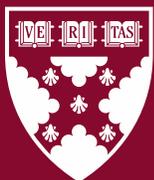# Climate Solutions Investments

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Climate Solutions Investments

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Abstract

An increasing number of companies are providing products and services that help reduce carbon emissions in the economy. We develop a methodology to identify those companies and create a sample of publicly listed climate solutions companies allowing us to study their geographic composition, accounting fundamentals, valuation ratios, and stock performance over time. The sample is equally split between developed and emerging markets with more companies located in China rather than the US or the EU. A portfolio of climate solutions companies exhibits higher revenue growth, higher investments in research and development, and talent and lower profitability margin. The portfolio exhibits superior stock market performance since 2018, driven by solutions in energy, fuels, battery, and transportation. Finally, the portfolio's returns exhibit very little correlation with the returns of portfolios that seek to reduce their carbon emissions by underweighting high carbon emission companies, suggesting that climate solutions portfolios are distinct from low carbon emission indices.

Keywords: *Climate Change, Decarbonization, Climate Solutions, Innovation, Carbon Emissions, Portfolio Construction*

1. Introduction

Climate change and the associated policy, technological, legal, consumer, and employee responses to it have given rise to increasing requests by asset owners to lower carbon emissions in portfolios and reduce exposure to transition risk. In turn, an increasing number of climate funds and indices have been launched. Most of these financial products seek to reduce the carbon footprint of a portfolio by excluding firms with very high carbon intensity (i.e., carbon emissions scaled by firm revenue to account for the fact that emissions scale with economic activity). Examples of these products include MSCI ACWI Low Carbon Index and MSCI ACWI Climate Change Index. Some products compare firms irrespective of industry membership while others create best-in-class benchmarking thereby allowing representation of all industries. A key characteristic of these products is that they achieve significant lowering of portfolio carbon emissions relative to the benchmark while still achieving very low tracking error. In that sense they allow an investor to reduce exposure to policy responses, such as carbon taxes, while offering risk-return profiles similar to the market (Andersson, Bolton and Samama 2016).

Such low carbon portfolios, while they could lower exposure to climate risk, do not necessarily provide an investor with exposure to climate opportunities. The transition to a low carbon economy requires the development, deployment, and scaling of several key new technologies, products, and services. These climate solutions range from renewable energy, electrification of transportation and processes, battery technology, energy and process efficiency, circularity, new agricultural practices, and plant-based protein alternatives to meat. These solutions should see top-line revenue growth as the world proceeds to decarbonize and meet the goal of reaching net-zero emissions close to mid-century, a goal that the scientific community agrees to be necessary to stay well below a 2-degrees Celsius increase in temperature before end of the century (IPCC 2021). It is estimated that the next generation climate-related technologies could attract $1.5 trillion to $2 trillion of capital investment per year by 2025.[1] To access to these markets, considerable understanding of the new technologies, policies and market demand is needed, which could be a formidable task for investors.

Several "pure-play" portfolios and indices provide exposure to such climate solutions, such as companies engaged in clean tech, renewable energy, and energy storage. Examples include S&P Clean Global Clean Energy and NASDAQ Clean Edge Green Energy. However, to our knowledge,

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[1] innovating-to-net-zero-an-executives-guide-to-climate-technology.pdf (mckinsey.com)

there is currently an absence of a systematic process through which an investor could identify climate solutions companies; this lacuna makes it challenging to scope the size of the market and its geography. Such a process is further complicated by the fact that there is no generally accepted definition of which economic activities are "green", a challenge that has given rise to the development of taxonomies in the EU, China, and Mongolia among other jurisdictions. In turn, the lack of process for constructing a sample of climate solutions companies inhibits the systematic study of their accounting and stock market performance over time.

In this paper, we develop a process that allows us to identify a large set of companies that are publicly listed around the world. We limit our analysis to companies that are publicly listed because of data availability. However, we note that there are many climate solutions companies that are privately held, a limitation of our analysis.

Our process relies on reviewing international reports, regional net zero frameworks, research papers, and relevant news, from which we identify 10 business areas central to climate change solutions: agriculture and food; building and housing; carbon capture, utilization, and storage (CCUS); energy generation; energy storage; materials; nature-based solutions; recycling and circularity; and transportation. Within each business area, we conduct a thorough investigation to assess the landscape of climate technology and innovation. From this research, we generate a list of 164 relevant keywords and phrases specific to these business areas and identify those in company business descriptions. To keep our sample and analysis as sensitive as possible to exposure to climate opportunities we exclude companies for which only part of their business is related to climate solutions, for example an automobile manufacturer that provides both electric and internal combustion engine vehicles. The drawback of this choice is that our sample underestimates the total number of companies and size of the publicly listed climate solutions market. However, this is outside the scope of our paper. We knowingly make a tradeoff to construct a purer but incomplete climate solutions sample, compared to a complete but contaminated with non-climate solutions sample.

After excluding companies with very limited stock market liquidity and very low market capitalization we are left with 632 companies. This represents a much larger sample compared to the 50-60 companies usually found in pure-play climate products, allowing an investor to deploy more capital across a more diverse set of economic activities and regions. Related to regions, one significant finding is the presence of climate solutions companies in emerging markets. Almost

half of companies (and market capitalization) of the sample is in emerging markets, with China representing the biggest country allocation both on an equal and market capitalization weighted basis. This finding has implications for the geographic location of where the innovation and solutions for climate are created but also the political, currency and regulatory risks that investors might assume as they seek exposure to climate solutions.

We find that climate solutions companies are less profitable but experience higher revenue growth than their industry peers, analyzing data from January 2011 to October 2021. Moreover, they have both higher capital and research and development expenditure intensities (e.g., scaled by firm revenues). Collectively, this evidence is consistent with a portfolio of climate solutions companies exposing an investor to lower profitability, higher top-line revenue growth and investment firms, which are focused on developing scale to provide solutions for their customers. Examining two key valuation ratios, earnings yield and book-to-market, complements this picture. The climate solutions portfolio exhibits lower earnings yield and book-to-market, consistent with the market reflecting the higher anticipated growth prospects and expecting that growth premium to materialize in the future. The one exception is that, on an equally-weighted basis, the climate solutions portfolio exhibits higher book-to-market, a reflection of some smaller climate solutions companies facing financial difficulties.

We next turn to an analysis of stock performance between January 2011 and October 2021. The climate solutions portfolio exhibits several characteristics that provide validation for its construction. First, it is highly correlated (0.82-0.85 on a value-weighted basis) with pure-play indices, such as S&P Global Clean Energy and NASDAQ Clean Edge Green Energy (~0.5 after stripping out market returns). Moreover, it shares with those indices a high tracking error relative to the market index (~15-20%). To provide a relative evaluation of those tracking errors, we also construct various decarbonized portfolios and show that those have much lower tracking error (~1.5%), consistent with existing financial products, such as MSCI low carbon ACWI. Importantly, after accounting for market returns, there is close to zero correlation between the returns of the climate solutions portfolio and those of low carbon indices, suggesting that the two products are distinct. While the low carbon index seeks to reduce the exposure of an investor to high carbon businesses that might be disrupted from regulatory and technological developments, the climate solutions portfolio provides an investor with exposure to innovative and growing businesses that seek to capitalize on the transition to a low carbon economy.

We decompose the stock performance of the climate solutions portfolio and find that its superior performance, relative to market and other factor exposures (i.e., value, size, momentum, investment, profitability), is concentrated in several ways. From a timing perspective, in the last four years; from a geographic perspective in developed markets primarily but also in emerging markets excluding China; from a solutions perspective in energy, fuels, battery and transportation. These results provide a deeper understanding of the performance of the climate solutions portfolio.

2. Sample Selection and Data

To construct our sample, we first set out to better understand the breadth of climate change solutions within the global economy. We reviewed international reports, regional net zero frameworks, research papers, and relevant news, from which we identify 10 business areas central to climate change solutions: agriculture and food; building and housing; carbon capture, utilization, and storage (CCUS); energy generation; energy storage; materials; nature-based solutions; recycling and circularity; and transportation. Within each business area, we conduct a thorough investigation to assess the landscape of climate technology and innovation. From this research, we generate a list of 164 relevant keywords and phrases specific to these business areas: 23 keywords and phrases relate to agriculture and food (e.g., "plant based") ; 6 to building and housing (e.g., "green building"); 17 to carbon capture, utilization, and storage (CCUS) (e.g., "carbon sequestration"); 51 to energy generation (e.g., "solar power"); 28 to energy storage (e.g., "lithium oxygen battery"); 8 to materials (e.g., "sustainable cement"); 5 to nature-based solutions (e.g., "carbon offset"); 11 to recycling and circularity (e.g., "circular economy"); and 14 to transportation (e.g., "electric vehicle"). In addition, we identify 23 keywords and phrases related to general climate change solutions (e.g., "low carbon") to account for any unacknowledged solutions both within and outside of the 10 business areas. Our final list consists of 187 climate change solution terms.[2]

Using global corporate databases provided by Worldscope and S&P Global Market Intelligence, we identify firms as of March 2, 2021 with business descriptions that incorporate at least one term from our list.[3] Of these firms, we limit our sample to only those publicly-listed at

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[2] These 187 keywords and phrases include conventional spelling and grammar variations for relevant terms. For example, "net zero" and "net-zero" are frequently used interchangeably. Both have been included in our list.
[3] The WorldScope corporate data was downloaded for all active and inactive public companies for the year 2019 from Worldscope Annual Fundamentals accessed via Wharton Research Data Services (WRDS). S&P Global Market

present or those publicly-listed at any point in the past. Specifically, we include only active and inactive public firms thereby excluding firms that have always been private as these companies do not have data for the analyses we perform. We keep inactive firms to mitigate survivorship bias. For these companies, we download financial data from Worldscope and S&P Global Market Intelligence and supplement this data using Bloomberg, FactSet Research Systems, S&P Capital IQ, and the International Securities Identification Number (ISIN) Database.[4]

To continue refining our sample, we remove companies primarily operating in industries traditionally unrelated to climate change solutions. These industries include health care, communications, and financials.[5] In addition, duplicate observations are identified and removed based on company name, ISIN, and six-digit Committee on Uniform Securities Identification Procedures number (CUSIP).[6] At this stage, the sample contains a unique list of active and inactive public firms operating within climate change solution industries.

To limit our sample to pure-play companies, we employ negative and positive screening techniques. We are interested in constructing a sample of pure-play companies, so the economics of the business are driven by the climate solutions they are providing instead of those solutions representing a small part of the business. For example, while Microsoft provides several solutions to clients seeking to lower their carbon emissions, arguably the fundamentals and performance of Microsoft are not historically or currently driven mostly by those solutions. Similarly, although BMW offers some electric vehicles, BMW is not classified as a climate solutions company, given the company's primary set of products are internal combustion engine vehicles. For each screen, we search business descriptions for relevant terms. We utilize all S&P Global Market Intelligence and Worldscope data in our screening process, including data from observations removed in prior

Intelligence corporate data was downloaded for all active and inactive public companies as of March 2, 2021 from the S&P Global Market Intelligence web platform.

[4] The supplemental ISIN data was obtained from Bloomberg, FactSet Research Systems, S&P Capital IQ, and the ISIN Database.

[5] Due to inconsistencies in availability of industry-level data provided by Worldscope and S&P Global Market Intelligence, we map two-digit Standard Industrial Classifications (SIC) onto Global Industry Classification Standard (GICS) Level 1 Sectors. In doing so, we are able to assign a GICS Level 1 Sector to all observations in the data. We then remove the following GICS Level 1 Sectors: Health Care, Communications, and Financials. In addition, for observations with S&P Global Market Intelligence 2nd Level Primary Industry data, we remove companies operating in the Media industry. The S&P Global Market Intelligence 2nd Level Primary Industry variable is only populated for observations downloaded from S&P Global Market Intelligence.

