29	0.31	0.28	0.26
SR Gain in Efficiency	–	0.05	0.06	0.03	0.06	0.02	0.00
ESG Gain in Efficiency	–	0.05	0.02	0.04	0.04	0.04	0.02
Ex post risk factor exposures							
Market	0.981*	0.949*	0.963*	0.961*	0.950*	0.946*	0.975*
SMB	0.311*	0.334*	0.330*	0.340*	0.339*	0.332*	0.408*
HML	0.152*	0.147	0.134*	0.150*	0.150*	0.123*	0.172*

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Table 2 (Continued)

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel E: ACWI – No regional restriction							
Annual. Return (%)	5.70	6.03	6.89	5.72	6.81	7.24	5.60
Annual. volatility (%)	16.15	15.96	15.85	15.77	16.00	15.74	16.08
Annual. Sharpe ratio	0.31	0.33	0.39	0.32	0.38	0.41	0.30
Annual. tracking error (%)	–	2.82	2.73	2.61	2.94	2.83	2.80
Annual. turnover (%)	10.52	98.79	99.74	101.27	100.98	100.95	83.45
Industry-adjusted score	5.57	9.11	8.80	7.40	8.09	7.57	7.07
Weighted score	5.27	6.94	7.06	6.41	6.67	6.32	5.98
E score	5.82	7.47	7.60	8.38	6.85	6.69	7.01
S score	5.05	6.55	6.66	5.62	7.24	5.83	5.51
G score	5.60	6.94	6.99	6.25	6.37	7.74	6.10
Carbon score	7.18	8.44	8.43	8.36	8.03	7.90	9.35
Efficiency measure	0.33	0.45	0.42	0.42	0.42	0.45	0.44
SR Gain in Efficiency	–	0.01	0.04	0.00	0.04	0.05	0.00
ESG Gain in Efficiency	–	0.11	0.06	0.09	0.07	0.07	0.07
Regional exposures							
United States	47.45	29.80	32.28	41.15	42.02	34.14	35.78
Europe	26.04	43.79	43.08	33.88	34.88	40.78	39.69
Pacific	13.34	15.66	14.25	17.46	14.65	12.24	12.74
Emerging countries	7.54	2.82	3.44	4.33	2.84	4.14	3.18
Ex post risk factor exposures							
Market	0.993*	0.965*	0.963*	0.952*	0.960*	0.964*	0.979*
SMB	-0.062*	-0.094*	-0.092*	-0.104*	-0.068	-0.140*	-0.141*
HML	-0.017	0.048	0.012	0.088*	0.067	-0.025	0.043
Panel F: ACWI – With regional restrictions							
Annual. Return (%)	5.70	5.81	6.88	6.03	6.46	7.06	5.32
Annual. volatility (%)	16.15	15.96	15.75	15.80	15.93	15.87	16.00
Annual. Sharpe ratio	0.31	0.32	0.39	0.34	0.36	0.40	0.29
Annual. tracking error (%)	–	2.63	2.75	2.52	2.75	2.80	2.79
Annual. turnover (%)	10.52	99.56	100.27	101.30	101.40	100.61	83.13
Industry-adjusted score	5.57	8.97	8.64	7.38	7.93	7.44	7.00
Weighted score	5.27	6.87	7.00	6.39	6.59	6.26	5.93
E score	5.82	7.44	7.61	8.36	6.76	6.68	6.99
S score	5.05	6.47	6.61	5.59	7.16	5.73	5.46
G score	5.60	6.80	6.85	6.23	6.34	7.68	6.03
Carbon score	7.18	8.40	8.38	8.32	7.87	7.84	9.32
Efficiency measure	0.33	0.44	0.42	0.43	0.40	0.44	0.43
SR Gain in Efficiency	–	0.01	0.04	0.01	0.03	0.05	-0.01
ESG Gain in Efficiency	–	0.11	0.06	0.08	0.07	0.07	0.07
Regional exposures							
United States	47.45	42.84	43.74	45.21	47.02	43.71	44.29
Europe	26.04	30.36	30.55	29.58	28.84	30.06	30.21
Pacific	13.34	16.06	14.75	16.75	15.64	12.69	13.07
Emerging countries	7.54	3.69	3.84	5.01	3.06	4.61	4.15
Ex post risk factor exposures							
Market	0.993*	0.969*	0.953*	0.954*	0.960*	0.973*	0.973*
SMB	-0.062*	-0.094*	-0.096*	-0.090*	-0.067	-0.158*	-0.143*
HML	-0.017	0.023	0.042	0.077*	0.044	-0.009	0.055

Note: The table reports summary statistics on the portfolios based on score maximization for the industry-adjusted average (IAA), weighted average (WA), environmental (E), social (S), governance (G), and Carbon scores. See Table 1 for the definition of the statistics. Column 1 corresponds to the portfolio of all firms in the benchmark with a score for the region considered. * denotes significance at the 5% confidence level.

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Table 3: Characteristics of Portfolios Based on Score Maximization - Subsamples

	Bench. w, score	IAA score	WA score	E score	S score	G score	Carbon score
Panel A: United States							
2007–2012							
Annual. Return (%)	3.81	3.88	3.40	2.72	2.95	4.10	4.30
Annual. volatility (%)	17.98	18.16	18.29	18.70	17.84	18.63	18.20
Annual. Sharpe ratio	0.16	0.16	0.13	0.09	0.11	0.17	0.18
Score	5.28	8.72	7.22	7.63	7.45	7.67	8.40
Efficiency measure	0.23	0.32	0.26	0.25	0.26	0.29	0.32
Gain in Efficiency	–	0.09	0.03	0.02	0.03	0.05	0.09
2013–2018							
Annual. Return (%)	12.01	11.97	13.83	13.74	13.09	12.65	13.00
Annual. volatility (%)	10.82	10.99	11.05	10.73	11.06	11.70	10.53
Annual. Sharpe ratio	1.05	1.05	1.21	1.24	1.14	1.04	1.19
Score	4.83	8.38	6.37	9.06	6.77	7.66	9.88
Efficiency measure	0.75	0.90	0.89	1.04	0.88	0.85	1.06
Gain in Efficiency	–	0.16	0.16	0.23	0.16	0.11	0.13
Panel B: Europe							
2007–2012							
Annual. Return (%)	1.93	3.44	2.84	2.54	2.99	3.68	4.05
Annual. volatility (%)	24.18	24.51	24.53	24.17	24.83	24.26	24.46
Annual. Sharpe ratio	0.04	0.10	0.08	0.07	0.08	0.11	0.13
Score	7.07	9.56	7.71	8.02	8.04	8.24	8.89
Efficiency measure	0.17	0.25	0.20	0.20	0.20	0.23	0.24
Gain in Efficiency	–	0.08	0.05	0.05	0.05	0.07	0.08
2013–2018							
Annual. Return (%)	4.66	8.13	9.23	6.99	8.84	7.78	7.16
Annual. volatility (%)	13.08	13.22	12.78	12.63	13.07	12.79	12.37
Annual. Sharpe ratio	0.32	0.58	0.68	0.52	0.64	0.57	0.54
Score	6.52	9.55	7.07	9.18	7.49	8.40	9.94
Efficiency measure	0.41	0.65	0.62	0.62	0.61	0.61	0.67
Gain in Efficiency	–	0.24	0.25	0.21	0.26	0.22	0.16
Panel C: Pacific							
2007–2012							
Annual. Return (%)	1.04	2.00	1.69	2.18	1.59	2.30	2.53
Annual. volatility (%)	18.97	18.43	19.08	19.23	18.80	19.12	18.91
Annual. Sharpe ratio	0.00	0.06	0.04	0.06	0.03	0.07	0.08
Score	5.83	9.17	7.42	7.84	7.59	7.44	8.63
Efficiency measure	0.16	0.28	0.21	0.24	0.22	0.23	0.27
Gain in Efficiency	–	0.12	0.06	0.08	0.07	0.08	0.10
2013–2018							
Annual. Return (%)	6.03	7.67	7.32	7.03	7.00	6.67	8.03
Annual. volatility (%)	12.22	12.17	11.52	12.11	12.30	11.51	12.38
Annual. Sharpe ratio	0.46	0.59	0.59	0.54	0.53	0.54	0.61
Score	5.58	8.79	6.58	8.45	7.28	7.65	9.94
Efficiency measure	0.46	0.66	0.58	0.62	0.56	0.60	0.71
Gain in Efficiency	–	0.20	0.14	0.15	0.14	0.14	0.14

