Migrating with Black Swans: Climate Change and Retirement Planning

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Executive Summary

This paper combines the thoughts of several authors to describe the migration of a retiree through the retirement phase of their life during a time of climate change. Taleb (2007) introduced the concept of the Black Swan, the (hopefully) infrequent but significant disruption of investment returns. Bernstein (2013) discussed sources of risk in portfolio design and the concept of Deep Risk, the long-term loss of real capital. Frank, Mitchell, and Blanchett (2012), among others, demonstrated how retirees move through retirement, frequently adjusting to changes in market performance and personal expectations of longevity. Nordhaus (2013) investigated the potential effects of climate change on economic performance and equity returns. The Intergovernmental Panel on Climate Change reports outlined many of the possible underlying climate changes that are likely to drive these risks and necessitate adjustment on the part of retirees. These sources, and others, motivate an exploration of climate change, its economic implications, and how retirees might cope as they migrate through their final years. Suggestions are made for how financial planners should prepare themselves, and their clients, for climate change related risks.Migrating with Black Swans: Climate Change and Retirement Planning

Introduction

Retirement is a moment, but also a process, a journey. As we move through retirement we migrate from the accumulation phase of life into the decumulation phase. Needs change. Motivations change. Health may change abruptly and we understand that. But the economic ground we stand on may also change suddenly. This paper explores how climate change may affect both needs and the resources available to cope with those changes. Time will reveal the ultimate significance of climate change. This paper lays the groundwork for avenues of investigation into those implications.

An evolution of thought

Taleb (2007) introduced the concept of the Black Swan, the highly improbable but profoundly significant event. Black Swans are unpredictable, massive in impact, and appear logical in retrospect. Climate Change is no longer a Black Swan, though some of its effects may be. The basic mechanism causing Climate Change has been known since 1896. (McKibben 2011, page 19). Despite continued denial by some, the Black Swans today are the uncertain effects of inevitable Climate Change.

Bernstein (2013) explored the concept of Deep Risk, the permanent loss of real capital. Climate Change has the potential to create Deep Risk in four ways: personal catastrophe if the investor is directly affected by climate change, inflation if Climate Change creates shortages of commodities or drains national treasuries forcing monetary expansion, confiscation of wealth if society reacts to Climate Change by limiting greenhouse gas emissions and thus preventing use of assets, and finally via devastation.

Frank, Mitchell, and Blanchett (2012) explained the dynamic process retirees experience as they adjust to changing market conditions. Blanchett (2014) and Lee, Sohn, Rhee, Lee, and Zan (2014) explored changing (life-cycle) needs over the retirement period while Kim, Hanna, and Chen (2014) found that income likewise changes in stages over retirement. Retirement planning researchers have been exploring variable withdrawal rates in response to changing returns dating back to 2001 (Bengen 2001); variable withdrawal rates that may be needed in response to Climate Change related uncertainty.

Retirement is not static; it is a time of periodic adjustment to changing needs, returns, and expected longevity. Retirement is a 'migration' through the retiree's final years. Climate Change raises the specter of migrating not alone, but in the company of Black Swans.

Evidence of Change

The basic mechanism of Climate Change is an increase in earth's retention of energy as the concentration of greenhouse gases (GHG) increases in the atmosphere. The Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) reported that 2010 emissions of GHG were 49 gigatons of CO_2 equivalents (Gt CO_2eq) with emissions increasing at an increasing rate and roughly half of all GHG emissions over the period 1750-2010 occurring since 1970. (IPCC 2014a, pages 6-7). Current concentrations of GHG are approximately 430 parts per million (ppm) of CO_2eq as compared to pre-industrial (1750) levels of 280 ppm (IPCC, 2014a, page 8). Approximately 76% of GHG emissions are CO_2 and other emissions (CH_4, N_2O, and fluorinated gases) are frequently converted to CO_2eq based on their 100-year effect on warming (IPCC 2014a, page 6).

Global average air temperature has increased approximately .85°C (Celsius) by 2012 compared to 1880 (IPCC 2014b, page 2). About 90% of the increased energy is absorbed by the ocean (IPCC 2014b, page 3), although the rate of absorption changes over time. As CO_2 is absorbed in the oceans it is converted to carbonic acid which increases ocean acidity, roughly by 26% to date (IPCC 2014b, page 3). The warming of oceans increases their volume. Average sea-level rise (1901 to 2010) is approximately .19 meter (7 inches) (IPCC 2014b, page 4).

