A competitor's strategy unclothed:
How indirect measurement justified *not* fighting an insurance price war

Stan Corcoran
Executive Vice President
Massachusetts Interlocal Insurance Association
One Winthrop Square, 2nd Floor
Boston, MA 02110

scorcoran@mma.org

Alan K. Graham
Greenwood Strategic Advisors
Zugerstrasse 40, CH-6314 Unterägeri,
Switzerland
Tel. +1 781 862 0866, Fax +41 41 754 7448
Alan.Graham@Greenwood-AG.com;
Alan.K.Graham@alum.MIT.edu

William B. Arthur
Ventana Systems
60 Jacob Gates Road Harvard, MA 01451
bill@ventanasystems.com

David W. Peterson
Ventana Systems
60 Jacob Gates Road Harvard, MA 01451
David.Peterson@Ventana.com

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Abstract

The nonprofit Massachusetts Interlocal Insurance Association (MIIA) offers insurance to cities and towns, even when it is unavailable commercially. But earlier, a commercial agency was offering very low premium rates, which had driven all other competitors from the market. He had reached twice MIIA's market share, threatening to become the "emperor" of this market.

MIIA had lowered rates also, threatening its financial reserves. But how could the competitor offer even lower prices? What did MIIA need to do to stay in business? Traditional actuarial analyses couldn't answer these questions, but dynamic modeling might.

There was good data about MIIA, and sufficient data about the competitor, often estimated from corresponding MIIA characteristics. Competitive intelligence and indirect measurement completed parameterization, and supported robust policy recommendations.

In the simulations, the competitor had very small reserves, and claims already in process would burn through what little reserves the low-price strategy had created. That would require abandoning the market. This emperor really had no clothes. Collateral analysis showed that customers were not inherently sensitive to moderate price differences. Thus encouraged, MIIA began raising its rates, and the competitor's insurers indeed left the market. MIIA's customers continued to get insurance at a stable, reasonable rates.[1]

MIIA: Sustainable insurance for municipalities

The nonprofit Massachusetts Interlocal Insurance Association (MIIA) was an entity formed in 1982 as a service offering of the Massachusetts Municipal Association (MMA) in response to the high costs and poor service of the workers' compensation commercial insurance market for municipalities and public entities in Massachusetts. MIIA originally partnered with a commercial carrier in a joint purchase arrangement to obtain better pricing and services. The collapse of the commercial insurance market in 1985/86 was the impetus to restructure as a self-insurance group. As a result of poor underwriting and rising municipal liability trends, commercial insurers were exiting the market. Towns and small cities were having trouble getting reasonable coverage for predictable prices. Most municipalities were not large enough to self-insure without jeopardizing the city or town's finances. Doubling of premiums was not unusual. Coverage was often restricted or simply unavailable. This was a nationwide problem, as Figure 1 below illustrates.

To fill the market need, the MIIA incorporated itself as a nonprofit insurance pool to provide workers' compensation insurance. A year later it added Property and Casualty insurance (P&C) to its offering, and several years later it added health insurance. MIIA primarily offers its products to cities and towns and other public entities that are associated with those municipalities such as water districts and school districts. MIIA hired third parties to manage insurance claims and provide the actuarial expertise for underwriting and premium rate setting.

From its inception, a key goal of MIIA was to stabilize municipal insurance coverage and prices for its members. Towns operated within a rigid budgeting framework, and the turbulence of commercial insurance rates and coverage imposed a greater relative burden on them than on private enterprises. Although some commercial firms re-entered the Massachusetts municipal insurance markets, MIIA grew healthily, experiencing continual growth in membership, and with sound finances. By the early 1990s it dominated workers' compensation coverage within its served market, and it increased its market share of Property and Casualty (P&C) insurance to about 40% of Massachusetts cities and towns and 30% of the total public sector market. But that comfortable position was about to change.

Figure 1. TIME magazine cover March 24, 1986, on sudden unavailability of commercial insurances. MIIA was founded to protect Massachusetts cities and towns from such shocks.

An existential competitive threat

In the mid-1990s, a commercial insurance agency started growing remarkably rapidly in P&C in Massachusetts. By FY 1996 it had all but wiped out all other commercial P&C insurers in the service area, and it was having success winning municipalities from the MIIA as well. Over about five years, the commercial insurer grew from less than 10% of the market to about 70%. Figure 2 compares the value of property insured by MIIA and the competitor up to the beginning of this story, in later 1995.

