Carbon Considerations and Pricing in Global Asset Classes

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Executive Summary

The Masters Project team worked with client, the Angeleno Group, a leading dedicated clean energy and sustainability investment firm, recognized for their sophisticated research driven approach and future forward-looking strategy, providing focused capital to clean energy and climate solutions companies, combating climate change from an investor perspective. The main objective of the master's project is to create a simulated case with clear analytical framework, model(s), and a holistic report for the Angeleno Group and its institutional investors that are looking to consider how a price on carbon may impact investments. Currently, carbon risks are not factored into valuations of stocks, but with a global push towards a low-carbon economy, there is a potential shift in policy and regulation in favor of pricing in carbon which creates a transition risk for the financial systems.

This project focuses on incorporating carbon emissions into investment and portfolio analysis for the US public equity market and involves three scenarios for the S&P 500: base case, high emission adjusted (divested), and climate solutions enhanced (swapped). The analysis relies on using the S&P 500 constituents for US public equities, companies' hypothetical carbon costs based on emissions, and a ten-year time horizon from 2013 to 2022. Relative to the base case, identifying S&P 500 companies with high exposure to carbon and divesting from these extreme emitters resulted in diminished returns alongside a reduction in risk. With Angeleno Group's climate solutions index swapped in for the divested carbon intensive companies, there was a substantial increase in returns, outperforming both the base and divested cases, adjacent to higher levels of risk.

To take this analysis further, there is an opportunity for investigating various public equity indices, adjusting the cutoff threshold for total cost of carbon emissions, and applying the carbon cost analysis process to other asset classes. Adjusting the parameters of the analysis process through the base companies and divestment thresholds can contribute to a better understanding of how companies and investors of varying sizes react to carbon prices. Furthermore, exploring the impact of carbon prices on different financial instruments can be done by incorporating the results into a multi-asset portfolio and

observing reallocation across asset classes. These steps can provide valuable insights into the clean transition and assist investors in gaining a competitive advantage over those who have not yet incorporated the cost of carbon into their investment strategies.

Introduction

In a study interviewing 45 Chief Investment Officers, investment strategists, and portfolio managers, 93% of participants consider disruptions due to climate change as a risk, which are yet to be priced and integrated within the global financial system.[i] Institutional investors and other forward-looking individual investors are interested in tracking the greenhouse gas emissions of their investments and have formed coalitions, such as Climate Action 100+, to also engage with companies for encouraging them to reduce their carbon emissions.[ii] Carbon emissions are viewed as a systemic risk factor across global asset classes and attempts to de-risk portfolios by internalizing carbon pricing is a growing push among institutional investors.[iii] Almost 400 largest publicly listed companies have rolled out commitments to net-zero emissions target, along with key countries who are responsible for 61%of GHG emissions. The push towards a low-carbon economy has created a compelling case for institutional investors because a shift in policy and regulations incorporating carbon impacts can help portfolios understand their exposure to climate risks.[iv] From a company perspective, this will in turn have an impact on increased cost of equity capital for companies leading to decreased valuation in the long run, making them less lucrative for investments.

The global regulation and policy shift has indicated an increased likelihood that governments of major developed and emerging economies will intervene in the fossil fuel markets through various modes like taxation, cap and trade mechanisms to align with the United Nations Sustainable Development Goals Agenda 2030 of reducing GHG emissions.[v, vi, vii]

As carbon pricing and its adjacent carbon markets develop, investors will need clear analytical frameworks to understand carbon pricing and its impacts and a standardized system across economies. In

2022, there were 68 carbon pricing instruments worldwide and 3 more scheduled for implementation with a 23% coverage of total global GHG emissions.[viii] Additionally, 2022 saw the highest prices of carbon pricing in several jurisdictions along with a 60% increase in global carbon revenues, totaling to USD $84 billion.[ix] Despite the growth of carbon pricing instruments, the lack of a shared framework and standardized system burdens businesses with uncertainty,[x] which means that investors also face uncertainty risks when considering where to allocate their capital. Furthermore, investors interested in understanding carbon costs across their entire portfolio face blind spots in markets without carbon pricing instruments.

The goal of this project is to simulate how a carbon price can be used to develop a portfolio of US public equities by converting a company's carbon emissions into a financial cost. Since the US does not have a carbon price, a screening threshold based on a company's total cost of carbon emissions was decided through conversations with the project client, Angeleno Group. Angeleno Group, a venture capital and growth equity firm located in Los Angeles, California, is focused on next generation clean energy and climate solutions companies. Therefore, understanding carbon pricing's impacts on assets provides key information for their investment strategy. Companies in their portfolio range from technology and software providers to system designers, as well as installation, logistics, and services companies. The project's focus of developing an analytical process that considers carbon costs can provide Angeleno Group with an understanding of how carbon prices can weigh on allocating capital for public equities.

In a study conducted by Kruger (2018), more than 400 survey respondents of individual asset managers and firms indicated that current equity valuations fail in capturing climate change's risks and impacts.[xi] Fossil fuels and the oil sector were perceived to lead this overvaluation, followed by traditional car manufacturers and electric utilities. This project attempts to address the gap by evaluating how carbon prices would affect equity evaluations over the past 10 years. Our project considers the different ways to embed carbon costs into equity evaluations, either as a transaction costs or negative contributor to return (e.g., carbon tax). After a base model that incorporates carbon pricing has been developed, investment

moves, such as swapping traditional energy for new/clean energy, are to be incorporated into the analysis of carbon pricing impacts on asset allocation. We also will look at how portfolio construction might be affected at different carbon pricing scenarios with a focus on carbon taxes.

