



What Makes Green Investment a Puzzle?

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Fighting climate change is expensive.¹ However, fiduciary duty² requires institutional investors to actively manage their climate risk. Given the nondiversifiable feature of climate risk, insurance products that can protect against climate change do not exist. For institutional investors, a more natural strategy to hedge climate risk is to replace a portion of the investment portfolio with a class of assets that can not only reduce the portfolio's carbon footprint but that also performs well when the climate is bad. As a starting point, institutional investors can hold "green" financial indexes to reduce their carbon exposure. Although it is still a gray area in terms of qualifying a green investment, this paper generally considers all the financial activities that present a positive exposure to green indexes as green investing.

Over the past decade, the green financial market has enjoyed a fast growth rate. According to the latest Bloomberg report, the global green bond market with an annual issuance of less than \$1 billion a decade ago has grown to more than \$170 billion by the end of 2017. Green bonds are bonds that green companies issue. Most of the institutional investors in developed markets have embraced the concept of Environmental, Social and Governance (ESG) into their investment process. According to the U.S. Forum for Sustainable and Responsible Investment Foundation (SIF)³ Biennial Report 2018, the ESG assets that institutional investors in the

U.S. own expanded to \$11.6 trillion in 2018, up 44% from \$8.1 trillion in 2016.⁴

However, despite the accessibility of the green financial market, the increasing financial risks that may occur due to climate change, and the awareness of the shift toward more stringent climate mitigation policies in many countries, the motivation behind investing in green financial instruments is, at present, more of a moral choice than a speculative opportunity (Riedl and Smeets, 2017). The myth behind the motivation of green investment is mainly driven by a lack of knowledge about the potential impact of climate change on various asset classes. Most investors believe that they cannot use their investment portfolio to improve environmental performance without sacrificing investment rewards (Walley and Whitehead, 1994), especially for short-term investors (Engle et al., 2018). In general, green investing puzzles investors in two ways. First, investors are not convinced that their exposure to green investment can lead to environmental improvement. Second, whether green investing is an efficient way of hedging climate risk is not verified.

¹ In order to achieve the two-degree Celsius threshold suggested by the International Panel on Climate Change (IPCC) and the Paris Agreement, leaders of many nations have taken actions to reduce the GHGs emissions. Effective GHG abatement actions include shifting energy supply from fossil fuels to low-carbon energy, such as wind, nuclear or hydro power and transiting toward energy-efficient vehicles, buildings and industrial equipment. An estimate from McKinsey (Nauclér and Enkvist, 2009) shows that the total upfront investment in abatement required to meet the 2 degree Celsius threshold may be as high as €530 billion in 2020 or €810 per year in 2030.

² Such as the Task Force on Climate-related Financial Disclosures and the International Panel on Climate Change (IPCC 2014).

³ See Bullard, Nathaniel and Daniel Shurey. How the World's Governments Are Approaching Earth-Friendly Investing. *Bloomberg*, July 24, 2018, <https://www.bloomberg.com/opinion/articles/2018-07-24/green-bonds-could-become-a-key-part-of-global-capital-markets> (accessed March 25, 2019).

⁴ See US SIF. Foundation Releases 2018 Biennial Report On US Sustainable, Responsible And Impact Investing Trends. *The Forum for Sustainable and Responsible Investment*, October 31, 2018, https://www.ussif.org/blog_home.asp?Display=118 (accessed March 25, 2019).

