Spring 5-1-2021

Climate Change Preparedness in the Insurance Sector

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Spring 2021

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Honors Scholar Thesis

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MATH 3796W

28 April 2021

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I. Introduction

It is rare to see an issue which has a truly global impact and will change the course of human history. Climate change will be such an event, and it will become increasingly severe in the near future. Assuming humanity is able to adapt and survive on a changing planet, the repercussions of climate change will be felt in daily life. Rising sea levels and a higher frequency of more severe weather events will inflict trillions of dollars worth of damage. Aside from the obvious human toll, there will certainly be impacts on the economy and business. A particular sector which will be forced to adapt is the property and casualty insurance industry. Insurer solvency could be an issue as traditional modeling methods using historical data will be less effective for predicting catastrophes in a climate changed world. Due to such issues, it will be necessary to adapt to this changing environment in order to maintain the viability of the insurance business. A successful response to climate change will require a combination of factors, including, but not limited to, cooperation with the government, promoting insurance friendly lifestyles for customers, and alternative modeling methods. However, it will be too late if plans are not preemptively set in motion.

II. Background

Natural disaster related losses are already beginning to increase in recent years compared to historical averages. Since historical data is an important ingredient in the insurance modeling

process, there is a great deal of unpredictability regarding these losses. In addition, the risk is going to vary by country because climate change effects will be quite dependent on geographical location. The insurance market is dominated by the United States of America, followed by other developed countries. One nation which has clearly taken notice and given some thought to this issue is Canada. The National Roundtable on the Economy and the Environment provided projections for climate costs in various scenarios. According to the report, costs should be expected, "under a low climate change-slow growth scenario, to grow from $5 billion a year in 2020 to somewhere between $21 billion to $43 billion a year by 2050. Alternatively, under a high climate change-rapid growth scenario, climate costs could increase to somewhere between $43 billion to $91 billion annually by 2050" (Dwyer 64). These estimates provide a wide range of values, showing the uncertainty in estimating climate costs. Current and future emissions will have a significant impact, as seen below.

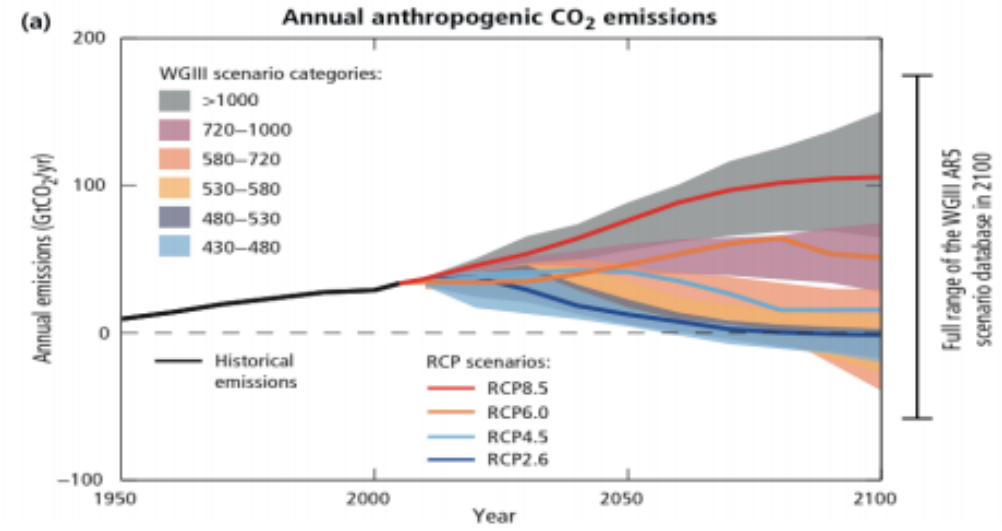

Figure 1: Potential emissions scenarios, which are directly correlated to the effects of climate change (Dwyer 62).

The uncertainty in future emissions is the main reason for the wide range of estimates for future climate costs. However, the lower end of these ranges still predict a massive increase compared

to current losses. As a result, insurers will need to find innovative ways of dealing with rising costs in any emissions scenario. In the future, they can adjust their strategies as the effects of climate change become more certain.

Analysis of recent insurer responses to catastrophic events is a useful consideration for determining what will work for the future. Historically, Florida has been a state which has faced far more catastrophic hurricanes than any other. This susceptibility has forced insurers to rethink their approach to Florida in recent years. The wake up call leading to this change was Hurricane Andrew, which caused the largest amount of damage in history at the time it occurred. This disaster made it clear that insurers were seriously underestimating catastrophe exposure, which is certainly a concern for climate change related catastrophes in the future. One response which was widely used among insurers is a hurricane deductible, which "moved the cost burden more to customers and less to the insurance company. The downside for the consumer, he said, is that many people may not have enough damage to their home to meet their deductible and can get stuck paying out of pocket for repairs" (O'Connor). So while this method is successful for reducing exposure for the insurer and keeping premiums reasonable, it can result in less people benefiting from their insurance. In current times, the higher deductible works well in that it protects from the most severe storms, which is beneficial for the insured. However, climate change will cause these storms to become commonplace, which will force deductibles to rise and the coverage will only really kick in for the most destructive storms imaginable. Herein lies the problem, as customers are forced to assume a larger dollar amount of the risk, making it less useful since many will not be able to deal with such losses on their own.