Statement of Objectives:

The objective of this Masters Project is to deliver a clear analytical framework, model(s), and a holistic report for the Angeleno Group and its institutional investors that are looking to consider how a price on carbon may impact investments from a portfolio allocation perspective using Modern Portfolio Theory. The team's purpose is to provide insights on the status of research on the topic and how carbon pricing such as a carbon tax per ton of emissions might alter the way investors allocate capital across global assets. This research project will look to explore the following:

1. Given a fund with X amount of capital, how will various prices of a carbon tax affect the weight of investments across global assets and what does optimal capital allocation look like?
2. How might forward-looking returns, expected risks, and transaction costs be impacted if carbon tax was implemented?

Due to the project's focus on modeling and analyzing the impacts of carbon pricing, the analysis conducted is based on the assumptions and limitations of the materials and methodologies used in the project.

Literature Review

More than 50 papers, consisting of newspaper articles, research papers, industry reports, and governmental documents, were reviewed to assess existing research on carbon considerations in assets classes for global markets, with special focus on US equities. The main finding is that asset classes are not equal when accounting for carbon intensity but require a variety of approaches to account for the impacts and subsequent cost of carbon.[xii, xiii]

The risks associated within the asset classes due to climate change and GHG emissions are currently not factored in the current valuations. For example, Harrison Hong (2019) highlights that droughts and other extreme events in food systems are not priced in valuation of food companies.[xiv] While Choi's study (2018) finds a trend where retail investors resort to selling high-emitting stocks and buy low-emitting stocks as a response to systematically abnormal temperatures,[xv] the institutional investors' portfolio decisions remain unaltered.[xvi] This presents a difference in how retail and institutional investors are internalizing risks caused or worsened by climate change.[xvii]

What risks do institutional investors face?

Globally, there is a push towards low-carbon economy and is starting to reflect in the policy and regulation, markets, technology or consumer behaviour which creates a 'transition risk' for financial systems. The assessments for the risk estimations are a challenging task due to lack of required granular data and the integrated modelling of the network linkages of these dynamic risks covering macroeconomy to climate-models.[xviii]

A combination of various physical and transition risks exist for the managers majorly in form of holdings and their focus has been on managing transition risks via divestment strategies, which focuses on selling a certain base-percentage of energy stocks followed by reallocation of capital across the wider portfolio.[xix,xx] This strategy may reduce the transitional risks but ends up creating more issues such as reduced dividends, or exposure to fluctuating energy prices.[xxi, xxii]

Using a ‘carbon footprint’, calculated by scaling emissions intensity (mTCO2e / $) with a portfolio company’s revenue, is argued to be a more effective strategy to inform the reallocation based on relative transition risk [xxiii]. However, according to Simm (2016) this concept has two main flaws:

(i) Currently, the carbon footprint of a company is based on its most current reported emissions data, dependent on the estimations under scopes 1, 2 & 3, and the sensitivity of methodology used to buy equity or value stocks based on a company’s cash-flow and financial prospects, which at present do not internalise the carbon consideration. [xxiv]

(ii) While a company’s carbon footprint has a high likelihood of being correlated with exposure to rising costs due to climate change, the company’s action of passing on increased costs to the consumer is unaccounted for.[xxv]

The literature review also highlighted how technological innovations threaten traditional business models of companies operating in heavily fossil fuel dependent industries, especially with the deployment of clean technology and energy technology companies.[xxvi]

Uncertainty in the policy landscape governing GHG and carbon pricing mechanisms is one of the key challenges for institutional investors because of the increased risk and complexity fund managers face when exiting an asset class that has been perceived as overvalued.[xxvii] Similarly, if an asset manager hedges against climate change impacts by divesting from stocks with a high carbon footprint, they bear the risk of underperforming relative to their benchmark.[xxviii]

Regulatory bodies are now promoting both voluntary and mandatory disclosures of corporations’ climate risk exposures and emission intensities. Currently, there is a lack of research on integrated assessment of climate risks with market efficiency and transmission channels covering the micro and macroeconomic landscapes with any geographical variation. [xxix] While this is a rapidly growing area, it is outside the scope of the project.

These physical, political, and technological risks can adversely impact the clients of institutional investors, while also presenting an opportunity for transition to a forward-looking fund and first mover in the new tech.[xxx] According to Bloomberg NEF Report 2022, the global push for low-carbon and clean energy accounted for 31% of clean energy transition investments raising over 1 trillion USD.[xxxi]

Carbon markets overview

Carbon markets can be broadly classified into compliance and voluntary markets. Compliance markets are mandatory, created by the government, and regulated by regional, national, or international carbon reduction regimes. Voluntary markets operate separately and allow individuals and organizations to purchase carbon offsets voluntarily without a compliance mandate or penalty.[xxxii]

Studies analyzing the factors influencing carbon markets suggest that energy and macroeconomic factors are key determinants, with energy influencing long-term market fluctuations and economic factors having more of a short-term impact.[xxxiii] This implies that the energy market has a negative relationship with the carbon market and a positive relationship with the stock market[xxxiv,xxxv]. Literature also suggests a 'spill-over' effect with financial or macroeconomic shocks on broader Environmental, Social, and Governance (ESG) indices[xxxvi], particularly true for the US, Canadian, UK and European markets. Major ESG markets like those in the US, Canada, Europe and the UK are classified as the net contributors of shocks to other markets, whereas Japan, China and India are generally net receivers. The US market exhibits bi-directional causal relationships with Canada, China, Europe, Russia and South Africa while Australia, India, Japan and the UK do not seem to have significant influence.

Carbon Pricing: What is it and why is it important?

Carbon pricing is a policy tool that was developed to lower emissions of carbon dioxide and its equivalents. Putting a price on carbon establishes a metric by which to measure carbon output in terms that can be related to a firm's operations and strategies. It also provides the public sector with a way to measure and quantify the impact of emitting activities.

