

Actuaries and Climate Change: Insights from Economic Theory

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As with any large complex system involving multifaceted parameters and processes, our planet's climatological system is a network of interconnections and interrelationships. Actuarial science, perhaps the ultimate interdisciplinary field, is well-positioned to add value to the study of climate change and its potential socioeconomic impact. The actuary's quantitative and analytical skills, along with an understanding of economic and financial processes, provide a basis for better measuring and evaluating the risks posed by global warming. In addition, with the emergence of enterprise risk management over the last twenty years, actuaries have become accustomed to analyzing the risk inherent in complicated organizations and systems on a holistic basis, something that is critical to an appreciation of the implications from climate change.

In this essay, three possible avenues for future actuarial innovation and research are suggested, each based on economic and financial theory. First, the implications for evaluating organizational decisions within an option pricing framework are described. Second, behavioral incentives and tax policy are considered. Finally, the value of climate change indices within market-based systems is discussed.

THE OPTION FRAMEWORK

Consider a stock insurance company. The stockholders that own the company have a right to the "residual value" of the company – i.e., due to limited liability, the stockholders essentially own a call option on the assets of the company, with an exercise price equal to the liabilities of the company. To the extent that the company's assets exceed its liabilities, that excess amount – or the payoff of the call option – represents the value to the stockholders. That call option, as can be shown via put-call parity, can also be characterized as a put option, which the owners hold, giving them the right to "put," or sell, the company to the debtholders (bondholders, etc.) of the company in the event its liabilities exceed its assets. This "default option" becomes more valuable when, among other factors, the volatility of the company's operational results increases. In particular, and with respect to climate change, assume that the company is permitted to take advantage of the opportunity, presented by the societal recognition of the potential adverse impact of climate change

on insurers, to increase its policy premiums. The impact on the owners of the company would be non-symmetric: the low-loss scenarios are welcome, and result in profitability; however, in scenarios involving large climate-generated losses, the owners have a stop-loss provision, since they can “put,” or default-away, the company. Thus, in this situation, the insurer’s owners might not mind, and would perhaps even welcome, the additional volatility associated with climate change.

Of course, in the real world, the company’s ability to increase premiums might very well be limited by regulators. In this event, the company will be motivated to provide policyholders with incentives to act in a manner that addresses, and hopefully minimizes or even diminishes, their contributions to overall climate risk, and thus loss. This could take on many forms, including provisions in policies with premium-reduction opportunities, direct risk mitigation services from the insurer, etc.¹

The actuary’s contribution in this area is essential: to identify and model losses (as well as company value and the value of the default option) under various future scenarios – scenarios which vary according to assumed type and level of climate activity, and according to the proposed risk mitigation strategies that might be undertaken by companies and / or the insurance industry.

INCENTIVES AND TAXES

Closely related to the incentive issues described above are Pigovian taxes and negative externalities. The economist Richard S.J. Tol (2009) has commented, “Climate change is the mother of all externalities: larger, more complex, and more uncertain than any other environmental problem.”

An economic negative externality occurs when an activity or transaction is undertaken that is favorable to the primary party or parties, but that produces costs to one or more third parties – e.g., to society. Thus, part of the total cost of a decision or transaction is borne not by the primary party or parties, but rather by an outside party. Frequently, such externalities are found in proximate geographic relationships, but depending upon the size and complexity of the externality, the impact can be felt by third parties which are significantly physically distant from the original activity or transaction (think: climate change / global warming). The end result is that, where there is a negative externality, costs will be imposed upon consumers and society typically in the form of higher prices and / or higher taxes.

Possible solutions to this situation can be either interventionist, or market-based. An interventionist solution is to provide an incentive to not undertake the externality-producing activity,

for example via an appropriately-defined tax that would be assessed against the firm undertaking the activity. The size of such a “Pigovian tax” (named after economist Arthur Pigou, 1920) might be determined by estimating the marginal cost of the loss to society from the activity. In this way, the tax can be set to provide a disincentive, and encourage behavior that is in the public interest.

Another possible interventionist approach toward a negative externality like climate change is through direct regulation and control. Similar to the Pigovian tax, this involves estimating the societal cost associated with various activities.

Insofar as actuaries are skilled in the economic and financial modeling of risks, they are well-positioned to contribute significantly to the discussion of whether, and to what magnitude, to implement such interventionist mitigation strategies.