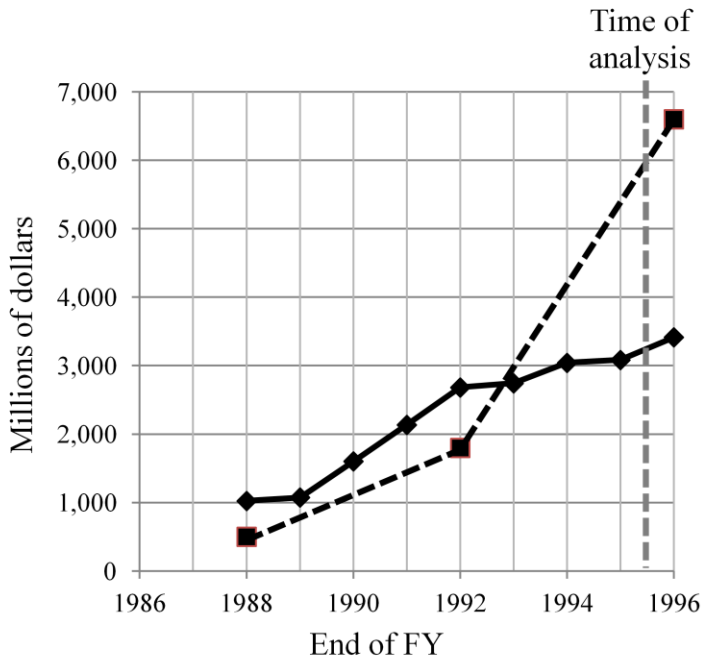

Figure 2. Value of property insured (in millions of current $) for MIIA (solid line) and the competitor (dashed line), showing explosive growth for the competitor. Years are July to June Fiscal Years. Competitor's figures were estimated as described below. At the end, MIIA and the competitor were the only ones left in the P&C business. The competitor's market share "clothing" gave every appearance of shortly "becoming the emperor" of the market.

In fiscal year 1989, the competitor had half of MIIA's volume of property insured, and by fiscal year 1996 the property insured (which was known by November 1995) was roughly double MIIA's volume, and almost all other competitors had been driven from the market. The obvious extrapolation to 100% market share in a small number of years was certainly disquieting. The competitor, at least in the figurative clothing of market share, was about to become the "emperor" of Massachusetts municipal Property & Casualty insurance, with daunting clothes indeed.

The driving force behind the competitor's strategy was its managing general agent. He had a formidable reputation with MIIA. The MIIA staff used words like persuasive, ruthless, driven, clever, and abrasive to describe him. It was rumored that more than once he had 'burned his book' of business, which is insurance slang for saddling an insurer with high losses from risks that the insurer was not fully aware it was assuming, and then walking away from that line of insurance (called a 'book') and leaving the insurer to pay the liabilities. This managing general agent apparently knew when and how to walk away. Yet, he now managed a program for public entities with a national insurer much larger than MIIA. This insurance company had a strong desire to write profitable business.

An insurance *agency* offers insurance policies underwritten by the actual (and much larger) insurance *company*. Your local insurance agency can sell you an insurance policy, but the contract is with an insurer, typically a national company with huge financial resources.

In the case of the competitor's agency, he was given the status of a Managing General Agent (MGA). An MGA may perform one of many tasks normally performed by an insurer. These include but are not limited to, sub-contracting with independent agents for placement of business, negotiating commissions, handling claims, issuing policies, processing endorsements, collecting policy premiums or being responsible for completion of regulatory reports for state or federal agencies (Wikipedia 2012a). He had broad powers, not only setting premium rates and coverage, but also managing the reporting of claims costs, which can be used to produce misleading reports.

The key attribute of the competitor's offering was a very low price for insurance. Coverage was essentially the same as for MIIA. The commercial insurer used local agents and this offered some 'political' advantages within some municipalities, but MIIA's nonprofit status afforded a clear countervailing advantage.

The low premium rates were leveraged by a very aggressive sales process, proactively offering city officials much lower prices. If city officials demurred, he would often make the situation public, which elected officials feared—in a couple cases, officials did in fact lose elections in part on this issue. This was the personal and business character of competition that MIIA could see and had to deal with.

To hold its market share, MIIA had effectively lowered its premium rates by offering various kinds of discounts, incentives and rebates. While this stemmed the erosion of P&C market share, MIIA's third-party advisors viewed the continued price cutting as imprudent. Over the first ten years of the company's life, it had amassed sizable cash and reserves to cover future losses. It was this reserve that promoted rate stability and ensured that the company could cover future losses. Continuing the now-low premium rates meant that MIIA could no longer maintain its conservative policy on maintaining cash and investment asset reserves.