One such measure that has been used in the US is the social cost of carbon, which quantifies the social externalities of one extra ton of carbon dioxide or equivalent emissions in terms of dollars.[xxxvii] These externalities vary by region, calculation methodologies, and time horizons; for example, carbon emissions impact crop productivity from droughts, healthcare costs from heat waves, and property damage from increased mass precipitation events or storm surges amplified by sea level rise.[xxxviii] The ability to price carbon emissions means giving the public and private sectors the infrastructure to align with one another and understand the shared impacts of those emissions.

However, pricing carbon emissions has no direct impact until that cost is internalized by the emitter, which may come in the form of an expense on a firm's P&L, or incorporation public project's cost-benefit analysis or investment valuation. Several approaches have been developed to directly integrate carbon prices into a decision maker's rationale: carbon taxes, emission trading systems (ETS), carbon crediting, internal carbon pricing, and results-based climate finance.[xxxix, xl]

With these various methods of pricing carbon, governments and companies can shape these pricing instruments to their goals or political and economic systems. One example of a carbon price methodology that is used across the economy regulates carbon emissions by enforcing firms to bear an additional operating expense. According to the World Bank's Carbon Pricing Dashboard, 70 carbon pricing initiatives have been implemented and cover roughly 23% of the global GHG emissions.[xli] While continued implementation of carbon pricing programs has been slow, programs have been expanding and a reduction of carbon emissions in regions with carbon pricing programs has been successful.

Significance of understanding carbon pricing impacts on US equities

While a carbon pricing program is unlikely to be implemented in the US in the near-term, the impacts of a carbon price on US equities should still be considered due to investor interest in environmentally friendly capitalism and potential use in representing an unaccounted cost of carbon. As mentioned previously, this project aims to explore how a hypothetical carbon price may impact US public equity returns so an

investor may learn to incorporate carbon pricing into their portfolio management. The first step to understanding the role of carbon pricing among other carbon considerations is to review the findings of existing literature on carbon considerations in the investing space.

Not all US firms incorporate carbon pricing into their operational or financial metrics, and thus do not analyze and incorporate carbon prices the way a company in a mandatory carbon market would. A key advantage of having a set price is that firms and investors have a tangible expense in relation to other financial metrics, as opposed to more abstract ESG scores which tend to be more difficult to quantify.[xlii] All firms will be impacted by a carbon price at an economic level, but the most pollutive firms will bear the highest burden due to their significant carbon footprint.[xliii] The increased costs may impact the broader economy as firms let increased costs trickle down to their consumers.[xliv]

Companies that do not integrate carbon pricing into their activities force investors to make decisions without carbon-informed rationale. Investors have become increasingly aware of carbon pricing metrics and their value, both from their role in the ESG space and as a robust risk management framework.[xlv] While pricing carbon does not provide insight into social or governance issues, it sheds light on a firm's environmental issues, such as examining the double materiality of carbon and financial information.[xlvi]

From an investor's perspective, a firm's cumulative carbon emissions can provide information on a firm's operations and efficiency, likely impact valuation. With respect to carbon impacting a firm's value, a carbon premium can be expected, where carbon inefficient companies would need higher returns to justify their carbon risk. The inverse of this expectation would be that carbon efficient firms have lower returns because of their lower risk. The claim that carbon efficient firms have lower risk is supported by a study from Trinks, Mulder, and Scholtens on 1,500 firms from 2009 to 2017, which finds that "on average, a 0.1 higher carbon efficiency is associated with a 1% higher profitability and a 0.6% lower exposure to systematic risk.[xlvii] These studies showcase the growing body of evidence validating the role of carbon efficiency in a firm's operations and how carbon emissions can be turned into financial indicators for investors.

However, carbon efficiency is not the only carbon metric used for environmentally informed financial analysis. The costs of carbon emissions from a set carbon price, mentioned previously, is another metric that can be used to inform investors but literature in this area is less conclusive. A Rabobank study of 900 companies showed that neither carbon emissions nor carbon prices were reflected in stock prices in Europe and that there was no carbon premium.[xlviii] The lack of a carbon premium could indicate that carbon is mispriced, that the current risk of carbon is negligible, or both. In the long run, this could mean that a carbon premium will emerge when carbon prices increase.

While Rabobank's study on European stocks does not reflect a carbon premium, a study by Patrick Bolton of Columbia University and Marcin Kacperczyk of Imperial College London with roughly 3400 companies found that firms with greater total CO_2 emissions had higher returns when controlling for their size, book-to-market ratio, and other return predictors. Their analysis showed that "investors are demanding compensation for their exposure to carbon emission risk",[xlix] implying the existence of a carbon premium.

Despite these studies disagreeing on the existence of a carbon premium, both realize that carbon emissions play a role in a company's finances and investor prospects, in line with the findings of Trinks, Mulder, and Scholtens. This aligns with the broader literature on carbon emissions, investing, and a firm's financial health synthesized in the January 2023 International Monetary Fund Working Paper on carbon pricing and stock returns. The paper, called "Carbon Policy Surprises and Stock Returns: Signals from Financial Markets", analyzed 2000 European firms from 2011-2021, and found that regulatory increases to carbon prices have a significant negative impact on stock returns, with impacts increasing with carbon intensity.[l] The negative relationship strengthened when EU ETS-participating firms were dropped, suggesting that investors price in transition risk stemming from a shift to a low-carbon economy. The estimates of this study imply that "a firm with an average carbon emission intensity, a one standard deviation increase in the carbon price is associated with a daily return which is 4.2% above average on non-regulatory event days (days when carbon prices are not increased by regulations), and a 7.3% below

average on regulatory event days (days when carbon prices are increased by regulations)."[li] This indicates that shocks occur when carbon prices are introduced or increased by way of regulation and the carbon premiums exist when the market adjusts.