Among other observed effects to date is a reduction of arctic sea ice (IPCC 2014b, page 4), loss of land ice mass in Greenland and Antarctica (NASA 2015b), loss of reefs (Mathiesen 2015), deterioration of shells in shellfish (Bednars^ek et.al. 2015), movement of some plant and animal species (IPCC 2014b, page 6) and human diseases (McMichael 2013), increased permafrost temperatures (IPCC 2014, page 4), increased severity of storms (IPCC 2014b, page 7), and increased weather-related insurance claims and supply-chain disruptions (Messervy, McHale, and Spivey 2014, page 12).

Climate Change is not only a future phenomenon; it is happening now and has been happening slowly throughout the lifetimes of all living humans. The IPCC now states that "Anthropogenic greenhouse gas emissions . . . are *extremely likely* to be the dominant cause of the observed warming since the mid-20th century" (IPCC 2014b). With over 97% of climate scientists and nearly 200 worldwide scientific organizations in agreement with that premise the financial planning community needs to take note (NASA 2015a).

The Nature of Climate Change

Climate change is global, long-term, irreversible on a human time scale, and uncertain (Wagner and Weitzman 2015, page 7). Climate change is global both in terms of its effects and its cause; though both effects and cause are not evenly distributed globally. Rich, and a few rapidly developing nations such as China and India, cause most of the emissions while much of the damage occurs in less-developed nations. Climate change is long-term. Each year adds approximately 2 ppm to the current 430 ppm of CO_2eq. Therefore, the change from year to year is small and adjustments toward equilibrium in the ecosystem are gradual. However, emissions of CO_2 stay in the atmosphere for hundreds of years and are slowly absorbed by oceans. Because CO_2 does stay in the atmosphere for long periods of time and because much of the atmospheric CO_2 is stored in oceans and can later be released, change is irreversible from the perspective of the human time scale. Finally, effects are uncertain. Many underlying mechanisms are difficult to predict in timing and amount. Possible trigger points for rapid methane release, ocean currents disruption, and aerosols effects are particularly difficult. Even effects such as rainfall patterns and localized temperature changes tend to be overshadowed by short-term variability.

Figure 1 shows likely global temperature and sea level increases for two possible pathways: business-as-usual (RCP8.5 in pink) and a drastic reduction in greenhouse gas emissions (RCP2.6 in blue). Effects on temperature and sea level differ only slightly through 2050 but diverge greatly in the late 21st century and beyond. Note that under business-as-usual both temperature and sea level are rising rapidly at the end of the century not yet having reached equilibrium. In the case of drastic cuts in GHG emissions temperature has stabilized by the end of the century but sea level is still rising toward equilibrium (IPCC 2015a).

