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Do the Investment Math: Building a Carbon-Free Portfolio

As university endowments face pressure to divest stocks of companies contributing the most to climate change, much of the public discussion has focused on the looming math of the environmental impact of a carbon-based economy. As endowments decide whether or not to divest or implement screens, another kind of math is needed as part of the process: the math of portfolio analysis. (Note: this version updates an earlier paper from December 2012.)

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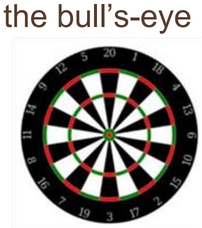
Do the Investment Math

In the past few months, a groundswell of public support has been pushing universities to divest their endowments of holdings in large fossil fuel companies. Writer and environmental advocate Bill McKibben has coined the phrase “Do the Math,” referring to the dangers of rising levels of carbon dioxide in the atmosphere. This focus on the math of climate change has been catalyzed by the publication of his influential article in *Rolling Stone* magazine this past July, “Global Warming’s Terrifying New Math.” This has been followed up by a 21-city college campus tour encouraging carbon divestment by large endowments and pension funds.

While some endowments like that of Hampshire college have announced plans to change their investment approach, many fiduciaries sitting on endowment boards dismiss with skepticism the idea of a portfolio helping to serve environmental goals. These skeptics often claim that incorporating environmental screening, however well intentioned, simply imposes a tax on investment return. While their wariness reflects a genuine and valid desire to protect the returns earned by the endowments, outright dismissal of any screening ignores another kind of math, the kind that measures the risk to a portfolio rather than the effects of carbon dioxide on our planet.

When the idea of fossil fuel screening gets floated, the first thing an endowment committee would want to know is the impact on return, especially whether screening imposes any penalty. The research data on a wide range of social and environmental screening show no such penalty (nor any benefit either), although the results are mixed.[1] Given the lack of evidence of a return penalty, the focus then shifts to the impact of screening on a portfolio’s risk, which is more predictable and easier to forecast than return. Skeptics are right when they claim that constraining a portfolio can only increase risk, but they frequently ignore the magnitude of the change in risk, which can be so minor as to be virtually irrelevant.

How can this risk impact best be estimated? For analysis, we’ll use a computer program called a multi-factor model, in this case the Aegis model from the company Barra. Aegis uses both industry and fundamental factors like price-earnings ratios to measure stock risk. The model generates a forecast for tracking error, which is the statistical measurement of deviation from a target benchmark like the S&P 500 or Russell 3000 for domestic stocks or the MSCI All Country World index for global stocks. Tracking error is analogous to the concept of darts thrown at a dartboard, where the bull’s-eye is the benchmark return and the measurement of the dispersion of dart throws around the bull’s-eye is the tracking error over a particular time frame, e.g. monthly returns over the past three years. A small or tight tracking error means the darts (each representing one monthly return) are clustered around the bull’s-eye, and a large or loose tracking error means the darts are all over the board.



As an example of the impact of screening on tracking error, we'll analyze the extra risk of excluding a small sample of companies that the climate change advocates have identified as particularly harmful, the so-called "Filthy Fifteen," U.S. companies judged by As You Sow and the Responsible Endowment Coalition as the most harmful based on the amount of coal mined and coal burned as well as other metrics. To measure the impact of excluding these companies, we'll start with a broad-market U.S. benchmark, the Russell 3000, then exclude the thirteen publicly traded stocks of the Filthy Fifteen[2] and finally use the multi-factor model to create an optimized portfolio as close to the Russell 3000 as possible. Investors who want a portfolio free of the Filthy Fifteen can get a tracking error versus the Russell 3000 of only 0.14%, a very minor difference from the benchmark.

What Does Additional Tracking Error Cost the Investor?

If investors are to decide whether a tracking error of 0.14% to exclude the Filthy Fifteen seems reasonable or excessive, they need some context for what that number implies. First, tracking error has an expected value of zero, meaning that in a passive management framework a portfolio's return is just as likely to be above the benchmark as below. Second, the average expected tracking error for institutional active management is 5.0% according to a survey of large U.S. pension funds,[3] which means that investors already bear comparatively significant tracking error with their active managers. Third, in the language of statistics, tracking error is an estimate of standard deviation of returns versus a benchmark, which is in turn the square-root of variance. That means that tracking error cannot be simply added to overall portfolio risk (see Table 1). In other words, if the total market's risk is 17.67% (the Barra Aegis forecast standard deviation for the Russell 3000 as of December 31, 2012), the portfolio risk does not rise by another 0.14% to 17.81%. Instead, the impact of screening on absolute portfolio risk must be calculated using variance terms.