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Table 3 (Continued)

	Bench. w, score	IAA score	WA score	E score	S score	G score	Carbon score
Panel D: Emerging countries							
2007–2012							
Annual. Return (%)	9.29	11.43	11.11	10.82	11.70	10.19	10.81
Annual. volatility (%)	27.85	27.11	27.41	27.52	27.17	27.24	28.05
Annual. Sharpe ratio	0.30	0.39	0.37	0.36	0.40	0.34	0.35
Score	4.48	6.35	5.84	5.83	6.11	6.08	5.55
Efficiency measure	0.23	0.31	0.29	0.28	0.31	0.28	0.27
Gain in Efficiency	–	0.08	0.05	0.05	0.07	0.04	0.04
2013–2018							
Annual. Return (%)	2.34	4.37	5.51	3.28	4.54	2.85	0.84
Annual. volatility (%)	14.63	14.93	15.00	15.26	14.68	14.09	15.65
Annual. Sharpe ratio	0.13	0.26	0.34	0.18	0.28	0.17	0.02
Score	4.46	6.88	5.58	7.16	5.99	6.59	7.76
Efficiency measure	0.21	0.36	0.35	0.33	0.34	0.32	0.26
Gain in Efficiency	–	0.15	0.14	0.10	0.13	0.09	-0.02
Panel E: No regional restriction							
2007–2012							
Annual. Return (%)	3.33	3.70	3.99	2.29	4.84	5.19	3.77
Annual. volatility (%)	20.28	19.85	19.76	19.64	19.81	19.42	20.05
Annual. Sharpe ratio	0.12	0.14	0.15	0.07	0.20	0.22	0.14
Score	5.84	9.27	7.51	7.86	7.61	7.85	8.79
Efficiency measure	0.20	0.30	0.27	0.23	0.29	0.31	0.29
Gain in Efficiency	–	0.10	0.07	0.03	0.09	0.11	0.08
2013–2018							
Annual. Return (%)	8.02	8.34	9.75	9.09	8.75	9.27	7.41
Annual. volatility (%)	10.75	10.96	10.77	10.72	11.14	11.08	10.97
Annual. Sharpe ratio	0.69	0.72	0.86	0.80	0.74	0.79	0.63
Score	5.31	8.94	6.57	8.87	6.85	7.59	9.87
Efficiency measure	0.59	0.77	0.74	0.82	0.68	0.74	0.77
Gain in Efficiency	–	0.18	0.16	0.19	0.13	0.15	0.04
Panel F: With regional restriction							
2007–2012							
Annual. Return (%)	3.33	3.04	3.55	2.64	4.08	4.44	3.37
Annual. volatility (%)	20.28	19.87	19.60	19.63	19.82	19.50	19.95
Annual. Sharpe ratio	0.12	0.10	0.13	0.09	0.16	0.18	0.12
Score	5.84	9.17	7.47	7.83	7.54	7.81	8.72
Efficiency measure	0.20	0.28	0.26	0.24	0.27	0.29	0.28
Gain in Efficiency	–	0.08	0.06	0.04	0.07	0.09	0.07
2013–2018							
Annual. Return (%)	8.02	8.54	10.17	9.36	8.81	9.65	7.23
Annual. volatility (%)	10.75	10.90	10.71	10.84	10.92	11.29	10.92
Annual. Sharpe ratio	0.69	0.74	0.90	0.82	0.76	0.81	0.62
Score	5.31	8.74	6.49	8.85	6.75	7.52	9.87
Efficiency measure	0.59	0.77	0.76	0.82	0.69	0.74	0.76
Gain in Efficiency	–	0.18	0.18	0.19	0.14	0.15	0.03

Note: The table reports summary statistics on the portfolios based on score maximization for the industry-adjusted average (IAA), weighted average (WA), environmental (E), social (S), governance (G), and Carbon scores. See Table 1 for the definition of the statistics. Column 1 corresponds to the portfolio of all firms in the benchmark with a score for the region considered.

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Table 4: Characteristics of Portfolios Based on Turnover Minimization

