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CARBON EMISSIONS AND ASSET MANAGEMENT

Ashwin Alankar[a] *and Myron Scholes*[a,b]

Two common methods that portfolio managers use to reduce the carbon footprint of their portfolios are either to exclude carbon emitters from their portfolios or to engage/cajole underlying companies to reduce their carbon footprint by taking actions to reduce emissions. We estimate the costs of excluding carbon emitters from a portfolio. We highlight the costs and benefits of a third alternative that seeks to preserve the separation principle such that managers select their optimal portfolio based on return and risk optimizations, and separately incur transaction costs to satisfy investors' demands toward "net zero" by purchasing carbon credits to offset the carbon footprint of their optimal portfolios. By doing so, although the composition of the portfolio may contain carbon emitters, the portfolio itself is carbon neutral. To acquire these carbon credits efficiently either directly or in secondary markets requires asset management skills. We believe that investors in mutual funds or ETFs would determine their own preferences toward carbon "net zero" by buying a combination of a fund that offsets fully emissions of the companies in the underlyingportfolioandanother(acloneoftheother)thatdidnot.

1 Introduction

The Environmental, Social and Governance (ESG) movement has encouraged firms to internalize the cost of their carbon emissions by changing their production methods and by making new investments to mitigate carbon emissions. This is not an immediate process for most firms, however, for new methods need to be invented and implemented efficiently. Moreover, many existing production methods cannot be abandoned immediately and replaced by non-existent carbon-free alternatives. Obviously, to do so might take many years as society either develops alternative energy sources or the demand for oil or coal falls because of the implementation of less expensive alternatives such as nuclear, solar, wind, hydrogen or hydro power. Moreover, once produced, the new energy sources must be stored and transmitted to match demand and supply. New investments must be made in myriad approaches. (For example, see reports from Ren21, 2022; Smil, 2022).

[a]Janus Henderson Investors, Inc., CO 80206, USA.
[b]Stanford University, CA 94305, USA.

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Many firms such as Exxon and Chevron[1] are investing in offsets such as carbon capture and other technologies to reduce their net carbon imprint while at the same time investing to provide alternative energy substitutes. Since many new technologies or methods are readily transferable to or duplicated by competitors, individual firms potentially save on costs to conduct their own research that might be duplicative of others—research by one benefits many. On the negative side, the good-citizen firm might incur costs to change emitting technologies and produce lower carbon substitutes while losing out through lower prices charged by the competitor shirking bad-citizen firm.

Most economists would argue that governments should encourage development and implementation of carbon reducing technology by imposing a form of carbon taxes on carbon emitters.[2] Carbon taxes are a penalty or stick to encourage change. One problem, however, is the distribution of the tax revenue. A more efficient approach, however, might be to combine the tax with a credit system. That is, instead of only penalizing old systems, encourage new approaches through granting credits for developing and implementing technologies that reduce CO_2 emissions to offset the tax.[3] These technological changes are forms of white credits that would be used to reduce net carbon by firms producing them. This is a form of an offset.[4] Firms in the US and Europe report estimates of their net carbon emissions that can be used to reward credits. These estimates are readily available in annual reports and from services such as Bloomberg.[5]

What routes are most effective for portfolio managers to take to address clientele demands to foster more green technology? We argue that portfolio managers should realize that the carbon offset market is broader than the white carbon offset generation of their underlying portfolio companies. The carbon offset market also involves investing in green technology such as planting new forests or stopping the cutting of old forests. It involves blue carbon, which uses the ocean and plants in the ocean to enhance and build carbon capture. These go hand in hand with white carbon methods to reduce carbon emissions. These carbon offsets are used internally by firms to reduce their net carbon emissions and are sold in the market to others as carbon credits. These credits can be applied to reduce residual carbon usage net of white offsets or the carbon usage of firms whose transition toward newer technologies is very costly and hence limited currently. The carbon offset market can allow for a smoother transition toward white credits, rather than penalizing companies toward a "corner solution." Jefferies, for example, believes "the voluntary carbon market is essential for achieving net zero."