Table 1: Impact of Tracking Error for Exclusion of Filthy Fifteen

	Standard Deviation	Variance = (Std. Dev.)^2	Theoretical Return Penalty
Market Risk (Russell 3000)	17.6657%	3.1208%	
Tracking Error vs. R3000	0.1400%	0.0002%	
Screened Portfolio	17.6662%	3.1210%	
Incremental Risk	0.0006%		0.0002%

Source: Barra Aegis and Aperio Group

As Table 1 shows, adding 0.1400% of tracking error increases absolute portfolio risk by only 0.0006%, or about a half of one one-thousandth of a percent. In other words, the portfolio does become riskier, but by such a trivial amount that the impact is statistically irrelevant. In other words, excluding the Filthy Fifteen has no real impact on risk.

Skeptics could accurately point out that even for such a trivial amount, investors are technically bearing additional risk for which they are not compensated. Modern portfolio theory holds that any increase in risk should earn an investor a corresponding increase in return. That theoretical loss of return in this case can be measured by using historical data for the "market premium," i.e. the amount of extra return stock market investors have been paid historically for bearing extra risk. As shown in Table 1, the foregone return is 0.0002%, or two one hundredths of a basis point. Please see Appendix I for details on the calculation of the return penalty.

Having seen that excluding the Filthy Fifteen incurs virtually no risk penalty, we'll now turn to a stricter set of screens for those endowments who may want to divest a more comprehensive list of companies from an entire industry, Oil, Gas & Consumable Fuels.[4] Table 2 shows the naturally higher tracking error resulting from stricter screens.

Table 2: Impact of Tracking Error for Industry Exclusion

	Standard Deviation	Variance = (Std. Dev.)^2	Theoretical Return Penalty
Market Risk (Russell 3000)	17.6657%	3.1208%	
Tracking Error vs. R3000	0.5978%	0.0036%	
Screened Portfolio	17.6758%	3.1243%	
Incremental Risk	0.0101%		0.0034%

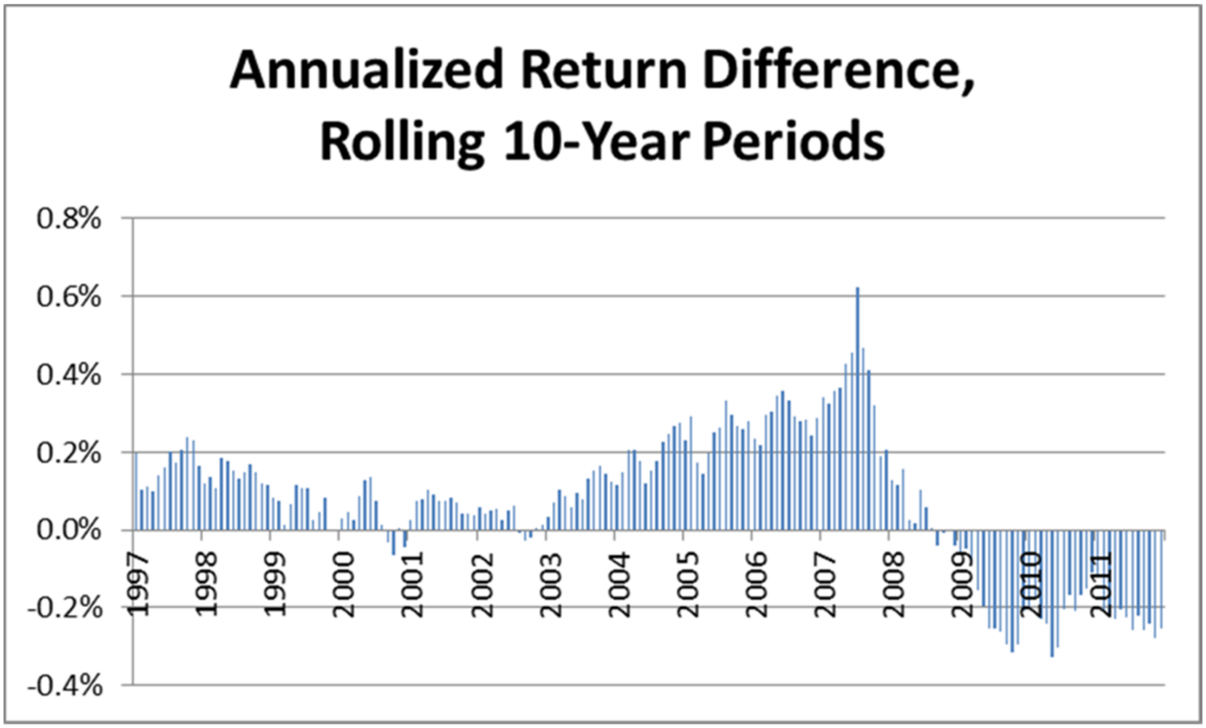
Source: Barra Aegis and Aperio Group. Numbers may not sum exactly due to rounding.

