Using Net-Zero Alignment Strength for Sustainable Portfolio Choice

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Abstract

We offer a new metric, *net-zero alignment strength* (NZAS), which can be used by socially responsible investors for portfolio selection. NZAS is based on the current corporate GHG emission intensity (EI) and its reduction rate (ERR). It can be used for choosing among the companies with high EI and high ERR versus the companies with low EI and low ERR. We have incorporated NZAS into the mean-variance portfolio (MVP) framework, which yields simultaneous optimization upon stock returns, NZAS, and price volatility. The NZAS contribution to the MVP minimization function is controlled by the *net-zero commitment* parameter, which is investor's choice. An example for a maximum Sharpe portfolio with 29 major constituents of the Energy sector illustrates an interplay between the portfolio holdings' Sharpe ratios and NZAS, which determines the effects of the net-zero commitment on the portfolio weights. We suggest to use this framework for finding current best-in-class companies within the chosen equity sectors.

Key words: climate finance, GHG emissions, portfolio choice, mean-variance portfolio

JEL codes: G11, M14, Q54, Q56

1. Introduction

Net-zero alignment implies corporate activity that mitigates global warming by attaining net-zero greenhouse gas (GHG) emissions. This goal can be achieved by decreasing and/or removing GHG emissions. Investment portfolios in which all holdings are aligned are called net-zero portfolios (NZP, e.g., Bolton et al. 2022).

Implied temperature rise (ITR) has become the leading indicator for evaluating net-zero alignment (PAT 2020, 2021; ILB 2020; Hohne-Sparborth et al. 2021; Haalebos and Fouret 2022; Le Guenedal et al. 2022; Nagy et al. 2023). ITR is based on the current estimates of the corporate GHG emission intensity (EI), GHG emission reduction rate (ERR), and the forecasts of the future GHG emissions based on various climate pathway scenarios (NGFS 2024). ITR provides a projection of the potential future temperature rise based on a company's current and planned GHG emissions. This forward-looking approach helps investors understand the long-term climate impact of their investments, offering a comprehensive view of how a company's emissions trajectory aligns with global climate targets. This holistic approach can be more suited for investors aiming to support long-term climate goals.

Another forward-looking measure, so-called distance-to-exit (DTE), was recently offered by Cendese et al. (2023). DTE is an estimate of the time period (in years) at which a company stops satisfying the NZP requirements and needs to be removed from it. Unfortunately, the accuracy of both ITR and DTE may suffer from various geopolitical, macroeconomic, regulatory, and technological uncertainties typical for long-term forecasts. As a result, there are significant differences among the corporate ITRs offered by different providers (Chmel et al. 2024).

In this work, we introduce a new metric complementary to and consistent with the forward-looking ITR that may be useful to the socially responsible investors who are interested in

the *current* best-in-class companies. It combines two main net-zero alignment metrics, EI and ERR, into a single indicator. Specifically for company *i*, the *net-zero alignment strength* ($NZAS_i$) at time t is

$$NZAS_i(t) = F*(1+ERR_i(t))/EI_i(t) \quad (1)$$

The numerical factor F of the order of magnitude of a typical EI is added to have the values of NZAS in a preferable range, which may be attained, e.g., by setting F to the minimum EI of the portfolio holdings. The unit in the numerator of (1) is added to avoid zero value of $NZAS_i$ in the case of zero ERR_i. We measure EI_i as the amount of GHG emissions per company revenue. Since the corporate business may change over time due to selling its part or acquiring (part of) another company, we define ERR_i with the difference between the past and present GHG emission intensities rather than with the difference between the past and present absolute GHG emissions, as it is generally suggested (e.g., PAT (2020) and the later ITR-related references)

$$ERR_i = [EI_i(t-1) - EI_i(t)]/EI_i(t-1) \quad (2)$$

NZAS (1) is defined in such a way that it decreases with growing EI and increases with growing ERR. Thus, NZAS can be helpful in choosing between a company that has a higher EI and a higher ERR versus a company that has a lower EI and a lower ERR.

Another problem for forming a sustainable portfolio is that the correlations between the corporate EI and stock returns are very low (Aswani et.al. 2023; Schmidt 2024a). As a result, portfolios with a better net-zero alignment may have lower Sharpe ratios (SR) than the net-zero neutral portfolios. This may lead to a conundrum for socially responsible investors. In order to address this issue we offered using the climate risk-tilted SR (Schmidt 2024a). The idea behind it

is that socially responsible investors need to account for climate risks by the same token as many rational investors account for price volatility risk and use SR rather than portfolio returns.