At the time, one of the authors (Stan Corcoran) was the Chief Operating Officer for MIIA. He remained unconvinced about the reserves issue, having noted that in earlier policy years his actuaries consistently had overestimated future losses. Indeed, it was the smaller than expected losses that made it so easy to offer deep discounts in the early 1990s. If the marketplace really wanted the lowest possible prices, perhaps it was appropriate to cut reserves and hope that losses remained low. Indeed, if low prices were imprudent, how was the competitor able to offer still-lower prices?

The issue of reserves came to a head in 1995 when the commercial competitor started writing a new kind of workers' compensation insurance. It had several attractive features, but by far the most desirable feature was a really low price. With this price, the competitor threatened the

MIIA's position in its most important line of insurance. The success of this line of insurance was the key to its financial health. One of its greatest advantages relative to the commercial competitor was its ability to offer a substantial discount to municipalities that opted to purchase both its P&C and workers' compensation insurance. Indeed, it was likely this advantage that the competitor sought to threaten with its new line of insurance.

MIIA's actuaries were already on record as saying that it couldn't afford to match the workers' compensation offering of its commercial competitor. Yet, price cuts were being considered anyway. In a meeting of the MIIA Board of Directors, one Director remarked "you know, in a couple years, we might not be here". The threat seemed literally existential.

How can the competitor possibly be doing it? How to Respond?

It was a mystery how the competitor could afford to offer such low premium rates; Corcoran had always thought that his company was the low cost provider. As a nonprofit, MIIA earned no profit and didn't pay the taxes that a commercial competitor would. Because MIIA sold policies directly, it did not pay commissions to brokers or agents, and its other costs seemed in line with industry norms. It certainly didn't pay large sales bonuses. Yet there was this explosive growth in the competitor's market share.

Standard actuarial analyses were saying it was imprudent or impossible for MIIA to match their low premium rates. Yet the use of actuaries and underwriters was not answering key questions. There was no place a resource could tell MIIA how far to reduce prices, for how long, or what to do to stay in business.

MIIA's staying in business was important for the broader goals of the umbrella organization, MMA, for supporting good government. Without MIIA, municipalities would once again be vulnerable to the abrupt changes that characterize the commercial insurance markets. Dependable pricing allowed cities and towns to focus on their core services rather than being preoccupied with issues such as whether a local official will have their house attached because of not having the appropriate coverage, or not being able to afford adequate coverage.

At this point, Corcoran had a conversation with Don Lewis, President of Netcare Services Inc, the third party administrator of MIIA's operations. Don Lewis met occasionally with William O'Brien, the former CEO of Hanover Insurance, who had learned about system dynamics[2] from Peter Senge and others at MIT in work that would later become part of Senge's *The Fifth Discipline*. Don Lewis suggested that Corcoran talk to O'Brien, which he did in a breakfast meeting.

O'Brien told a startling story. He made a distinction between reductionist thinking and systemic thinking to understand complex systems. He described a modeling methodology, system dynamics, which opened a new world to have a better sense of what outcomes would be. He likened Jay Forrester to Sir Isaac Newton. Corcoran, by his recollection, was "floored" at this message,

coming from an extremely successful and obviously practical CEO. Acting on this information, Corcoran eventually engaged Ventana to re-look at the competitive situation and make policy recommendations.

Simulating an insurance business

The system dynamics work was proposed in September 1995, and the letter of intent signed October 23. From the initial meetings, the Ventana team (primarily David Peterson and William Arthur) defined the kind of simulation model needed to get started.[3] Momentarily putting aside the business strategy questions, the model would need to be a framework for understanding the long-term financial consequences of alternative pricing strategies. This framework had to encompass both MIIA and its competitor in both the P&C and workers' compensation product lines.

Because losses often continued for many years after the close of a policy year, an understanding of today's situation required a historical perspective—perhaps the examination had to go all the way back to the start of the two insurance organizations. Relatively quickly, a highly aggregated strategic model of an insurance company's financial structure was put together. In some ways it looked almost too simple, but it did capture the key dynamics associated with insurance cash flows. Some of the model equations were complex, but a person in any industry would recognize the concepts, illustrated by the informal flow diagram in Figure 3.

The figure summarizes a straightforward series of financial relationships: An insurance company assesses the potential losses for a given type of insurance, and computes a commensurate premium rate, which a new customer will begin to pay. Incurred losses can happen at any time, starting at the beginning of the policy. But there will be a delay, sometimes years, before payments by the insurance company to the insured customer for those losses, for the loss to be assessed, and claims settled. For P&C, roughly 80% of claims are paid out within 5 years of the loss, with essentially all claims paid out within 9 years. This delay is a key to the financial dynamics of P&C and Worker's Compensation insurance.