There is a ready market for carbon credits. That is, entities that might be more efficient at producing carbon offsets by planting forests, for example, might sell their credits to firms that produce goods and services resulting in carbon emissions. This is another example of the division of labor and the outsourcing of production to more efficient producers. For example, Chevron recently launched its first carbon offset project reforesting thousands of acres in Louisiana by collaborating with the Restore the Earth Foundation, that has much more expertise and experience in reforestation than Chevron.[6] Portfolio managers value securities based on market prices. Carbon offsets are priced in the carbon credit markets and available credits create a viable path for portfolio managers to efficiently decarbonize the net emissions of the underlying securities in their portfolios, just as companies like Chevron do.[7]

Markets align incentives and this compatibility is an extremely powerful force to realize "net

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zero" ambitions. The price of credits change as the demand and supply of credits change. As the price of carbon credits increases, there is an incentive for those with skills to develop more offset projects to meet demand. There is a corresponding penalty for those who are emitting carbon and using credit offsets to reduce net carbon emissions for the price increase is akin to a tax increase. This encourages more research and development. Both are net benefits to a society to internalize the costs of the carbon offset externality and to encourage the development of more offsets.

Furthermore, the carbon credit market has expanded beyond the spot market to a futures market that provides hedging and risk transfer mechanisms. Given uncertain changes in credit pricing, these markets facilitate the hedging demands of credit producers and buyers.

Without measurement and verification issues, changing production technologies or developing alternative carbon credit sources at the margin are perfect substitutes to reduce global net carbon emissions. Some, however, disagree with this for they argue that buying carbon credits and relying on a net carbon standard is a slippery way to balance the production of CO_2. They want only the penalty and not the incentive to affect change.[8] The goal, however, is to reduce net carbon emissions to slow and reverse global warming using either white, green, or blue carbon alternatives. Global warming is global and not the sole province of publicly listed companies.

Given that companies still report (or produce) the generation of CO_2 emissions, what should portfolio managers do, if anything, to reduce carbon emissions of their portfolio holdings? One approach is to ignore the carbon content of the portfolio and to optimize the portfolio on risk and return considerations. This is the unconstrained approach. The manager will exclude firms that are expected to underperform significantly, which could include carbon emitters. An alternative approach is to constrain the portfolio to not exceed a given level of carbon emissions or to exclude carbon-emitting firms from the universe of securities that might be included in the portfolio and/or engage with companies to change their operations to be more climate friendly. We study an alternative competing approach that might dominate or be part of the arsenal used by portfolio managers; that is, buying carbon credits to offset the residual carbon emissions of its investment portfolio.[9] We estimate the benefits and costs of this alternative compared to constraining the portfolio's composition or cajoling underlying companies to reduce carbon emissions.

2 The Role of Portfolio Managers

One portfolio management approach is not to alter portfolio composition, regardless of the net carbon emissions of the constituent firms in the portfolio. In this group we find the passive index funds for example, but also include those active funds who do not subscribe to any form of impact investing. These passive investment managers are long changes in economic risks and do not underweight carbon-emitting stocks.

Some large passive portfolio providers such as Blackrock[10] cajole their portfolio companies to move faster to decarbonize.[11] The success of their efforts, however, are hard to measure. And in fact, they are receiving pushback from investors and regulators who prefer that they provide passive investment services and do not overclaim success in reducing portfolio emissions.[12]

The literature and practitioners have argued that managers should exclude stocks deemed to be carbon emitters such as coal, oil, and gas producers from their portfolios.[13] Following this approach constrains the composition of portfolios. This points to the obvious conclusion that there might be a cost to this constraint, an implicit cost in

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lost returns or in excess uncompensated volatility of uncertain and changing magnitudes.[14] Furthermore, there is no convincing evidence that exclusion leads to positive change (for example, Berk and van Binsbergen, 2022). If there were a cost, not all investors would agree to incur it, especially if the benefits are unclear.

We would like to introduce or argue for the net advantages of a new approach for those investors who are willing to incur a known cost for a known benefit and to create incentives to produce carbon offsets and construct investment portfolios that are carbon neutral. We argue that portfolio managers construct an optimal unconstrained portfolio of assets (i.e., maximize expected reward for a level of risk). This portfolio would be bought by those investors who are indifferent to carbon emissions. The next step would be to create a "green" version of this portfolio that also buys carbon credits to neutralize the net carbon emissions of the portfolio for a class of investors who desire net zero carbon. This two-pronged approach allows an investor to select which portfolio or combination of the two is the preferred alternative, given the cost to buy credits for the carbon-neutral portfolio. This individualizes the carbon-offset decision. Investors would segment based on their own preferences creating a separation between investment management and portfolio selection.[15]

Since the carbon credits are fixed payments unrelated to the portfolio risk and return characteristics, the returns of each of the above portfolios are perfectly correlated. The carbon credit buying portfolio would have the same return as its sister except for the reduction in return resulting from the cost of the credits. Moreover, this provides a route for passive investors to be net zero and still maintain their passive mandates.[16] Or allows active investors to buy credits and maintain their optimal holdings.