In this work we incorporate both concepts, NZAS and NZAS-tilted SR (NZAS-SR), into the mean-variance portfolio (MVP) framework that has been used for accounting for various ESG risks (Pedersen et al. 2021; Schmidt 2020, 2024a, 2024b; Blitz et al. 2024). In this methodology (sometimes called 3D investing), portfolio weights are optimized in terms of stock returns, price volatility, and various non-pecuniary risks.

As an example of a NZAS MVP, we apply our approach to a portfolio of 29 major constituents of the energy sector. The NZAS MVP framework, the data used in this work, and the results are described in the next three Sections, respectively. The discussion concludes.

2. The mean-variance model for optimal net-zero portfolios

The classical MVP theory is based on minimizing the following objective function (see, e.g., Elton et al. 2009)

$$U_{MVP} = 0.5\lambda\sigma_p^2 - r_p \quad (3)$$

In (3), λ is the volatility risk aversion parameter that is chosen in this work for yielding the maximum SR. Portfolio variance σ_p^2 equals

$$\sigma_p^2 = \sum_{i,j=1}^{N} w_i w_j \sigma_{ij} \quad (4)$$

N is the number of portfolio holdings; w_i are portfolio weights, i = 1, 2, …, N; $\sum_{i=1}^{N} w_i = 1$, and σ_{ij} are covariances between the asset returns, r_p is mean portfolio return

$$r_p = \sum_{i=1}^{N} w_i r_i \quad (5)$$

and r_i are mean portfolio asset returns. In classical finance, SR is defined as

$$SR = (r_p - r_f)/\sigma_p \quad (6)$$

where r_f is risk-free rate of return (neglected in this work).

For the optimal NZP, U_{MVP} is expanded with the portfolio NZAS (PNZAS)

$$U_{NZP} = U_{MVP} - \delta * \text{PNZAS} \quad (7)$$

In (7), δ is the *net-zero commitment* parameter, which is investors' choice. PNZAS is assumed to be a weighted sum of the portfolio holdings' $NZAS_i$

$$\text{PNZAS} = \sum_{i=1}^{N} w_i NZAS_i \quad (8)$$

PNZAS is included with the negative sign in the minimizing function (7) since it represents a positive sentiment.

Since unconstrained MVPs may have large short positions undesirable for most investors (see, e.g., Jacobs et al. 2013), the long-only constraint ($w_i \geq 0$) is used in this work. Then, the derivation of optimal NZP represents the following quadratic programming problem:

$$\min [0.5\sum_{i,j=1}^{N} w_i w_j \sigma_{ij} - \delta \sum_{i=1}^{N} w_i NZAS_i] \quad (9)$$

$$\text{s.t.} \quad \sum_{i=1}^{N} w_i r_i = r_p \quad (10)$$

$$\sum_{i=1}^{N} w_i = 1 \quad (11)$$

$$w_i \geq 0;\ i = 1, 2, \ldots, N \quad (12)$$

Portfolios with maximum SR were found by comparing results for various values of the expected returns r_p (which is equivalent to choosing volatility risk aversion parameter λ) and net-zero commitment δ.

A general problem with MVPs is that they are usually highly concentrated. One might expect that minimization of portfolio variance would produce well diversified portfolios. Yet, the optimization algorithm usually chooses only a handful of past top winners and assigns negligible weights to the rest of the long-only portfolio holdings. One option to increase MVP diversity is to replace Pearson's correlations in (9) with partial correlations conditioned on the total market returns (Nadler & Schmidt 2014). The motivation for introducing the partial correlations based MVP (PartMVP) as an alternative to the Pearson's correlations based MVP (PearMVP) is that individual stock returns generally follow the equity market trend according to the capital asset pricing model, which increases their Pearson's correlations. On the other hand, partial correlations conditioned on the market return describe co-movements of the excess asset returns unaffected by market momentum. As a result, partial correlations are lower than the corresponding Pearson's correlations, and the PartMVPs are often much more diversified than the PearMVPs. Also, the PartMVPs may outperform the PearMVPs and equal-weight portfolios out of sample (Nadler & Schmidt 2014; Cai & Schmidt 2020).