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel A: United States							
Annual. Return (%)	7.94	7.72	7.89	7.04	7.89	8.68	7.92
Annual. volatility (%)	14.81	14.81	15.83	15.13	14.82	15.36	14.84
Annual. Sharpe ratio	0.49	0.47	0.45	0.42	0.48	0.52	0.49
Annual. tracking error (%)	–	2.39	3.69	2.91	2.80	3.09	2.38
Annual. turnover (%)	9.38	14.72	148.33	52.17	60.83	127.12	135.32
Industry-adjusted score	5.05	7.04	8.31	6.87	7.08	6.48	6.20
Weighted score	5.05	6.00	6.91	6.06	6.16	5.82	5.58
E score	5.74	6.73	7.48	7.73	6.22	6.23	6.55
S score	4.79	5.65	6.50	5.36	6.76	5.28	5.19
G score	5.45	6.13	6.76	6.07	6.16	7.36	5.84
Carbon score	6.98	7.80	8.03	8.19	7.56	7.35	8.74
Efficiency measure	0.41	0.47	0.44	0.46	0.47	0.50	0.54
SR Gain in Efficiency	–	-0.01	-0.02	-0.03	0.00	0.02	0.00
ESG Gain in Efficiency	–	0.07	0.05	0.06	0.07	0.06	0.06
Ex post risk factor exposures							
Market	0.986*	0.975*	1.000*	0.981*	0.959*	0.995*	0.977*
SMB	-0.023*	-0.043	0.100*	0.001	0.030	0.030	-0.055
HML	0.007	0.036	-0.013	0.034	-0.007	-0.045	0.066*
Panel B: Europe							
Annual. Return (%)	3.30	4.95	5.95	4.29	3.85	5.38	5.02
Annual. volatility (%)	19.34	19.35	19.87	19.61	19.59	19.46	19.55
Annual. Sharpe ratio	0.13	0.22	0.26	0.18	0.16	0.24	0.22
Annual. tracking error (%)	–	2.34	3.88	3.32	2.88	2.98	2.51
Annual. turnover (%)	9.82	20.69	160.42	89.02	85.19	108.38	161.92
Industry-adjusted score	6.79	8.78	9.37	8.17	8.60	8.47	7.56
Weighted score	5.80	6.80	7.55	6.77	6.94	6.77	6.22
E score	6.42	7.33	7.94	8.33	7.14	7.05	7.01
S score	5.52	6.54	7.31	6.12	7.44	6.23	5.85
G score	6.13	7.00	7.60	6.65	6.80	8.06	6.42
Carbon score	7.89	8.26	8.44	8.43	8.06	8.03	9.39
Efficiency measure	0.24	0.34	0.32	0.30	0.27	0.33	0.35
SR Gain in Efficiency	–	0.04	0.06	0.02	0.01	0.05	0.04
ESG Gain in Efficiency	–	0.05	0.04	0.05	0.05	0.05	0.04
Ex post risk factor exposures							
Market	0.992*	0.990*	1.006*	0.998*	0.992*	1.002*	0.997*
SMB	-0.047*	0.011	0.078	0.062	-0.015	0.024	0.009
HML	0.016	-0.023	-0.055	-0.052	0.009	-0.072*	-0.012

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Table 4 (Continued)

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel C: Pacific							
Annual. Return (%)	3.55	3.68	4.84	4.00	3.67	4.16	5.44
Annual. volatility (%)	15.90	15.59	16.16	15.78	15.72	16.09	15.71
Annual. Sharpe ratio	0.18	0.19	0.26	0.21	0.19	0.21	0.30
Annual. tracking error (%)	–	2.24	3.97	2.56	2.99	3.16	2.59
Annual. turnover (%)	8.85	14.66	164.07	48.92	72.54	111.35	106.24
Industry-adjusted score	5.71	7.71	8.73	7.52	7.70	7.28	6.99
Weighted score	5.34	6.21	7.13	6.39	6.54	6.18	6.02
E score	5.80	6.81	7.59	7.77	6.58	6.26	6.72
S score	5.20	6.07	7.03	5.80	7.16	5.80	5.74
G score	5.45	6.13	6.75	6.07	6.11	7.38	5.93
Carbon score	7.25	7.98	8.25	8.36	7.56	7.55	9.08
Efficiency measure	0.16	0.16	0.16	0.16	0.16	0.16	0.16
SR Gain in Efficiency	–	0.01	0.04	0.01	0.00	0.02	0.06
ESG Gain in Efficiency	–	0.07	0.05	0.06	0.06	0.06	0.06
Ex post risk factor exposures							
Market	1.016*	0.984*	0.982*	0.982*	0.977*	0.999*	0.991*
SMB	0.051*	0.100*	0.197*	0.201*	0.207*	0.121*	0.099
HML	0.051*	0.076*	-0.032	0.015	0.069*	0.019	0.114*
Panel D: Emerging countries							
Annual. Return (%)	5.79	7.94	6.47	7.14	8.80	5.21	6.13
Annual. volatility (%)	22.14	21.73	22.37	21.74	21.64	22.10	22.76
Annual. Sharpe ratio	0.23	0.33	0.26	0.30	0.37	0.20	0.24
Annual. tracking error (%)	–	3.50	6.68	5.33	4.78	5.34	4.66
Annual. turnover (%)	27.63	84.82	173.71	108.96	209.25	173.51	193.67
Industry-adjusted score	4.47	6.47	7.39	6.12	6.45	5.92	5.62
Weighted score	4.68	5.56	6.29	5.60	5.75	5.44	5.31
E score	4.84	5.69	6.43	6.72	5.41	5.43	5.74
S score	4.63	5.53	6.21	5.23	6.57	5.17	5.04
G score	4.79	5.69	6.29	5.35	5.56	6.69	5.25
Carbon score	5.53	4.29	4.65	4.57	4.31	4.21	7.40
Efficiency measure	0.99	1.01	0.99	1.00	1.01	0.99	1.02
SR Gain in Efficiency	–	0.05	0.01	0.03	0.07	-0.01	0.00
ESG Gain in Efficiency	–	0.05	0.03	0.05	0.05	0.04	0.04
Ex post risk factor exposures							
Market	0.981*	0.948*	0.935*	0.918*	0.927*	0.937*	0.966*
SMB	0.311*	0.352*	0.287*	0.346*	0.346*	0.336*	0.327*
HML	0.152*	0.141*	0.191*	0.177*	0.153*	0.173*	0.228*