The broader literature on carbon emissions and carbon pricing finds that carbon pricing does reduce emissions and makes small but significant impacts on a firm's productivity and innovation.[lii] Even in markets with established carbon pricing mechanisms, such as the EU ETS, Mexico's and Norway's carbon tax policies, Korea's cap and trade, etc., pricing signals to the market are modest and lack major impact because carbon is underpriced for the impact needed to achieve a net-zero goal by 2050.[liii] The recent news of Europe's carbon permits passing €100 indicates a turning point,[liv] but consequences of the carbon price remaining or increasing have yet to be realized.

Carbon pricing impacts in this Master's Project

Determining and interpreting the impacts of carbon prices

As articulated in the literature review on carbon considerations in company operations and financial metrics, incorporating carbon emissions into investment and portfolio analysis can have multiple approaches. The scenario that this project focuses on is the impact screening out equities based on the total cost of their emissions in the US public equity market, specifically the S&P 500 from 2013 to 2022.

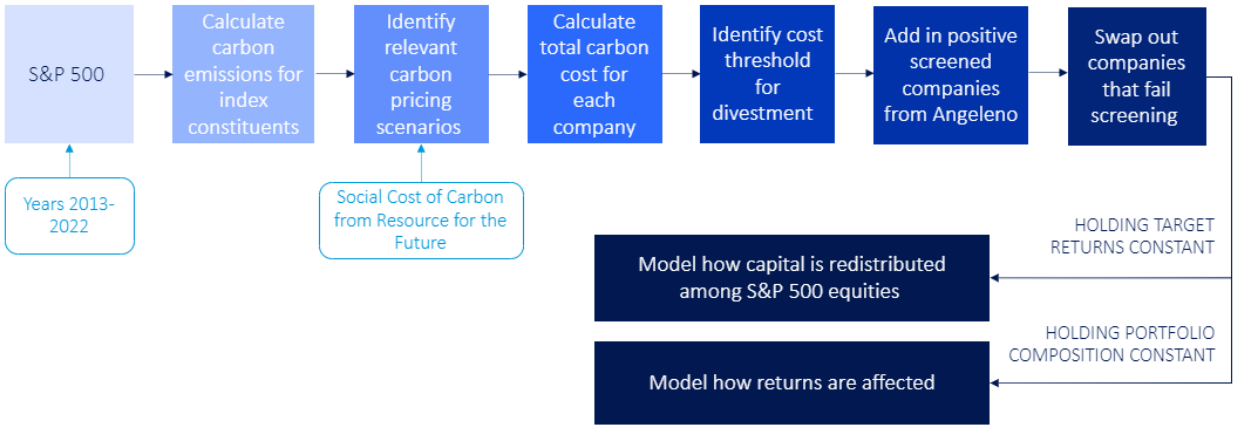
The S&P 500 was selected because the US market does not price carbon emissions, allowing the stocks of companies without carbon expenses to be screened with a hypothetical carbon cost. The years 2013 – 2022 were selected to provide a long-term trend analysis and offset the recent economic downturn from the COVID-19 pandemic and the tight-labor/high inflation style recession.

Each year, the sample portfolio is changed to reflect the updated S&P 500 companies to maintain our sample portfolio's goal of representing the largest public US equities. In addition to analyzing the impacts of a carbon price on a portfolio of S&P 500 companies, a screening based on carbon emissions is done to

view how US equities respond to such screening, and which companies fail the screening. The failed companies are then swapped out with firms from Angeleno Group and the returns are compared to the S&P 500 portfolio that was analyzed.

Methodology and Data

Our analysis first translates the impacts of carbon pricing on the carbon costs each individual company would have to pay out. Companies within the S&P 500 index were analyzed over a 10-year horizon from 2013 to 2022, in addition to the companies from Angeleno Group due to their availability and the absence of an implemented carbon pricing scheme in the US. Using data from the US public equities market allows an analysis with and without carbon pricing to be conducted, and thus gives the opportunity to see the impacts of carbon pricing, if any, on index returns and investing strategy.



The variables used to perform the analysis are described in Table 1. The boundary of the impact of an abstract carbon price is limited to large-cap US equities through the S&P 500, an index used extensively as a gauge for tracking the performance of large publicly traded companies in the United States due to its size, stability, and diversified sectors; it represents 80-85% of the US stock market.[lv] Our methodology consists of evaluating the monthly returns of the constituents of the S&P 500 at the end of each year over

a time horizon of ten years from 2013 to 2022. There are three cases to consider in the analysis: base portfolio, divested portfolio, and swapped portfolio.

Table 1. Datasets used in the analysis

Variable	Unit	Source	Description
S&P 500 Constituents	N/A	Bloomberg	List of companies included in S&P 500 index at the end of each year
Monthly Total Return	%	Bloomberg	Total return for each month of the year for each company
Market Capitalization	$	Bloomberg	Total value of a publicly traded company's outstanding common shares
Weight	N/A	Calculated	Individual company market capitalization divided by total market value of all companies
GICS Sector	N/A	Bloomberg	Systematic classification of company by sector using Global Industry Classification Standard (GICS)
Total CO_2e Emissions	Million tCO_2e	Bloomberg	Total greenhouse gas (GHG), if available, otherwise total carbon dioxide (CO2) emissions in millions of metric tonnes. Sum of Scope 1 and 2 GHG emissions or sum of direct and indirect CO_2 emissions
Carbon Intensity by Sector	tCO2e/$M Revenue	S&P Global	Index weighted average of individual company intensities (operational and first tier supply chain emissions per USD revenues)

