

CHALLENGES IN VALIDATING AND IMPLEMENTING LARGE-SCALE SIMULATION MODELS TO INFORM STRATEGIC DECISION MAKING

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ABSTRACT

Compressed decision time and complexity brought on by globalization and the new economy are swamping the orderly flow of information and authority characteristic of traditional decision making. This is exacerbated when multiple decision makers or multiple organizations are involved. Increasingly, large-scale simulation models are being used to provide a focal point for discussion, strategy formulation and on-going control in these environments. However, such models are themselves complicated and expensive to construct and validate, and there are many challenges associated with using simulation models in support of strategy and policy in different environments. This presentation considers three case studies in which I have been intimately involved over the past five years to illustrate some of these challenges and to stimulate a discussion on where future research may be useful.

1 INTRODUCTION

The three case studies I consider are the following:

1. Catastrophe modeling for natural hazards to support policy analysis related to insuring and mitigating the risks of natural hazards such as hurricanes and earthquakes (similar models are being developed to treat problems of terrorism and pandemics);

2. Energy modeling to support risk management in deregulated energy markets, with a focus on a particular case study on the valuation of energy supply portfolios involving renewable energy in these markets;

3. Postal and logistics sector modeling to support public policy related to opening of national postal markets in the EU to competition.

Note some of the differences in the above contexts. The first involves highly sophisticated actors in the private sector (insurers and reinsurers) and a number of less sophisticated national and international regulators. It is a public-private sector problem, focused on national or re-

gional integration of risk bearing and recovery policies. The second involves primarily sophisticated private sector actors, including their interfaces with financial markets. The third involves a super-regional regulator (the European Commission) and a host of public and private organizations, together with consumer groups of various stripes. What is common to these problems is the huge complexity of the interactions between the decision instruments, the large amount of data necessary to make reasonable projections on outcomes, and the size of the financial stakes involved in the strategies and policies adopted. Let me note a few of the particulars about each of these areas to underline these points.

2 CATASTROPHE MODELING

The insurance industry faces complex challenges in addressing catastrophic risks. Recent disasters such as the Indonesian Tsunami of 2004 and Hurricane Katrina in 2005 have pointed to the huge problems which natural disasters can cause. In the U.S. and Europe, these disasters have also strained private insurance markets and created troublesome problems for disaster-prone areas. The threat of mega-catastrophes resulting from intense hurricanes or earthquakes striking major population centers has dramatically altered the insurance environment. Estimates of probable maximum losses (PML) to insurers from a mega-catastrophe in the U.S. range from \$50-\$150 billion depending on the location and intensity of the event, with even more frightening numbers for several other countries presaged by losses in excess of \$100 billion in the Kobe earthquake in 1995 (only a small fraction of which were actually covered by insurance at the time). The threat that climate change may be adding to the virulence of hurricanes and typhoons is an additional cause for concern. How can insurers and reinsurers address these complex challenges?

Consider the strategies of an insurer writing business in a catastrophe-prone area. Such an insurer must consider: 1) the structure and geographic concentration of its risk portfolios; 2) contract design of its policies, including bundling of perils and cross-marketing of insurance prod-

ucts; 3) the purchase of reinsurance and use of capital market instruments to hedge catastrophe risk; and 4) the pricing of its catastrophic-risk insurance. Of special interest is how these strategies are affected by the tradeoff between the efficiencies gained from geographic concentration and the higher risk of a catastrophic loss due to concentrated exposures. The answers to these questions involve the integration of actuarial science, geological and engineering data, and financial assessment procedures. Large-scale simulation models are now recognized as the primary vehicle for integrating these strands of knowledge, and the disciplines that support these, in a manner that allows the multiple stakeholders involved in the cat risk puzzle to “reason together”. The results of this reasoning are used in both internal contractual negotiations between insurers and reinsurers (and their brokers) as well as in public debates on the regulation of insurance prices. I will discuss two key challenges in the use of cat risk simulation models: a) understanding and dealing with epistemic risk and uncertainty and b) validation for multiple stakeholders with varying levels of sophistication.

3 ENERGY MODELING FOR RISK MANAGEMENT

The U.S. and Europe have undertaken a radical restructuring of energy markets, reflecting the worldwide trend to introduce competition into these markets. The changes have been facilitated by new technologies in generation, power systems control, demand-side management and information systems. The debate on climate change and renewable energy has further fueled the entry of significant new players (in bio-fuels, in wind and solar power, and in new transportation technologies). These developments have also been propelled by new actors (brokers, financial intermediaries and risk managers) and by huge sources of new real-time accessible data on energy prices, on the weather, and on scores of other elements that affect the demand and supply of energy. I will focus here on one case study on renewable energy (wind power) in the electric power sector in Europe to illustrate the complexities of the investment and risk management problems triggered by these developments.