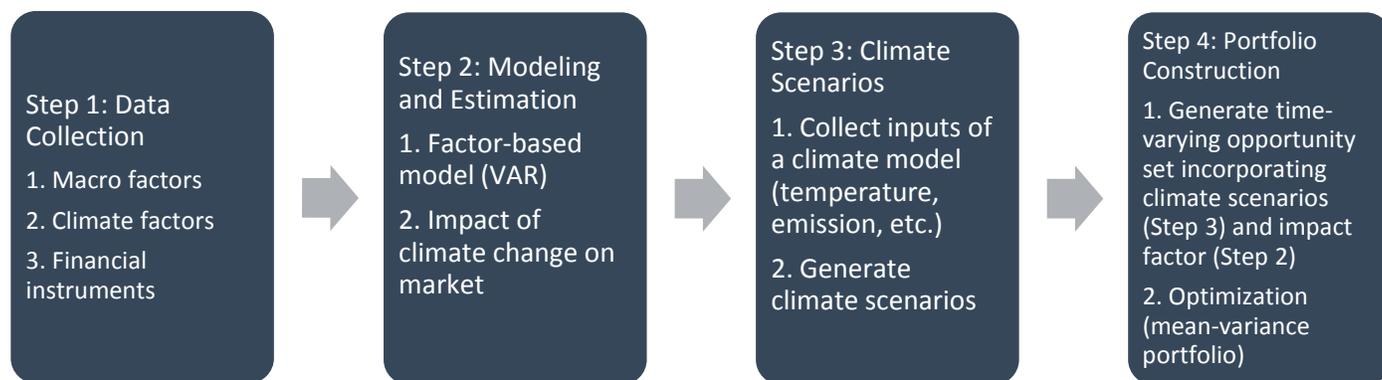
To hedge climate risk, investors are confronted with two types of unknowns: (1) unknown knowns where they have data but cannot predict future outcomes and (2) unknown unknowns⁵ where they cannot foresee future outcomes. There are two typical unknown knowns that green investors are confronted with. First, the impact of climate change on various asset classes is unclear to most investors. Second, returns of financial instruments are unpredictable, especially those of green assets,⁶ due to their short time series of returns.

The second type of unknown—the unpredictability of returns—worries investors most. The main source of unknown unknowns is an unpredictable climate-change trajectory. The projected Earth’s surface temperature changes vary between 1.4 to 5.8° C by the end of 21st century (Gitay et al., 2002). The large dispersion reflects the unpredictability of the climate change path. The other challenge is a mismatched and unknown timing between market awareness of the rewards of green investing and the limited investment horizons. Climate risk is an ultra-long (30 years and beyond) term risk. Thus far, temperature change has had minimal influence on the

financial market performance, especially for active managers with short-term investment horizons. Therefore, many fund managers find it risky to replace their portfolio fully with green instruments because of the short-term risk before the possibility of significant gain from their green investment.

This paper develops a four-step approach to help investors address the two layers of unknowns and to find a strategic pathway for green investing (see Figure 1). As a starting point (Step 1 and Step 2), investors can obtain historical information to determine the probability distribution of their investment opportunity set and the likelihood of climate impact on various asset classes. Table 1 presents a snapshot of the climate effect on asset returns, using a factor-based vector autoregression model (VAR). In the VAR model, we use temperature change as an indicator of climate risk. Table 1 shows that green assets are in general resilient against temperature shocks, while many traditional asset classes are negatively related to the risk of global warming.

Figure 1: A Strategic Pathway of Green Investing



⁵ “Unknown unknown” is a phrase from a response that United States Secretary of Defense Donald Rumsfeld gave to a question at a U.S. Department of Defense news briefing on Feb. 12, 2002, about the lack of evidence linking the Iraq government with the supply of weapons of mass destruction to terrorist groups.

⁶ This is driven by the fact that the standard error of the historical average return shrinks at the square root of the sample period’s time. The longest existing market instrument has a history of no longer than 100 years, and the length of low-carbon indexes is even shorter, with a history of fewer than 10 years.

Table 1: Impact of Instantaneous Temperature Change on Various Asset Classes

Assets	Stocks	10-Year Bonds	Corporate Bonds	Commodity	Real Estates	Hedge Funds	Green Bonds	Green Equity	SRI Index	Clean Tech	Clean Energy
Impact	-0.09*	-0.01	-0.03*	-0.79*	-0.18	-0.14*	-0.21	0.23	0.30*	0.57*	-0.38