As Table 2 shows, adding 0.5978% of tracking error increases absolute portfolio risk by 0.0101%, with a theoretical return penalty of 0.0034%, or less than half a basis point. While that tracking error remains very low compared to active stock picking, the industry emphasis still means that if this industry outperforms the overall stock market, a portfolio with these exclusions will perform worse, while of course if those industries perform poorly relative to the market a screened portfolio would perform better.

The approach shown here of using a multi-factor model to manage risk in screened portfolios has been validated in a number of articles in academic finance journals that prove and explain this math in greater detail.[5] Furthermore, while this analysis shows the effects for U.S. stocks, the math looks very similar for non-U.S. and global portfolios as well. Excluding more industries increases the tracking error slightly, as presented in an earlier version of this paper, more details of which can be found in Appendix II.

Historical Back Test

The risk data discussed so far reflect estimates of future incremental impact on a portfolio's volatility. Another approach involves back testing hypothetical portfolios to see how they would have performed over different historical periods, i.e. looking backwards instead of forwards. Although such back testing should be taken with a healthy grain of salt, it can still provide at least some sense of how a screened portfolio would have performed. Using the same multi-factor Barra model used to create the portfolio shown in Table 2, the performance has been analyzed using historical return data. This screened portfolio has been optimized to track the Russell 3000 benchmark but with no stocks from Oil, Gas & Consumable Fuels. Shown below is a graph of rolling ten-year return periods from the end of 1987 through the end of 2012 for the screened portfolio, called Full Carbon Divestment. The blue bars above the 0.0% line indicate that the screened portfolio earned a higher average annual return over the trailing ten-year period, while those below the line indicate the periods for which the portfolio performed worse than the benchmark.



Return numbers show annualized return difference between Full Carbon Divestment portfolio and Russell 3000 for periods from Jan 1988 to Dec 2012.

Average Annualized 10-year Return Difference	+0.08%
Percentage of Periods Higher than R3000	73%
Percentage of Periods Lower than R3000	27%
Tracking error, current forecast	0.60%
Tracking error, historical simulation	0.78%

As the chart and table show, the average return for a 10-year rolling period over the past 25 years was slightly positive, with 73% of the ten-year periods earning higher returns. If there is no return bias, then theoretically such a screened portfolio would be expected to perform better than the benchmark only half the time. In other words, the historical data may show superior performance, but the model forecasts only risk, not any ongoing excess return. The hypothetical historical tracking error over the period was 0.78%, slightly higher than the currently forecasted 0.60%.

Summary

In deciding whether to implement any divestment, university endowments face compelling arguments on both sides. From the advocates of divestment, endowments hear about the serious environmental damage already incurred, the frightening trajectory of the math and the benefit from taking a public stance on a critical ethical issue. From the skeptics they hear that screening will adversely affect risk and return and that the goal of any endowment should be to focus exclusively on returns. The math shown in Tables 1 and 2 does support the skeptics' view that screening negatively affects a portfolio's risk and return, but it also shows that the impact may be far less significant than presumed. It's beyond the scope of this paper to judge whether endowments should implement or avoid screening, but anyone on an endowment board facing that decision should at least do the math, in this case the investment math.

Appendix I: Calculation of Theoretical Return Penalty

We can convert the uncompensated risk to a theoretical return penalty by using a simplified historical risk premium. Based on S&P 500 returns and risk (as a proxy for the U.S. stock market) from January 1926 to June 2011, we find a total market annual return of 9.88 percent versus T-bills over the same period of 3.60 percent for an excess return of 6.29 percent. From the same data set, the S&P 500 has had an annualized standard deviation of 19.14 percent, giving a simplified market Sharpe ratio of 0.33, calculated as follows: Market Sharpe ratio = $(r_m - r_f)/\sigma_m$, where r_m is return on market, r_f is risk-free rate, and σ_m is the risk of the market as measured by standard deviation. The simplified historical market Sharpe ratio is calculated as follows: (9.88% – 3.60%) / 19.14% = 0.33. The theoretical return penalty in Table 1 is calculated as follows: 0.0005% incremental standard deviation times a Sharpe ratio of 0.33 equals 0.0002%, or two one-hundredths of a basis point in theoretical foregone return. In other words, the impact on return, according to standard portfolio theory, is virtually nonexistent for eliminating the Filthy Fifteen.

Appendix II: Screening Impact of Broader Exclusions

In an earlier version of this paper, published in December 2012, Aperio Group analyzed a broader range of industry exclusions, as listed below.