For energy companies and investors, the complexities are gripping. They represent critical choices about the organizational structure to be adopted, technology bets to place, new forms of risk management and trading to understand and hedge risks, and a host of other strategic options not hitherto faced and for which no blueprint exists. These matters are not just the traditional uncertainties of markets, but also involve Mother Nature and regulators. The resulting problems are being increasingly analyzed using simulation models of the markets, the rules of exchange, physical power flows, and

so forth. The case study I consider on wind power highlights two interesting challenges for large-scale simulation modeling in support of strategic investment choices for private companies in the energy arena: a) integration of real-time market data and models of financial instruments with prospective simulation analyses, and b) optimization engines for large-scale simulation models (in this case optimization across portfolios of trading and supply contracts, including wind assets, where the evaluation of each portfolio can only be accomplished by simulation).

Postal and Logistics Sector Modeling

Postal reform has taken off, and especially in Europe. The proposal for the 3rd Postal Directive, submitted to the European Parliament on October 18, 2006, has as its main ingredient the abolition of the Reserved Area/Monopoly in all Member States of the EU by January 1, 2009. Leading up to this major policy proposal a number of studies were undertaken. The primary focus of these was on whether national post offices (POs) could survive and prosper under liberalized market conditions while continuing to provide mail and parcel service to all parts of their respective countries. The answer to this question turns out to be highly country specific.

This matter was studied in detail in a study in which I participated, commissioned by the European Commission (EC) and completed in May of 2006. The study showed that some countries may find that market opening provides opportunities of which they can take advantage and, as a result, could be successful under market opening. Others, the study showed, could experience serious financial problems under FMO. The study covered 30 countries, facing a variety of historical circumstances and market conditions. The most important vehicle used in the study was a comparative analysis using a large-scale simulation model calibrated for each of the 30 countries considered (the 27 EU Members, plus 3 related European countries). The stakes were large and very different views prevailed among the multiple stakeholders involved, as between small and large customers, labor unions, POs in large countries vs. small countries, etc. The challenges revealed by this study in the use of large-scale simulation models to support major public policy choices are interesting in their own right and they may have broader applicability as well. These challenges included a) the problem of supporting a highly contentious public policy debate with a simulation model, and b) the problem of crafting a comparative analysis, using common scenarios, across 30 countries with very different demographic and market conditions.

4 SUMMARY

In summary, this talk will provide three vignettes on important applications of large-scale simulation models from the past five years. I will use these case studies to highlight some new and old challenges for the simulation community in the following three areas:

1. These vignettes all illustrate the increasingly important role that simulation modeling is playing as an integrating vehicle across multiple disciplines, data sources and stakeholders for strategic decision making in complex environments. These studies indicate continuing challenges in achieving this integration. Some of these arise from the different levels of sophistication among stakeholders. Others arise because of inherent uncertainties that must be explored by various means (from sensitivity analysis of underlying parameters to structural corroboration of key assumptions). For a sophisticated consumer of such models, the key challenge in integration is to provide a sufficiently rich set of valuation options to allow informed experimentation. For an unsophisticated consumer, the key challenge is often to provide a deeper understanding of the limitations of the model.
2. These vignettes point to the validation problem as especially salient in large-scale simulation modeling, with interesting aspects, and perhaps some new aspects, of this classic problem depending on the nature of stakeholder knowledge and their interdependencies. In particular, when the interests of different stakeholders are at odds, as is often the case in public sector policy evaluations, questions of validation and knowledge exploration are often confounded with differences in values, along the lines of “what you see is what you want to see” (or “believing is seeing”).
3. The optimization problem and its more modest variants (e.g., avoiding truly stupid outcomes) presents continuing challenges in these contexts. These involve providing theoretically justified confidence intervals for decisions and their outcomes for sophisticated decision makers (e.g., those involved in energy trading and hedging). In other contexts, such as the EU postal context, merely explaining the intricacies and limitations of current optimization programs to multiple stakeholders and regulators, often unsophisticated in their knowledge of simulation or statistics, is the key challenge.

REFERENCES

- Crew, Michael A. and Paul R. Kleindorfer (eds), *Liberalization of the Postal and Delivery Sector*, Edward Elgar, Cheltenham, UK: 2007.
- Grace, Martin F., Robert W. Klein, Paul R. Kleindorfer and Michael Murray, *Catastrophe Insurance: Supply, Demand and Regulation*, Kluwer Academic Publishers, Boston, 2003.
- Kunreuther, Howard, Paul R. Kleindorfer and Patricia Grossi, “The Impact of Risk Transfer Instruments: An Analysis of Model Cities”, in P. Grossi and H. Kunreuther (eds), *Catastrophe Modeling: A New Approach to Managing Risk*, Kluwer Academic Publishers, Boston, 2005.
- Kleindorfer, Paul R., Dongjun Wu, and Chitru S. Fernando, “Strategic Gaming Models for the Electric Power Industry”, *European Journal of Operations Research*, Vol. 130, Jan. 2001, pp. 156-168.
- Kleindorfer, Paul R. and Lide Li, “Multi-Period, VaR-Constrained Portfolio Optimization in Electric Power”, *Energy Journal*, January, 2005, 1-26.

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