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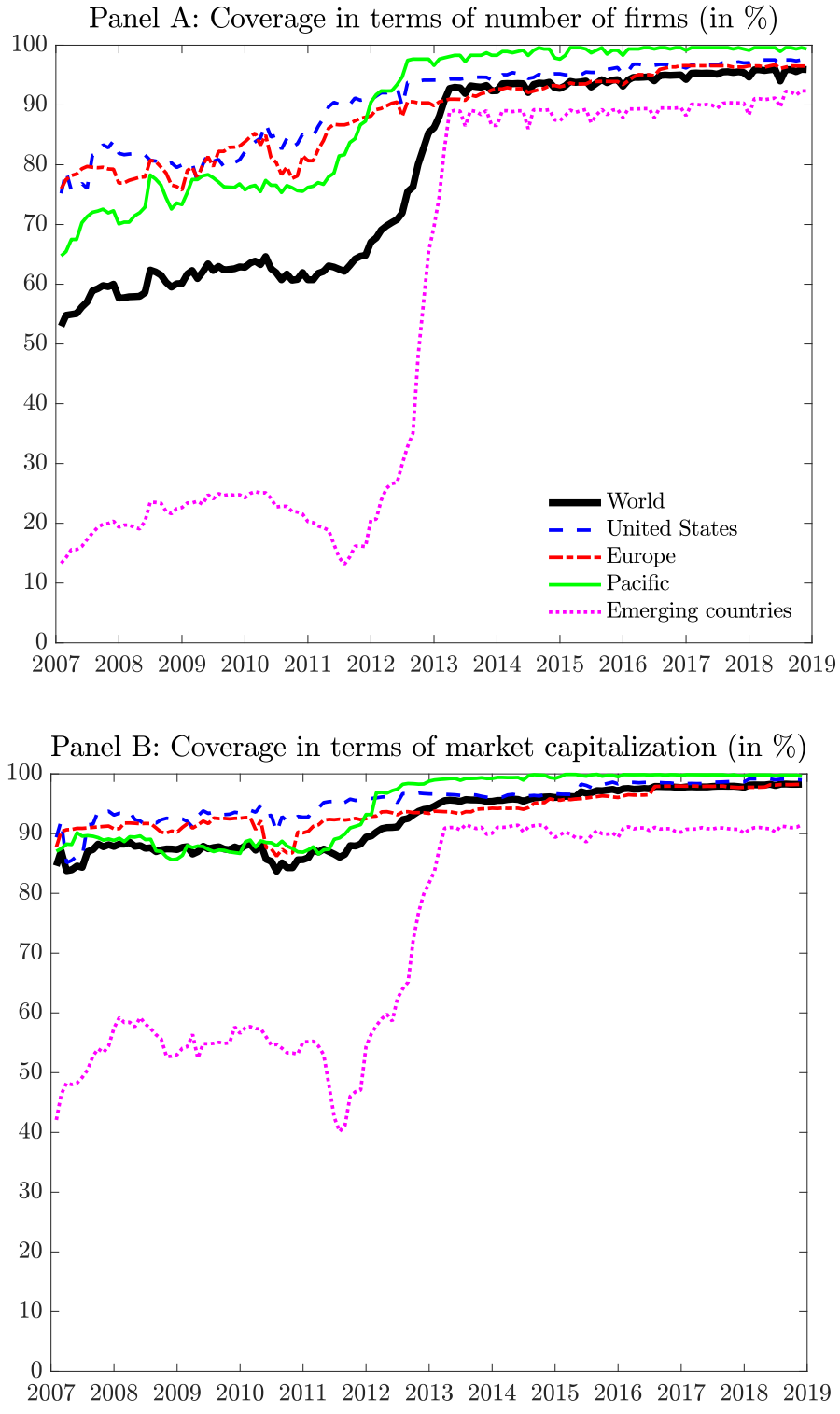
Table 4 (Continued)

	Bench. w. score	IAA score	WA score	E score	S score	G score	Carbon score
Panel E: ACWI – No regional restriction							
Annual. Return (%)	5.70	5.89	6.49	6.17	7.25	7.11	5.26
Annual. volatility (%)	16.15	15.68	15.74	15.87	15.81	15.89	15.83
Annual. Sharpe ratio	0.31	0.33	0.37	0.34	0.41	0.40	0.29
Annual. tracking error (%)	–	2.53	3.17	2.59	3.02	2.94	2.59
Annual. turnover (%)	10.52	20.39	157.02	44.08	77.47	119.83	153.98
Industry-adjusted score	5.57	7.57	9.01	7.46	7.99	7.61	6.65
Weighted score	5.27	6.21	7.18	6.34	6.59	6.31	5.76
E score	5.82	6.93	7.70	7.81	6.83	6.68	6.74
S score	5.05	5.86	6.74	5.72	7.02	5.79	5.36
G score	5.60	6.20	7.13	6.18	6.30	7.52	5.86
Carbon score	7.18	8.08	8.48	8.46	8.01	7.86	8.94
Efficiency measure	0.22	0.31	0.27	0.30	0.34	0.25	0.28
SR Gain in Efficiency	–	0.01	0.03	0.02	0.05	0.05	-0.01
ESG Gain in Efficiency	–	0.07	0.07	0.07	0.07	0.06	0.06
Regional exposures							
United States	47.45	40.17	30.47	38.60	42.71	36.12	35.44
Europe	26.04	34.10	46.02	36.76	33.68	39.07	38.55
Pacific	13.34	15.33	14.05	17.51	14.48	12.66	14.49
Emerging countries	7.54	6.38	2.62	3.86	3.86	4.35	4.13
Ex post risk factor exposures							
Market	0.993*	0.955*	0.950*	0.959*	0.948*	0.972*	0.964*
SMB	-0.062*	-0.164*	-0.061	-0.100*	-0.057	-0.143*	-0.167*
HML	-0.017	0.105*	-0.014	0.081*	0.054	-0.010	0.092*
Panel F ACWI – With regional restrictions							
Annual. Return (%)	5.70	6.15	6.89	5.96	6.93	7.60	4.80
Annual. volatility (%)	16.15	15.62	15.75	15.80	15.69	15.93	15.70
Annual. Sharpe ratio	0.31	0.35	0.39	0.33	0.40	0.43	0.26
Annual. tracking error (%)	–	2.48	2.91	2.54	2.95	2.75	2.46
Annual. turnover (%)	10.52	21.55	174.82	44.56	84.78	142.32	155.34
Industry-adjusted score	5.57	7.57	8.86	7.43	7.89	7.44	6.63
Weighted score	5.27	6.21	7.13	6.33	6.54	6.23	5.75
E score	5.82	6.92	7.71	7.81	6.77	6.65	6.75
S score	5.05	5.86	6.74	5.70	7.02	5.70	5.33
G score	5.60	6.17	6.96	6.13	6.29	7.50	5.85
Carbon score	7.18	8.10	8.41	8.45	7.86	7.78	8.95
Efficiency measure	0.21	0.34	0.34	0.36	0.37	0.38	0.40
SR Gain in Efficiency	–	0.02	0.04	0.01	0.04	0.06	-0.02
ESG Gain in Efficiency	–	0.07	0.06	0.07	0.07	0.06	0.06
Regional exposures							
United States	47.45	44.16	44.18	44.18	46.48	44.33	43.84
Europe	26.04	29.99	30.68	30.45	29.97	29.97	29.98
Pacific	13.34	15.30	14.39	17.42	13.91	12.43	13.57
Emerging countries	7.54	6.30	3.53	4.25	3.80	4.58	4.97
Ex post risk factor exposures							
Market	0.993*	0.953*	0.956*	0.954*	0.944*	0.977*	0.954*
SMB	-0.062*	-0.166*	-0.086*	-0.078*	-0.058	-0.150*	-0.094*
HML	-0.017	0.097*	-0.006	0.062	0.036	-0.022	0.043

Note: The table reports summary statistics on the portfolios based on turnover minimization for the industry-adjusted average (IAA), weighted average (WA), environmental (E), social (S), governance (G), and Carbon scores. See Table 1 for the definition of the statistics. Column 1 corresponds to the portfolio of all firms in the benchmark with a score for the region considered. * denotes significance at the 5% confidence level.