AG Climate Index	%	Angeleno Group	AG climate index returns composed of companies across climate solutions and resilience

Establishing the Base Case:

Constituents of the S&P 500 index change quarterly due to reasons such as mergers and acquisitions or market capitalization changes[lvi]. To minimize this variation during our portfolio construction, a snapshot of the index at the end of each year was used to represent the portfolio each year. This means that the companies in our base case will look different from year to year. Each year, the index will have a monthly total return based on an individual company's market weight relative to the entire index and the company's monthly total return. In practice, the sum of the products of the two variables for each company *i* at month *t* in the portfolio of approximately 500 companies will provide the index returns:

$$\sum_{i=1}^{\sim 500} \text{Weight}^{i} \times \text{Monthly Total Return}^{i,t}(\%) = \text{Portfolio Monthly Total Return}^{t}\ (\%)$$

Developing a High Emissions Adjusted Case:

i. As a first step towards creating a divested index case, carbon emissions data were estimated for each company in the S&P 500 over the 10-year period. This data was found from Bloomberg wherever possible and where there were gaps in the data, sector-level carbon emissions intensity factors were used. These sector-level emissions intensity factors were scaled by the revenue of each company *i*, in a given year *t*, to give a proxy annual carbon emissions value. The calculation for proxy carbon emissions of company *i* in year *t* is performed by:

ii. $$\text{Carbon Intensity by Sector}\left(\frac{\text{tCO}_2\text{e}}{\$\ \text{Revenue}}\right) \times \text{Revenue}^{i,t}\ (\$) = \text{Carbon Emission}^{i,t}\ (\text{tCO}_2\text{e})\text{A}$$

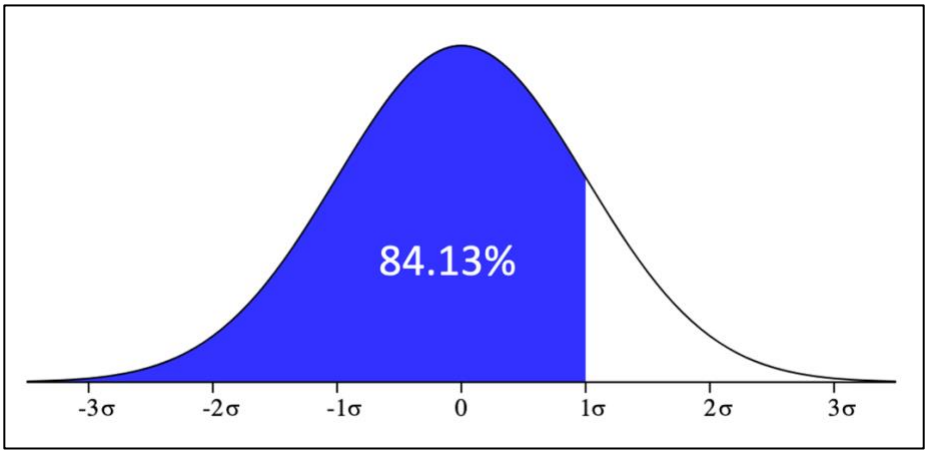
cost of carbon of \$100/ton CO_2e was identified as appropriate based on the UN Global Compact's agreement with private sector companies for a \$100/ton CO_2e[lvii] and the range of \$80 to \$185/ton

CO_2e from an analysis on the cost of carbon impacts by Resources for the Future, an environmental think tank.[lviii] Once a carbon price was identified, it was applied to the total emissions associated with each company. This results in a theoretical carbon cost to the company based on its absolute Scope 1 and 2 emissions in a particular year.

$$\text{Carbon Emission}^{i,t}\ (\text{tCO}_2\text{e}) \times \text{Carbon Price}\left(\frac{\$}{\text{tCO}_2\text{e}}\right) = \text{Carbon Cost}^{i,t}\ (\$)$$

iii. Once the carbon cost for each company is normalized using a logarithmic transformation, a criterion of above one standard deviation is established for divesting or swapping a company in the index. See *Figure 1* for a general normal distribution of data that would fall within the inclusion framework. Companies that fall in the right tail of the distribution, above one standard deviation, will be excluded, a process done for each year across the time horizon.

Figure 1. Normal distribution with area below one standard deviation



Developing a Climate Solutions Enhanced Case:

Using the divestment threshold of one standard deviation for carbon emission costs serves a way of screening out companies with high exposure to carbon. The aggregate weight of the companies that were removed from the base case index each year are replaced with Angeleno Group's Climate Index consisting of companies across climate tech solutions and climate resilience, resulting in the development of a climate solutions enhanced S&P 500.

Analysis

Figure 2 represents an example distribution of carbon emission costs per company using a logarithmic transformation. The log transformation allows for converting skewed data to fit a normal distribution, and if the original data is log-normal, the transformed data will follow a normal distribution.[lix] Companies that are one standard deviation or greater above the mean normalized cost are divested from and replaced with alternative clean companies. When a company does not have a revenue figure and emissions value, it is left out of the exclusion process since it is not possible to find an estimated carbon emission cost. The number of companies that is divested from according to the criteria is detailed in each year in Table 2.