[6] The first six digits of a CUSIP are unique to the issuing firm of a given security. Legal entity types traditionally used in company names are standardized across sources to better identify duplicate observations. For example, company names ending "incorporated" and "incorporation" are all given the common suffix "Inc."

steps. Hence, companies with observations from both S&P Global Market Intelligence and Worldscope often have multiple business descriptions. Before conducting these screens, we systematically review the content and structure of the business description data to ensure each description is informative of firm operations. We find that business descriptions from Worldscope associated with current and former special purpose acquisition companies (SPACs) are generic and often uninformative of current company operations. For these firms, we download new business descriptions from Bloomberg and use these descriptions in place of those from Worldscope.

We first employ a negative screen to exclude companies that engage in business practices unrelated to climate change solutions.[7] Companies are removed from the sample if any of their business descriptions contain at least one of the 21 negative terms. Examples of negative terms include "coal," "petroleum," and "refinery." Conceptually, companies are not considered pure-play if they are described as operating in business segments external to climate change solutions.

Alternatively, to ensure a company's primary business operations are climate-solution centric, we employ a positive screen. Upon analyzing the business description data, we recognize the first sentence of each description often begins with the company name followed by an explanation of primary business activities.[8] Thus, we are able to use the content of the first sentence to assess if a company is predominantly focused on climate solutions. Due to variation in punctuation usage within the business description data, we elect to search a string of characters approximately equivalent in length to that of the first sentence. We estimate the length of the first sentence to be approximately 100 characters. To be conservative and to treat companies with short and long names alike, we screen the sum of 200 characters and the number of characters in the company name.[9] In the initial sample, a company name is on average approximately 25 characters

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[7] Unrelated business practices include those harmful to the climate as well as those external to climate-change.

[8] Only a small portion of observations from S&P Global Market Intelligence include business descriptions that deviate from this structure.

[9] For observations in which the first sentence of the business description does not describe company operations, we analyze the structure, function, and length of the first sentence. We find these observations primarily consist of firms previously involved in acquisitions or firms previously having filed for bankruptcy. In either case, the second sentence in these descriptions contains an explanation of the company's primary business activities in the common structure (i.e., company name followed by a description of business activities). This sentence is preceded by one describing the bankruptcy filing or acquisition. We estimate the length of the first sentence for each case independently. Regardless of case, we find the first sentence of these business descriptions measures approximately 60 characters in length. For these observations, we screen the sum of the first 160 characters of the business description and the number of characters in the company name.

in length. Thus, we search approximately the first 225 characters of each business description for any of the terms related to climate change solutions.[10] Companies are included in the sample if any of their business descriptions contain at least one of the positive terms within the relevant portion of text. Following the positive screen, the sample consists of 944 firms.

We acknowledge the challenges associated with using industry data and business descriptions to identify pure-play climate change solution companies. Hence, we conduct a manual audit of the remaining firms in both samples to ensure continuity. From this review, we remove 27 firms. We also add 29 pure-play firms to the sample, identifying such firms through lists compiled by industry publications. Following these manual adjustments, the final sample consists of 946 firms.

Next, we match the companies by ISINs in our sample with their primary equity securities in DataStream from January 2011 to October 2021. The total returns and market capitalizations in US dollars as well as primary exchange and delist information for these securities are collected from DataStream as well. Based on this matching, we are able to identify 874 stocks in this process. After removing 8 stocks which are delisted before January 2011, we are left with 866 stocks.

We notice this sample of 866 stocks contains a number of illiquid securities that trade irregularly with low volume, and exhibit extremely volatile returns. Some of these stocks are only traded over the counter, or have the trading exchange information missing in DataStream. Moreover, since we have delisted stocks in our sample, even though we have filtered them out after their delist dates, we find these securities could have little or no trading activity and price movement long before they are finally delisted. Given these considerations and that most investors would not invest in these very illiquid stocks, we drop stocks that are only traded over the counter or for whom we cannot identify a trading exchange. In addition, we apply a filter requiring that prices be equal or greater than $1 USD for the observations in developed markets and $.1 USD for the observations in emerging markets. After this process, we have in total of 632 stocks matched for our sample companies. Exhibit 1 summarizes the sample selection process.

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[10] The 187 keywords and phrases are the same as those used in the initial sample identification. For observations in which the first sentence of the business description does not describe company operations, we search approximately the first 185 characters (125 characters plus an additional 60 characters for the estimated length of the first sentence) of each business description for any of the positive keywords and phrases.

Exhibit 1: Sample Selection

Screening Criteria	Number of Observations
Firms Identified in Keyword Search	
Thomson Reuters - Worldscope	3,041
S&P Global Market Intelligence	3,573
Active and Inactive Public Firms	6,614
Remove Observations in Unrelated Industries	
Less: Communication Services	43
Less: Financials	300
Less Healthcare	10
Firms in Climate Solutions Industries	6,261
Remove Firm Duplicates	
Less: Duplicates	2,107
Unique Firms in Climate Solutions Industries	4,154
Business Description Keyword Screening	
Less: Negative Keyword Screen	2,184
Less: Positive Keyword Screen	1,026
Climate Solutions Firms	944
Manual Adjustments	
Additions	29
Removals	27
Climate Solutions Firms	946
Match Firms with Primary Securities in DataStream	
Less: Stocks not matched by ISIN	72
Less: Stocks delisted before January 1st, 2011	8
Climate Solutions Stocks	866
Illiquidity Stock Screening	
Less: Stocks only traded over the counter or exchange not identified	178
Less: Observations by date and stock with price < $1 USD in DM, and <$.1 USD in EM	56
Final number of climate solutions stocks	**632**

Note: Exhibit 1 presents the sample selection process. Sample data are from Thomson Reuters Worldscope access via WRSD and S&P Global Market Intelligence. Worldscope Annual Fundamental data was downloaded for the year 2019. S&P Global Market Intelligence data was downloaded as of March 2, 2021. Active and inactive public firms are identified by searching Worldscope and S&P business description fields for a predefined list of 187 climate change solution terms. Duplicate observations are identified and removed based on company name, ISIN, and six-digit Committee on Uniform Securities Identification Procedures number

(CUSIP). The negative screen includes 21 terms specific to business practices external to climate change solutions. The negative screen is applied to each full-length business description. The positive screen is applied to only a portion of each business description. The identified companies are then matched to their primary securities based on ISIN from DataStream. Observations are dropped from this study for the stocks that are only traded over the counter or miss trading exchange information, or if the stock price is less than $1 USD in the developed markets or less than .1 USD in the emerging market.

Other data used in in this study include valuation multiples such as earnings yield, book-to-market, and accounting ratios containing return to equity, one-year revenue growth, selling, general & administrative expenses/revenue, capital expenditure/revenue and research & development/revenue, all obtained from the Refinitiv Worldscope Point in Time database.

3. Portfolio Construction

Based on the list of stocks we identified from previous section, we construct value- and equal-weighted climate solutions portfolios (CSP). These portfolios are formed at the end of 2010 and rebalanced monthly. On the rebalance day, which is the last business day of the month, the value-weighted portfolio is calculated based on the market capitalization weights of stocks in our sample from previous business day, while the equally-weighted portfolio is calculated based on an equal weighting of stocks in the sample from previous trading day.

To have a better understanding of the evolution of climate solutions portfolios, we report the characteristics and performance of these portfolios for three time periods including 2011-2021, 2016-2021, and 2018-2021. Note that for year 2021 we include the months from January to October given the data availability at the time of this study. Our full sample period spans from January 2011 to October 2021, which is not a particularly long time; however even within this horizon subperiods may exhibit meaningful differences, as the climate solutions businesses and activities of interest have only begun to develop in most recent years. This is because research and investment cycle for these new climate technologies could be rather long. For example, in solar-power generation it took three decades of research and investment to achieve cost parity with coal in 2013 and gas power in 2015.[11] Therefore, we also look at the time period 2016-2021, which is after the adoption of the Paris Agreement at COP 21 in December 2015, and the most recent three years from 2018 to 2021, during which these climate solutions companies have started to gain momentum.

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[11] Levelized cost of energy, levelized cost of storage, and levelized cost of hydrogen, Lazard, October 19, 2020, lazard.com.

Besides, we also build portfolios for developed markets and emerging markets as well as for a few major regions such as US, Europe, China, and EM excluding China respectively to understand the market and regional differences.

4. Key Insights

In this section we document the key observations and findings based on our Climate Solutions portfolios. We start by examining statistics for our sample constituents by market/region and then focus on the fundamental characteristics by accounting and market valuation ratios. Furthermore, we document our findings regarding the tracking errors, correlations and market performance of the climate solutions portfolios relative to market benchmarks and other climate change indices.

4.1. The Anatomy of a Climate Solutions Portfolio

Exhibit 2 Panel A and B present the average statistics for our sample climate solutions stocks from January 2011 to October 2021 by country/region. On average, we have 432 stocks across any given month, representing 499 billion of US dollar market capitalization. We observe quite significant growth in this market segment as seen through the 993.5% increase in market capitalization in Exhibit 2 Panel C, to almost $2.5 trillion by October 2021.

Particularly, we find emerging markets have a very large presence in our portfolio — almost half of our portfolio is in emerging markets in terms of average total market capitalization and number of climate solutions stocks, while the other half is in developed markets as shown in Exhibit 2 Panel B.[12] When breaking down by regions, we observe China has the largest share about 36.1% by market capitalization, followed by US 30.6%, Europe 14.5%, and EM ex China 10.0% on average during this time period.

This finding challenges the impression that developed markets dominate emerging markets in the domain of climate solutions. In fact, companies in emerging markets have been actively participated in transitioning to low carbon by providing climate-smart products and services. For example, China, relying on its growing economic and technological strength, is leading many developed countries in combatting climate change with new technologies in batteries and

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[12] Developed markets include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK, and the US. All other regions/markets are classified as emerging markets in this study.

electronic vehicles, stimulated by the government's preferential policies towards these new-energy technologies and businesses.[13] In our sample, we have Contemporary Amperex Technology Co Ltd (CATL), a Chinese company actively engaged in research and development, production, and sale of batteries in China and internationally. The company is ranked No.1 in the global EV battery installation volume according to SNE Research in 2021.[14]

Exhibit 2 Panel A: Summary Statistics by Market (from Jan 2011 to Oct 2021)