3 Carbon Credits

In constructing a portfolio, investors generally maximize the expected return of their portfolio subject to risk (and other) constraints. The risk constraint might be absolute or relative to a benchmark. Their investment managers might be willing to assume tracking error (i.e., assume excess volatility) relative to their benchmarks to achieve greater expected returns by underweighting or overweighting securities to generate significant excess returns or "alphas." Other managers are constrained to take little, if any, tracking error, the so-called "passive managers," for they replicate the systematic risk or so-called "beta" risk of the market. These might include those who deem various factors to provide risk premiums (such as small or value stocks) and invest passively to replicate these factors.[17]

Buying carbon credits to offset the net carbon emissions of a portfolio satisfies a client's demand for carbon reduction while also yielding zero tracking error from the optimal unconstrained portfolio. There is an exact reduction in portfolio returns by the cost of the credits that are known ex-ante.

A carbon credit has a market price. The credit is bought from a producer of carbon capture/reduction alternatives such as those developing a new forest that will capture carbon and remove it from the atmosphere, thereby reducing the net carbon produced by a global society. The higher the price of a ton of carbon credits, the more the incentive to generate additional credits and find new alternative technologies to reduce carbon. Most new forests produce carbon offsets not only for one year but also credits that can be used over multiple years. The credits can be sold each year or credits can be sold in strips for multiple years. If the credit is not used in a year, it can be used in a subsequent year. This allows for storage of credits if producers or buyers anticipate that

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prices will increase. Once used, however, a credit is no longer usable again; it has been "burned" or "retired" so-to speak.

As an aside, it is not obvious that the price of credits should increase more than the rate of interest over time net of the increases in the storage costs of new credits.[18] Other than the option value of holding inventory (such as the price of stored nickel or oil increasing by unanticipated external conditions) and changing production costs to generate credits, the expected price of credits in real terms should remain unchanged. As with most markets, the pricing of credits is efficient or becoming more so as spreads decrease. Only with unanticipated increases in demand given supply will prices increase. And this will generate more supply, restoring equilibrium.

The carbon credit market is new, growing and maturing. Some credits for sale are spurious and of little economic value.[19] Some are sold many times. Some are of higher quality or longer lasting than other credits. Markets separate the credits into grades for sale. Like credit rating agencies, auditing firms and others are authenticating new carbon capture and reduction credits and through modern technology, such as the blockchain, to validate its generation, to transact single sales of carbon offsets and to keep track of an offset to avoid "double" selling or crediting. Banks and broker/dealers are acting as custodians and dealers in carbon credits. They register the suppliers and owners of the carbon credits. While nascent, this market is surprisingly large, with nearly 350 million metric tons of voluntary carbon offsets traded in 2021.[20] As some context, 350 million metric tons of carbon offsets would currently neutralize fully a $4.3 trillion investment in the S&P 500; it is a big number. As the demand for credits continues to grow, the infrastructure to support the market will grow. Therefore, as portfolio managers develop skills to validate the authenticity of carbon credits, they will develop skills to ascertain the value of available credits. They will make the market more efficient and reduce costs and spreads. This is a value-added service that has economies of scale. As portfolio managers demand more carbon credits, additional supply will be generated with the benefit that global net carbon emissions fall.

We have estimated that with current pricing of high-quality verified credits based on the Global Emissions Offset (GEO) pricing, a portfolio manager in the S&P 500 would need to spend approximately 7 basis points a year to reduce the reported carbon footprint of the index to zero.[21] Its investors would have a carbon-neutral portfolio investment. To do so in the less developed market indices would increase the cost to 35 basis points a year. Although the 7-basis point cost reduces the return on the portfolio, it provides a benefit to the portfolio holder for it pays for the removal or reduction of carbon with certainty from the environment with certified credits and helps to generate more climate benefiting carbon offsets in the economy. Investors who worry about global warming might be willing to incur this reduction in return. It does so without any tracking error to their optimal holdings of securities and without measurement error.

