APPLICATION OF INSURANCE MECHANISMS IN WATER RESOURCES

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Urbanization, economic development, and climate variability and change present major challenges to water resources managers, including increasing competition between users, and increasing financial, human and economic losses from extreme hydroclimatic events. Managed water resources are an essential component of growth, social and economic development, poverty reduction and equity. Although droughts and floods are the principal risks typically associated with water management, frequently taxing the limits of existing infrastructure or water policy, year to year fluctuations may also prove challenging. Managing this variability (streamflow, precipitation, etc.) is becoming increasingly difficult given the high and diversified demand on water and inflexible design of system infrastructure (Brown and Carriquiry 2007). Current climate variability and weather extremes already severely affect economic performance, with the poor often carrying the largest burden; their livelihoods are most deeply affected and they posses fewer resources to help them manage climate risks. The need for a mechanism to hedge against these risks in an effort to manage extreme events and help buffer impacts without having to implement costly (and sometimes controversial) infrastructural adjustments is rapidly gaining attention and momentum. This brief discusses the applicability of index-based and traditional insurance as risk transfer mechanisms within the field of water resources.

Financial insurance provides a means for regularizing the impact of extreme climate events. The design of insurance contracts typically requires long, high-quality datasets through which the likelihood of an extreme event, the level of vulnerability and exposure, and the losses incurred may all be reliably estimated. Such datasets rarely exist in the field of hydrology, especially in developing countries. Another shortcoming of traditional insurance is its susceptibility to moral hazard; it is not infeasible that the insured may tamper with or alter the system to attain a higher payment from the insurer. Index insurance attempts to circumvent these deficiencies by basing the insurance contract on a timely observable, easily measured, stable, and sustainable variable (Dick 2006). Rather than being based on the variable insured, as in traditional insurance, it is traditionally based on a highly correlated variable – the index. Ideally indexes are objective, transparent, independently verifiable, and reported in a timely manner (Dick 2006).

Reservoir index insurance

In Brown and Carriquiry (2007) insurance indexed on reservoir inflows is proposed as a mechanism for smoothing variable costs associated with water market provisions. Within the proposed framework, these variable costs have been mapped from the hydrologic space to the financial space through option contracts. This option contract – reservoir index insurance framework was designed for the case of two bulk water users: an urban water supplier and irrigated agriculture near Manila in the Philippines. In dry years, the urban water supplier has the option of restricting flows to the agriculturalists for monetary compensation. Without the index insurance piece of the proposed framework, the urban water supplier is left exceptionally vulnerable to highly variable year-to-year costs. The proposed index insurance consequently smoothes the variability by requiring the urban water supplier to pay a relatively stable annual premium, eliminating the risk of large unforeseen compensations. The proposed insurance is designed for total coverage of the in-season cost of water supplied through the option contract.

Alternatives include covering only a portion of the full cost at a reduced insurance premium, in which case the urban water supplier would retain a larger portion of the supply cost risk.

An alternative reservoir management insurance scheme is proposed by Skees and Leiva (2005) for a reservoir in the Rio Mayo irrigation district in Sonora, Mexico, to mitigate the adverse impact of uncertain irrigation supply. For one reservoir, a double-trigger contract is devised in which payments may be discounted under occurrences of "bonus" inflows in each Fall/Winter season. The design attempts to take advantage of the natural hedging provided by these inflows. An intermediary farmer group is suggested to coordinate premium and indemnity payments among farmers vis-à-vis the insurance company. During water scarcity periods, indemnity payments would provide the liquidity needed to spur water market transactions. Thus, in some fashion, this contract would not only mitigate the losses to the irrigation district as a whole, but would also encourage the development of water markets that lead to an efficient use of the resource.

Many reservoirs are designed as multi-purpose reservoirs, covering water supply, hydropower generation and flood control. Traditionally, reservoir storage is "allocated" to each of these uses, and rules based on a risk analysis using a relatively short record or stochastic models are used to operate the system. A combination of insurance, forecasting and adaptive operation strategies has the potential for improving the efficiency of reservoir operation for all the purposes. Such applications need to be researched at this point. The use of reservoir inflows as indices for insurance is actually problematic, especially for multiple reservoir systems, or for insuring against low flow in regions where there is likely to be significant diversion of upstream flow. In these settings, alternate indices or proxies need to be developed and tested to ensure that the conditions outlined by Dick (2006) are met.