ISO Alpha-2 Country Code	Average Market Cap(in Million USD)	Average Market Cap As % of Total Sample	Average Number of Stocks	Average Number of Stocks As % of Total Sample
AU	1,167.11	0.23%	13.89	3.21%
BA	200.18	0.04%	3.00	0.69%
BE	215.79	0.04%	1.00	0.23%
BG	4.09	0.00%	1.00	0.23%
BR	7,042.93	1.41%	6.19	1.43%
CA	9,370.99	1.88%	32.11	7.43%
CH	3,365.31	0.67%	3.35	0.78%
CL	2,091.49	0.42%	1.88	0.43%
CN	180,169.41	36.11%	78.63	18.20%
CO	1,457.06	0.29%	1.21	0.28%
CY	48.16	0.01%	1.35	0.31%
CZ	9.26	0.00%	0.94	0.22%
DE	3,935.76	0.79%	14.35	3.32%
DK	18,626.16	3.73%	2.19	0.51%
ES	14,023.05	2.81%	6.04	1.40%
FI	867.75	0.17%	2.26	0.52%
FR	3,983.74	0.80%	8.81	2.04%
GB	2,147.82	0.43%	8.26	1.91%
GR	654.11	0.13%	1.00	0.23%
HK	14,863.71	2.98%	19.70	4.56%
HU	45.90	0.01%	1.00	0.23%
ID	147.26	0.03%	0.18	0.04%
IE	265.65	0.05%	0.39	0.09%
IL	1,418.83	0.28%	8.05	1.86%
IN	11,400.57	2.28%	51.93	12.02%
IT	4,957.06	0.99%	8.40	1.94%
JP	19,342.42	3.88%	10.37	2.40%
KR	5,481.41	1.10%	10.92	2.53%
LK	96.09	0.02%	4.00	0.93%
MA	200.88	0.04%	1.00	0.23%
MY	261.12	0.05%	6.97	1.61%
NL	142.05	0.03%	1.05	0.24%
NO	2,394.62	0.48%	6.36	1.47%
NZ	5,801.73	1.16%	3.50	0.81%
PE	1,495.26	0.30%	1.00	0.23%
PH	1,870.68	0.37%	0.73	0.17%
PK	323.87	0.06%	6.00	1.39%

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[13] China becomes a leader in global war against climate change - Global Times
[14] http://www.sneresearch.com/_new/eng/sub/sub2/sub2_04_view.php?sub_cat=3&bbsId=45397&tbl=bbs&indepth_part=1

PL	469.78	0.09%	8.15	1.89%
PT	8,182.49	1.64%	1.00	0.23%
RU	6,652.67	1.33%	3.00	0.69%
SE	773.01	0.15%	9.94	2.30%
SG	308.23	0.06%	2.91	0.67%
TH	3,604.50	0.72%	9.20	2.13%
TN	1.21	0.00%	0.67	0.15%
TR	414.44	0.08%	4.72	1.09%
TW	5,679.69	1.14%	31.10	7.20%
US	152,612.55	30.58%	31.42	7.27%
ZA	395.08	0.08%	1.00	0.23%
Total Sample	498,982.91	100.00%	432.13	100.00%

Exhibit 2 Panel B: Summary Statistics by Region (from Jan 2011 to Oct 2021)

Region	Average Market Cap(in Million USD)	Average Market Cap As % of Total Sample	Average Number of Stocks	Average Number of Stocks As % of Total Sample
DM	268,765.82	53.86%	195.36	45.21%
EM	230,217.09	46.14%	236.77	54.79%
US	152,612.55	30.58%	31.42	7.27%
Europe	72,126.42	14.45%	92.21	21.34%
China	180,169.41	36.11%	78.63	18.20%
EM ex China	50,047.67	10.03%	158.14	36.60%
Total Sample	498,982.91		432.13	

Exhibit 2 Panel C: Market Capitalization for Sample Climate Solutions Stocks from Jan 2011 to Oct 2021
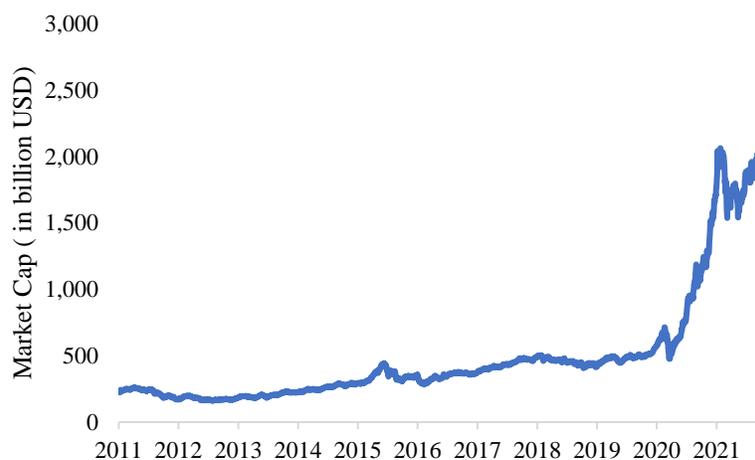
Note: Exhibit 2 Panel A and Panel B list the average market capitalization and number of stocks for the global sample of climate solutions companies identified from Section 2 and aggregated by market and region from January 2011 to October 2021. Developed markets include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK, and the US. All others are

classified as emerging markets in this study. Panel C presents the evolution of the make capitalization of the global sample during the same period.

4.2. Accounting Analysis

To gain a deeper understanding of the climate solutions portfolio, we analyze the profitability, business growth, and investment profile by calculating the value-weighted and equally-weighted return on assets (ROA), 1-year revenue growth, selling, general & administrative expenses to revenue (SG&A/revenue), capital expenditure to revenue (CAPEX/revenue), and research and development expenses to revenue (R&D/revenue) ratios. These financial ratios are sourced from the QAD Worldscope Point in Time Database, and winsorized at 2% and 98% to reduce the influence of outliers.[15] As shown in Exhibit 3, we present these accounting ratios before and after industry-adjustment, allowing us to control for industry effects and understand the relative performance of climate solutions companies compared to their industry peers. The industry adjustment is calculated by subtracting the industry median value of the accounting number for a global investable universe based on SIC 4-digit industry code at the company level first and then aggregated up based on either value or equal weighting. Differences over time are driven by changes in company profitability, growth and investment behavior, the composition of the sample, and in the case of value-weighted portfolios, changes in the weights. Note that, given the evolving universe of companies we track, the results should be interpreted as delineating the characteristics that an investor in public markets is exposed to and how those change over time, rather than solely how climate solutions companies are changing.

We find that the climate solutions companies have higher revenue growth but are less profitable on average than their industry peers. Both value- and equally-weighted sale growth for these companies are positive after industry adjustment, suggesting climate solutions companies have faster revenue growth than other companies in the same industry. At the same time, similar to many high growth companies, climate solutions companies in our portfolio are trailing their peers in profit generation, reflected in the negative value- and equally-weighted industry-adjusted ROA ratios. However, since late 2019, we see a positive trend in the value-weighted and industry-adjusted ROA ratios for these portfolios, with larger companies in our portfolio starting to reach median industry profitability. For example, Tesla, the largest market capitalization company in our

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[15] We pulled monthly snapshot of these fundamental data from Worldscope based on the nearest data before the value date, which could be based on either annual, semi-annual or quarterly earnings report of a company.

sample by 2021, reported first positive earnings in Q1 2021. In contrast, the equal-weighted portfolio becomes even less profitable over time.

Moreover, we note that the portfolio of climate solutions companies has higher capital expenditures, higher R&D investments as well as greater SG&A expenses than their industry peers. This observation is consistent with our understanding that companies which provide decarbonization solutions to the market are transforming industries with new technologies, and that these innovations require significant investment in human, intellectual, and physical capital.

For example, in our sample we have Beyond Meat (BM), a company that sells plant-based products as meat substitutes. It is estimated that the greenhouse gas emissions of a Beyond Meat Burger is only 7.9% of a regular beef burger, substantially reducing product carbon footprint.[16] Compared to traditional players in this industry such as Tyson Foods (TF), BM has a R&D/revenue ratio of 6.8% in 2020, 6.1% in 2019 and 10.9% in 2018, much higher than that for TF at 0.2%, 0.2% and 0.3% in respective years. [17] The capital expenditure to revenue ratio for BM is on average 5.5 times larger than that for TF, and the SG&A to revenue ratio for BM is about 5.1 bigger than that for TF from 2018-2021. When it comes to 1-year net revenue growth, BM is about 148.4% annually, compared to 4.1% growth rate for TF from 2018 to 2020. However, BM is much less profitable than TF, with a ROA of -29.0% in 2018. Although BM has improved significantly in 2019 and 2020 to an average of -7.2%, it is still not generating profits while TF's ROA is on average 8.88% during these years.

Collectively, these findings are consistent with a portfolio of climate solutions companies exposing an investor to lower profitability, higher top-line revenue growth and investment firms focused on developing scale to provide solutions for their customers. On an equal-weighted basis, the portfolio provides exposure to companies that invest heavily in innovation and talent but also exposure to higher losses.[18]

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[16] https://consumerecology.com/beyond-meat-burger-carbon-footprint-environmental-impact/

[17] For Beyond Meat, we use the annual reporting with calendar year end on 12/31 from 2018 to 2020. For Tyson Food, we use the annual reporting with calendar year end on 9/30 from 2018 to 2020.

[18] Besides having higher SG&A/revenue ratio (of which the largest part is typically expenditure on employee salaries), we observe that the portfolio of climate solutions companies also has higher employee 1-year growth rate than their industry peers, which collectively supports that these companies are investing more in talent.