INDICES AND MARKET-BASED STRATEGIES

Yet another approach to dealing with an externality is via a market-based strategy. With respect to climate change, probably the technique in this category that has been most frequently discussed is a carbon permit-and-trade (or cap-and-trade) systemⁱⁱ, which might allow the market to self-determine a price for a tradable permit at which the market would clear. However, a straight carbon tax is a very credible alternative to cap-and-trade. In fact, most economists, if confronted with a choice between these two methods, would probably prefer the carbon tax approach. This is because it is more direct and straightforward, and (at least conceptually) can be calculated more easily; also, it is unclear how to properly set the cap amount, or the overall “permissible level,” of carbon in a permit-and-trade system.

With a carbon tax approach, the creation of an appropriate index which measures the incidence and impact of climate change is essential. Once such an index (or, more likely, indices, as each application of an index-based system will likely have different specific needs and goals) is determined, however, its uses will be many. Two are mentioned as examples here: a carbon tax measure that would vary with a global warming index and a system of futures and / or options based upon such an index.

Economist Ross McKittrick (2007) identified an interesting possible use for an index within the context of a carbon tax. Because

“... climate models predict that, if greenhouse gases are driving climate change, there will be a unique fingerprint in the form of a strong warming trend in the tropical troposphere... this will be an early and strong signal of anthropogenic warming... only sustained greenhouse warming will (yield this pattern).”

He suggests implementing a carbon tax in each country that is a function of the mean tropical

tropospheric anomaly (the “index”), updated annually. (In McKittrick’s version, the carbon tax would be revenue-neutral, as income taxes would be reduced and offset by the amount raised by the carbon tax.) If the tropical troposphere temperature increases abnormally, the anomaly figure will rise and the tax amount will increase – as it should, as this would indicate anthropogenic carbon-based warming. If the temperature, and thus the anomaly, do not increase (or possibly decrease), the tax would remain low, or perhaps even disappear (or possibly even become negative, producing a subsidy for carbon emission, although certainly a floor limit might be enacted so that the tax would not fall below zero) – as it should, as this would indicate that human-based carbon emissions are not a cause (or at least a questionable cause) of climate change.

One could envision this general idea going further, and leading to a market for climate change futures and / or options which are based upon appropriate indices. These derivative products could either be stand-alone securities, or their prices might also be the basis for a version of a carbon tax. In any case, over the last decade or so, a large and successful market in weather derivatives has evolved; with the innovation of appropriate climate change indices, this range of products could be extended to allow for capital markets trading and hedging of global warming risks. An active derivatives market would also facilitate the writing of insurance policies in which indemnity is defined as a function of such indices; with derivatives trading on the same basis, climate change-related insurance policies and derivatives would have a common measurement foundation, and hedging opportunities and price determination would be enhanced.

Regardless of the public policy implemented, it is an extremely complex and difficult task to measure the impact of a policy provision on carbon emissions, on damages, and on other socioeconomic factors. This will be a challenging and important area for actuarial innovation and research. In addition, future strategic and operational planning for both public and private organizations would be hugely affected, in terms of their estimated economic and financial impacts, by projected future values of such indices. This would make their accurate and efficient determination critical, and would undoubtedly result in extensive analytical efforts to understand and improve the calculation of these indices. Actuaries would logically have great input, if not into the calculation of the indices themselves, certainly into the modeling and projections associated with the socioeconomic and financial implications of index values.

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The issues discussed in this essay are largely optimization problems: determining organizational strategy, or countrywide or global public policy, that might be expected to maximize benefits within certain risk-level constraints. Actuaries, with their quantitative skill set and interdisciplinary perspective, are uniquely positioned to be a key player in these deliberations, and in risk mitigation

and financial risk management efforts associated with climate change.

REFERENCES

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ⁱ Climate change has the potential to affect a company's risk profile, for example through potential increases in frequency and/or severity, relative to numerous risk exposures – e.g., raw materials procurement and other production chain factors, impacts on markets due to changes in public attitudes, etc. Both traditional and innovative risk management techniques will help to address these risks. See, for example, Baglee, et al (2012).

ⁱⁱ Of course, for the sake of this discussion, it has been assumed that climate change is anthropogenic and works through a largely carbon-based greenhouse effect.