Figure 22. Distribution of Log Carbon Emissions Cost Per Company in 2013 @ $100/tCO$_2$e

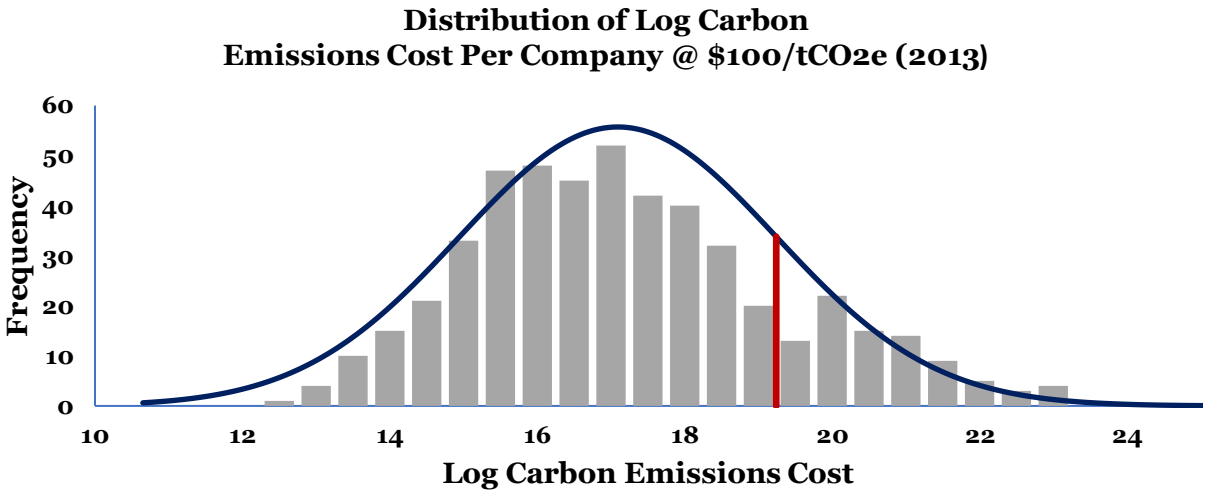
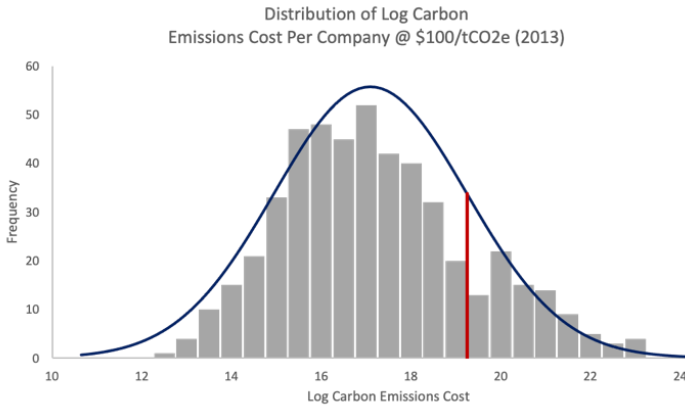
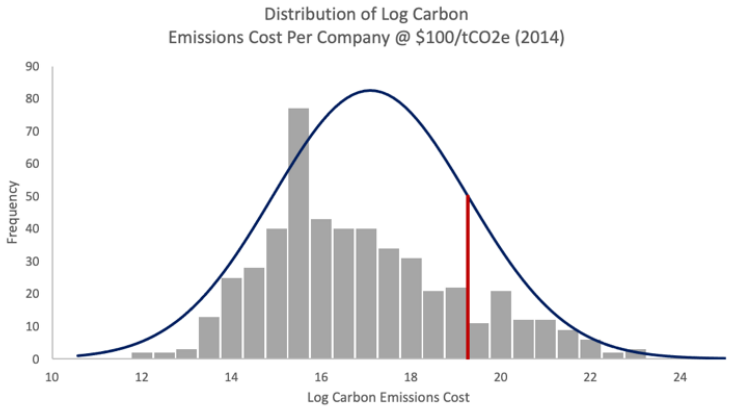


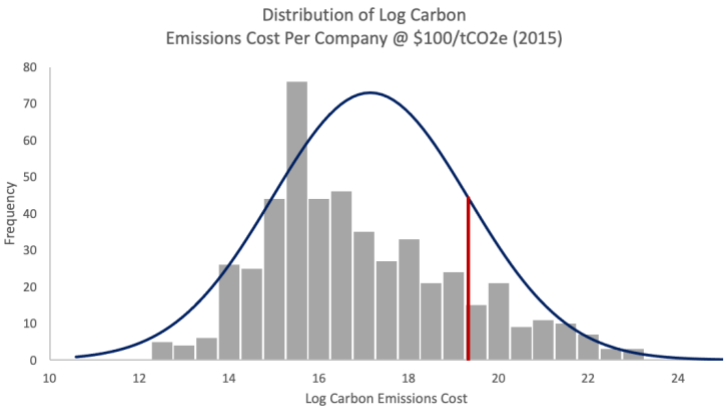
Table 2. Number of Divestments per Year

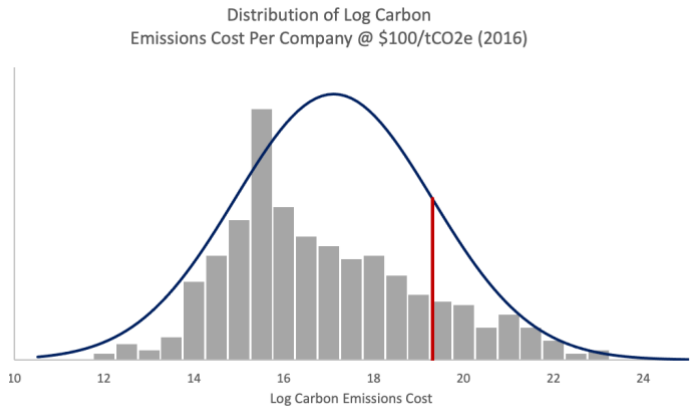
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of Divestments	83	89	87	86	89	86	81	88	90	93