Exhibit 3: Accounting Ratios

Value-Weighted Revenue Growth

■ VW   ■ VW Industry-adjusted

Equally-Weighted Revenue Growth

■ EW   ■ EW Industry-adjusted

Value-Weighted ROA

■ VW   ■ VW Industry-adjusted

Equally-Weighted ROA

■ EW   ■ EW Industry-adjusted

Value-Weighted SGA/Revenue

■ VW   ■ VW Industry-adjusted

Equally-Weighted SGA/Revenue

■ EW   ■ EW Industry-adjusted
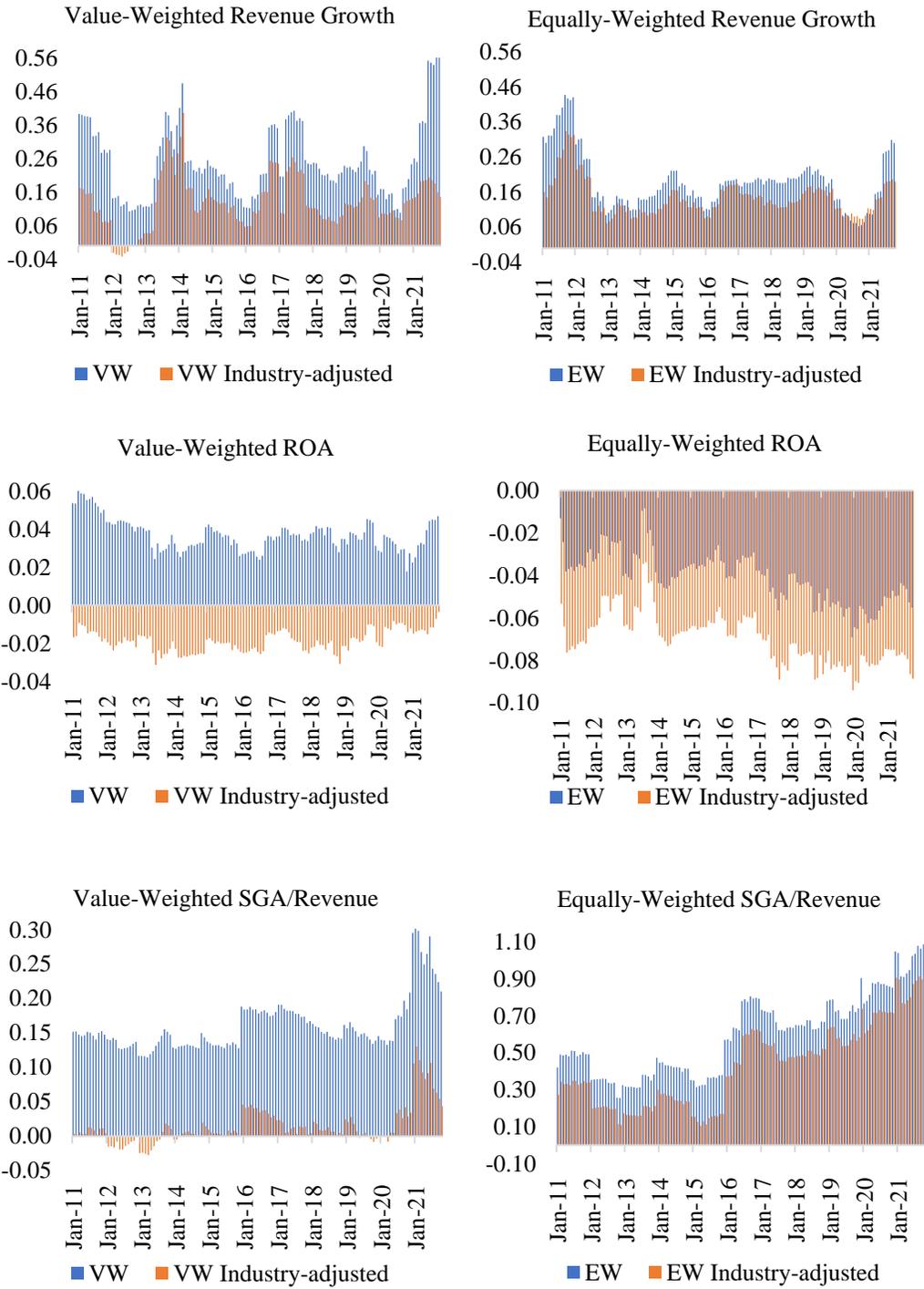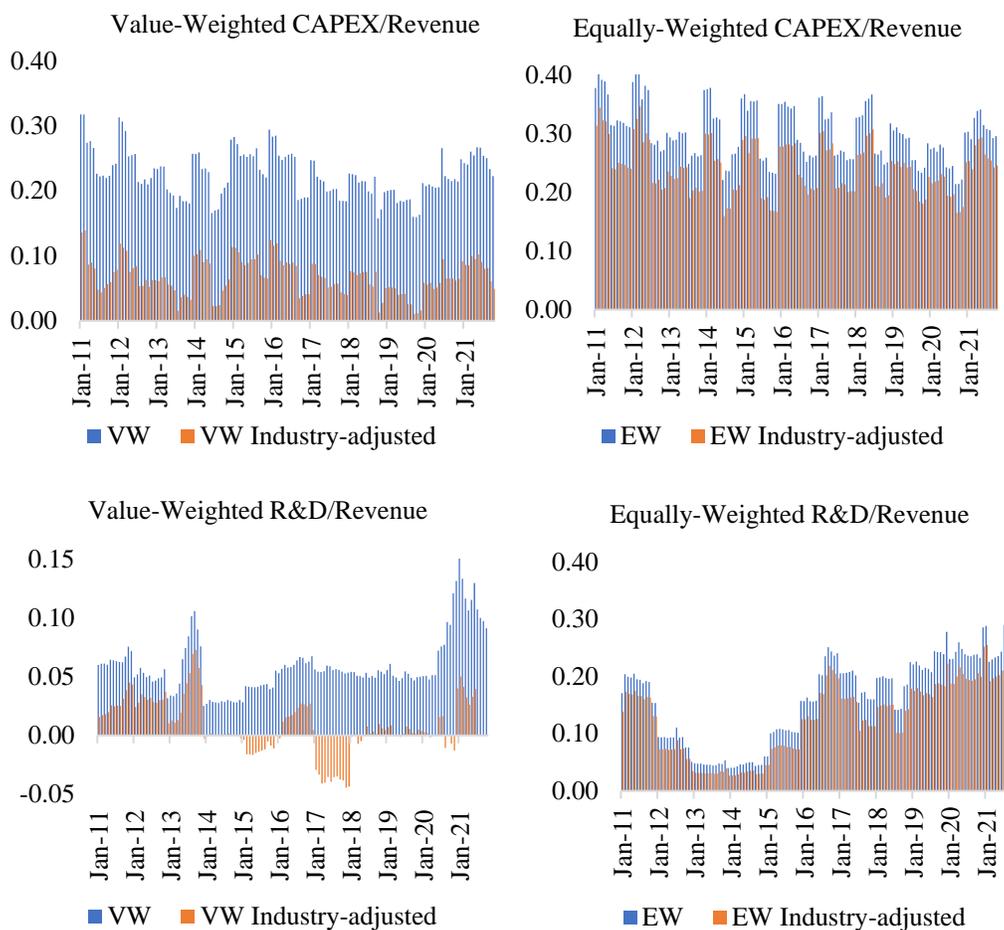
Note: Exhibit 3 presents the accounting and financial ratios including return to equity (ROA), one-year revenue growth, selling, general & administrative expenses/revenue (SG&A/revenue), capital expenditure/revenue (CAPEX/revenue) and research & development/revenue (R&D/revenue) for the global sample of climate solutions companies from January 2011 to October 2021. Data were obtained from the Refinitiv Worldscope Point in Time database on December 1st, 2021, with monthly frequency base on the most recent annual, semi-annual, or quarterly earnings report from the value date, and were winsorized at 2% and 98% values. The industry adjustment is calculated by subtracting the industry median of global investable universe based on SIC 4-digit industry code at the company level first and then aggregated up based on either value or equal weighting.

4.3. Valuation Analysis

Turning to two key valuation ratios, earnings yield and book-to-market (BTM) as presented in Exhibit 4, we find the climate solutions portfolio have lower earnings yield and BTM compared to their industry peers. This observation is consistent with our findings earlier that these companies are less profitable but have higher growth rate, and that investors anticipate fast business growth leading to better financial performance and profitability in the future. An exception although exists in the case of the equally-weighted BTM, where the climate solutions portfolio has a higher value than the industry peers despite on average faster revenue growth, suggesting some smaller climate solutions companies potentially experiencing financial distress. In the example of Beyond Meat

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and Tyson Foods, TF's BTM ratio is about 15 times of that for BM at the end of 2020; also, TF has much higher earnings yield about 9.1% at the end of 2020, while BM's value is still negative, at -0.3%. Therefore, investors, on average, are recently factoring the high growth rate of the climate solutions companies into prices, even though most of these companies are still not profitable.

Exhibit 4: Valuation Ratios
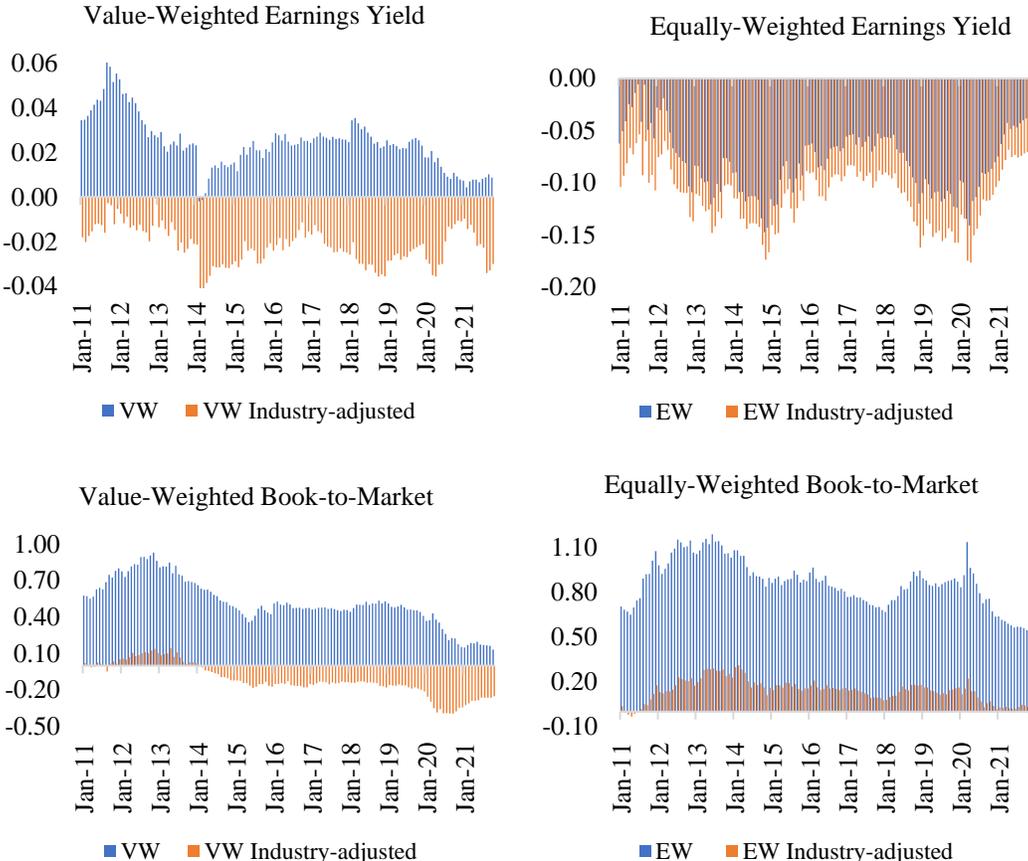
Note: Exhibit 4 presents the earnings yield and book-to-market ratios for the global sample of climate solutions companies from January 2011 to October 2021. Data were obtained from the Thomson Worldscope Point in Time database on December 1st, 2021, with monthly frequency base on the most recent annual semi-annual, or quarterly earnings report from the value date, and were winsorized at 2% and 98% values. The industry adjustment is calculated by subtracting the industry median of global investable universe based on SIC 4-digit industry code at the company level first and then aggregated up based on either value or equal weighting.

4.4. Correlation Analysis

Exhibit 5 below presents the correlations of the climate solutions portfolios — value-weighted (VW) global, DM, EM portfolios, equally-weighted (EW) global, DM and EM portfolios, and the correlations of those with prevalent market benchmarks and climate change

indices including MSCI ACWI, MSCI ACWI Low Carbon[19], MSCI ACWI Climate Change[20], S&P Global Clean Energy[21] and NASDAQ Clean Edge Green Energy[22] from 2011 to 2021.