4 Portfolio Underweights or Exclusions

Many investment managers attempt to satisfy their client demands for carbon reduction by attempting to underweight or exclude firms with poor carbon scores from their portfolios.

Exclusions add a constraint to the portfolio construction process, which creates a cost in either greater tracking error or risk to the portfolio and/or return give-up. And, how to measure lost returns, if any, or excess risk is difficult and debatable. To estimate a loss in return might take many years of data. And how to know the benefits of

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incurring these costs. Investors must judge their uncertain costs and benefits.

This leads to a debate as to whether excluded or underweight firms sell at a discount in the market to generate a higher cost of capital for the carbon-emitting firms. What is the investor gaining by excluding firms? If they do sell at a discount, investors who continue to hold these securities would earn a higher return. The cost of capital for these firms would increase. Thus, excluding these firms has two costs, greater tracking error (which increases uncompensated risk) and lower expected returns. This is the cost of the so-called ESG constraint. Therefore, passive funds who cannot exclude stocks profit at the expense of active managers who do. Managers who do not value the constraint highly, buy these discounted low ESG securities and earn excess returns until the premium is eliminated.

As Cornell (2022), Berk and van Binsbergen (2022), and Pastor *et al.* (2020), among others, demonstrate that it is hard to estimate the underlying costs and benefits of exclusion and the dynamics of the benefits to society.[22] Moreover, they show that even with measurement issues, that the impacts of divestiture on a firm's cost of capital appear to be too low to have a real impact on investment decisions.

While proponents argue exclusion does have a real impact on the cost of capital of firms leading to changes in behavior, there is another side to the argument. The exclusion may be counterproductive, as excluded firms, while having a large carbon footprint, may also be actively researching and developing ways to reduce their footprint. Such research is an investment that has significant future value that is lost. Hence exclusion penalizes current carbon usage at the expense of much larger future potential gains—a tradeoff that may not be optimal. Or exclusion frees the companies from socially conscious investors and they pursue no capital improvements. Or exclusion might lead to strategies that are suboptimal in that the emitting firm that is engaging in carbon reducing research and development realizes that it can increase its value by selling off its larger emission generating assets to private investors or investors from countries who are not environmentally conscious. Society is worse off. It is hard to determine whether there are net positive or negative effects of exclusion.

If it were only investment managers excluding firms from portfolios, however, our expectation is that firms would go private and be acquired by investors who wish to earn a greater return. As a result, the cost of capital would then fall.[23]

Regardless of whether the portfolio manager gives up expected returns by excluding firms, there is a cost to doing so. What firms should be excluded? Should it be any firm that reports carbon emissions or should the utility function of investors be satisfied by a weighted emission score. We might be forced to lose the pooling of risks and cost reductions afforded by mutual funds or ETFs to satisfy each investor's ESG utility function. Between potential return loss or bearing additional risk and diversification loss, excluding firms from a portfolio might be costly. While paying for this cost does arguably demonstrate an active response to advocates for ESG, it is not clear what return is gained by excluding stocks to encourage companies to adjust their behaviors to better the climate or society. We will now turn to some of our estimates of the cost.

5 Cost of Exclusion

Excluding or underweighting stocks from a portfolio to improve its carbon footprint or ESG character is a portfolio constraint. Constraints, if binding, always come with an associated cost. In the portfolio context, this cost can be reflected in

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either "richness" or return give-up and/or diversification loss. Below we empirically look at the cost of ESG constraints to re-weight a portfolio from both perspectives. To do this, we compare the returns and risk of the MSCI World ESG Leaders Index with the passive market cap-weighted MSCI World Index, along with a similar US only comparison using the S&P 500 ESG Index and the passive market cap-weighted S&P 500 Index. Both ESG indices overweight stocks with greater ESG scores according to MSCI and S&P Global research, while maintaining similar sector and regional exposures to their parent indices. All data used in the analysis below are sourced from Bloomberg, unless otherwise indicated.