Loss mitigation could be a very effective method for keeping premiums reasonable in a climate changed world. Insurers already utilize incentives such as safe driving discounts, since

both parties benefit from safe behavior. The lower risk corresponds to a lower premium for the insured and a decrease in expected losses for the insurer. The variety of dangers posed by climate change will force insurers to find specialized methods for mitigating losses. For example, floods and wildfires cause different damage, so they will require preventative measures specific to the threat at hand. A potential idea for mitigation of wildfire losses is giving "homeowners insurance customers access to wildfire-defense services to help them with prevention and mitigation measures. Services include relocating valuables and deploying certified fire professionals to homes if a wildfire is approaching" (Grimaldi et al.). Relocation of valuables will likely be a constant in any loss mitigation measures, because it is less expensive than replacement, and it is effective for any type of natural disaster. Insurers can build these services into policies or simply offer incentives to customers who employ safe practices, although this may be less effective at achieving the goal of loss mitigation.

However, incentives only function as intended if policyholders are honest about their activities, rather than lying to get cheaper premiums. As a result, insurers must consider the cost of verifying that customers are truly engaging in safe practice. This is an industry wide concern, not a concept unique to the issue of climate change. The idea of people behaving less cautiously when they are protected from the consequences is known as moral hazard. Common methods for reducing this effect include coinsurance and deductibles, since it exposes the policyholder to some of the losses. While these traditional methods are useful, they may be less effective in a climate changed world, since they do not explicitly mitigate losses. As a result, in a climate change context, "the problem of moral hazard, which consists in prevention incentives being reduced on the part of the policy holder through the existence of an insurance, is minimised through the regulation and observation of prevention" (Porrini et al. 11). People tend to be overly

optimistic and will not sufficiently prepare for a catastrophe on their own, so it will be important for insurers to take a more proactive approach. If the cost of ensuring prevention is too great to justify premium incentives, insurers could explicitly require certain measures in dangerous areas by including them in the policy language. Either way, mitigation should be the top priority for insurers, since the cost will be well worth it.

III. Legal Solutions

Insurers can carefully control the terms of their policies, because they have all of the power in setting the terms of the contract. This is known as a contract of adhesion, since the customer has no ability to bargain for more favorable terms. As touched on previously, this can be a useful tool for reducing climate change costs by inexpensively enforcing loss mitigation measures. Insurers can offer lower premiums for policies that require certain prevention efforts on the part of the policyholder. If it is discovered that these terms were breached, then insurance companies will have legal grounds to avoid paying for losses in those scenarios. While unrelated to climate change, COVID-19 has sparked some interesting debate over policy language. In essence, insurers have been denying business interruption claims resulting from the pandemic, some of which have been taken to court. Up to this point, “in the 229 cases where courts have ruled, insurers have succeeded in having about 80% of the cases dismissed, with the majority of the dismissals coming on policies that had virus exclusions. There have also been a few victories for insureds where the policies lacked virus exclusions” (Simpson). Clearly, insurers have been successful in their defense, since courts will enforce unambiguous policy language, such as virus exclusions. This is promising for insurers, because carefully written insurance contracts with the goal of minimizing climate change costs should hold up in court.

If successful, climate litigation would be a useful tool for insurers to avoid some of the costs of climate related damages. Due to the indirect nature of the issue, there would certainly be difficulties in proving that carbon polluters are responsible for specific incidents. For example, in 2008, the Village of Kivalina faced hundreds of millions of dollars in relocation costs when their coastline was eroded by melting sea ice. They attempted litigation against ExxonMobil in order to recover these costs in court. Unfortunately, "Kivalina's claim was unsuccessful for a number of reasons, but most importantly it failed because the District Court held that Kivalina lacked standing, since there was 'no realistic possibility of tracing any particular alleged effect of global warming to any particular emissions by any specific person, entity, [or] group at any particular point in time'" (Dwyer 72-73). This decision does not bode well for any future possibilities of climate litigation. Proving causation is a significant impediment, since it is impossible to say that certain carbon emissions caused a specific catastrophe. Climate change is a large scale issue, with the individual natural disasters being its manifestation. As a result, climate litigation is not a particularly promising legal avenue in the future. Insurers should look to more viable options for managing the costs of climate change.