We also build long-only global decarbonization factors by selecting companies with low carbon intensity, following the methodology in Cheema-Fox et al. (2021a, 2021b). These portfolios are formed at the end of June each year based on the previous trading day's market capitalization weights and have one-year holding period. The variations in these factors reflect the difference in choice of climate data and portfolio construction constraint. Operational Carbon-in-industry (OC-in-industry), Operational Carbon-in-sector (OC-in-sector), and Operational Carbon-in-market (OC-in-market) strategies select low carbon companies within each industry with industry constraint), sector (with sector constraint) and market (no constraints) respectively, based on Scope 1 and Scope 2 carbon intensity (i.e., scaled by firm revenues) from S&P Trucost. While these three decarbonization factors focus on the carbon efficiency from the business operations, the other two factors consider the full value chain emissions. Total Value Chain-in-industry (TVC-in-industry) is constructed with low carbon intensity companies with industry constraint using all three scopes of emissions from S&P Trucost, while Analyst Rating-in-industry (AR-in-industry) using the climate change theme and environmental opportunity scores from MSCI ESG IVA. [23]

We observe generally high correlations among the climate solutions portfolios, regardless of portfolio construction or market segment, except the equally-weighted portfolio for emerging markets. The value-weighted climate solutions portfolio with the global sample has a high correlation (0.85-0.86) with both value-weighted DM and EM portfolios. The lowest correlations we observe are between the value-weighted and the equally-weighted climate solutions portfolios; in particular we see low correlations with the EM equally-weighted one, which may reflect the

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[19] The MSCI ACWI Low Carbon Target Index aims to track MSCI ACW Index with a target tracking error of 0.3% while minimize the carbon exposure by overweighting companies with low carbon emissions (relative to sales) and those with low potential carbon emissions (per dollar of market capitalization). For more detail, see MSCI ACWI Low Carbon Target Index

[20] The MSCI ACWI Climate Change Index aims to represent the performance of an investment strategy that re-weights securities based upon the opportunities and risks associated with the transition to a lower carbon economy, while seeking to minimize exclusions from the MSCI ACW Index. For more details, see MSCI ACWI Climate Change Index

[21] The S&P Global Clean Energy Index targets constituent count of 100 to measure the performance of companies in global clean energy-related businesses from both EMs and DMs. For details of index construction, see Table of Contents (spglobal.com)

[22] The NASDAQ Clean Edge Green Energy Index is a modified market capitalization weighted index designed to track the performance of companies that are primarily manufacturers, developers, distributors and/or installers of clean energy technologies, as defined by Clean Edge. For more details, see CELS Methodology (nasdaqomx.com)

[23] For details of the construction of the decarbonization factors, please refer to Cheema-Fox (2021a, 2021b).

illiquidity of EM small-cap stocks. Moreover, as expected, the value-weighed global climate solutions portfolio is highly correlated with pure-play indices such as S&P Global Clean Energy (0.82) and NASDAQ Clean Edge Green Energy (0.85), more than with other climate change indices which aim to gain more balanced or broad market access such as MSCI ACWI Low Carbon (0.68), and the decarbonization factors (0.65 to 0.67). This pattern is even more noticeable in Exhibit 5 Panel B where we present the correlations of climate solutions portfolio return residuals after regressing out the MSCI ACWI returns. The correlations of these residuals with the decarbonization factors, MSCI ACWI Low carbon, and other climate change indices are close to zero, once we strip out the effect from market co-movement, whereas they are still highly correlated with pure-play indices S&P Global Clean Energy and NASDAQ Clean Edge Green Energy.

Exhibit 5 Panel A: Correlations of Climate Solutions Portfolio and with Other Market Indices

		Climate Solutions Portfolios					
		VW Global	VW DM	VW EM	EW Global	EW DM	EW EM
Climate Solutions Portfolios	VW Global	1.00	0.86	0.85	0.92	0.85	0.66
	VW DM	0.86	1.00	1.00	0.74	0.64	0.68
	VW EM	0.85	1.00	1.00	0.74	0.64	0.68
	EW Global	0.92	0.74	0.74	1.00	0.96	0.67
	EW DM	0.85	0.64	0.64	0.96	1.00	0.52
	EW EM	0.66	0.68	0.68	0.67	0.52	1.00
Decarbonization Factors (long-only, global sample)	OC in industry	0.65	0.80	0.80	0.65	0.53	0.68
	OC in sector	0.66	0.80	0.80	0.66	0.54	0.68
	OC in market	0.67	0.79	0.79	0.66	0.55	0.68
	TVC in industry	0.66	0.80	0.80	0.65	0.54	0.68
	AR in industry	0.67	0.81	0.81	0.66	0.55	0.69
Other market indices	MSCI ACWI	0.68	0.81	0.81	0.67	0.55	0.69
	S&P Global Clean Energy	0.82	0.79	0.79	0.77	0.66	0.76
	NASDAQ Clean Edge Green Energy	0.85	0.76	0.76	0.87	0.81	0.66
	MSCI ACWI Climate Change	0.70	0.80	0.80	0.69	0.58	0.70
	MSCI ACWI Low Carbon	0.68	0.80	0.80	0.67	0.56	0.69

Exhibit 5 Panel B: Correlations of Climate Solutions Portfolio Return Residuals and with Other Market Indices

		Climate Solutions Portfolios (return residuals)					
		VW Global	VW DM	VW EM	EW Global	EW DM	EW EM
Climate Solutions Portfolios (return residuals)	VW Global	1.00	0.71	0.70	0.85	0.77	0.35
	VW DM	0.71	1.00	1.00	0.47	0.40	0.29
	VW EM	0.70	1.00	1.00	0.46	0.39	0.29
	EW Global	0.85	0.47	0.46	1.00	0.95	0.39
	EW DM	0.77	0.40	0.39	0.95	1.00	0.22
	EW EM	0.35	0.29	0.29	0.39	0.22	1.00
Decarbonization Factors (long-only, global sample)	OC in industry	0.01	-0.04	-0.04	0.01	0.01	-0.15
	OC in sector	0.02	-0.04	-0.04	0.02	0.02	-0.16
	OC in market	0.03	-0.05	-0.05	0.03	0.02	-0.15
	TVC in industry	0.02	-0.03	-0.03	0.01	0.01	-0.15
	AR in industry	0.04	-0.03	-0.03	0.03	0.02	-0.15
Other market indices	MSCI ACWI	0.04	-0.03	-0.03	0.03	0.03	-0.15
	S&P Global Clean Energy	0.52	0.39	0.39	0.45	0.36	0.31
	NASDAQ Clean Edge Green Energy	0.51	0.27	0.27	0.54	0.51	0.12
	MSCI ACWI Climate Change	0.07	-0.03	-0.03	0.07	0.06	-0.13
	MSCI ACWI Low Carbon	0.04	-0.03	-0.03	0.03	0.03	-0.14

Note: Exhibit 5 presents the correlations of climate solutions portfolios with MSCI ACWI, MSCI ACWI Low Carbon, MSCI ACWI Climate Change, S&P Global Clean Energy, NASDAQ Clean Edge Green Energy index as well as global decarbonization factors from January 2011 to October 2021 based on monthly frequency data. For detail of decarbonization factors, please refer to the main text in section 4.4. VW stands for value-weighted, and EW for equally weighted. Panel B presents the correlations of climate solutions portfolio return residuals after regressing out the MSCI ACWI returns.

4.5. Tracking Error Analysis

As expected, we find the climate solutions portfolios demonstrate large tracking errors versus the MSCI ACWI, varying from 11.0% to 26.0% by construction and sample period as shown in Exhibit 6. For comparison, we also report tracking errors of other climate change indices or factors with MSCI ACWI, even though not all of them are tracking the index. Not surprisingly, MSCI ACWI Low carbon and MSCI ACWI Climate Change track MSCI ACWI most closely, with tracking errors of 45 bps and 109 bps respectively from January 2011 to October 2021, followed by the decarbonization factors which are built based on the MSCI IMI universe ranging from 105 bps to 207 bps. S&P Global Clean Energy and NASDAQ Clean Edge Green Energy on the other hand have large deviations from the ACWI, similar in magnitude to the climate solutions portfolios.

The dichotomy of the low and high tracking errors of these strategies characterizes two different methodologies for building a climate change related index. Most of the existing financial

instruments for climate change in the market aim to lower a portfolio's carbon footprint by excluding or downweighing companies with high carbon emissions (relative to revenue or market capitalization), represented by MSCI ACWI Low Carbon Index and MSCI ACWI Climate Change Index. This can be achieved by including firms without consideration of industry membership or by creating best-in-class strategies thereby allowing representation of all industries, as demonstrated through different portfolio constructions in the Decarbonization Factors. A key characteristic of these products is that they can achieve considerable reduction in portfolio carbon emissions relative to the benchmark while maintaining a low tracking error. Consequently, these indices can obtain lower carbon exposure while still offering risk-return profiles similar to the market. However, such low carbon profiles do not necessarily provide investors access to climate change opportunities. As the transition to a low carbon economy requires the development, deployment and scale of several key new technologies, products, and services, not all companies, industries or sectors are equally in the forefront of accessing climate opportunities.

On the other hand, our climate solutions portfolios represent a different approach that does not focus on the immediate carbon reduction based on the status quo but rather long-term climate change opportunities with pure-play companies from ten most relevant business areas such as energy generation and storage, batteries, and transportation. These companies are key businesses that provide solutions to lower carbon emissions. Therefore, these portfolios are characterized by high tracking errors, high growth potential, and concentrated industry/sector membership as demonstrated through the climate solutions portfolios.

Exhibit 6: Tracking Errors with MSCI ACWI

		2011-2021	2016-2021	2018-2021
Climate Solutions Portfolios	VW Global	14.99%	16.51%	18.89%
	VW DM	17.95%	21.96%	26.02%
	VW EM	20.11%	20.86%	22.84%
	EW Global	11.02%	11.30%	12.65%
	EW DM	11.09%	11.32%	12.62%
	EW EM	14.52%	14.68%	16.16%
Decarbonization Factors Global (long only)	OC in industry	1.47%	1.63%	1.84%
	OC in sector	1.75%	1.89%	2.07%
	OC in market	1.78%	1.79%	1.93%
	TVC in industry	1.56%	1.71%	1.92%
	AR in industry	1.05%	1.12%	1.24%
Other market indices	S&P Global Clean Energy	15.85%	16.20%	18.42%
	NASDAQ Clean Edge Green Energy	21.58%	22.21%	25.44%
	MSCI ACWI Climate Change	1.09%	1.11%	1.23%
	MSCI ACWI Low Carbon	0.45%	0.44%	0.46%

4.6. Stock Performance Analysis

Now turning to the portfolio performance results in Exhibit 7, we find the climate solutions portfolios have evolved substantially over the sample period from January 2011 to October 2021, with significant upside particularly since 2018. This finding is consistent with our prior that the development of key climate change technologies and innovations requires considerable investment and time to lower cost in production and gain momentum in the market. Recent policy trends seem likely to provide tailwinds for these climates solutions business as well, particularly after the Paris Agreement.

When examining the performance, we see climate solutions portfolios outperform the overall market index MSCI ACWI for both value-weighted and equally-weighted portfolios from 2011 to 2021, as shown in Exhibit 7 Panel A and Panel B. Using multi-factor regressions, we calculate alphas for climate solutions portfolios after controlling for Fama-French DM and EM five factors including market, value, size, profitability and investment as well as DM and EM momentum factors.[24] The value-weighted portfolio generates a total return of 14.8% annually, an alpha of 10.0% (significant at 10% level) and a Sharpe ratio of 0.80 from 2011 to 2021, while the period from 2018 to 2021 has seen a much higher total return of 40.1% per annum, higher excess return of 22.9% (significant at 10% level) and higher Sharpe ratio of 1.70.[25] The equally-weighted portfolio produces more statistically significant alphas, about 11.9% during 2011 to 2021, and 13.8% after 2018. To put this into context, MSCI ACWI has a return of 10.1%, a risk level of 14.3%, and a Sharpe ratio of 0.71 annually from 2011 to 2021.

Compared to the two climate clean tech/green energy indices included in this study, we find our climate solutions portfolios (both equally-weighted and value-weighted) have outperformed in risk-adjusted terms. The S&P Global Clean Energy (SPGCLE) has an annual return of 6.3%, a risk of 23.2%, a Sharpe ratio of 0.27 since 2011. While the NASDAQ Clean Edge Green Energy (NASCEUL) generates higher total returns at 16.3% per annum, the risk level

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[24] We also tested a model with Pastor-Stambaugh liquidity factor from January 2011 to December 2020. We did not find significance of liquidity factor in the global climate solutions portfolios. Given the unavailability of the liquidity factor data for 2021, we leave it out in the multi-factor regressions.