Figure 1

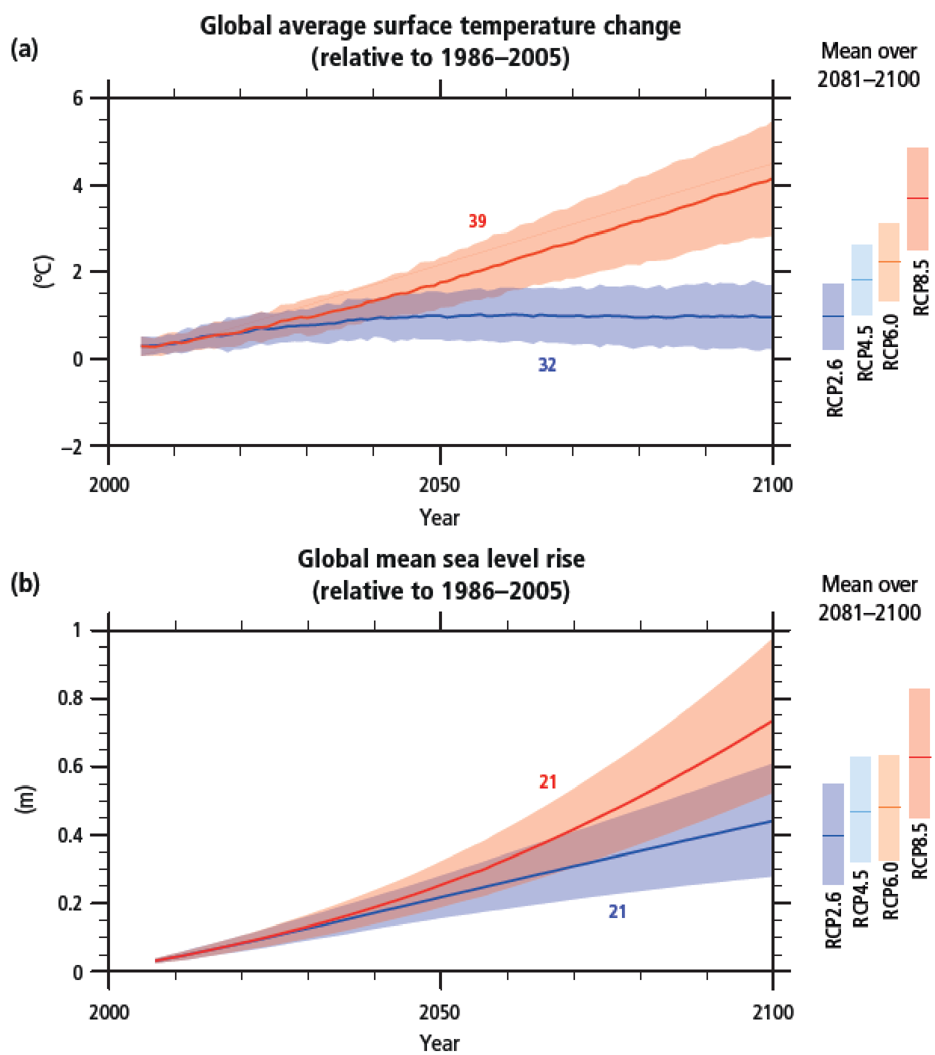

Figure SPM.6 | Global average surface temperature change **(a)** and global mean sea level rise[10] **(b)** from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars at the right hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated. *{2.2, Figure 2.1}*

Today's actions have little effect on short-term climate change but significant effects on the long-term. In effect, current generations must sacrifice to prevent uncertain consequences for future generations. This very nature, combined with a political divide over action (at least in the U.S.), increases the odds of inadequate action to prevent possibly catastrophic long-term consequences.

Economic Implications

Nordhaus has developed econometric models (DICE and RICE) to predict carbon prices likely to contain global warming to various target levels (Nordhaus 2013a). Carbon prices, whether achieved via cap-and-trade or taxes, have both been proposed as mechanisms for efficiently limited greenhouse gas emissions. Nordhaus estimated that a carbon tax beginning near $20 in 2015 and rising gradually to $200 in 2115 would eliminate CO_2 emissions by that time. This policy would, by DICE estimates, result in a 3^oC increase in global temperature by 2100 falling very gradually over the following centuries. This is Nordhaus's preferred policy according to his 2013 model. Per capita worldwide consumption rises throughout the century about six-fold compared to current levels. CO_2 concentrations in the atmosphere cap out around 2100 at slightly above 550 ppm.

The DICE model predicts that by 2100 business as usual will result in CO_2 near 800 ppm and less per capita consumption, due to environmental damages, compared to a carbon tax system. Temperatures in 2100 are likely 3.7–4.8^oC higher than pre-industrial temperatures in this baseline scenario (IPCC 2014a, page 13). In contrast, the DICE model predicts that the Copenhagen Accord, if followed by the 'rich' nations, would achieve shorter-term reductions in emissions through non-price measures and with carbon prices similar to the DICE model optimal solution but capping near $150. The Copenhagen Accord would likely limit temperature increases to 1.7^oC and CO_2 levels at approximately current levels (Nordhaus 2013b).