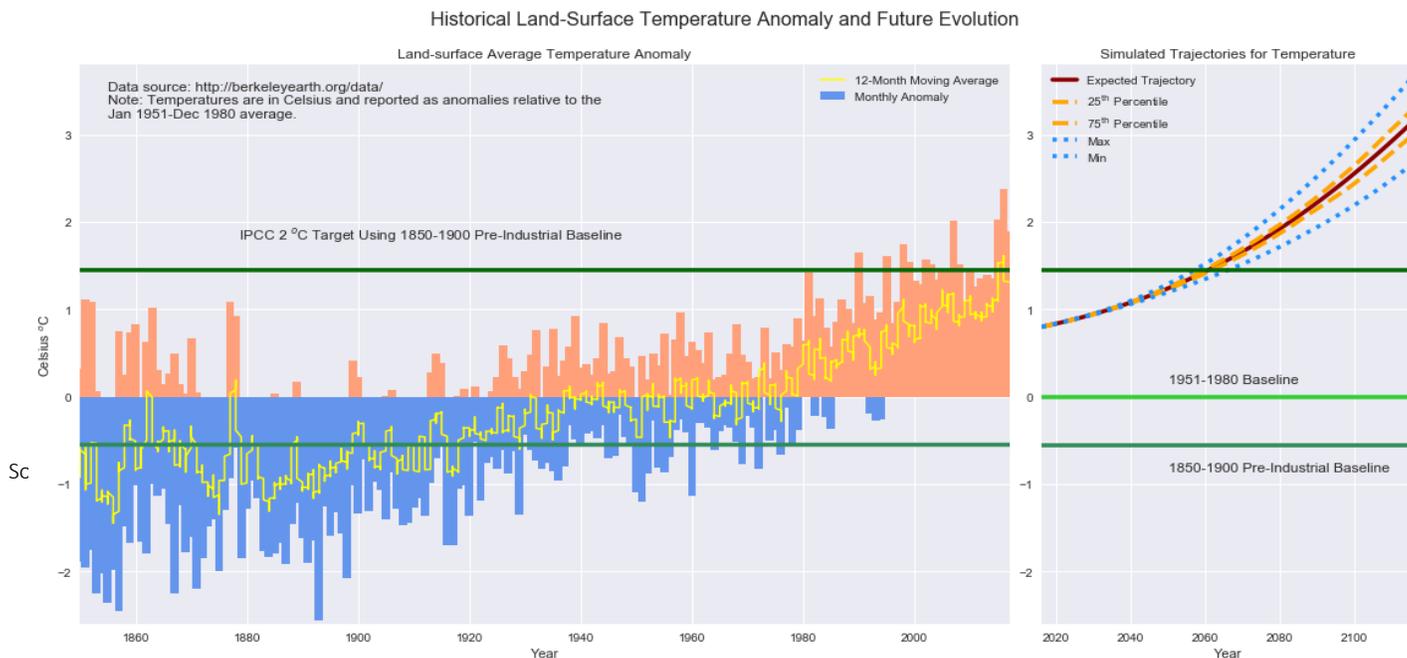
We consider five eco-friendly asset classes, including green bonds, green equity, socially responsible funds, clean technology and clean energy funds in addition to stocks, bonds and alternatives. SRI = Socially Responsible Index, Clean Tech = Clean Technology Portfolios. * = significance level with the p-value less or equal to 0.15.

Source: Author’s own calculation based on the findings from Shen, S. and LaPlante, A. and Rubtsov, A., 2018. Strategic Asset Allocation with Climate Change. SSRN, <https://ssrn.com/abstract=3249211> (accessed March 26, 2019).

In Step 3, investors need to employ climate models to generate future scenarios. Figure 2 plots an example of quantitative climate scenarios using the DICE model. In the last step, investors can project a time-varying investment opportunity set incorporating the estimated climate impacts (Step 2) and future climate scenarios (Step 3), then solving an optimal mean-variance optimization problem to obtain their optimal portfolio.

The four-step approach not only quantifies the historical climate effect on assets but also brings this impact to the unknown future. Shen et al. (2018) show green investing should not be a puzzle if investors consider the dynamic impact of climate change on various assets.

Figure 2: Climate Scenarios Using DICE Model



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