Climate legislation is another option for mandating carbon polluters to pay for climate change related damages. Continuing with Canada as an example, tobacco legislation should be a useful precedent, since these issues have many similarities. Tobacco companies misled the public about the health effects of smoking, and carbon polluters deceived the public regarding the environmental impact of greenhouse gas emissions. The concern with climate litigation is "that insurers and carbon polluters will simply frustrate the process of climate litigation in a manner similar to how tobacco companies successfully defended litigation for decades" (Dwyer 78). It was tobacco legislation that finally broke through and allowed the government to recoup the

healthcare costs of tobacco related disease. Due to the similarity of these issues, the government could use similar arguments for recovering costs due to climate change related damages. For example, tobacco use increases the likelihood of certain diseases, and greenhouse gas emissions increases the frequency and severity of natural disasters. Tobacco legislation "solved many of the issues relating to causation and the apportionment of damages, which are two of the biggest hurdles in the climate context" (Dwyer 80-81). Apportionment is a complex problem, since the government will need to decide how far in the past is appropriate for considering the emissions of each carbon polluter. In addition, it is difficult to estimate the damages, since they will be incurred in the future. There are many hurdles to overcome, but climate legislation is likely the most promising legal option.

If climate legislation becomes a reality in the future, then the government will need to determine the most efficient way of allocating the collected damages. One option would be to funnel it through disaster relief programs. However, repeated catastrophes in vulnerable areas will result in wasting of funds. In fact, "studies show that adaptation and mitigation spending will save more money in the long run and lead to more efficient results. These additional funds could be used to improve flood plain mapping, help build above code, or improve deficient infrastructure" (Dwyer 84). An international focus on minimizing damages would be excellent for insurance companies, since it would protect them against catastrophic losses. If mitigation measures are successfully implemented, then disaster relief can act as a useful complement for insurance coverage, rather than wasting funds. For example, if a claimant receives a payment from the government after incurring a loss, this would effectively serve as a deductible for their insurance from the perspective of the insurer. Premiums can remain reasonable as insurers can offer high deductible policies, while still providing useful coverage for the insured. This is one

example showing that “the interplay between disaster relief funding and private insurance provides the potential for a number of creative solutions to maintain comprehensive coverage despite increasingly unpredictable risk” (Dwyer 87). Of course, it is somewhat idealistic to expect such a strong program to come to fruition. In addition, it may be decades before it takes full effect due to legal hurdles. Insurers will need to find alternative methods in order to be prepared for a climate change scenario with little governmental assistance.

Due to the difficulties associated with recouping losses, another beneficial approach would be to enact preventative legislation to curb climate change. This is by far the simplest solution, since many governments are already committed to reductions in greenhouse gas emissions. As discussed previously, most of the variability in climate change losses is due to different potential emissions scenarios. As a result, maintaining a legal commitment to low emissions scenarios would have a massive impact on the insurance industry in the future and ensure its viability. Insurers would be well served to call for government action and stir up public support for preventative climate legislation. Once enacted, “legislation can embed climate change planning within the administrative structure of a State, ‘locking in’ a policy direction by tying policy goals into a rule of law framework for governance. This is distinct from government policies that can be more vulnerable to marginalization or revocation” (Scotford et al. 72). In other words, legislation is more permanent in that it is difficult to undo when administrations change, so enacting climate law as soon as possible would be a major success. Of course, this is easier said than done, since climate change has been made into a political issue. In addition, carbon polluters will continue to lobby for favorable legislation in order to maximize their profits. Insurers must take the opposite stance in order to protect their own interests, which are nicely aligned with the good of the public as well.

IV. Flood Insurance

Almost all flood insurance is written under the National Flood Insurance Program, which is run by the Federal Emergency Management Agency, abbreviated as FEMA. Historically, the program has operated at a significant loss due to premiums not being commensurate with flood risk. This business model essentially made the program a subsidy in order to keep premiums reasonable for risky properties. Since insurance companies need to turn a profit, most left the flood insurance business after it became clear that the risk was too great. Being a government controlled program, the NFIP has more legal tools at its disposal, since it can require flood insurance in particularly risky areas, such as floodplains. In addition, "because the federal government has no control over land-use planning or building codes, which are set by state and local governments, the flood insurance program is one of its most powerful tools to influence how and where Americans build homes" (Flavelle). If premiums are set at appropriate levels and flood insurance is required in dangerous areas, then the high cost of living should be a strong deterrent to residential development in floodplains. The main concern with this approach is that rate increases could cause financial harm to existing homeowners. Increased premiums will put a strain on household income, and home values would decline since there will be very few buyers interested in such properties.

In order to avoid this system being counterproductive, it is important to find a way to resolve the economic situation for existing homeowners in floodplains. A home is by far the most valuable asset owned by the average person, and crashing home values would leave many families in financial ruin. A promising option is "a 'discounts for buyouts' program that would offer qualifying homeowners a guarantee of a future buyout as a benefit of their flood insurance coverage, in exchange for a discounted insurance rate" (Adler et al. 10322). The goal of this

program is to expedite the process of a buyout in order to avoid spending on repairs. A flood causing significant enough damage to a home will initiate a buyout of the property, which is subsequently demolished. The homeowners will receive assistance in moving to a safer location on higher ground. In order to protect the value of the home, a purchase price is agreed upon beforehand "through a three-way agreement between the homeowner, FEMA, and the local community or state that would establish a minimum purchase price" (Adler et al. 10323). Of course, discounted premiums will not be sufficient to cover home values, so this option depends upon the amount of funding available. Those who authorize funding must realize that, in the long run, such a program would be mutually beneficial. The NFIP avoids repeatedly paying claims for damage to risky homes, and homeowners are able to maintain their financial health while being relocated out of harm's way.