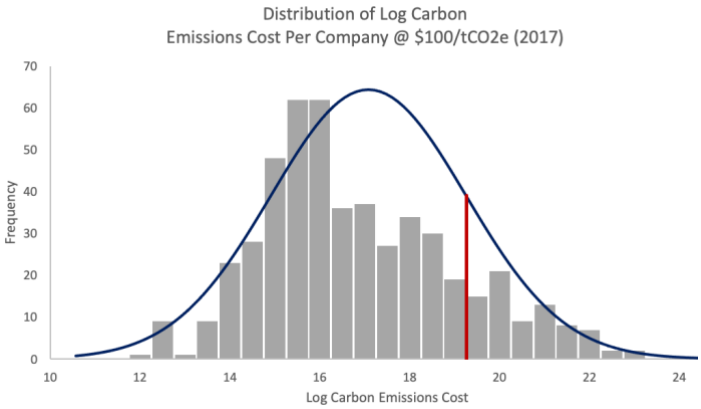
Distribution of Log Carbon Emissions Cost Per Company in 2013-2022 @ $100/tCO2e

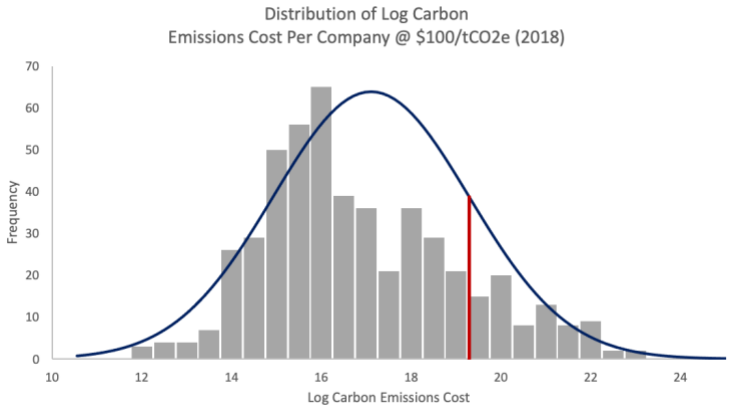












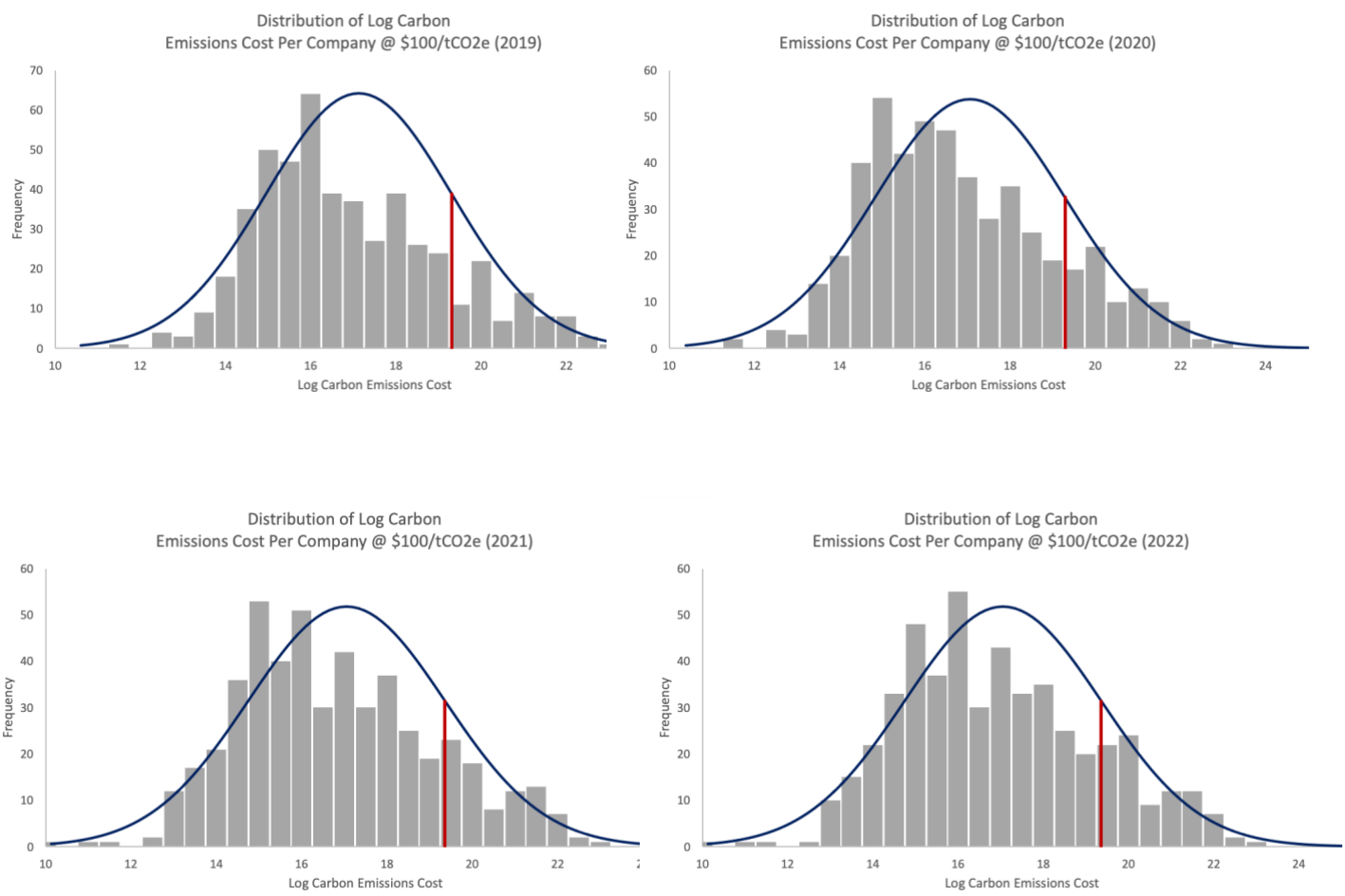
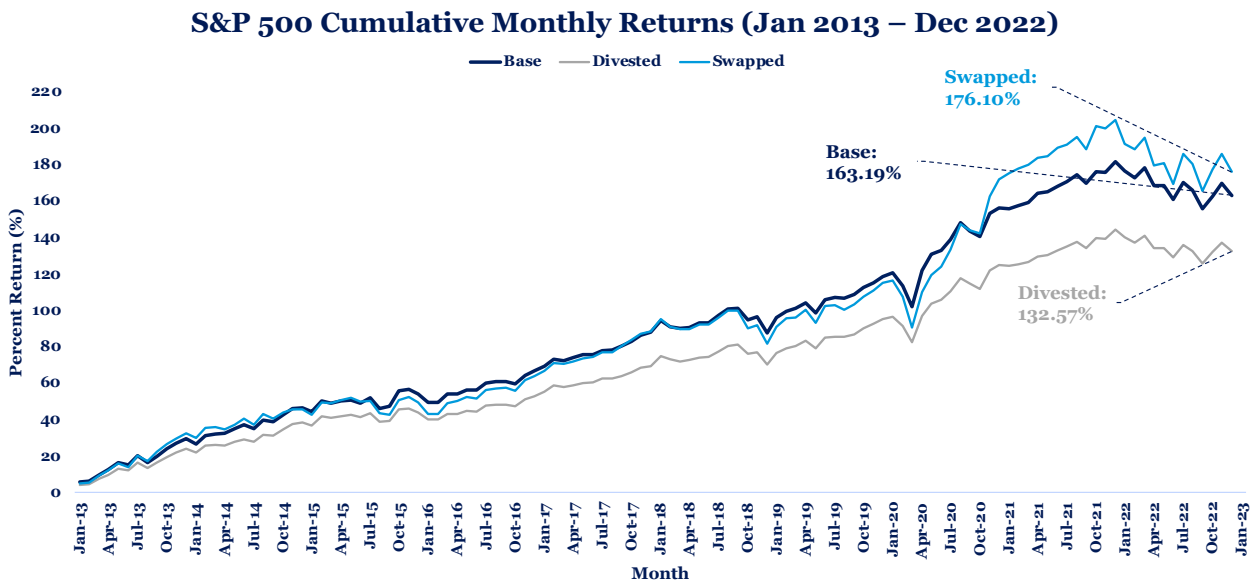