While Nordhaus presented a largely benign view of the economic implications of climate change, with steadily increasing per capita consumption, there are reasons to suspect substantially greater negative effects. Nordhaus assumed a single consumption variable (Nordhaus 2013a, page 8). In effect, he assumed that all consumption, e.g. steel, education, and wheat, is interchangeable. Nordhaus pointed out that food production represents only a small percentage of global GDP (about 1% in the U.S.). However, food production is 100% of what sustains human life. Likewise, potable water is crucial to our existence yet exogenous to the DICE model.

Long-term drought in major food producing areas, such as the Central Valley of California, may create significant food price inflation. Large areas of rice production in major river deltas may be lost to rising sea level and increased losses to pests may contribute additional food price pressure (Wagner and Weitzman 2015). Much of the world's population lives within a small margin of starvation. Even relatively small increases in prices of staples such as wheat, corn, and rice could spell large scale starvation and unrest. Rising sea level will force hundreds of millions to migrate and the act of their migration will create conflict as evidenced by the large migrations currently taking place between Central America and the US and between Africa, Asia, and Europe.

Failure of the economic system to adequately meet human needs will come not because of a lack of total per capita consumables, but because of the inadequacy of those items essential to survival.

Kurtosis, Kurtosis, Kurtosis

Climate Change is difficult to predict in amount and timing. This uncertainty is obvious from the range of estimates presented as a 90% confidence interval by the IPCC. They predicted that CO_2eq concentrations roughly at current levels and emissions 40-70% lower than today by 2050 and near zero (or below via mitigation) by 2100 would generate a cumulative 1.5-1.7^{o}C temperature increase by 2100 with a 66% confidence interval and 1.0-2.8^{o}C with a 90% confidence interval. However, a Normal distribution, based on the 66% confidence interval of +/- .1^{o}C, would suggest an upper bound of only 1.8^{o}C at a 90% confidence interval. Also note skewness toward the upper end of the range.

In contrast, a business-as-usual projection is for a cumulative temperature increase of 4.1-4.8^{o}C (66% confidence interval) and 2.8-7.8^{o}C (90% confidence interval). Again note excess kurtosis and skewness toward higher temperatures. The same business-as-usual strategy is expected to produce a 6^{o}C eventual equilibrium temperature increase, again with a large range of possible outcomes. It is this eventual temperature change that should be society's focus due to irreversibility. Similar variability exists in estimates of sea level change and even in historic points of reference. (IPCC 2014a, pp. 10-13).

Wagner and Weitzman (2015) provided a useful description of the kurtosis problem. In their opinion these temperature change predictions, and their frequent upward revisions, are based on climate models unduly influenced by a known history that does not include observations of rapid and large change. Suitable analogies are the known history of security returns on which researchers (this author included) tend to base projections of portfolio adequacy and the experience of Taleb's turkey on Thanksgiving when the care received for its entire life is suddenly curtailed. (Wagner and Weitzman 2015, page 10) and (Taleb 2007, page 40). Sometimes our database simply does not reflect the longer–term distribution.

The key question is whether the possibility of much higher temperatures indicated by current estimates has significant negative consequences? Do Black Swans exist?

The Black Swans of Climate Change

It is difficult to list many of the possible impacts of Climate Change reported in the scientific literature without appearing alarmist. But Black Swans are, by definition, alarming. Let's focus on four related Black Swans: land ice melt, sea level, water resources, and stranded assets.

Many scientists have indicated that temperature increases above the approximately 2^oC cumulative increase expected by 2100 bring the world into a region of Black Swans, the largely unknown unknowns of methane release from arctic tundra, rapid land ice melt, ocean current disruption, and other possible effects, and that in order to avoid this dangerous territory GHG emissions need to be halved by about 2050 and virtually eliminated by 2100. (IPCC 2014a, page 10). According to *The Carbon Brief*, the 2^0C limit can be traced back to insight by William Nordhaus in 1975 but was not written in international agreement until the Cancun Agreement of 2010. (Hope and Rose 2014).

In order to achieve a 2^oC limit scientists in the IPCC Fifth Assessment Report suggested a new approach to climate change targets, a limit on cumulative emissions. Brown reported that about 1000 $GTCO_2$ can yet be emitted as compared to reserves of 2,860 $GTCO_2$. This would "strand" (Stranded assets are defined here as assets with economic value but blocked from use by regulation.) 65% of known fossil-fuel reserves, primarily in coal, which tends to be the dirtiest fossil fuel. (Brown 2015, page 13). Carbon pricing will reduce the value of fossil fuel-rich companies and associated infrastructure. Divestment of fossil-fuel companies began largely on ethical grounds but will likely continue on the basis of economics as the world realizes the inevitability of change and markets react accordingly. What other potentially stranded assets exist?