In order to concentrate the benefit of the discounts for buyouts program on families in need, it would make sense to have requirements for eligibility. The goal of such a program would be to assist low to middle class families with eventual relocation to a safer area, since wealthier families have the ability to pay higher flood insurance premiums or choose to relocate without the need for assistance. Factors such as home value and income provide a good view of the financial strength of the owner. Using such criteria, "NRDC estimated that the NFIP could help 0.51 to 1.59 million eligible families move out of areas vulnerable to sea-level rise. NRDC estimates indicate that acquiring all of these properties would cost from $52 billion to $163 billion between now and the end of the century" (Adler et al.10324). These values contain a good deal of uncertainty, but clearly show the staggering cost of buyouts. However, "purchasing this many properties would actually represent significant savings over the existing approach of 'flood, rebuild, repeat'. NRDC estimates damages to the same pool of properties would be

between $72 billion and $224 billion" (Adler et al.10324). It is important to note that these estimates are as of the end of the century, and damages will continue to occur beyond that point as well. On the other hand, the cost of purchasing these properties is a one time expense. Of course, the NFIP cannot force homeowners to agree to a buyout, but the financial considerations should serve as a strong motivation for families facing flood risk.

In order for the program to be as successful as possible, it is important to raise awareness of flood risk. Homeowners are more likely to be interested in a discounts for buyouts program if they understand its long term benefits. An accurate estimate of flood risk would encourage homeowners to invest in loss mitigation measures, since they could clearly see the money this would save. In addition, this information would deter new buyers from purchasing homes in flood prone regions, which encourages long term migration out of floodplains. The NFIP would find it less expensive to invest in raising awareness rather than continuing to repeatedly rebuild damaged homes. For example, "a 'public right-to-know' provision could direct FEMA to create a public, open-data system to share information related to a community's or region's flood risk, such as current and historical policy information, the total number of multiple-loss properties in a community, and whether a community was in compliance with the NFIP" (Adler et al. 10328). If state and federal governments were to require sellers to disclose past flood related costs and other relevant information, this would ensure buyers are fully aware of the risk. Currently, flood disclosure laws are inconsistent between states, so the federal government could intervene to mandate more useful laws across the board. Only a small portion of states already have sufficient disclosure laws, as shown below.

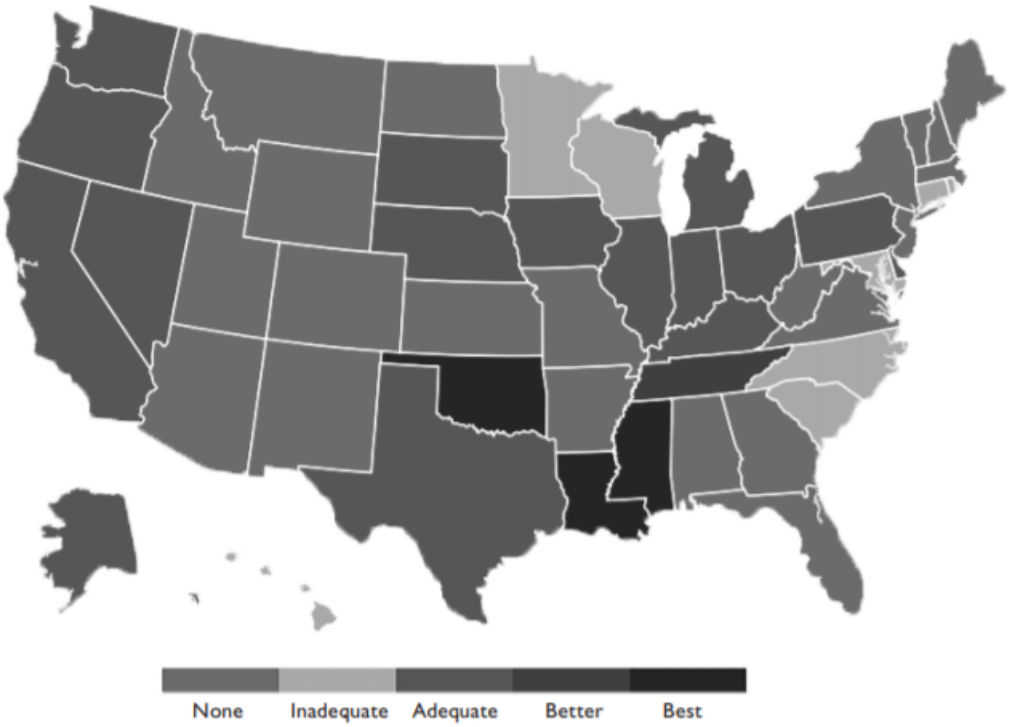

Figure 2: The five categories are based on the quality of state flood disclosure laws as of June 2018. Relevant factors include disclosure of flood insurance requirements, past flood damages, and whether the property is in a designated floodplain (Adler et al. 10330).