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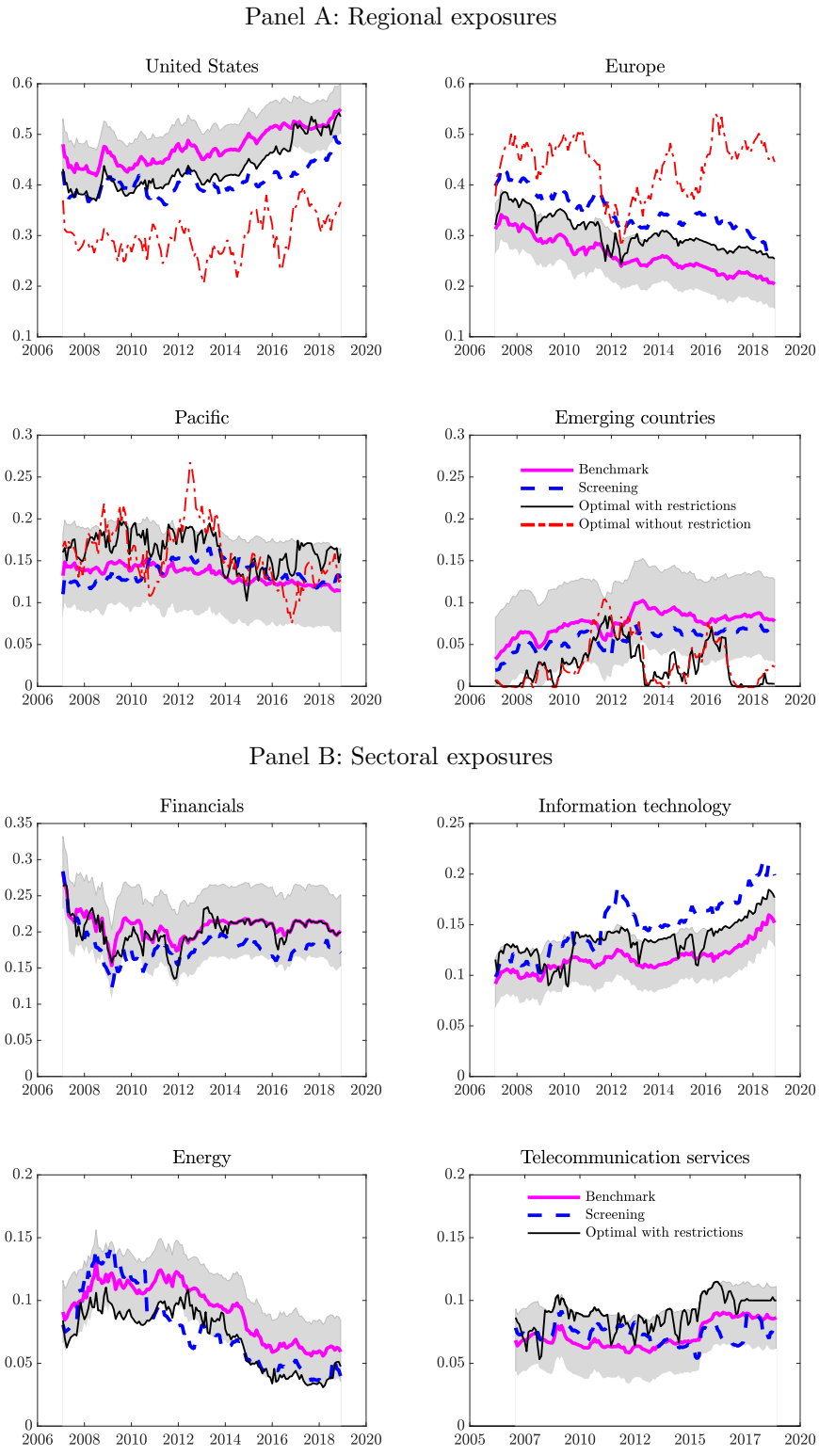
Figure 1: Coverage of the Regional MSCI Standard Indexes by Firms with an ESG Score



Note: The figure reports the temporal evolution of the coverage of firms belonging to a given regional MSCI index by firms with an ESG score. MSCI indexes correspond to the World (ACWI index), the United States, Europe, Pacific, and Emerging countries.

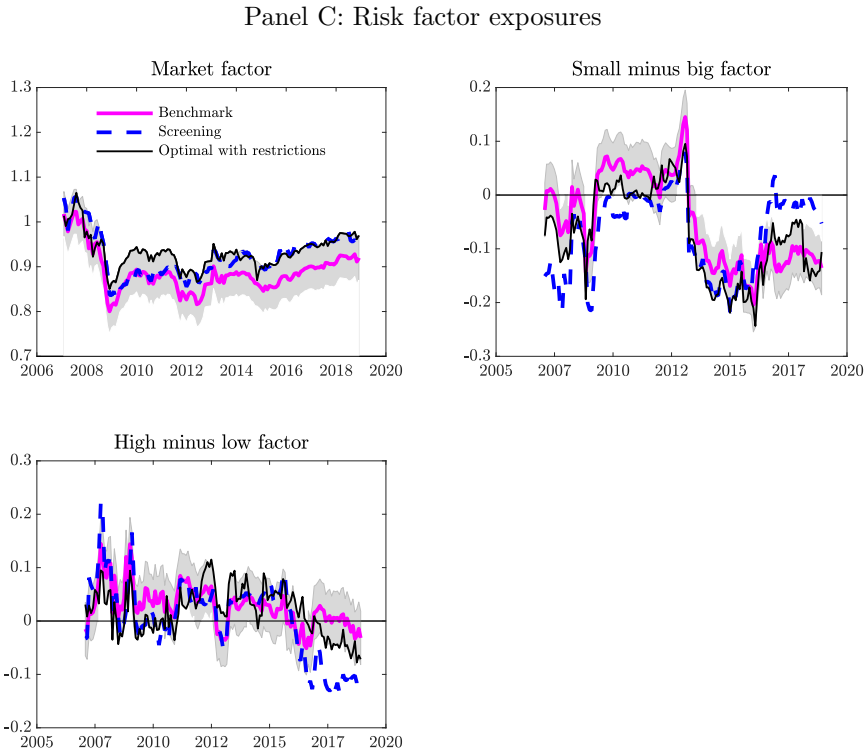
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Figure 2: Temporal Evolution of Risk Exposures – ACWI – IAA Score