Oil, Gas & Consumable Fuels
Metals & Mining
Electric Utilities
Independent Power Producers & Energy Traders
Multi-Utilities

To avoid penalizing cleaner companies in those industries, those scored by MSCI's environmental research as receiving 100% of their revenue from environmentally sustainable businesses have been added back and made available. Table 3 shows the naturally higher tracking error resulting from stricter screens.

Table 3: Impact of Tracking Error for Broad Carbon Exclusion

	Standard Deviation	Variance = $(\text{Std. Dev.})^2$	Theoretical Return Penalty
Market Risk (Russell 3000)	17.9500%	3.2220%	
Tracking Error vs. R3000	0.6900%	0.0048%	
Screened Portfolio	17.9633%	3.2268%	
Incremental Risk	0.0133%		0.0044%

Source: Barra Aegis and Aperio Group. Estimates as of November 30, 2012.

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Disclosure

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With respect to the description of any investment strategies, simulations, or investment recommendations, we cannot provide any assurances that they will perform as expected and as described in our materials. Past performance is not indicative of future results. Every investment program has the potential for loss as well as gain.

Assumptions underlying simulated back test:

- Based on Barra Aegis multi-factor risk model
- Quarterly rebalancing.
- Exclude stocks from Oil Gas & Consumable Fuels industry as defined by MSCI Barra industry for back test.
- No transaction costs or management fees included.
- Benchmark returns are simulated using underlying holdings to ensure apples-to-apples comparison.

The benchmark for back-test simulation is the Russell 3000 total return index. The simulated portfolios are actively managed, and the structure of the actual portfolios and composites may be at variance to the benchmark index. Index returns reflect reinvestment of dividends but do not reflect fees, brokerage commissions, or other expenses of investing, which can reduce actual returns earned by investors.

Performance results from back tests of particular strategies exclude any trading or management fees that would reduce the return. Furthermore, future returns for any such strategies could be worse than the results shown or the identified benchmark. Back-testing involves simulation of a quantitative investment model by applying all rules, thresholds and strategies to a hypothetical portfolio during a specific market period and measuring the changes in value of the hypothetical portfolio based on the actual market prices of portfolio securities. Investors should be aware of the following: 1) Back-tested performance does not represent actual trading in an account and should not be interpreted as such, 2) back-tested performance does not reflect the impact that material economic and market factors might have had on the manager's decision-making process if the manager were actually managing client's assets, 3) the investment strategy that the back-tested results are based on can be changed at any time in order to reflect better back-tested results, and the strategy can continue to be tested and adjusted until the desired results are achieved, and 4) there is no indication that the back-tested performance would have been achieved by the manager had the program been activated during the periods presented above.

Endnotes

[1] United Nations Environment Programme (UNEP) Finance Initiative and Mercer. 2007. Demystifying Responsible Investment Performance. http://www.unepfi.org/fileadmin/documents/Demystifying_Responsible_Investment_Performance_01.pdf. *

[2] The following companies incorporate the thirteen publicly trade stocks of the Filthy Fifteen:
Arch Coal Inc
Ameren Corp
American Elec Pwr Inc
Alpha Natural Resource
Consol Energy Inc
Dominion Res Inc
Duke Energy Corp
Consolidated Edison
Edison Intl
Firstenergy Corp
Genon Energy Inc
PPL Corp
Southern Co

[3] Based on a survey of Callan Associates, Inc., Mercer Investment Consulting and Watson Wyatt Worldwide. For details see GMO. 2007. White Paper, "What Should You Pay For Alpha?", https://www.gmo.com/NR/rdonlyres/F8E38661-0CD6-49EB-97DF-8D7B6AC32B43/1007/HowMuchPayForAlpha.pdf. *

[4] Based on the Global Industry Classification Standards developed by MSCI and Standard & Poor's.

[5] See the following articles:

Geddes, Patrick. 2012. Measuring the Risk Impact of Social Screening. *Journal of Investment Consulting* 13, no. 1: 45-53.

Jennings, William W., and Gregory W. Martin. 2007. Socially Enhanced Indexing: Applying Enhanced Indexing Techniques to Socially Responsible Investment. *Journal of Investing* 16, no. 2 (summer): 18–31.

Kurtz, Lloyd, and Dan diBartolomeo. 2011. The Long-Term Performance of a Social Investment Universe. *Journal of Investing* (fall): 95–102.

Milevsky, Moshe, Andrew Aziz, Al Goss, Jane Thompson, and David Wheeler. 2006. Cleaning a Passive Index. *Journal of Portfolio Management* 32, no. 3 (spring): 110–118.

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