Table 3 provides the summary results of annualized risk and return for each case developed. The climate solutions enhanced case has the highest returns followed by the base and high emissions adjusted index. In terms of standard deviation (risk), the index adjusted for high emissions results in the lowest risk followed by the base and climate solutions enhanced. The monthly trend of returns over the past 10 years from 2013 to 2022 is highlighted in Figure 3 for each case.

Table 3. Annualized Scenario Results

	Base	High Emissions Adjusted	Climate Solutions Enhanced
Returns	16.32%	13.26%	17.61%
Standard Deviation	15.79	12.00	21.36
Sharpe Ratio	1.03	1.10	0.82

Figure 3. S&P 500 Cumulative Monthly Returns (Jan. 2013 – Dec. 2022)



Conclusion and Next Steps

To summarize the results of divesting from extreme emitters and then swapping in Angeleno Group's climate resilient companies, screening S&P 500 companies by the cost of their carbon emissions and divesting from extreme emitters reduces returns but also reduces risk, which produces a higher Sharpe ratio. When Angeleno Group's climate focused companies replace the extreme emitters, there is an increase in returns, beating both the base and divested cases, but also a higher risk.

The increase in risk from the divested case to the clean case seems to be a different type of risk compared to the reduction in risk when the base case was turned into the divested case. Since the divestment method used the total cost of carbon emissions, the reduction in risk implies a relationship to a company's total emissions. The risk that comes with Angeleno Group's companies, on the other hand, is different because Angeleno Group's companies have fewer carbon emissions and are smaller compared to the companies in the S&P 500. Therefore, this transition risk that seems to be captured by the clean case suggests how smaller and cleaner companies will impact an equity portfolio as it replaces large carbon emitting companies with smaller, less carbon emitting, companies.

The differences seen in the risks and returns are also dependent on the companies used in this analysis, as well as the thresholds that were set to determine which firms were extreme emitters. Therefore, the next steps to be explored are:

1. Applying this carbon cost analysis process to other groups of companies, such as the Russel 3000 index, to see the impacts screening by the total cost of carbon emissions on mid, small, and microcap firms.
2. Adjusting the cutoff threshold for total cost of carbon emissions or changing it to a different threshold, such as carbon emissions intensity (ton CO_2e/ $ Revenue), to see which companies are deemed as extreme emitters.
3. Applying the carbon cost analysis process to other asset classes to see how a more diverse portfolio changes when targets for returns and risk are set. For example, seeing how much capital is allocated to real assets compared to private equity or fixed income assets when carbon is incorporated into a multi-asset portfolio.

By adjusting the base companies and thresholds of the analysis process, a greater understanding of how different sized firms and investors react to carbon prices can be reached. Additionally, the impact of carbon prices on different financial instruments can be explored by applying this analysis process to a multi-asset portfolio. The insight generated from these steps can help develop expectations for the clean transition and inform investors, such as Angeleno Group, on how to establish a competitive advantage compared to others that are not yet considering the cost of carbon in their investment strategies.

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