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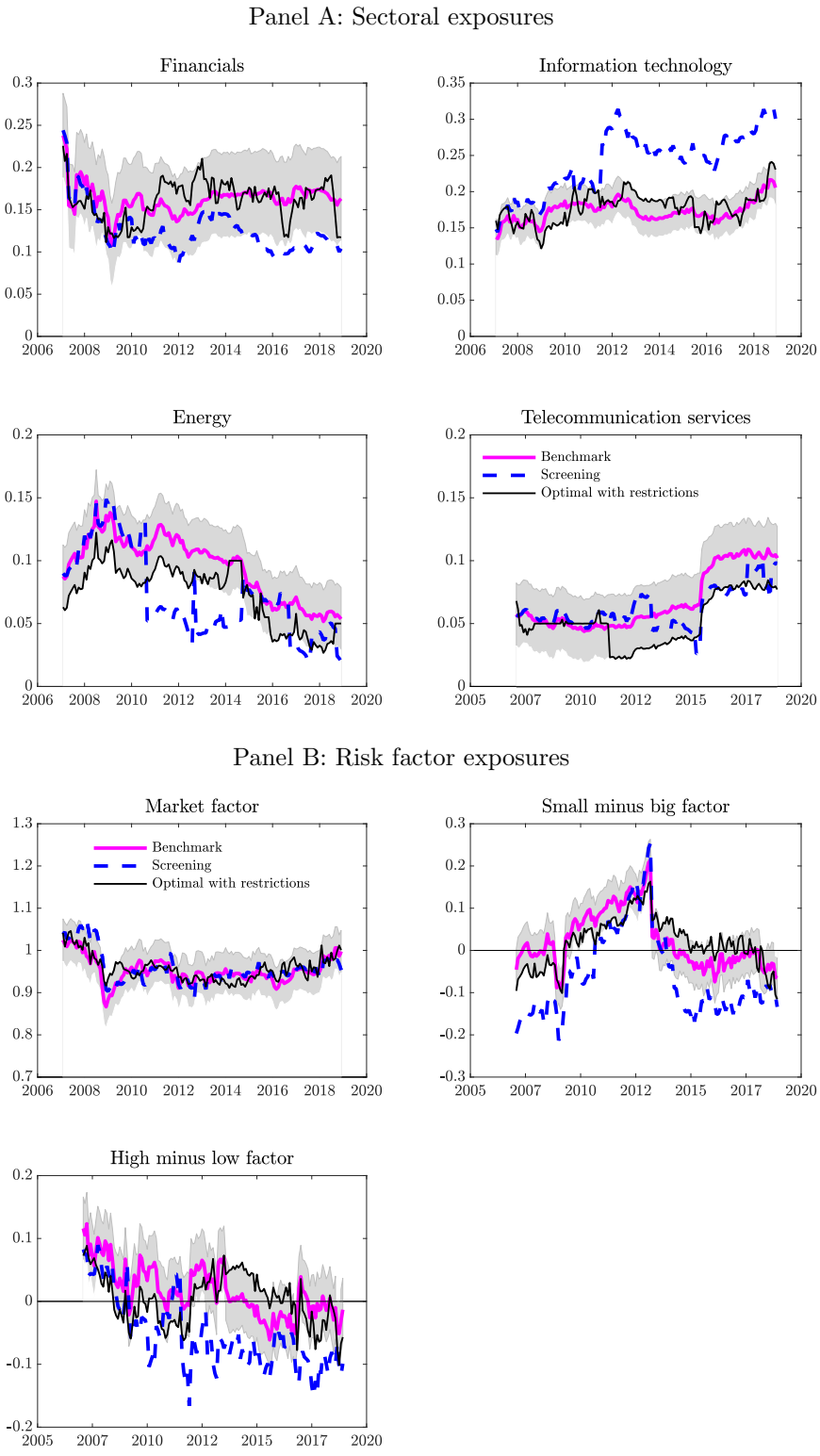
Figure 2: Temporal Evolution of Risk Exposures – ACWI – IAA score (Continued)



Note: The figure reports the temporal evolution of the risk exposures in the worldwide investment set for the allocation based on the industry-adjusted average score. Panels A, B, and C correspond to the regional, sectoral, and risk factor exposures, respectively. The optimization is based on score maximization.

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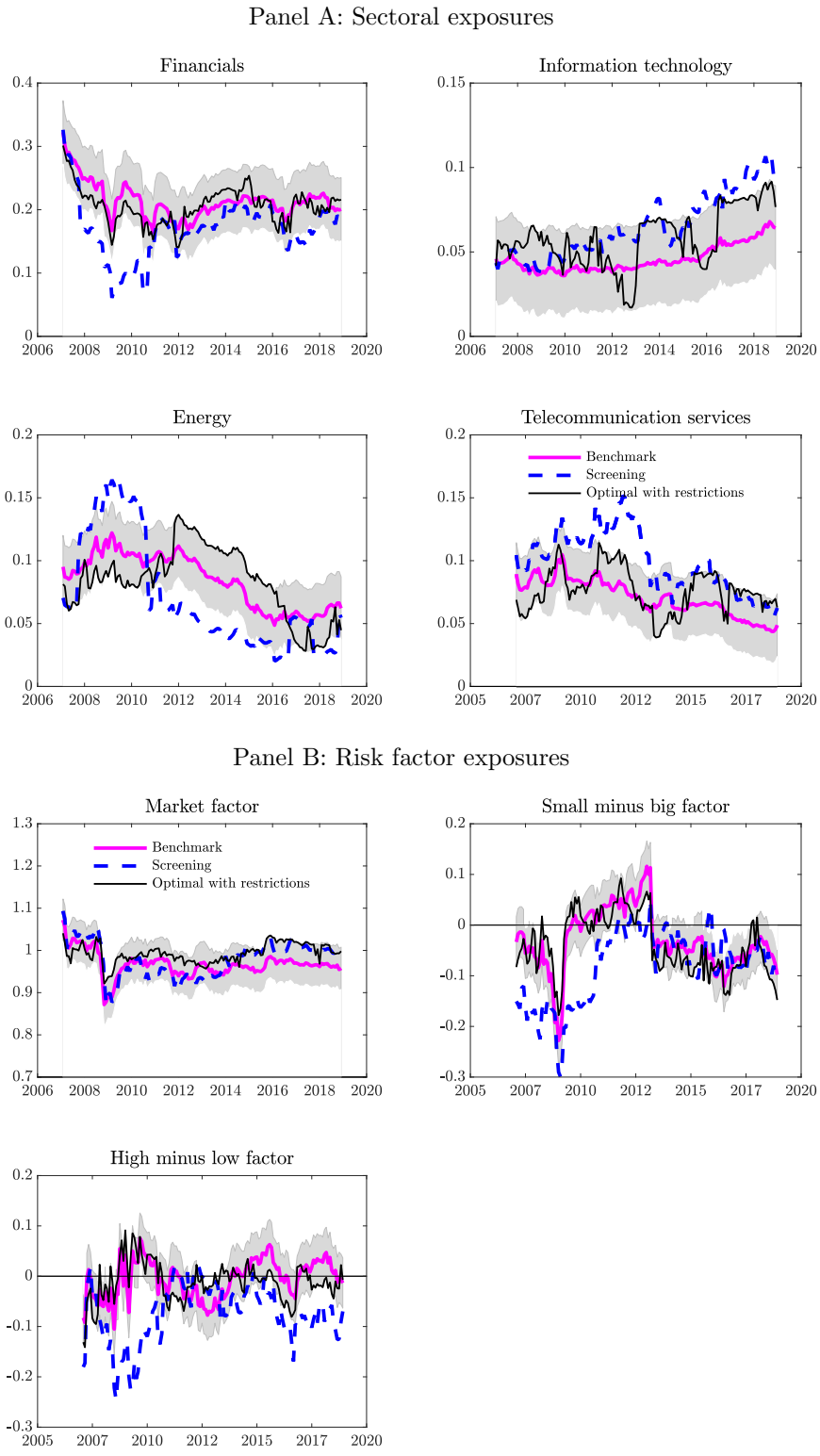
Figure 3: Temporal Evolution of Risk Exposures – United States – IAA Score



Note: The figure reports the temporal evolution of the risk exposures in the U.S. investment set for the allocation based on the industry-adjusted average score. Panels A and B correspond to the sectoral and risk factor exposures, respectively. The optimization is based on score maximization.