[25] The insignificance could be due to small number of observations with monthly return data from 2018 to 2021.

is much higher at 29.9%, resulting in a modest Sharpe ratio of 0.54. Both indices have lower Sharpe ratios than those for the value-weighted and equally-weighted climate solutions portfolios. Data from the most recent time periods point to similar findings. Also notably, our climate solutions portfolios start to diverge from other climate clean tech/green energy indices since the beginning of 2021. Both SPGLE and NASCEUL have experienced severe drawdowns from 37.2% to 38.1%, leading to losses for 2021 of -22.5% and -2.6% respectively. On the other hand, the climate solutions portfolios not only have experienced smaller drawdowns (27.2% for value-weighted, 5.5% for equally weighted), but they have exhibited greater resilience, bouncing back to finish 2021 with positive returns of 25.4% and 26.0% respectively. [26]

In terms of factor exposures, both value- and equally-weighted climate solutions portfolios with the global sample have positive and significant loadings on the DM and EM market factors and the EM size factor, and negative and significant loadings on the DM value and DM profitability factors.[27] These results are consistent with our observations earlier that the pure-play climate solutions companies are characterized with relatively smaller size, higher growth rate and lower profitability. The multi-factor regression results are reported in Exhibit A1.

One company in our sample — Tesla experiences a phenomenal growth in valuation in 2020 and 2021, and the market size quickly swells to about 44.9% of our global sample at the end of October, 2021. In Exhibit 7 Panel C, we have constructed a value-weighted portfolio without Tesla. This ex-Tesla portfolio has similar factor exposures to the one including Tesla, while the portfolio performance has decreased to 6.5% for 2011-2021 period and 13.4% for 2018-2111 period in terms of excess returns, with the latter still statistically significant at 10% level. Leaving out Tesla doesn't change the results for equally-weighted portfolio, since any given company has very limited influence on the portfolio. It is worth noting that the equal-weighted portfolios, although they exhibit lower returns, also have lower volatility and more significant alphas.

Exhibit 7 Panel A: Performance for Climate solutions portfolios

	2011-2021	2016-2021	2018-2021
Value -weighted			
Returns	14.79%	26.06%	40.14%
Risk	18.39%	20.44%	23.55%

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[26] Up until January 19th, 2022, we continue to observe the climate solutions portfolios outperform SPGLE and NASCEUL.

[27] We have also considered EUA futures prices downloaded from Bloomberg, but we do not find a significant relationship between climate solutions portfolio returns and EUA future returns.

Return/risk	0.80	1.28	1.70
Sortino ratio	1.15	1.88	2.55
Hit rate	54.93%	55.00%	56.65%
Max drawdown	40.69%	32.47%	32.47%
Alpha	10.0%	11.4%	22.9%
Alpha t-stat	1.68	1.22	1.87
Equally-weighted			
Returns	14.99%	21.49%	22.85%
Risk	11.92%	11.88%	13.07%
Return/risk	1.26	1.81	1.75
Sortino ratio	1.73	2.55	2.44
Hit rate	57.11%	57.58%	57.46%
Max drawdown	36.12%	31.94%	31.94%
Alpha	11.41%	9.20%	13.83%
Alpha t-stat	3.22	1.83	2.18

Exhibit 7 Panel B: Cumulative Performance for Value-Weighted Climate Solutions Portfolios and Other Climate-Related indices, Jan 2011- Oct 2021
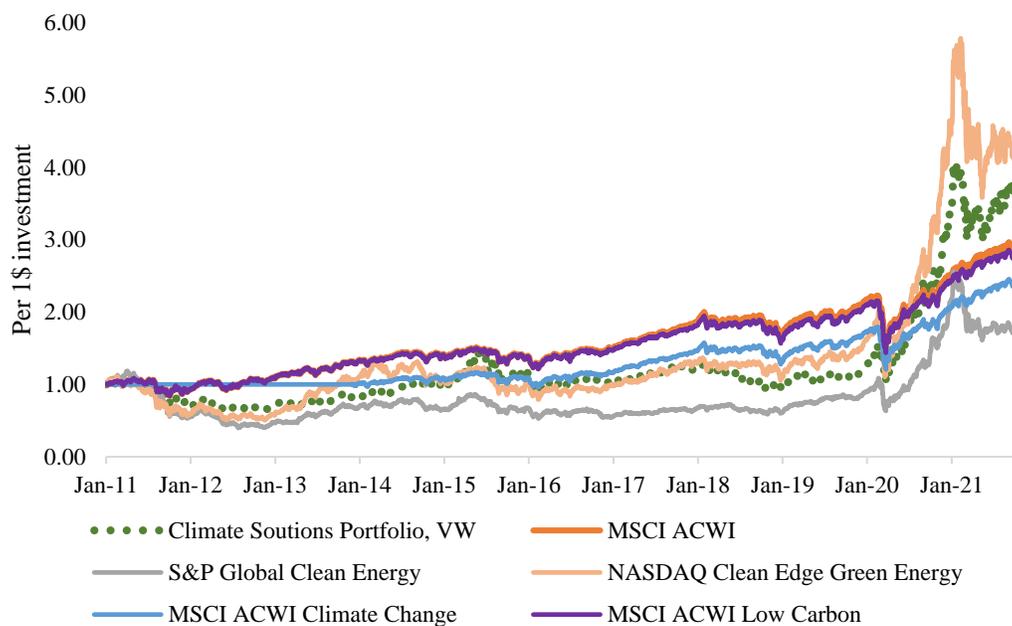
Exhibit 7 Panel C: Climate Solutions Portfolios Performance Excluding Tesla

	2011-2021	2016-2021	2018-2021
Value -weighted			
Returns	8.41%	15.01%	22.58%
Risk	15.96%	16.19%	17.85%
Return/risk	0.53	0.93	1.26
Sortino ratio	0.73	1.31	1.84
Hit rate	54.54%	54.20%	54.44%
Max drawdown	41.15%	26.95%	26.95%

Alpha	6.53%	5.05%	13.37%
Alpha t-stat	1.31	0.83	1.70

Note: Exhibit 7 Panel A presents the portfolio performance statistics for value-weighted and equally-weighted climate solutions portfolios based on the global sample for three time period January 2011 to October 2021, January 2016 to October 2021, and January 2018 to October 2021. These portfolios are formed at the end of 2010, and rebalanced on a monthly basis. On the rebalance day, which is the last business day of the month, the value-weighted portfolio is calculated based on the market capitalization weights of stocks in our sample from previous business day, while the equally-weighted portfolio is calculated based on an equal weighting of stocks in the sample from previous trading day. We allow portfolios to drift between rebalance dates. We calculate alphas for climate solutions portfolios using multi-factor regressions controlling for Fama-French DM and EM five factors including market, value, size, profitability and investment as well as DM and EM momentum factors. The multi-factor regression results are reported in Exhibit A1. The t-statistics for alphas are estimated based on HAC standard errors. Exhibit 7 Panel B presents the cumulative performance for value-weighted climate solutions portfolios and other climate-related indices from January 2011 to October 2021 per $1 investment at the end of 2010. Exhibit 7 Panel C presents the portfolio performance for value-weighted climate solutions portfolio excluding Tesla in the sample. Source Data: DataStream, Bloomberg.

4.6.1. Geographic Variation

To understand the performance of climate solutions portfolios, we build portfolios for developed and emerging markets[28], and for a few major country/regions including US, Europe, China and EM excluding China. Results are reported in Exhibit 8 Panel A and Panel B. When comparing developed market with emerging markets, we find the DM portfolios have outperformed the EM portfolios under the value-weighted construction. Notably, the DM portfolio generates a total return of 54.8% annually and a substantial alpha about 27.7%, statistically significant from 2018 to 2021. Similarly, the equally-weighted portfolio for developed markets demonstrates positive performance as well statistically significant and increasing excess returns from 2011 to 2021. The results for the EM portfolios are less clear-cut – across the value-weighted and equally weighted constructions and the three sample periods, even though excess returns are on average positive, only the equally-weighted portfolio from 2011 to 2021 has a significant alpha.[29]

Across the regions, we observe US and European portfolios have positive and improving performance over time. Particularly, the US climate solutions companies have experienced substantial uptick in price in most recent years with a total return of 81.2% from 2018 to 2021 under the value-weighting, compared to European peers at 22.4%. Although this growth is accompanied by considerable risk (about 51.3%), rewards exceed risks such that the Sharpe ratio

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[28] The developed markets in our sample include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK and the US. All other countries/regions in our sample are classified as emerging markets.
[29] One caveat of this conclusion is that we define region/country based on where the security is traded, instead of where the company is incorporated or headquartered. Therefore, a Chinese EV company mainly traded in the NASDAQ Stock Exchange is categorized in the DM sample.

is greater than 1.5 and the Sortino ratio is greater than 2.4 for the US portfolio. After controlling for traditional risk factors, we find the value-weighted US and European portfolios have an excess return of 28.3% and 14.0% respectively. Since the US portfolio has a substantial exposure to the market risk factor, we only observe the European portfolio obtaining a weakly significant alpha from 2018-2021.[30] Similar results are observed for the equally-weighted portfolios, except more significant alpha for the European index.

Within emerging markets, we find evidence of improving performance in climate solutions portfolios in EM excluding China, with an excess return of 1.6%, 7.3%, 13.6% for 2011-2021, 2016-2021, and 2018-2021 sample periods respectively, and a statistically significant alpha for the most recent years. For the Chinese market, although we observe the portfolio generates positive returns, the results are not significant after controlling for other risk factors.

To summarize, we find that developed market climate solutions portfolios have outperformed those in emerging markets. This differential is driven by several factors. First, the European climate solutions portfolio has performed well. Second, the China climate solutions portfolio has performed subpar relative to other emerging markets, while being a very big part of the portfolio. Third, the US climate solutions portfolio has performed exceptionally well due to Tesla.

Exhibit 8 Panel A: Climate Solutions Portfolios Performance for DM and EM

	DM Portfolios			EM Portfolios		
	2011-2021	2016-2021	2018-2021	2011-2021	2016-2021	2018-2021
Value -weighted						
Returns	20.70%	37.22%	54.83%	8.71%	14.40%	23.84%
Risk	23.83%	27.85%	32.63%	19.61%	20.00%	21.72%
Return/risk	0.87	1.34	1.68	0.44	0.72	1.10
Sortino ratio	1.27	2.00	2.53	0.61	1.02	1.63
Hit rate	54.90%	55.72%	56.25%	54.26%	54.40%	54.03%
Max drawdown	46.43%	44.35%	44.35%	54.84%	36.13%	34.89%
Alpha	9.11%	14.18%	27.72%	5.45%	0.03%	8.51%
Alpha t-stat	1.50	1.47	2.06	0.89	0.00	0.91
Equally-weighted						
Returns	17.37%	29.29%	32.52%	12.62%	14.97%	14.90%
Risk	14.66%	14.86%	16.62%	13.19%	12.89%	13.72%

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[30] For the US portfolios, we are controlling for US Fama-French five factors, US momentum factor, and the liquidity factor. For the European portfolios, we are controlling for European Fama-French five factors, European momentum factor, and the liquidity factor. For both China and EM ex China portfolios, we are controlling for the EM Fama-French five factors, EM momentum factor, and the liquidity factor.