Figure 2 demonstrates the relationships between cumulative emissions, temperature increases, risks, and emissions through 2050. Here business-as-usual is labelled 'baseline' and is associated with about 7,500 $GTCO_2$, a temperature increase of about 4^0C, high to very risks, but allows more than a 50% increase in GHG emissions. Drastic cuts (light blue) result in less than 3,000 $GTCO_2$, a temperature increase of less than 2^0C, and moderate risk, but require a 50% reduction in GHG emissions by 2050.

Even with controls on carbon emissions there are also likely to be significant imperiled (devalued) assets. Much of the world's economic infrastructure is located within a few feet of sea level. Even modest rises in sea level forecast for 2100 (1-3 feet) will force significant allocation to hardening or moving infrastructure. While this will create opportunities for certain industries, it will inevitably divert resources and increase prices; all for a cause that may prove fruitless. Wagner and Weitzman reported that "the last time world CO_2 levels were at 400 ppm was 3 million years ago and . . . sea level 65 feet higher" (Wagner and Weitzman 2015, page 10). While such a change could probably occur only over hundreds of years, it would displace over a billion people and require repeated relocation of infrastructure. To make matters worse, we should expect that society will not simply relocate once. No one can accurately predict the

Figure 2

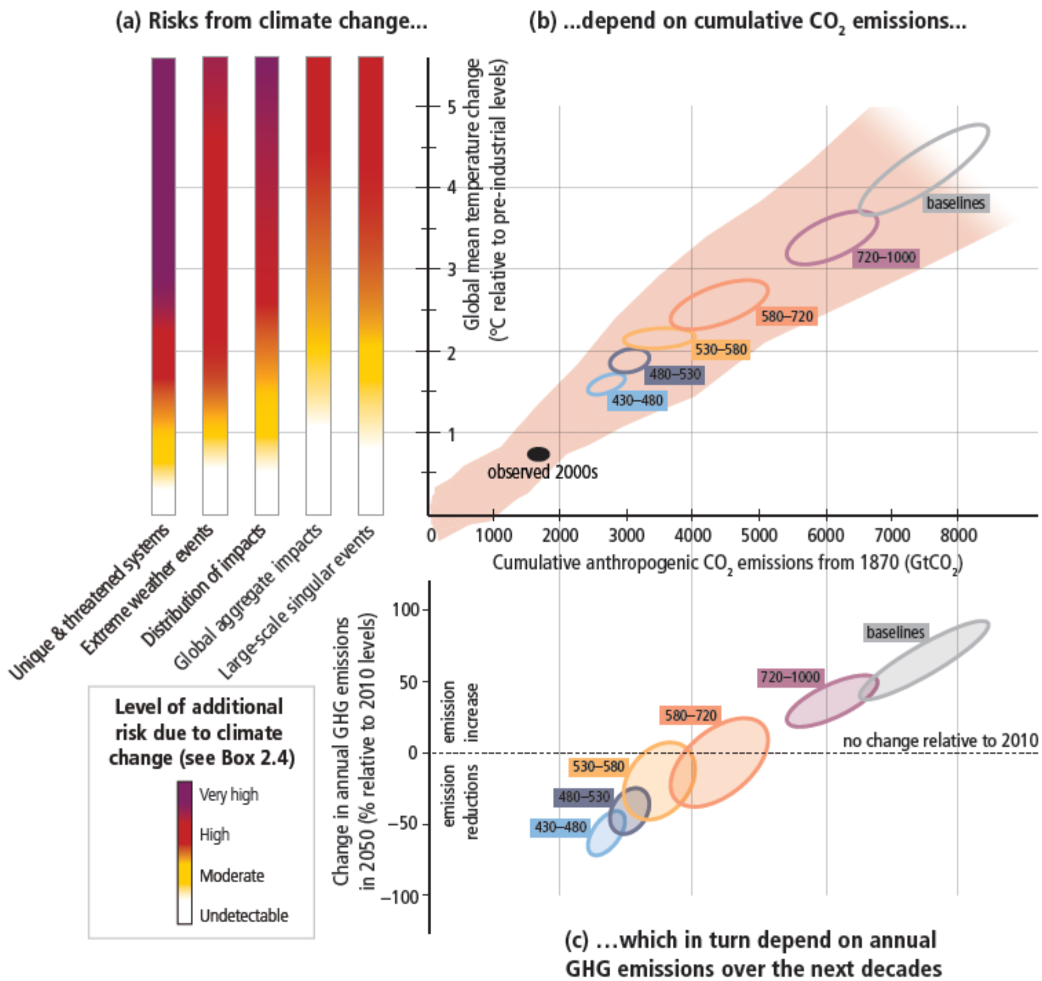

Figure SPM.10 | The relationship between risks from climate change, temperature change, cumulative carbon dioxide (CO_2) emissions and changes in annual greenhouse gas (GHG) emissions by 2050. Limiting risks across Reasons For Concern **(a)** would imply a limit for cumulative emissions of CO_2 **(b)** which would constrain annual GHG emissions over the next few decades **(c)**. **Panel a** reproduces the five Reasons For Concern *{Box 2.4}*. **Panel b** links temperature changes to cumulative CO_2 emissions (in $GtCO_2$) from 1870. They are based on Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations (pink plume) and on a simple climate model (median climate response in 2100), for the baselines and five mitigation scenario categories (six ellipses). Details are provided in Figure SPM.5. **Panel c** shows the relationship between the cumulative CO_2 emissions (in $GtCO_2$) of the scenario categories and their associated change in annual GHG emissions by 2050, expressed in percentage change (in percent $GtCO_2$-eq per year) relative to 2010. The ellipses correspond to the same scenario categories as in Panel b, and are built with a similar method (see details in Figure SPM.5). *{Figure 3.1}*