There remains a lot to be desired for flood disclosure laws in most states. If potential buyers had access to this information, it would promote long term migration out of flood prone areas. A discounts for buyouts program would not succeed if new homeowners continue to purchase these properties, as this would necessitate more future buyouts. It will take significant time and money to move people out of floodplains, so it is important to avoid steps in the wrong direction. FEMA and the NFIP can take charge of this matter to some degree, but government cooperation would optimize the process.

V. Catastrophe and Climate Modeling

Catastrophe modeling has been a useful tool in recent years to give insurers a better idea of their exposure to tail events. A main issue with reconciling catastrophe models and climate models is the difference in timescale. In essence, “catastrophe risk models typically provide a

sophisticated understanding of potential insured loss over the next 12 months, while climate risk models can project economic losses decades into the future" (Stärtzel et al.). Another relevant consideration is that historical data is often used for modeling losses of future events. However, this assumes that the past is indicative of the future, which will not be the case in a climate changed world. In addition, the future climate is heavily dependent upon future greenhouse gas emissions, so there is a great deal of uncertainty regarding the severity of climate change. As such, more forward thinking methods will be necessary to create useful models. A potential solution to these concerns is "dynamical modelling, using the current climatic status to initialise predictions. This will enable more accurate short-term and seasonal forecasting, but will require far more computational power" (Dlugolecki et al 18). For example, catastrophe models for flooding can use current sea levels, rather than looking at historical data. In general, catastrophe models will need to incorporate climate data and projections in order to produce accurate forecasts of insurer risk in the future.

Another issue with modeling future risk for insurers is the interconnected nature of the global economy and climate change. Most developed countries are currently equipped to deal with the occasional natural disaster, but an increasing rate of severe catastrophes is likely to put a strain on the economy. In addition, "financial markets can rapidly reprice assets that are exposed to climate risk, affecting insurers' investment portfolios and their own market valuations negatively" (Grimaldi et al.). It is imperative for insurers to understand the economic effects of climate risk, since they rely on investment income for profit. Therefore, insurers should consider a twofold approach to modeling climate risk, by combining "detailed climate data, down to the risk of a flood or fire for a single address, with an analysis of the macroeconomic implications of climate change to inform pricing and portfolio adjustments" (Grimaldi et al.). It will take time

for insurers to set long term business plans in motion, so it is of utmost importance to recognize the issue as early as possible. Climate modeling will be an invaluable tool for making accurate predictions in the face of the uncertainty of climate change.

A leading example in the insurance sector of using data to monitor climate change is the Actuaries Climate Index, abbreviated as the ACI. According to the ACI website, the calculation involves six components, each of which must be standardized prior to being combined for the index. These components, referred to as standardized anomalies, are high temperature, low temperature, heavy rainfall, drought, high wind, and sea level. Of course, there are other climate change concerns which are not captured by this calculation. For example, "the ACI is calculated for three-month meteorological seasons (and by month) for 12 large land regions in the United States and Canada. At this temporal and geographical scale, tropical cyclones are relatively brief occurrences that occur rarely in most of these regions and not at all in some" (Collins 3). Insurers are familiar with the devastation caused by hurricanes, so it would be useful to have a method for tracking tropical cyclone data. Fortunately, a convenient feature of the ACI methodology is its applicability to other climate data and regions. One can create a standardized anomaly for a new variable using the methodology of the index. Continuing with hurricanes as an example, there is less historical data available due to the necessity of satellite data in monitoring the severity of tropical cyclones. A useful variable to track, given the available data, would be accumulated cyclone energy, known as ACE. Individual storms can be summed to measure global cyclone energy over a time period, thus providing a reliable estimate of storm severity. Using the ACI methodology, the standard anomaly for ACE is shown below.