Return/risk	1.18	1.97	1.96	0.96	1.16	1.09
Sortino ratio	1.67	2.84	2.80	1.30	1.59	1.49
Hit rate	54.36%	56.19%	55.44%	57.53%	57.78%	56.85%
Max drawdown	43.04%	33.12%	33.12%	36.63%	36.63%	36.63%
Alpha	10.72%	16.74%	24.99%	9.49%	2.84%	6.41%
Alpha t-stat	1.92	2.14	2.59	2.78	0.55	1.01

Exhibit 8 Panel B: Climate Solutions Portfolios Performance by Region/Country

	US			Europe			China			EM ex China		
	2011-2021	2016-2021	2018-2021	2011-2021	2016-2021	2018-2021	2011-2021	2016-2021	2018-2021	2011-2021	2016-2021	2018-2021
Value - weighted												
Returns	31.28%	49.10%	81.23%	6.76%	17.56%	22.41%	11.54%	13.96%	25.52%	1.40%	13.85%	13.94%
Risk	39.16%	44.64%	51.34%	21.19%	20.75%	22.56%	23.73%	23.13%	24.87%	15.16%	14.77%	15.86%
Return/risk	0.80	1.10	1.58	0.32	0.85	0.99	0.49	0.60	1.03	0.09	0.94	0.88
Sortino ratio	1.19	1.67	2.45	0.44	1.18	1.39	0.67	0.85	1.52	0.13	1.31	1.22
Hit rate	53.30%	53.41%	53.78%	53.05%	55.26%	55.95%	53.92%	54.43%	53.15%	51.69%	54.20%	54.13%
Max drawdown	56.90%	56.90%	56.90%	55.52%	30.57%	30.57%	62.58%	44.01%	38.70%	54.06%	35.11%	35.11%
Alpha	7.97%	10.40%	28.32%	-0.11%	6.83%	14.03%	3.53%	3.90%	5.69%	1.62%	7.32%	13.57%
Alpha t-stat	0.80	0.61	1.12	-0.02	1.19	1.78	1.17	0.95	1.04	0.43	1.29	1.98
Equally-weighted												
Returns	18.04%	24.99%	41.04%	12.24%	23.32%	28.02%	11.43%	6.16%	11.82%	12.00%	18.51%	15.59%
Risk	29.12%	28.92%	32.06%	16.70%	16.58%	18.18%	27.29%	25.15%	25.77%	11.69%	11.55%	12.42%
Return/risk	0.62	0.86	1.28	0.73	1.41	1.54	0.42	0.24	0.46	1.03	1.60	1.26
Sortino ratio	0.91	1.29	1.93	1.02	1.95	2.12	0.56	0.33	0.63	1.39	2.20	1.70
Hit rate	52.86%	53.13%	53.58%	53.15%	56.32%	56.65%	54.60%	53.43%	53.25%	56.57%	57.45%	56.45%
Max drawdown	55.53%	45.99%	45.99%	49.37%	35.01%	35.01%	65.87%	54.25%	48.43%	39.83%	39.83%	39.83%
Alpha	6.62%	4.25%	15.84%	7.27%	14.04%	20.07%	6.24%	0.98%	1.49%	8.50%	5.17%	6.59%
Alpha t-stat	0.76	0.38	1.09	1.51	1.94	2.36	1.21	0.14	0.20	2.45	1.23	1.44

Note: Exhibit 8 Panel A presents the portfolio performance for value-weighted and equally-weighted climate solutions portfolios based on the developed market sample and the emerging market sample for three time period January 2011 to October 2021, January 2016 to October 2021, and January 2018 to October 2021. These portfolios are formed at the end of 2010, and rebalanced on a monthly basis. On the rebalance day, which is the last business day of the month, the value-weighted CSI is calculated based on the market capitalization weights of stocks in our sample from previous business day, while the equally-weighted CSI is calculated based on an equal weighting of stocks in the sample from previous trading day. We allow portfolios to drift between rebalance dates. For the DM portfolios, we calculate alphas for climate solutions portfolios using multi-factor regressions controlling for Fama-French DM five factors including market, value, size, profitability as well as the DM momentum factor. For the EM portfolios, we calculate alphas controlling for Fama-French EM five factors and the EM momentum factor. The t-statistics for alphas are estimated based on HAC standard errors. In Panel B, the alphas for the regional portfolios are calculated after controlling for regional factors: for US using US FF5 factors and US momentum factor, for Europe using European FF5 factors and European momentum factor, for China using MSCI China A Onshore Index (USD), and EM FF5 factors excluding market, and EM momentum factor, and for EM ex China using EM FF5 and EM momentum factor.

4.6.2. Solutions Variation

From a solutions perspective, we find climate solutions companies in Energy, Alternative Fuels, Battery, Transportation have better performance than Agriculture & Food and sectors such as Nature-Based Solutions, Recycling & Circularity, Industrials and Recycling & Circularity, which are combined together and labelled as "others" due to smaller sample size as shown in Exhibit 9.[31] For example, the Battery sector generates an annualized return of 42.9% from 2011 to 2021, of which the most recent years have seen 93.4% returns on average.[32]

While transportation and energy storage portfolios have delivered superior performance, on both value and equal-weighted basis, energy, alternative fuels, and materials portfolios exhibit superior performance on an equal-weighted basis. In general, equal-weighted portfolios show more consistent outperformance across solutions, with significant positive alphas.

Exhibit 9: Climate Solutions Portfolios Performance by Categories (2011-2021)

	Agriculture & Food (A)	Batteries (B)	Energy (E)	Fuels - Alternate (F)	Housing (H)	Materials (M)	Transportation (T)	Others
Value -weighted								
Returns	2.54%	42.92%	7.88%	10.33%	13.07%	-2.02%	13.34%	3.62%
Risk	47.90%	42.76%	14.64%	24.52%	26.59%	32.54%	28.45%	28.27%
Return/risk	0.05	1.00	0.54	0.42	0.49	-0.06	0.47	0.13
Sortino ratio	0.08	1.55	0.74	0.60	0.72	-0.09	0.67	0.18
Hit rate	49.27%	52.83%	54.47%	52.40%	51.21%	50.27%	52.44%	50.41%
Max drawdown	73.63%	57.57%	38.66%	49.36%	55.22%	78.43%	69.73%	71.36%
Alpha	22.44%	32.58%	5.08%	10.07%	5.83%	5.33%	20.59%	-2.63%
Alpha t-stat	1.26	1.85	1.16	1.22	0.67	0.45	1.97	-0.43
Equally-weighted								
Returns	9.02%	21.78%	12.06%	16.58%	8.85%	15.70%	23.53%	12.60%
Risk	25.08%	23.63%	11.83%	18.13%	26.64%	24.49%	19.33%	20.07%
Return/ risk	0.36	0.92	1.02	0.91	0.33	0.64	1.22	0.63
Sortino ratio	0.55	1.41	1.40	1.37	0.51	0.96	1.83	0.94
Hit rate	49.34%	52.57%	56.03%	52.17%	50.68%	50.92%	53.57%	51.10%
Max drawdown	50.66%	39.18%	37.98%	40.76%	49.41%	55.53%	42.32%	52.40%
Alpha	13.77%	19.95%	8.42%	13.60%	8.52%	16.03%	25.80%	0.87%
Alpha t-stat	1.47	2.21	2.69	2.54	1.14	2.55	3.18	0.20

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[31] We have combined Nature-Based Solutions, Industrials and Recycling & Circularity sectors into "Others" given that these sectors have relatively small sample size with the number of companies less than 20.

[32] We have classified Tesla in Battery instead of Transportation, given the company's battery production advantage being a major competitive driver. Moreover, the company's increasing range of solutions is more broadly in the sustainable energy space, which makes it challenging to classify the company as a pure car manufacturer. Reclassifying Tesla to Transportation would raise both return and risk for that solution.

Number of stocks	10.4	27.9	274.9	30.8	9.4	14.6	41.8	14.7

Note: Exhibit 9 presents the performance for climate solutions portfolios by different categories. For some of the categories with number of observations less than 20 companies, we combine them in to "Others", including Nature-Based Solutions ,Industrials, Recycling & Circularity and Carbon Capture and Storage. Alphas are calculated after controlling for Fama-French DM and EM five factors including market, value, size, profitability and investment as well as DM and EM momentum factors.

5. Implications

Our analysis reveals several insights about the growing market for decarbonization. First, investors in public markets increasingly can gain exposure to climate solutions companies. Both the number and the market capitalization of those companies in public markets has increased over time. While just ten years ago, we found less than 300 such companies with enough liquidity and size for institutional investment, this number has doubled in the most recent years. Of course, this underestimates the total exposure to climate solutions revenues that an investor can gain exposure in public markets, as many companies are developing products and services to decarbonize the economy, but those might represent only a (small) fraction of their overall revenues.

Second, a significant percentage of these companies, almost half, are in emerging markets. Within this set many companies are in China. In fact, more climate solutions companies are in China rather than the US or the EU. Again, a caveat to this result applies as it could be that more companies in the US or the EU are developing climate solutions, but those companies are also providing other services and therefore they are not included in our sample (or they are private companies) and the relative prevalence of those companies might be higher in US/EU relative to China.

Third, most companies provide energy low carbon solutions, such as solar or wind power generation. Only recently, investors can gain exposure in public markets to an increasing number of companies that provide other solutions, such as batteries and storage, food, materials, and transportation.

Fourth, those companies exhibit high growth, high investment, and low profitability. Therefore, they are likely to exhibit higher risk, especially if that growth stalls and expectations for regulatory climate action or shifting consumer preferences towards low carbon products do not materialize. Coupling this with the fact that many companies are in emerging markets, exposing investors to political, regulatory and currency risks, also elevates the risk profile of these portfolios.

Fifth, our results suggest that it is important to clearly differentiate climate solutions investments from more broadly based, less pure-play investment products that take climate change

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into account: they provide investors with different exposures. Specifically, the returns of a climate solutions portfolio exhibit zero correlation, after accounting for market returns, with those of indices that lower the carbon emission exposure. Labelling those products clearly and differently could serve investors well. Generic labels, such as "climate change," fail to communicate what the products are seeking to achieve and could lead investors to allocate capital away from their preferences. We recommend that products seeking to decarbonize portfolios by underweighting high carbon companies are clearly labelled as "Low Carbon Exposure" portfolios. In contrast, products that include companies that provide solutions to decarbonize the economy, are labelled as "Climate Solutions" portfolios.

6. Conclusion

In this paper we develop a process to identify a list of publicly traded "pure-play" companies that provide climate solutions products or services and contribute to the transition to a low carbon world. Our sample of global companies are mainly in ten business areas central to climate change solutions, including agriculture & food, building & housing, carbon capture, utilization, and storage (CCUS), energy generation & storage, materials, nature-based solutions, recycling and circularity, and transportation.

We find emerging markets have a significant presence in our sample — almost half of the climate solutions companies are from emerging markets. This suggests that many EM businesses have been actively participating in the market of decarbonization, which allows investors to deploy capital not only to developed markets but across a more diverse set of regions.

Based on this list of climate solutions companies, we build value-weighted and equally-weighted climate solutions portfolios for the global sample as well as by different market, region and sector segments. We find these pure-play climate solutions companies are characterized with lower profitability, higher revenue growth, and higher investment and capital expenditure relative to their industry peers, which is also reflected in their relative lower valuation ratios, such as earnings yield and book-to-market.

Our stock selection and portfolio construction for climate solutions portfolios aim to gain exposure to long-term climate change opportunities and innovations as economies attempt to transition to a low carbon economy rather than to achieve immediate carbon reductions. This represents a different approach from existing indices in the market which overweight low carbon companies and underweight high carbon companies. As expected, we observe our climate

solutions portfolios have large tracking errors to MSCI ACWI due to more active security selection and portfolio weights.

Lastly, we examine the stock performance of the climate solutions portfolios from January 2011 to October 2021, and find evidence of outperformance of climate solutions portfolios, particularly noticeable in the past four years, in both developed markets and emerging markets excluding China, as well as in energy, fuels, battery and transportation segments.

We hope our study provide investors practical examples of how to identify pure-play climate solutions companies, how to build portfolios to gain exposure to climate change opportunities, and a better understanding of the properties and financial performance of these portfolios.