new equilibrium and it is so long in coming that it is of relevance only in a multi-generational context. Trillions of dollars are likely to be spent hardening existing assets before eventually abandoning them. New Orleans provides a good example of a doomed city temporarily propped against the tide. The killing blow may not come directly from sea level. It is likely to occur in insurance rates which price new owners out of the market and from insurance companies pulling out of high-risk markets which combine to force existing owners to self-insure one last time. (Messervy et al. 2014, page 7).

A recent study of the Black Swan of sea level rise, (Hansen et al. 2015), reported a likely rise in sea level within the next 50 years of 10 feet. This change, if it occurs, is roughly 10 times faster than previously predicted. It is based on satellite imagery only recently available. Previous rapid changes in sea level (roughly 40 mm per year) have been detected and the possibility should not be dismissed (Blanchon and Shaw 1995) and (Edwards 2006). It is difficult to imagine an orderly retreat from major coastal cities such as Miami, New Orleans, and New York; financial losses too staggering for insurance companies to bear and even for the federal government to cost-share significantly. Deep Risk would abound.

Sea level is not the only Black Swan of Climate Change. Significant areas, especially in Asia, live to a great extent from fossil water: glaciers. Additional water will be available short-term as melting increases. Long-term carrying capacity of those areas will be reduced. Combined with depleted aquifers and changed precipitation patterns, water shortages will negatively impact agricultural output and drive environmental migration and food price inflation.

We recognized in the previous section of the paper that distributions of temperature changes are not Normal distributions. They are both highly kurtotic and skewed toward higher outcomes. When we combine the temperature uncertainty, the unknown unknowns of feedback loops and cascading risks, and the Deep Risk associated with the economic consequences of the higher end of the temperature outcome ranges it seems prudent to plan for increased temperatures, increased environmental impacts, increased economic consequences, and increased societal reaction in the form of restrictions on emissions.

Climate Change and Retirement Planning Research

What are the issues faced by retirement planning researchers? We develop models of savings, investment, and decumulation based on assumptions of mean returns, dispersion of returns, and expected longevity. Such assumptions are typically based on historic distributions of returns and longevity. If returns and/or longevity are heteroskedastic due to Climate Change, it may be prudent to base assumptions on conservative forward-looking distributions. The highly kurtotic nature of Climate Change risk due to the Black Swans of methane release from thawing tundra, changing ocean currents, and other factors, further reduces the predictive value of historic distributions.