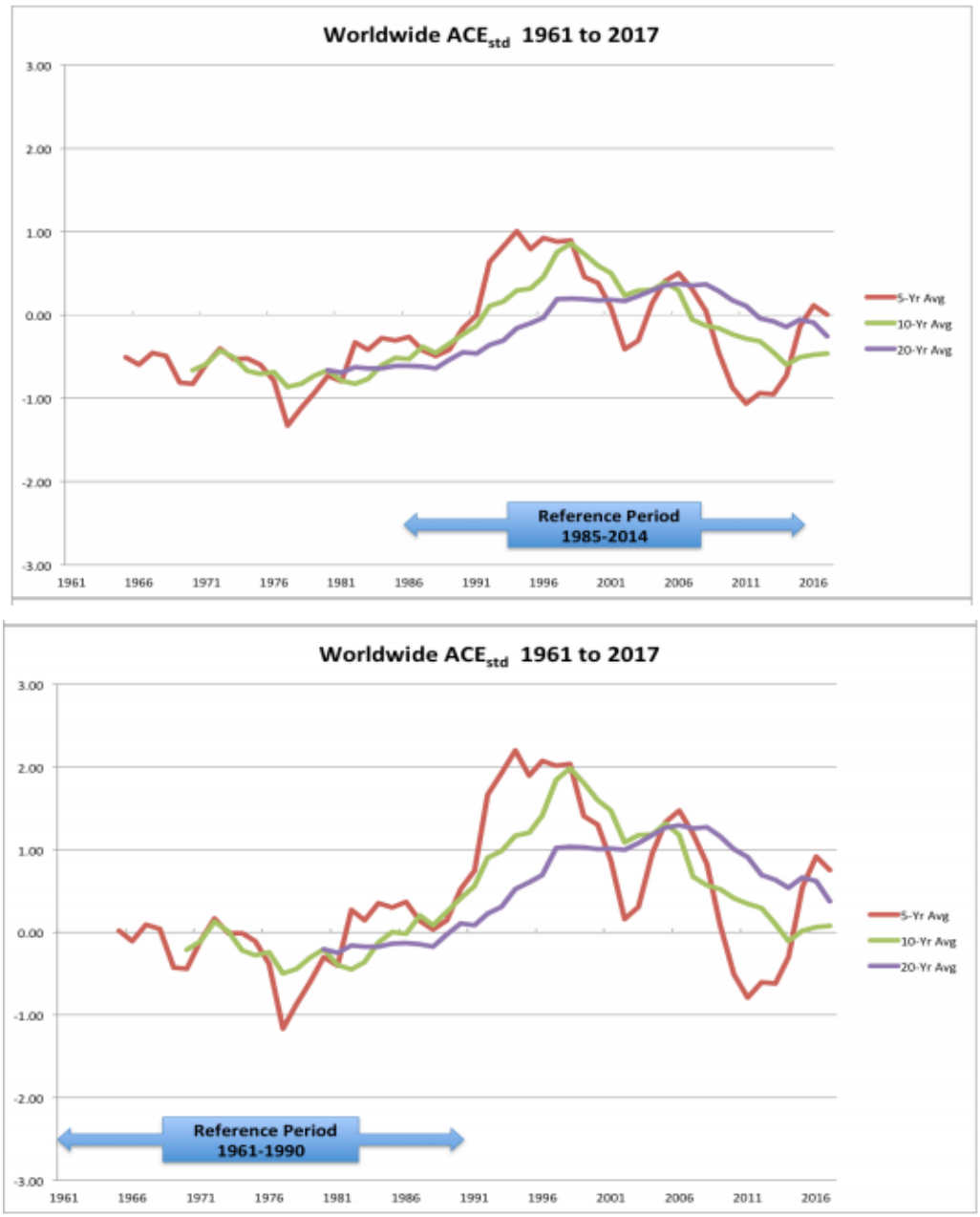

Figure 3: The trend of the ACE standard anomaly with different reference periods

It is worth noting that results produced under this methodology are highly dependent on the reference period. According to these results, the standardized anomaly for ACE gives no conclusive trend for cyclone energy in recent years. However, it is still worth monitoring in the future as more data becomes available. By comparison, "the warm temperature component of the Actuaries Climate Index, and global temperature studies, have shown rapidly increasing

anomalies since the late 1970s. Evidence that these warmer temperatures, along with warmer oceans, have increased the frequency and intensity of tropical cyclones remains to be seen" (Collins 12). In essence, the ACI is a useful monitoring tool which can advise insurers on the greatest dangers of climate change, and the methodology has great potential for application to other climate concerns.

The applicability of the ACI makes it useful in a variety of scenarios, beyond simply considering the potential climate related losses for insurers. Arguably, the impact on financial markets is more relevant since insurers rely on investment income for profit. Currently, studies indicate "that institutional investors are less aware of climate change risk and the market is not adequately pricing the risk. As a result, investors could reduce ex-post risks through divestment in some fossil fuel stocks" (Jiang 3). Insurers must carefully consider their investment portfolios to identify their exposure to climate risk. In addition, it may be possible to earn extra profit if the market is inefficient, meaning it is incorrectly pricing climate risk. As previously mentioned, the ACI provides insight for a dozen regions in the United States and Canada. In order to see if the ACI has predictive value, it makes sense to consider companies in these regions with great exposure to climate risk, such as in the agricultural industry. Through the use of regression models, it becomes clear that "as a type of production climate risk, ACI trends have an adverse impact on agricultural production in Canada and the United States. This verifies the credibility of ACI trends reflecting climate change risk" (Jiang 55). This implies that the ACI can predict the profitability of agricultural companies, since profit is reliant on production. In addition, stock prices generally depend upon the profitability of a company. As such, the ACI becomes useful for investment strategies looking to exploit the inefficiencies of the market arising from climate

risk. This example displays the versatility of the ACI, and indicates its potential for driving insurer strategy, rather than being a simple monitoring tool.