As a starting point, since the inception of the MSCI World ESG Leaders Index on September 30, 2007 to June 30, 2022, it has underperformed the MSCI World Index by 93 basis points per year, with similar volatility (Table 1(a)). Similarly, we find that the S&P 500 ESG Index has underperformed the S&P 500 Index by 183 base points per year since its inception on April 30, 2010, with again similar volatility (Table 1(b)). Historically there has been a cost in lost return by imposing ESG constraints or screens on a portfolio.

Interestingly as Figure 1(a) shows, over the recent years, the ESG indices traded in line with their market cap passive parent indices. This could be an artifact of the increased demand for ESG stocks resulting in an increased cost to ESG constraints

Table 1(a) Historical return and volatility of the MSCI World ESG Leaders (GSIN Index) and MSCI World indices from the inception of the ESG Leaders Index on September 30, 2007 to June 30, 2022.

	MSCI World ESG Leaders (%)	MSCI World (%)
Return	4.80	5.73
Volatility	16.46	16.51

Table 1(b) Historical return and volatility of the S&P 500 ESG (SPESG Index) and S&P 500 indices from the inception of the ESG Index on April 30, 2010 to June 30, 2022.

	S&P 500 ESG (%)	S&P 500 Index (%)
Return	10.36	12.19
Volatility	14.15	14.32

Figure 1(a) Relative historical performance of the MSCI World ESG Leaders vs the MSCI World Index. The relative performance is plotted from the inception of the ESG leaders Index on September 30, 2007 to June 30, 2022.

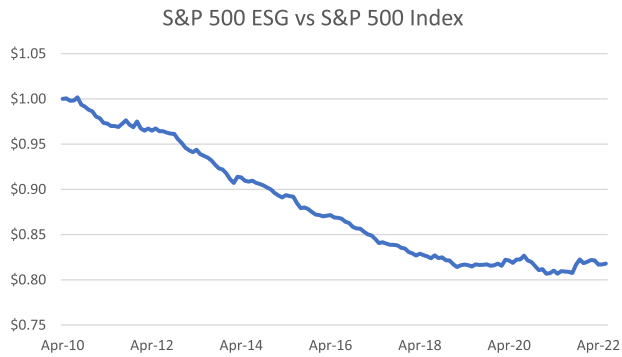

Figure 1(b) Relative historical performance of the S&P 500 ESG Leaders vs the S&P 500 Index. The relative performance is plotted from the inception of the S&P 500 ESG Index on April 30, 2010 to June 30, 2022.

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as more managers are imposing them onto themselves bidding up the price of the higher rated ESG companies. (This still implies a lower cost of capital for them relative to the low ESG-rated firms).

6 Richness

An external portfolio constraint, if binding, creates supply/demand imbalances that cause assets to trade cheap or rich. This valuation impact represents a cost to the constraint and potential return give-up. To assess whether ESG constraints lead to richness and therefore lower expected returns to ESG factors, we calculate the forward one-year price-to-earnings ratio, where forward earnings are based on the mean analyst one-year forward earnings estimate according to Bloomberg, for the MSCI World ESG Leaders and the MSCI World indices.[24]

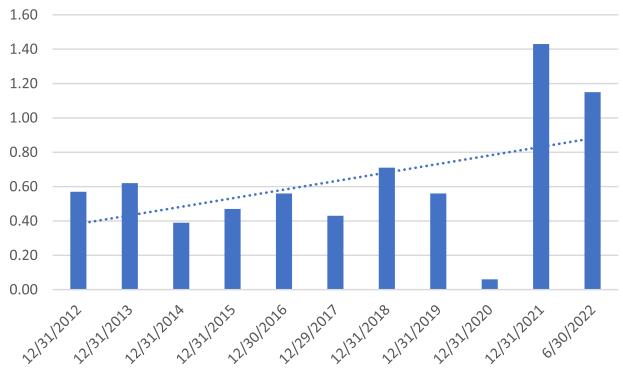

Figure 2 Forward price earnings ratio. We plot the forward price earnings ratio of the MSCI World ESG Leaders vs the MSCI World Index according to the Bloomberg estimates. The ESG Leaders Index overweights higher score ESG firms as measured by MSCI. Our history of holdings begins for the MSCI World ESG Leaders Index in 2012.