What are the withdrawal rate implications of changing mean and standard deviation of returns? Finke, Pfau, and Blanchett (2013), among others, has already sounded a warning that the 4% Rule may no longer apply in today's economic environment. And what withdrawal rate might apply in a world with a sky dotted with Black Swans? How quickly will markets react to carbon pricing and/or cap and trade limits? What industries will be negatively or positively affected? How does this affect portfolio construction? All of these are crucial issues to financial planners and investors in general.

The IPCC 5th Assessment indicated that in order to meet a 2^{0}C target major shifts in investment are likely to occur over coming decades. Massive increases in investment in energy efficiency and renewable energy sources will be offset by decreases in investment in extraction of fossil fuel and in power plants without carbon capture and storage (IPCC 2015a, Figure SPM.9). See Figure 3. Other investment shifts are likely to occur away from fossil fuel intensive industries, such as aircraft manufacture, airlines, and travel-related businesses, and towards less fossil fuel dependent industries.

Figure 3

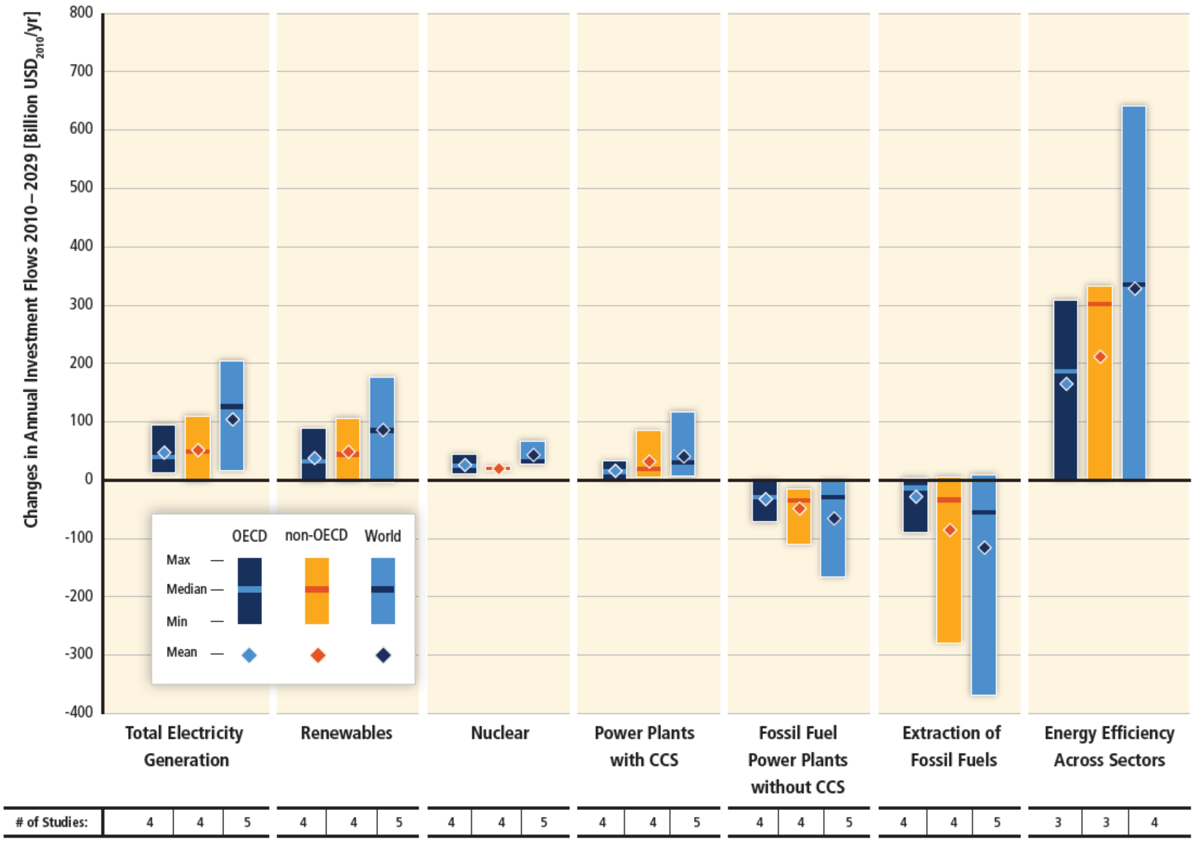

Figure SPM.9| Change in annual investment flows from the average baseline level over the next two decades (2010–2029) for mitigation scenarios that stabilize concentrations within the range of approximately 430–530 ppm CO_2eq by 2100. Investment changes are based on a limited number of model studies and model comparisons. Total electricity generation (leftmost column) is the sum of renewables, nuclear, power plants with CCS and fossil fuel power plants without CCS. The vertical bars indicate the range between minimum and maximum estimate; the horizontal bar indicates the median. Proximity to this median value does not imply higher likelihood because of the different degree of aggregation of model results, the low number of studies available and different assumptions in the different studies considered. The numbers in the bottom row show the total number of studies in the literature used for the assessment. This underscores that investment needs are still an evolving area of research that relatively few studies have examined. [Figure 16.3]

How will the extent to which companies incorporate Climate Change into their decision process affect company risk and returns? Insurance companies are perhaps unique in that they can be significantly affected on both the asset and liability sides of their business. Messervy et al.

(2014*, page 6)*, reporting on the National Association of Insurance Companies (NAIC) 2014 survey, stated that barely 10% of insurance companies in their sample issue "climate risk management statements articulating the company's understanding of climate science and its implications for core underwriting and investment portfolios. Given the insurance sector's key role in addressing societal risks, this near total silence on climate change is deeply troubling and is thwarting constructive public engagement on appropriate responses." If insurance companies are representative of business in general, there is not yet significant planning for Climate Change. While the relationship between corporate social responsibility and security returns has been well studied, the relationship between Climate Change risk and security returns has not. SEC rules effective February, 2010 that require Climate Change risk reporting in 10-K reports may provide data for such a comparison.