VI. Crop Insurance

Most crop insurance is written by the federal government under the Federal Crop Insurance Program, abbreviated as the FCIP. Farmers are provided with subsidized insurance, meaning the program is a cost for the government. As discussed previously, the agricultural sector is particularly vulnerable to the effects of climate change. Adaptation measures are especially important for farmers since food production is at stake. In addition, preventative action will be important for controlling the cost of the program in the future. As of today, some of the "existing strategies available to farmers to respond to long-term changes in climatic conditions include changing crops, the adoption of soil conservation and water harvesting technologies" (Di Falco et al. 486). Some of the proposed solutions for the NFIP could be applicable to the FCIP as well. For example, relocation efforts could save money in the long run if climate change affects which lands are suitable for agriculture. Of course, there are several key differences between the goals of these two programs. The NFIP is interested in assisting families facing flood risk, which requires more attention to public policy. In addition, the program is not meant to be a subsidy for people who want to live in floodplains. On the other hand, the FCIP has historically been a subsidized program, and must maintain this costly strategy because it is necessary for supporting the agricultural business. As such, it will require unique solutions due to these differing goals.

Crop diversification can be a useful tool for farmers to mitigate losses in adverse scenarios. If the harvest for a particular crop is ruined, at least there may be other crops to provide some income for farmers and reduce the cost for the FCIP, so it would be mutually

beneficial. However, it appears that “restricted access to insurance markets may drive much of the observed crop diversification in the field as a means to manage risk. A quite different situation appears when we consider agricultural systems in most developed countries where insurance products are available. In this setting, very highly specialised agriculture is often observed with much less crop diversity” (Di Falco et al. 499). Due to this effect, crop insurance has an adverse impact on mitigation efforts, which is problematic for the insurer. One study estimates a 3.5 percent and 22 percent increase in costs under moderate and higher emissions scenarios, respectively. However, “if the study did not include adaptation in its models, the estimates of cost increases would jump to 10 percent and 37 percent, under the moderate and severe greenhouse gas concentration scenarios, respectively” (Crane-Droesch et al.). Adaptation efforts will be a necessity for controlling the cost of the FCIP. Since it is a subsidized program, premium incentives may be less effective for encouraging mitigation. Instead, the FCIP could choose to only offer coverage to farmers meeting certain requirements.

Another concern with crop insurance is the expected decline in crop yield due to climate change, namely due to increasing temperatures. There is a great deal of uncertainty in expected yields due to the variability in emissions scenarios. As such, it may be difficult to predict which regions will be best for agriculture in the future. Some of the most widely planted crops, such as corn and soybeans, are particularly sensitive to extreme heat. As a result, “on average, climate models project declining average corn and soybean yields, while changes to winter wheat are modest and variable” (Crane-Droesch et al. 9). Anticipated changes in these expected yields are shown below in different scenarios.

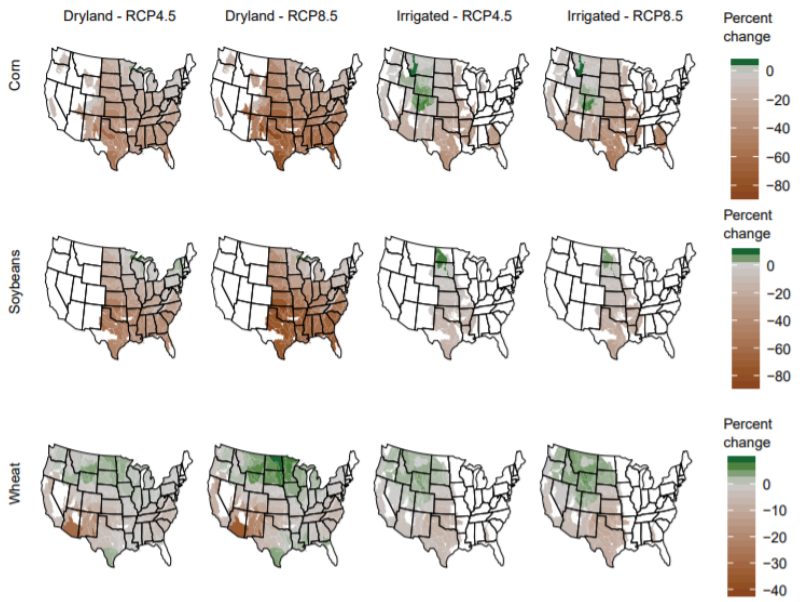

Figure 4: Yield projections are based on averaged climate model simulations of the time period 2060-2099. RCP4.5 and RCP8.5 refer to lower and higher emissions scenarios for climate change, respectively (Crane-Droesch et al. 10)

Irrigation offers a noticeable improvement in expected yield for all scenarios, making it a useful adaptation for farmers to consider. However, there are still widespread decreases in expected yield in these optimistic scenarios, and FCIP policies usually pay a portion of market price to compensate farmers for lost crops. Due to supply and demand, "because average prices are driven by average production, the most pessimistic climate models in terms of yield show the largest increases in price. This implies larger liabilities to be insured, which is a major driver of increases in the cost of the FCIP Revenue Protection program" (Crane-Droesch et al. 15). In response, premiums will rise to control the cost of the program. Decreased yields and higher premiums should help to financially encourage farmers to relocate. Alternatively, the above figure suggests irrigation as a promising option that would avoid relocation. Such adaptations would help maintain the viability of the FCIP in worst case scenarios.