Theory would suggest as ESG demand increases and its constraint is more widely imposed, the cost of the ESG constraint increases and the valuation of so-called ESG factors becomes more expensive. As shown in Figure 2, the forward P/E ratio of the MSCI World ESG Leaders Index is not only greater than the MSCI World Index but also has increased over time. And one could argue that the demand for ESG has increased over this period as well increasing the cost of the ESG constraint. Over the past five years, investors are paying \$0.80 on average more for \$1 of expected earnings to hold the MSCI World ESG Leaders Index compared to the passive market cap-weighted MSCI World Index. This is a significant premium—a premium investors pay to hold a portfolio with higher ESG ratings.

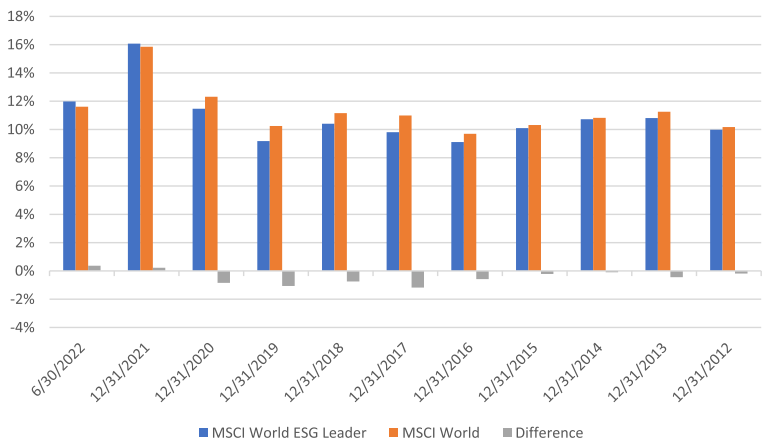

Figure 3 Analyst long-term earnings growth estimates. We compare the analyst long-term earnings growth estimates for the MSCI World ESG Leaders vs the MSCI World Index. The analyst estimates are supplied by Bloomberg.

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However, it is true that this premium could be due to either or both the cost of ESG constraints or the market perception of greater expected growth to higher ESG-rated firms. To help differentiate between the two sources, in Figure 3 we plot the analyst long-term earnings growth estimates for the MSCI World ESG Leaders and the MSCI World indices. As shown, the earnings growth estimates for the ESG Leaders index are no higher than the World Index and in fact on average are much lower. This suggests that the higher premium for ESG names is driven more so by the cost of the ESG constraint rather than greater expected future growth.

The empirical evidence points to ESG constraints having a positive cost. Investors pay a premium to hold higher ESG-rated stocks. The theory and evidence, however, is at best mixed as to whether this extra cost is altering company behavior significantly to do better for the environment and society (see Berk and van Binsbergen, 2022).

7 Diversification

The cost of the ESG constraint can also show up in diversification give-up or reduced diversification. While there are many ways to measure diversification, a straightforward intuitive way is "normalized portfolio variance."[25] Normalized portfolio variance is defined as the ratio of portfolio variance over the average variance of the portfolio holdings. With greater diversification, the portfolio variance would be lower relative to the average variance of its holdings. Hence the lower the normalized portfolio variance, the greater the diversification of the portfolio.

We calculate the normalized portfolio variance for both the MSCI World ESG Leaders and MSCI World indices at the end of each year starting in 2012 to obtain a high-level estimate of the diversification properties behind each index. The variances are based on Bloomberg's equity factor model whose estimates are based on historical variances and correlations. As summarized in Table 2, we find that the normalized portfolio variances for the MSCI World Index to be lower than the MSCI World ESG Leaders Index indicating greater diversification. As expected, given the limited sector and regional exposure differences between the two indices, the difference in the normalized portfolio variances is small, but nevertheless points in the direction of weaker diversification for the MSCI World ESG Leaders Index. This is consistent with the diversification costs a portfolio incurs due to constraints; the constraint here being the ESG constraint.

Table 2 Normalized variances of the MSCI World ESG Leaders and MSCI World indices. The normalized variance is the ratio of the variance of the index over the average variances of the stocks held by the index. Variances are based on Bloomberg's US equity factor model. On average, over the last ∼11 years the MSCI World Index shows a lower normalized variance indicating greater diversification than the MSCI World ESG Leaders Index.