As we indicated in Introduction, we define optimal NZAS MVP as a portfolio with the maximum value of the NZAS-tilted SR. Since higher NZAS values have a positive sentiment, we suggest using the following definition of SR-NZAS:

$$\text{SR-NZAS} = \text{SR}(1+ \text{PNZAS}) \tag{13}$$

Thus, socially responsible investors may want to accept lower portfolio returns to be compensated by addressing climate risks, similarly to how volatility risk-averse investors use SR as the portfolio performance measure rather than portfolio returns.

The data

Portfolio considered in this work was formed with 29 major constituents of the Energy equity sector (see Table A1 in Appendix). The NZAS values of the portfolio holdings were calculated using their GHG EIs obtained from Trucost at the end of 2024. The ITRs of the portfolio holdings in 2024 were calculated using the LOAM methodology (Hohne-Sparborth et al. 2021). The optimal NZAS MVP was calibrated using the adjusted daily closing stock prices for 2023 - 2024 available on *finance.yahoo.com*.

The Results

The data listed in Table 1 shows a weakly negative correlation between ITR and NZAS. While its negative sign is expected, it implies that the ITR forecast cannot be reduced to analysis of the current GHG emissions. A positive correlation between ITR and SR is exactly the reason for possible investor confusion that we mentioned in the Introduction since increasing ITR has a negative sentiment. Finally, very weak correlations between NZAS and SR imply that NZAS cannot be the sole motivation for investment as long as investors strive for increasing their wealth. Hence, the 3D investing.

Table 1. Correlations among the Energy portfolio holdings

ITR vs NZAS	ITR vs SR	NZAS vs SR	NZAS vs NZAS-SR
-0.17	0.35	0.04	0.22

The Energy portfolio listed in Table A1 has an outlier, Targa Resources (ticker TRGP) that has the highest SR *and* the highest NZAS-SR (but only the third highest NZAS). Both the Energy portfolio PearMVP and PartMVP are highly concentrated. Note that since the dynamics of energy stock prices differed significantly from the total market price in 2023 - 2024, PartMVP with three non-zero weights yields only marginal improvement of portfolio diversity in respect to PearMVP that has two non-zero weights. In this case, the PearMVP SR is not affected by the net-zero commitment parameter δ while the PartMVP SR decreases with δ. However, NZAS-SRs and the TRGP weights of both PearMVP and PartMVP grow with increasing δ until TRGP becomes the sole portfolio holding (see Table 2).

Table 2. Performance and weights of the Energy NZAS MVP

Net-zero commitment	PearMVP					PartMVP					
	PNZAS	SR	SR-NZAS	Porfolio weights		PNZAS	SR	SR-NZAS	Porfolio weights		
				TRGP	WMB				TRGP	WMB	KMI
0	0.588	2.12	2.12	0.84	0.16	0.485	2.34	2.34	0.67	0.25	0.07
1.00E-05	0.581	2.12	3.35	0.83	0.17	0.526	2.34	3.57	0.74	0.21	0.05
3.00E-05	0.636	2.12	3.41	0.87	0.12	0.608	2.33	3.74	0.87	0.13	0
5.00E-05	0.688	2.11	3.56	0.99	0.01	0.691	2.30	3.89	1	0	0
6.00E-05	0.691	2.11	3.57	1	0	0.691	2.30	3.89	1	0	0

If the outlier TRGP is dropped from the Energy portfolio, its SRs for both PearMVP and PartMVP monotonically decay with growing net-zero commitment while NZAS-SR has two maximums: at intermediate and high values of δ, which can also happen in the optimal ESG portfolios (Schmidt & Zhang 2024). Usually the latter maximum has a higher value but relates to

a less diversified portfolio; sometimes it has just a single holding with a maximum ESG or NZAS value. By the same token, one these maximums can be interpreted as an optimal NZAS MVP (see Table 3). The choice between these two maximums depends on whether investors prefer more diversified portfolios with a lower SR-NZAS.