The effect of climate change on crop insurance is a widespread concern, since it is relevant in every part of the country. On the other hand, only specific regions are susceptible to

natural disasters such as floods and wildfires. For example, one of the main threats to agriculture is rising temperatures. In theory, climate change will make some regions worse and others better for farming purposes. However, relocation efforts may not be as effective as discussed with flood insurance, since these temperature fluctuations may be unpredictable. In addition, moving a family is a much simpler endeavor than relocating an entire farm. Therefore, adaptation will be the key to controlling crop insurance costs. Drought resilience will be important for maintaining crop production in the future. Irrigation solves the problem of a lack of rain, but would require vast amounts of water, which may be difficult or expensive to obtain. A more feasible option would be to utilize organic matter in soil, which researchers have argued "can retain more water under vapor pressure deficit, protecting crops from losses induced by extreme heat and drought better than low organic matter soils" (Kane et al. 1-2). The FCIP can promote such an adaptation by requiring or incentivizing farmers to use such soil if they wish to buy crop insurance. The relationship between soil organic matter and loss cost is shown below.

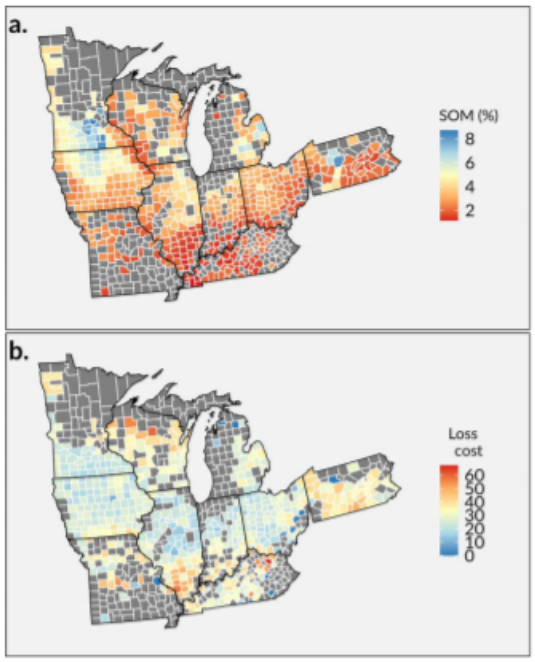

Figure 5: Higher levels of soil organic matter are associated with lower loss cost under drought conditions (Kane et al. 6)

Drought resilience measures increase expected crop yield, which decreases the expected losses of policies. As a result, "soil organic matter is associated with reduced loss cost under drought conditions and that the marginal effect of soil organic matter increases as drought severity increases" (Kane et al. 6). The fact that its benefits are strongest in the most severe droughts make it a much more favorable option than irrigation in the face of climate change. The FCIP would find it mutually beneficial to share this information with farmers, since higher levels of soil organic matter have been shown to reduce crop insurance payouts.

VII. Conclusion

Adaptation and relocation are the two constants between the discussed insurer responses to the increased threat of natural disasters due to climate change. The more favorable option is dependent upon the nature of the costs associated with the disaster. In the past, funds have been wasted on repeatedly rebuilding in flood prone areas, leading to the conclusion that long term relocation should be the goal of the NFIP. On the other hand, farmers with crop insurance should focus on adaptation since there is no permanent safe zone for relocation. Extreme temperature and drought are widespread issues, and the regions most susceptible to these threats can change over time as climate change progresses. Both of these examples require forward thinking in order to be properly executed, which places an ever greater importance on catastrophe and climate modeling. Economic effects should be considered in modeling approaches, since climate change will affect the market as well. For example, crop insurance could get more expensive as lower yields drive up the market price of crops. The ACI has been shown to be a useful monitoring tool for climate change, and has predictive capabilities as well. The success of the ACI reinforces the idea that climate modeling should be an integral part of insurance modeling in the future. While there are some potential legal avenues that could result in lower costs for insurers, the main focus

should be on informing and incentivizing policyholders to behave optimally in response to the threats of climate change. This will require careful planning by insurers and be most successful if set in motion as soon as possible. Climate change will perhaps be the greatest challenge to date for the insurance sector, and the most prepared companies have the potential to continue thriving in an uncertain future.

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