Will climate change affect longevity and retirement age? The 2014 NAIC Survey report stated "Despite growing concerns about climate related impacts on public health, temperature extremes, decreased air quality, and increased waterborne and vector-borne diseases . . . most health insurers are not preparing. With access to large sets of detailed claims data, health insurers are uniquely positioned to advance climate and health-related research . . ." and "L&A insurers also need to consider how global warming will affect human health and mortality, a point made clear by warnings in the 2014 National Climate Assessment of growing air pollution impacts on vulnerable populations, and extreme weather and wildfires." (Messervy et al. 2014, page 8).

Does Climate Change risk and the availability of property insurance affect real estate prices and rates of return? In Florida, with private insurers routinely excluding coverage of storm surge and wind, public insurers and the general public are left covering the risk (Linden 2014). Both retirement location and investment decisions are affected.

Climate Change is expected to be a slow but long-term change. Perhaps kurtosis will not rear its ugly head. Perhaps the associated effects will slowly be built into security and real estate pricing with no sudden market changes. Perhaps the expected slowness of environmental change will mean little impact over the next 20-30 years. Perhaps.

Conclusions

Climate Change poses a real threat to the retirement planning community. Historic assumptions regarding reasonable withdrawal rates and investment allocations may need to change. The problem is that the pace of Climate Change and its economic implications are difficult to accurately predict. Yet, with Climate Change effects already evident, it would be myopic to ignore the threat. The retirement planning profession needs to stay informed, educate their clients, and study key issues of market effects on returns, variability of returns, inflation, longevity, and portfolio design. While most Climate Change effects are likely to be slow to materialize, societal reaction to climate change may cause regulatory action which accelerates effects on asset values.

Practical Applications for Practitioners

- Stay Informed - Educate yourself on Climate Change risks and trends.
- Educate Clients – Ensure that your clients, especially younger clients, are informed of Climate Change risks. Urge clients to consider Climate Change risk in both real and financial asset holdings.
- Scan Portfolios for 'Stranded Asset' risk - Be careful of portfolios heavily weighted towards fossil fuel and related infrastructure. 'Stranded Asset' risk is a 'Deep Risk' and has elements of environmental and political risk, both of which deserve consideration.

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