Table 3. Performance of the Energy NZAS MVP without TRGP*

Net-zero commitment	PearMVP				PartMVP			
	# of weights >0.1%	PNZAS	SR	SR-NZAS	# of weights >0.1%	PNZAS	SR	SR-NZAS
0	3	0.067	1.75	1.75	4	0.091	1.95	1.95
1.00E-05	3	0.068	1.75	1.87	4	0.117	1.95	2.18
2.00E-05	4	0.076	1.74	1.87	4	0.157	1.94	2.24
3.00E-05	4	0.115	1.73	1.93	4	0.183	1.92	**2.28**
3.50E-05	4	0.128	1.72	**1.94**	3	0.117	1.92	2.14
4.00E-05	2	0.066	1.72	1.83	3	0.126	1.92	2.16
5.00E-05	2	0.064	1.72	1.83	3	0.126	1.91	2.16
6.00E-05	2	0.062	1.72	1.83	3	0.127	1.91	2.15
1.00E-04	1	0.060	1.72	1.82	2	0.126	1.90	2.14
3.00E-04	1	0.060	1.72	1.82	2	0.125	1.90	2.14
3.50E-04	2	0.267	1.66	2.10	2	0.303	1.85	2.41
4.00E-04	2	0.510	1.47	**2.23**	2	0.549	1.62	**2.51**
5.00E-04	2	1.000	0.98	1.96	2	1.050	1.02	2.09
6.00E-04	1	1.108	0.88	1.86	1	1.110	0.95	2.01

*Maximum SR-NZAS values are in bold font.

The evolution of the Energy NZAS MVP (without TRGP) weights as a function of the net-zero commitment parameter δ is shown in Fig.1. At small to moderate values of δ, WMB (that has the 2nd highest SR after TRGP) has increasing weight. However, at sufficiently high values of δ, the weight of BKR (that has the highest NZAS in the Energy portfolio) becomes dominant and, ultimately, the only portfolio holding.