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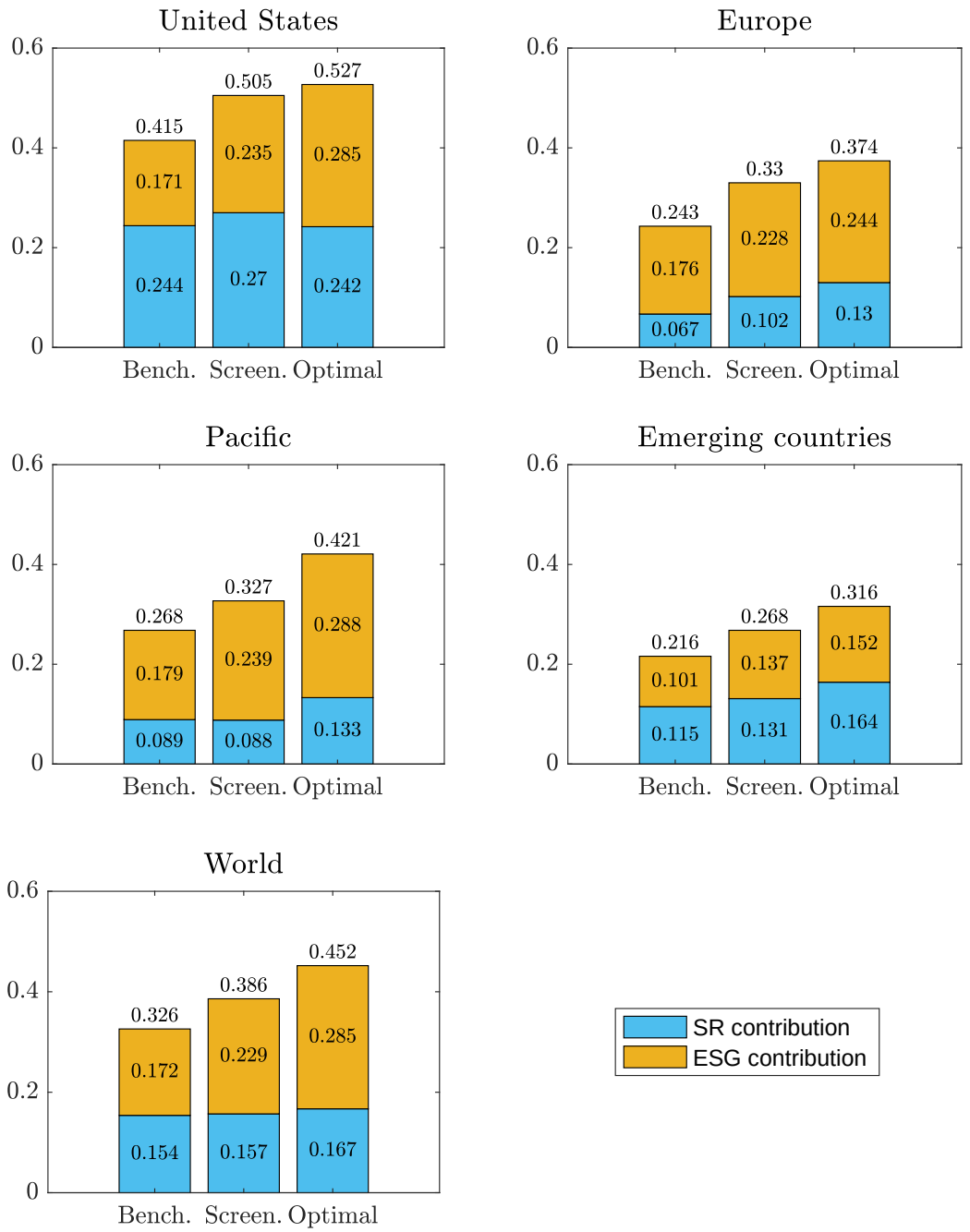
Figure 4: Temporal Evolution of Risk Exposures – Europe – IAA Score



Note: The figure reports the temporal evolution of the risk factor weights in the European investment set for the allocation based on the industry-adjusted average score. Panels A and B correspond to the sectoral and risk factor exposures, respectively. The optimization is based on score maximization.