Disaster Management

Index insurance has also been advocated as a useful risk transfer tool for disaster management situations where rapid fiscal relief is desirable and where estimating insured losses may be difficult, time consuming, or subject to manipulation and falsification. Governments and relief agencies would be likely candidates for acquiring this type of insurance. For climate-related hazards, a rainfall or temperature index may be proposed, however rainfall may be highly spatially variable relative to the gauge network, and in many locations data are inadequate to develop an index because of short time series and the spatial dispersion of stations. In such cases, it may be helpful to consider a climate proxy index as a regional rainfall index. This is particularly useful if a long record is available for the climate index through an independent source and it is well correlated with the regional rainfall hazard. Khalil et al. (2007) suggest utilizing the El Nino–Southern Oscillation (ENSO) as a proxy to extreme rainfall/regional floods in one of the districts of Peru, Piura. Crop losses in the region are highly correlated with floods but are difficult to assess directly. Basic infrastructure is destroyed during the most severe events, disrupting trade for many microenterprises.

The use of the ENSO-based index provides access to a much longer historical record to verify exceedance probabilities and payout frequency attributes. Since the index data is provided by an agency outside the country, it is not subject to manipulation by those who may seek such insurance. The index insurance product could be purchased by a microfinance authority or local state or district authority to facilitate rapid loans and relief in the event of a disaster that matches the triggered event, or be purchased directly by individual farmers.

Some issues with the implementation of the proxy ENSO index need be explored, including assessment of the reliability of the index at different levels of probability of exceedance of maximum seasonal rainfall, quantifying the effect of sampling uncertainties and the strength of the proxy's association to local outcome, and estimating the potential for clustering of payoffs. Potential adjustments for the increased volatility due to climate change or non-stationarity will be necessary, and the Khalil et al (2007) procedures for estimating and pricing the impact of these uncertainties and clustered payouts need to be further developed and demonstrated.

Compared to index insurance designed for droughts (slow onset over expansive areas), flood index insurance may pose an additional technical challenge due to the nature of flooding, namely being more acute in both space and time. For a number of reasons (e.g. data availability), developing models and indexes that strongly correlate with streamflow and/or flooding extent at specific points in the basin may prove exceptionally difficult. Alternatively, a strategy targeting models and techniques to provide an aggregate flood probability (e.g. over an entire basin) based on an index, when coupled with other complimentary tools, may prove attractive.

Pizarro (2006) suggests that a hierarchical risk management strategy for managing the impact of floods is needed. Depending on the spatial scale of the region or the entity of interest, a combination of index insurance, structural mitigation, catastrophe bonds, and other innovations may be useful. He also advocates considering a spatial correlation structure for flood insurance, regardless of whether it is of an index or traditional type, to reduce issuing and premium costs. An approach that recognizes the correlation matrix of the entire set of locations insured, and the probability distribution of losses, would be needed. Pizarro claims that if a diversified natural hazards cat bond market were to evolve, countries could set up individual insurance programs. Then, countries whose flood risks are negatively correlated (e.g., those located at the opposite ends of the tropical Pacific) could seek to be a part of a reinsurance pool that could in turn offer Cat bonds that are more attractively priced than individual Cat bonds.

Future Directions

In spite of the technical challenges highlighted above, applications of index-based and traditional insurance to water resources applications is a rapidly emerging field. This is largely due to the encouraging performance of other types of index insurance, which has led to increasing knowledge, capacity and experience. Perhaps the largest obstacle to implementation is the need for a paradigm change in decision making at high levels and amongst water managers. Concerted and creative research, in addition to pilots/demonstrations, is required to better recognize avenues for buffering against costs and losses associated with hydrologic extremes, and to gain practical experiences. This may require bundling multiple contracts (e.g. traditional insurance for flooding and index insurance on reservoir contents in single basin) or designing a framework for dealing with multi-owner scenarios (e.g. transboundary rivers with dams in series.) These innovations would work best if they were linked to clearly defined operating rules for the water systems, and the corresponding assessment of the residual climate risk, its predictability and variation over time and across the elements of the water system. A particularly promising area for such applications is the use of index insurance with a strategy for conjunctive use of surface and groundwater. Such a strategy would consider increased pumping in drought years and groundwater recharge in wet years. The index insurance or traditional insurance strategy could then mitigate the associated increase or volatility in energy costs. However, a systematic analysis of such an option is needed to assess how best the premiums could be structured considering both the correlated climate risk, and the separate jurisdictions of the users who are likely to be insured.

Likewise, research needs to be directed towards how best operation and insurance strategies can be balanced for a multi-purpose reservoir. An interesting example is that for the Folsom-Shasta reservoirs above Sacramento, CA. Sacramento has one of the highest vulnerabilities to floods in the United States, and these reservoirs and a levee system were designed to handle the estimated 500-year flood. However, there have been 7 events in the last 50 years that have approached a critical level. At the same time the reservoirs hold water to meet much of San Francisco and the Central Valley's domestic and irrigation needs. Drawing down the reservoir to mitigate flood risk, given a flood forecast, exposes the risk of subsequent water shortfalls. The opportunity to cover both risks using insurance and forecast based operation is an interesting and challenging research problem.

References

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