Year	MSCI World ESG Leaders	MSCI World
2012	0.58	0.58
2013	0.51	0.51
2014	0.52	0.52
2015	0.50	0.49
2016	0.47	0.47
2017	0.38	0.38
2018	0.52	0.51
2019	0.48	0.47
2020	0.62	0.61
2021	0.54	0.52
June 2022	0.61	0.60
Average	**0.52**	**0.51**

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8 Conclusion

Investment managers' and investors' ESG goals are important. They emphasize the need for the private sector to address climate and societal issues. There are different approaches that managers take to address these goals. The approach that has become more favored by investment managers is exclusion based on ESG filtering and/or activism; build higher ESG-rated portfolios by excluding or underweighting companies whose ESG scores are low. And by imposing such ESG constraints on a portfolio, investors bear a cost either in return or diversification give-up, which is confirmed empirically. In theory, investors might be willing to bear this cost with the hope that excluding or underweighting low ESG-rated firms increases the cost of capital of these firms, thereby incentivizing them to change their ways. Unfortunately, it is difficult to assess the strength and effectiveness of this incentive.

An alternative approach that we introduce is purchasing carbon credits to offset the carbon footprint of a portfolio.[26] The purchase directly finances projects to reduce carbon in the atmosphere and so the price paid for the credit has a certain and positive environmental impact. Furthermore, as the price of carbon credits increases, supply will increase, bringing more projects online to reduce carbon from the atmosphere. This increase in price provides additional incentives for corporates that are currently utilizing carbon credits to reduce their footprint to invest in research and alternative ways to reduce their footprints further, thereby changing their ways for the better of the environment. The carbon credit market uses the forces of economics to incentivize both the demand and supply side to improve the climate. The market for carbon credits is new and decently deep, and it is global, whose quality and traceability are audited by agreed upon industry standards. It is expected to become deeper and more efficient. Based on current pricing, we find the cost to purchase carbon credits to neutralize the carbon footprint of a portfolio to be likely significantly lower and more certain than the costs borne by imposing ESG constraints on a portfolio.

Moreover, by establishing a portfolio that is unconstrained as to its carbon content, and another portfolio that buys credits to offset its estimated carbon footprint, investment clones of one another, investors are able, based on their utility functions and the cost to offset the emissions (in known) lost return, to decide whether to buy one or the other portfolio or in what proportions. This makes the investment process easier and more informed for portfolio managers. They continue to concentrate on building their "optimal" portfolios and delegate to other experts in the firm to source and manage the carbon credit offsets. The investment management process creates two spanning portfolios that are efficient and satisfy the utility functions of all investors.

This separation not only provides investors with their own optimal carbon portfolio but also satisfies the demands of investors to address climate issues with known benefits and costs, an important demand that needs to be served. It may not be possible to eliminate the portfolio managers role, but over time, as corporations reduce emissions, produce offsets, or buy credits, the portfolio manager will play less of a role.

Acknowledgments

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Notes

[1] Sustainability Report, Chevron 2021 Annual Report.

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[2] "Economists' Statement on Carbon Dividends," *Wall Street Journal* (January 16, 2019).

[3] There are many constraints on drilling for oil or gas and changes in regulations that increase the costs of adding new supplies or continuing to produce from reserves. Changes in rules and taxes create sources of uncertainty that reduce incremental investment. See, for example, "A letter of President Biden from Chevron CEO Mike Worth," June 21, 2022, and statements on CNBC, September 2021 that Chevron should pay dividends to shareholders to let them invest in alternative energy sources that Chevron, the firm, is unable to recover its investment costs and add value for share holders.

[4] We use offsets to designate the production of CO_2 reduction quantities and carbon credits to refer to the sale of offsets, usually the price per ton of offsets. A firm generates its own offsets by investing in related or unrelated projects to reduce carbon emissions for own use or for the sale to others in the form of credits. Firms buy credits and produce their own offsets to report lower net carbon emissions.

[5] The accuracy of these estimates has been challenged. See, for example, a report by BCG, Degot *et al*., Carbon Measurement Survey Report, 2021, which states that although 85% of organizations are concerned about reducing their greenhouse gas emissions, . . . yet only 11% have cut their emissions in line with their goals over the last years. Inability to measure accurately and exhaustively is a leading roadblock. They report an average error rate of 30% to 40% in their own emission measurement. This is, however, what is available currently.

[6] Chevron newsroom, March 28, 2022.