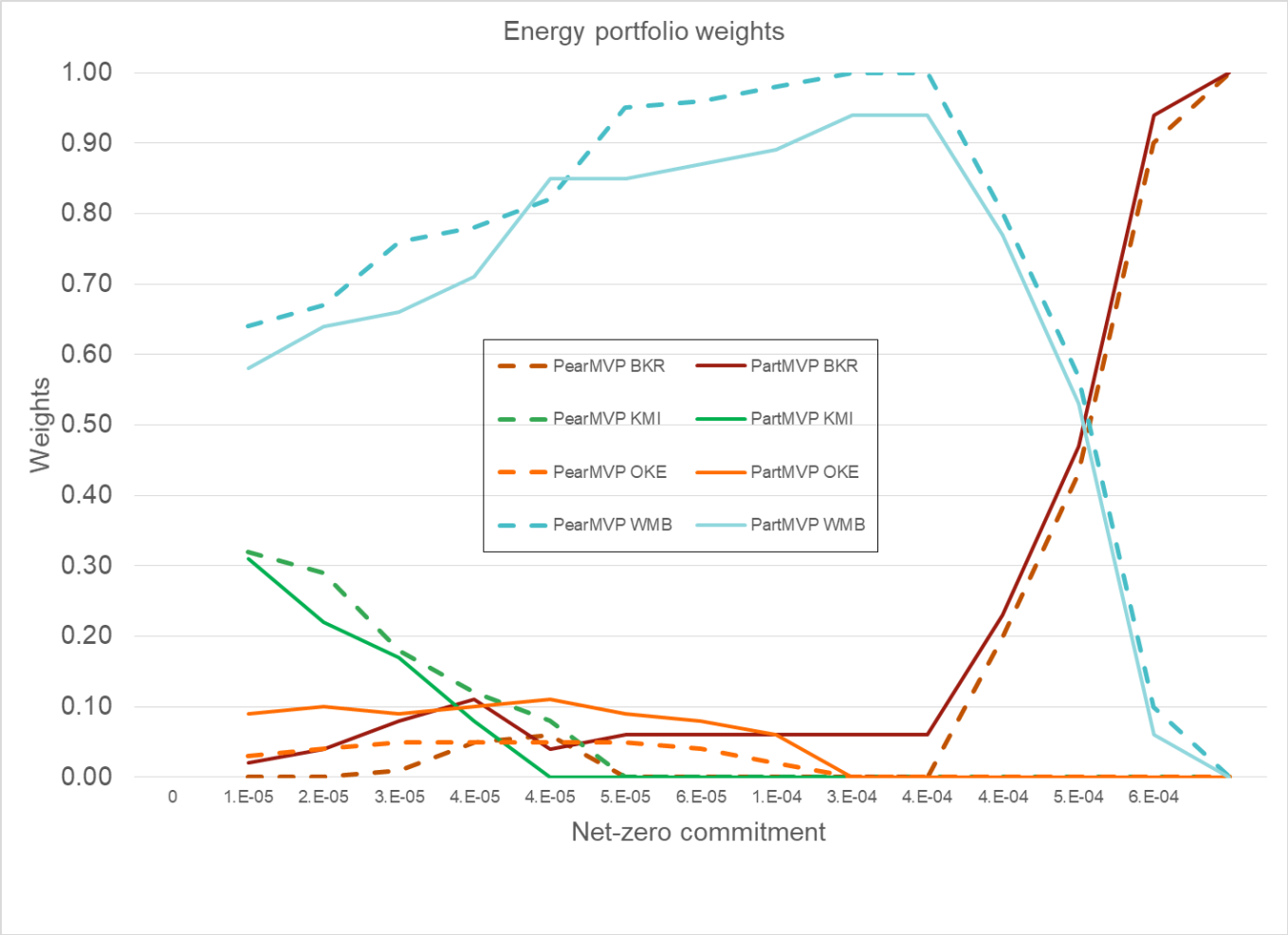


Fig.1. Energy NZAS MVP (without TRGP) weights

The discussion

In this work, we offer a new metric, net-zero alignment strength (NZAS), which can be helpful to socially responsible investors for their portfolio selection. NZAS is determined by the current GHG emission intensity (EI) and its reduction rate (ERR) and, hence, can be used for choosing among the companies with high EI and high ERR versus the companies with low EI and low ERR.

Unfortunately, the correlations between the company stock returns and NZAS in some portfolios are very low, which may not motivate (even socially responsible) investors to use NZAS as a single investment criterion. We have incorporated NZAS into the mean-variance portfolio (MVP) framework, which yields simultaneous optimization upon stock returns, NZAS, and price volatility. The NZAS contribution to the MVP minimization function is controlled by the net-zero commitment parameter, which is investor's choice. This may help investors to select portfolios according to their priorities. While MVPs are notoriously highly concentrated, we do not suggest to blindly implement them. As with other non-pecuniary (e.g. ESG) risks that may significantly vary in different industries, we recommend to use this approach for finding current best-in-class companies within the chosen equity sectors (Schmidt 2024b). By integrating both NZAS and ITR, investors can gain a holistic understanding of a company's climate performance, balancing immediate actions with future commitments. This combined approach enables more informed and robust investment decisions, aligning financial returns with sustainable development goals.

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Appendix

Table A1. Net-zero metrics for the Energy sector holdings

Company	Ticker	ITR	NZAS	SR	NZAS-SR
APA Corporation	APA	2.572	0.087	-0.650	-0.706
Baker Hughes Co	BKR	2.376	**1.108**	0.881	1.857
BP plc	BP	2.462	0.374	-0.026	-0.036
Canadian Natural Resource	CNQ	5.519	0.201	0.572	0.686
ConocoPhillips	COP	2.498	0.195	-0.047	-0.056
Cenovus Energy	CVE	2.671	0.384	-0.093	-0.129
Chevron	CVX	3.589	0.252	-0.167	-0.210
Devon Energy	DVN	2.365	0.250	-0.700	-0.875
Eni	E	**1.957**	0.186	0.290	0.344
EOG Resources Inc	EOG	2.585	0.277	0.217	0.277
Equinor ASA	EQNR	2.323	0.416	-0.040	-0.057
Diamondback Energy Inc	FANG	3.826	0.244	0.672	0.836
Halliburton Company	HAL	4.585	0.416	-0.304	-0.431
Hess	HES	2.244	0.402	0.133	0.186
Kinder Morgan	KMI	3.077	0.073	1.596	1.712
Marathon Petroleum	MPC	5.360	0.260	0.563	0.709
ONEOK, Inc.	OKE	4.162	0.161	1.364	1.583
Occidental Petroleum	OXY	2.671	0.108	-0.288	-0.319
Phillips 66	PSX	5.984	0.290	0.461	0.594
Repsol	REPYY	3.464	0.283	-0.213	-0.274
Shell	SHEL	2.190	0.308	0.556	0.727
Schlumberger NV	SLB	4.280	0.743	-0.290	-0.505
Suncor Energy	SU	3.112	0.200	0.566	0.680
Targa Resources	TRGP	3.698	0.691	**2.109**	**3.566**
TC Energy	TRP	5.649	0.072	0.813	0.872
TotalEnergies	TTE	2.239	0.297	0.031	0.041
Valero Energy	VLO	4.634	0.277	0.247	0.316
Williams Companies	WMB	5.481	0.060	1.716	1.820
ExxonMobil	XOM	2.892	0.269	0.247	0.313

The lowest ITR, and the highest NZAS, SR, and NZAS-SR are in bold font.