References

Andersson, M., P. Bolton and F. Samama. 2016. "Hedging Climate Risk." *Financial Analysts Journal* 72(3): 13-32.

Cheema-Fox, A., B.R. LaPerla, G. Serafeim, D. Turkington, and H. Wang. 2021(a). "Decarbonization Factors." *Journal of Impact & ESG Investing* 2 (1): 47-73.

Cheema-Fox, A., B.R. LaPerla, G. Serafeim, D. Turkington and H. Wang. 2021(b). Decarbonizing Everything." *Financial Analyst Journal* 77 (3): 93-108.

Hellstern, T., K. Henderson, S. Kane, and M. Rogers. 2021. "Innovating to Net Zero: An Executive's Guide to Climate Technology. Available at: innovating-to-net-zero-an-executives-guide-to-climate-technology.pdf (mckinsey.com)

IPCC, 2021. "Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis." Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

Appendix

Exhibit A1 Panel A: Multifactor Regressions for Global Climate solutions portfolios

	Global					
	VW			EW		
	2011-2021	2016-2021	2018-2021	2011-2021	2016-2021	2018-2020
Alpha	10.04%	11.40%	22.91%	11.41%	9.20%	13.83%
	1.68	1.22	1.87	3.22	1.83	2.18
DM Mkt-RF	0.59	0.96	0.98	0.32	0.38	0.46
	2.54	2.38	2.12	3.55	3.08	2.58
DM SMB	-0.06	-0.75	-0.54	0.07	-0.01	0.16
	-0.16	-1.26	-0.87	0.32	-0.04	0.48
DM HML	-0.84	-1.54	-1.78	-0.43	-0.70	-0.99
	-1.31	-2.14	-1.69	-1.96	-2.91	-3.24
DM RMW	-1.07	-1.87	-1.61	-0.49	-0.68	-0.87
	-2.07	-3.03	-2.03	-2.00	-1.85	-1.80
DM CMA	-0.18	1.06	2.17	0.16	0.73	1.27
	-0.19	1.06	1.58	0.47	2.29	3.37
DM WML	0.01	0.12	0.07	-0.13	-0.15	-0.20
	0.02	0.23	0.11	-0.92	-0.90	-0.99
EM Mkt-RF	0.52	0.58	0.61	0.65	0.75	0.68
	2.66	2.01	1.59	6.33	5.29	3.28
EM SMB	0.69	0.90	0.97	0.78	0.87	1.00
	2.15	2.00	1.91	4.86	3.74	3.25
EM HML	0.11	0.08	-0.13	0.21	0.21	0.25
	0.32	0.18	-0.27	1.01	0.87	1.12
EM RMW	-0.58	-0.29	-0.46	-0.27	-0.27	-0.14
	-1.13	-0.41	-0.52	-1.34	-0.97	-0.47
EM CMA	-0.08	-0.08	-0.02	-0.28	-0.17	-0.24
	-0.12	-0.10	-0.02	-0.79	-0.42	-0.68
EM WML	0.01	-0.06	0.03	0.00	0.17	0.13
	0.05	-0.17	0.07	-0.02	1.11	0.67
Adjusted R-squared	56.25%	52.84%	46.50%	80.31%	80.65%	79.16%
N	130	70	46	130	70	46

Exhibit A1 Panel B: Multifactor Regressions for DM and EM Climate Solutions Portfolios

	DM						EM					
	VW			EW			VW			EW		
	2011-2020	2016-2020	2018-2020	2011-2020	2016-2020	2018-2020	2011-2020	2016-2020	2018-2020	2011-2020	2016-2020	2018-2020
Alpha	9.11%	14.18%	27.72%	10.72%	16.74%	24.99%	5.45%	0.03%	8.51%	9.49%	2.84%	6.41%
	1.50	1.47	2.06	1.92	2.14	2.59	0.80	0.91	0.93	0.82	0.86	0.83
DM Mkt-RF	1.46	1.96	2.06	1.19	1.35	1.42						
	5.63	4.83	5.06	10.65	7.36	7.71						
DM SMB	0.23	-0.60	-0.38	0.65	0.70	0.87						
	0.44	-0.87	-0.44	2.13	2.05	2.27						
DM HML	-1.06	-1.88	-2.10	-0.69	-1.08	-1.23						
	-1.35	-1.95	-1.68	-2.15	-2.66	-2.99						
DM RMW	-1.22	-2.01	-2.41	-1.17	-1.64	-2.49						
	-2.44	-2.45	-2.32	-3.13	-2.44	-3.35						
DM CMA	0.07	1.56	2.18	0.37	1.13	1.23						
	0.07	1.26	1.22	0.65	1.99	1.92						
DM WML	-0.05	0.05	0.14	-0.21	-0.09	-0.09						
	-0.14	0.10	0.21	-1.05	-0.32	-0.24						
EM Mkt-RF							0.80	0.91	0.93	0.82	0.86	0.83
							5.52	5.12	6.54	12.62	11.70	11.54
EM SMB							0.94	0.82	0.75	1.18	1.11	1.17
							2.52	2.00	1.83	6.99	5.45	4.97
EM HML							0.30	0.26	-0.06	0.40	0.57	0.50
							0.89	0.64	-0.13	1.64	2.06	1.56
EM RMW							-0.16	0.22	0.61	0.17	0.24	0.46
							-0.40	0.68	1.79	0.63	0.67	1.20
EM CMA							-0.67	-0.17	0.44	-0.52	-0.40	-0.32
							-1.52	-0.25	0.67	-2.30	-1.40	-0.92
EM WML							0.18	0.58	0.88	-0.05	0.24	0.24
							0.92	2.11	3.33	-0.46	1.64	1.22
Adjusted R-squared	51.49%	50.70%	50.06%	68.71%	68.12%	72.46%	43.98%	43.33%	48.53%	72.48%	75.41%	74.89%
N	130	70	46	130	70	46	130	70	46	130	70	46

Note: Exhibit A1 Panel A presents the portfolio performance for value-weighted and equally-weighted climate solutions portfolios based on the global sample for three time period January 2011 to October 2021, January 2016 to October 2021, and January 2018 to October 2021. For the global portfolio, we calculate alphas for climate solutions portfolios using multi-factor regressions controlling for Fama-French DM and EM five factors including market, value, size, profitability and investment as well as DM and EM momentum factors. Exhibit A1 Panel B presents the portfolio performance for value-weighted and equally-weighted climate solutions portfolios based on the developed market sample and the emerging market sample for three time period January 2011 to October 2021, January 2016 to October 2021, and January 2018 to October 2021. For the DM portfolios, we calculate alphas for climate solutions portfolios using multi-factor regressions controlling for Fama-French DM five factors including market, value, size, profitability as well as the DM momentum factor. For the EM portfolios, we calculate alphas controlling for Fama-French EM five factors and the EM momentum factor. The t-statistics for alphas are estimated based on HAC standard errors.

Exhibit A2 Panel A: CSI Performance by Category (2016-2021)

	Agriculture & Food (A)	Batteries (B)	Energy (E)	Fuels - Alternate (F)	Housing (H)	Materials (M)	Transportation (T)	Others
Value -weighted								
Returns	-8.67%	57.89%	13.82%	12.80%	30.74%	16.26%	14.74%	4.50%
Risk	52.95%	49.55%	14.32%	24.57%	27.59%	34.63%	30.63%	27.19%
Return/risk	-0.16	1.17	0.97	0.52	1.11	0.47	0.48	0.17
Sortino ratio	-0.25	1.81	1.35	0.77	1.69	0.65	0.71	0.24
Hit rate	48.51%	52.48%	54.33%	52.48%	53.81%	52.02%	51.16%	50.63%
Max drawdown	72.79%	57.57%	24.86%	41.53%	44.21%	58.62%	53.14%	71.36%
Alpha	-4.32%	34.36%	3.77%	12.19%	10.38%	12.50%	13.53%	-4.11%
Alpha t-stat	-0.31	1.19	0.75	1.65	0.86	0.58	1.07	-0.49
Equally-weighted								
Returns	15.41%	34.96%	17.44%	27.51%	22.07%	28.85%	26.20%	18.60%
Risk	26.54%	23.31%	11.61%	17.50%	23.92%	18.87%	18.84%	20.37%
Return/ risk	0.58	1.50	1.50	1.57	0.92	1.53	1.39	0.91
Sortino ratio	0.89	2.45	2.08	2.36	1.51	2.36	2.05	1.36
Hit rate	49.93%	53.44%	56.81%	54.63%	51.40%	52.74%	54.14%	52.25%
Max drawdown	50.66%	39.18%	29.42%	30.15%	40.27%	44.12%	42.32%	52.40%
Alpha	6.20%	20.68%	5.30%	12.19%	11.55%	15.78%	22.51%	3.64%
Alpha t-stat	0.56	1.65	1.08	1.51	1.27	1.92	2.53	0.58
Number of stocks	12.6	30.1	304.4	34.1	11.4	15.4	50.4	15.5

Panel B: CSI Performance by Category (2018-2021)

	Agriculture & Food (A)	Batteries (B)	Energy (E)	Fuels - Alternate (F)	Housing (H)	Materials (M)	Transportation (T)	Others
Value -weighted								
Returns	-14.90%	93.45%	20.59%	18.02%	37.93%	9.01%	29.16%	-3.20%
Risk	56.42%	57.74%	15.45%	28.17%	30.38%	37.59%	34.41%	29.26%
Return/risk	-0.26	1.62	1.33	0.64	1.25	0.24	0.85	-0.11
Sortino ratio	-0.40	2.54	1.92	0.96	1.90	0.32	1.30	-0.15
Hit rate	48.33%	53.83%	54.84%	52.42%	54.64%	52.82%	50.30%	49.60%
Max drawdown	70.44%	57.57%	24.86%	41.53%	44.21%	58.48%	44.62%	71.36%
Alpha	-6.73%	54.05%	13.60%	19.04%	17.22%	15.70%	23.00%	-13.19%
Alpha t-stat	-0.32	1.55	2.12	1.96	1.36	0.52	1.44	-1.01
Equally-weighted								
Returns	15.33%	39.95%	19.90%	24.43%	26.42%	15.18%	25.65%	13.86%
Risk	27.30%	24.86%	12.79%	18.88%	25.40%	19.59%	20.09%	21.96%
Return/ risk	0.56	1.61	1.56	1.29	1.04	0.77	1.28	0.63
Sortino ratio	0.87	2.66	2.14	1.90	1.71	1.15	1.90	0.92
Hit rate	50.33%	53.48%	57.13%	54.36%	52.15%	49.94%	53.26%	52.38%
Max drawdown	50.66%	36.70%	29.42%	30.15%	40.27%	44.12%	42.32%	52.40%

Alpha	8.38%	25.10%	12.30%	8.94%	14.50%	6.33%	26.26%	-1.51%
Alpha t-stat	0.66	1.61	2.12	0.94	1.01	0.69	2.31	-0.16
Number of stocks	14.2	31.0	314.7	35.6	12.9	15.4	56.2	16.0

Note: Exhibit A2 presents the performance for value-weighted and equally-weighted climate solutions portfolios by different sectors/industries based on the global sample for January 2016 to October 2021, and January 2018 to October 2021. For some of the categories with number of observations less than 20 companies, we combine them in to "Others", including Nature-Based Solutions , Industrials, Recycling & Circularity and Carbon Capture and Storage. Alphas are calculated after controlling for Fama-French DM and EM five factors including market, value, size, profitability and investment as well as DM and EM momentum factors.