[7] Since Chevron produces carbon emissions each year, the offset can only be used once and is consumed as used. Thus, if a forest has, for example, 30 years of offsets, at the end of the first year, there will only be 29 years of uncertain offsets left for that forest, if that year's offset is used. Alternatively, it can be stored as a credit or sold into the carbon credit markets. The portfolio manager competes with Chevron to buy and burn credits.

[8] For example, see Frances Schwartzkopff and Natasha White, Bloomberg, April 29th, 2022, "Many of the world's biggest money managers don't currently include funds they define as passive in their emissions estimates. An analysis of 30 major investment firms showed that none applied fossil-fuel restrictions to all their index-tracking funds, according to nonprofit *Reclaim Finance*. Of those, 25 are signatories to the Glasgow Financial Alliance for Net Zero, including Vanguard Group Inc., BlackRock Inc. and State Street. Several referees of this paper expressed skepticism in their review comments that credits are a viable solution.

[9] Wealth and asset managers are beginning to adopt this approach. For example, IG Wealth Management announced, on May 31, 2022, a suite of new portfolios aligned with global net-zero emission goals through the purchasing and retirement of carbon credits to offset the emission of underlying companies held.

[10] Blackrock, for example, has launched a Center for Stakeholder Capitalism to explore stakeholder engagement and shareholder value due to increasing interest in ESG investing.

[11] See Berk and van Binsbergen (2022) who conclude that currently impact investing will have little impact on the long-term cost of capital of firms. They recommend a policy of engagement. Buyers or holders of assets could control the actions of firms through the proxy process or replacing management.

[12] See Bloomberg, Schwartzkoff and White (2022a, 2022b), Friedman (1920).

[13] Many managers screen securities on ESG scores and underweight or exclude those with low ESG scores.

[14] Many including Berk and van Binsbergen (2022), Pastor *et al*. (2020) have modelled the exclusion constraints theoretically with mixed empirical results. See also Cornell (2022).

[15] We have found one small UCITS fund in the UK that has implemented the idea of establishing a clone that produces carbon offsets for one active portfolio and the other that does not. See VIA webpage, https://www.via-am.com/en. In addition, IG Wealth, management which manages approximately $260 billion (as part of IG Financial, one of the largest wealth managers in Canada) announced that it has teamed up with Carbon Streaming to purchase offsets to create carbon neutral portfolios. They source offsets directly from Carbon Streaming, which is engaged in deforestation projects.

[16] See Schwartzkopff and White (2022a, 2022b), who report that passive managers face crackdowns from regulators over their CO_2 emission claims since they were excluding passive investments funds in their calculations of emissions in the complex. See Editorial Board, *Wall Street Journal*, "ESG Investing Backlash Arrives," August 15, 2022.

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[17] See, for example, Fama and French (2007). See Alankar *et al*. (2013) for discussions on the costs of constraints.

[18] References to Hotelling's Rule in Wikipedia and Brennan and Schwartz (1985).

[19] The Integrity Council for the Voluntary Carbon Market (ICVCM) is working to standardize the criteria that determine a high-quality carbon credit, with its July 2022 draft release of Core Carbon Principles. This will then help ensure that registries and auditors are consistent in their evaluation of the authenticity of credits. Standardization will further facilitate the growth of the voluntary carbon offset market.

[20] Discussions with carbon credit trading group at Goldman Sachs.

[21] We only consider the market value of the common stock of included securities. Unless the debt is very risky, it will have little weight. Debt holders have little economic interest in the firm.

[22] See Berk and van Binsbergen (2022).

[23] See Nick Ferris, The New Statesman, "Is the energy industry's dirty asset sell-off really good for the planet. https://www.newstatesman.com/spotlight/energy/2022/02. There are public pension funds that had invested in oil and gas royalty payments. These are private assets not included in the public emission disclosures. Many pension funds have pressure to reduce these holdings. As a result, many private partnerships are buying these assets at a discount. The liquidity costs are high. See, Tim Mc Donnel, Net Zero MCA, "Big oil is cutting its carbon footprint in a way that's terrible for the planet." May 2022, page 3.

[24] The aggregate price earnings for the index is estimated as the harmonic weighted average of the stocks held so that very large *P*/*E* positive or negative ratios have very little impact on the index ratio. Unfortunately, we do not have constituent data for the S&P 500 ESG Index.

[25] See Goetzmann and Kumar (2008).

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