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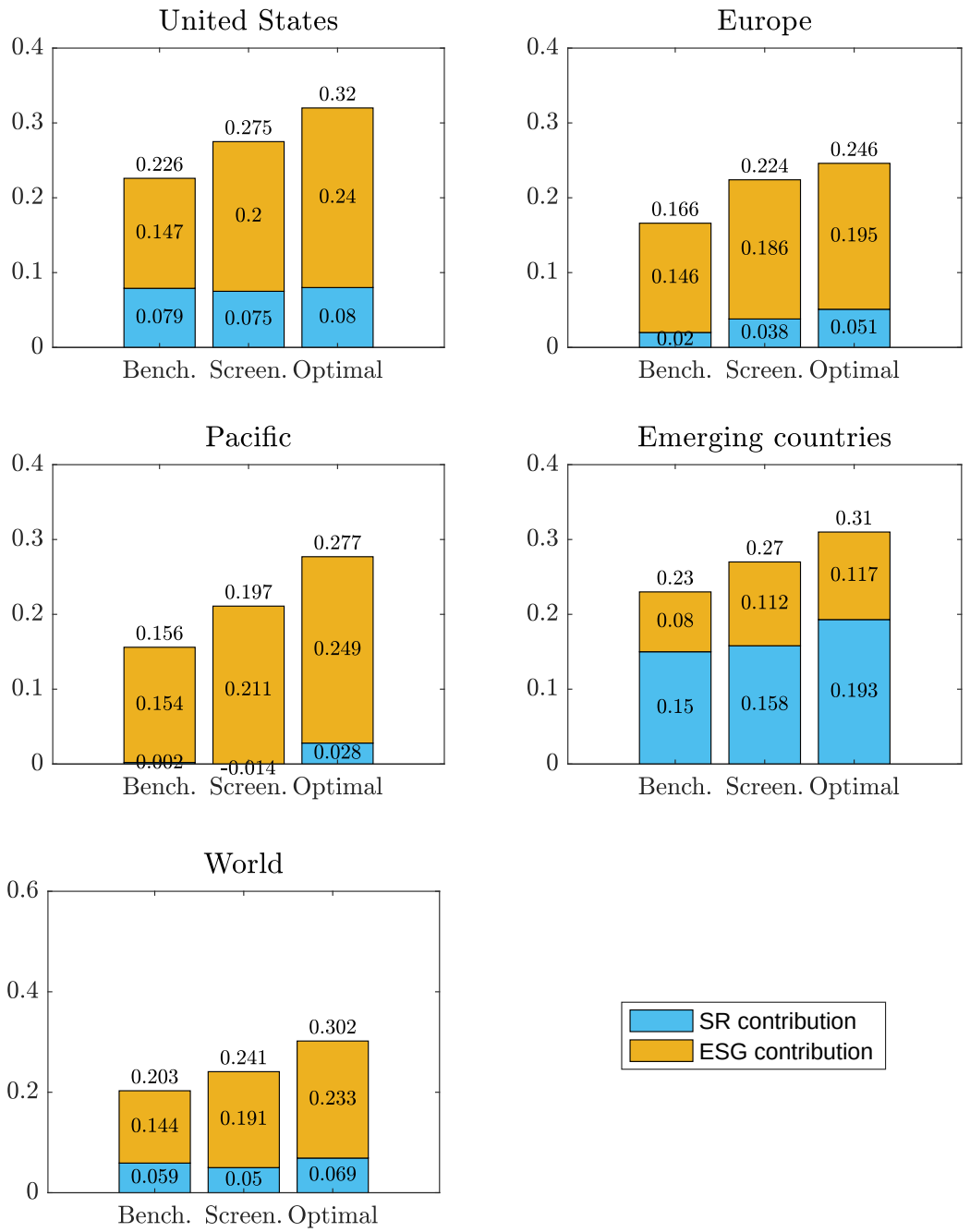
Figure 5: Efficiency Measure and its Contributions – IAA Score (2007–2018)



Note: The figure reports the efficiency measure and the contribution of the Sharpe ratio and the ESG quality for the allocation based on the industry-adjusted average score over the 2007–2018 sample. The optimization is based on score maximization.

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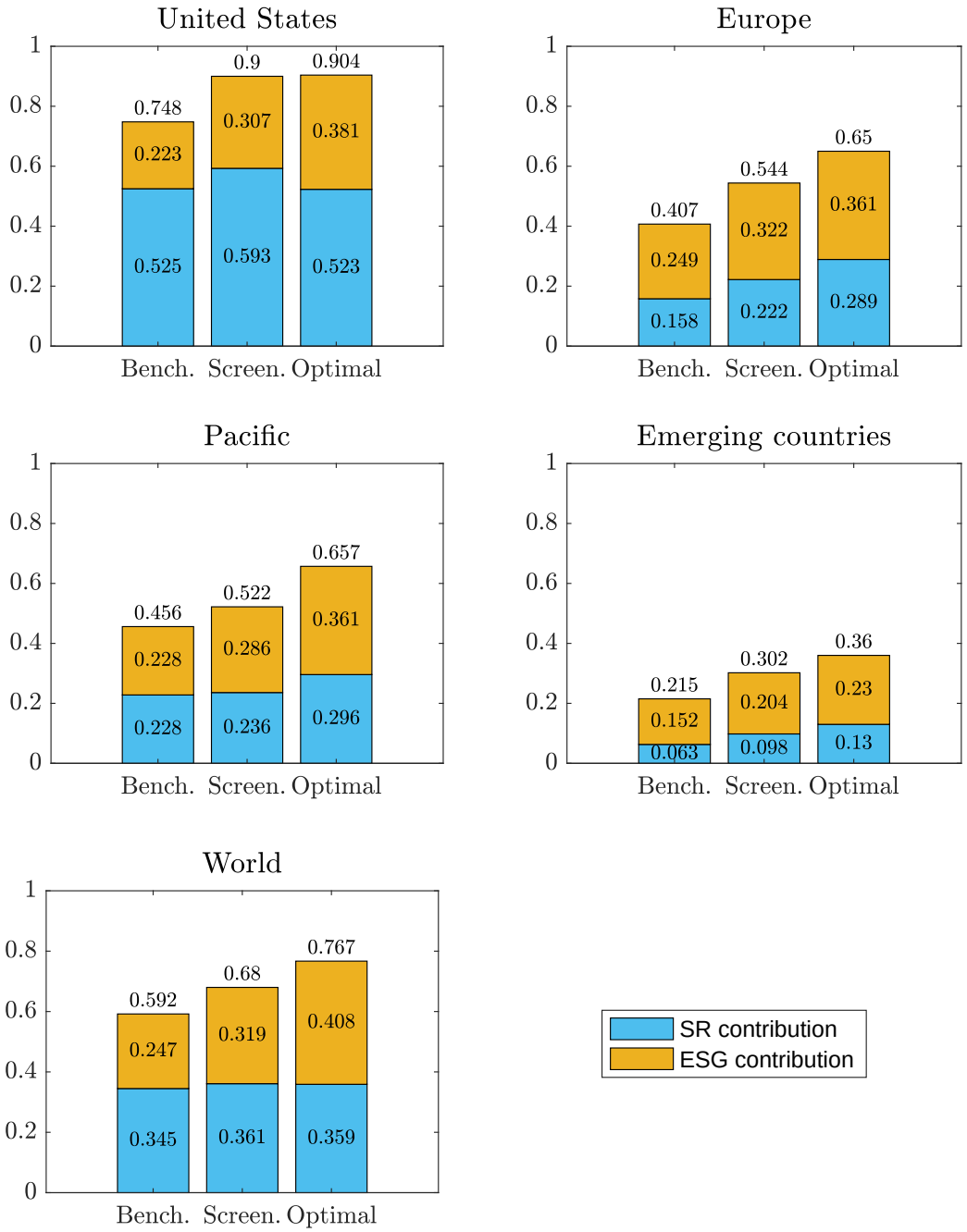
Figure 6: Efficiency Measure and its Contributions – IAA Score (2007–2012)



Note: The figure reports the efficiency measure and the contribution of the Sharpe ratio and the ESG quality for the allocation based on the industry-adjusted average score over the 2007–2012 sample. The optimization is based on score maximization.

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Figure 7: Efficiency Measure and its Contributions – IAA Score (2013–2018)



Note: The figure reports the efficiency measure and the contribution of the Sharpe ratio and the ESG quality for the allocation based on the industry-adjusted average score over the 2013–2018 sample. The optimization is based on score maximization.

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