In the meantime, the insurance company will have invested the premiums in financial assets, primarily cash or bonds (and possibly stocks or other financial instruments in the case of for-profit insurance companies). Those assets create investment income, which add to the pool of cash and reserves. Operating expenses come out of cash as well. There is also a flow of excess insurance "ceded", which is the cost of reinsuring ("ceding") against huge, catastrophic losses. Just as a modestly-sized insurer like MIIA pools risks across Massachusetts for typical losses (say, fire damage to a building), a reinsurer pools across many insurers to insure against huge, catastrophic but much less common losses (say, earthquake damage across many buildings and facilities). So MIIA has to pay a kind of premium ("insurance ceded") for that (re)insurance.

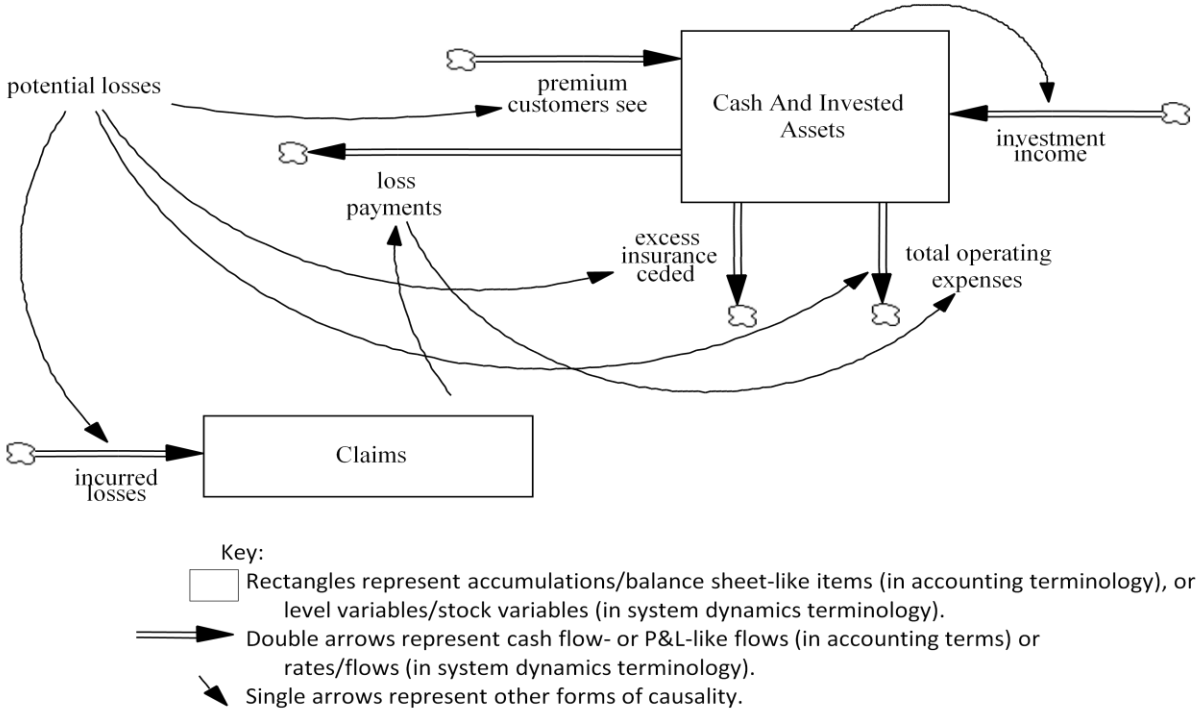

Figure 3. Diagram of the insurance business simulator. The same structure is repeated for MIIA Property & Casualty (P&C), Competitor P&C, and MIIA Worker Compensation. This relatively simple structure, when quantified through data analysis, became the basis for policy recommendations.

The financial health of an insurance company is determined by the relationship between the company's reserves and latent claims against those reserves. Of course, the trick is to figure out how the size of the cash and reserves and claims change over time, which depend on the specific numbers involved—the parameters of the model.

Characterizing MIIA—using what data is there

The model implied a list of the data that would be useful. A list of data 'requirements', however, must balance usefulness with ease of collection. Unlike some other forms of modeling that need time series data for every model variable, system dynamics models can use a broader range of data and information, and also do not require complete "coverage".[4] So there was flexibility in what data to collect.

Easier: Money and people. After the normal give-and-take discussions about data availability and usefulness with MIIA liaison, the Ventana team decided to collect data on each of the measured cash flows and accumulations shown in the diagram. Annual time series data were easy,

while quarterly or monthly data would take much more effort. (Annual time series data covered all the way back to the first year of the company's operation.) Given the issues under study, the annual data seemed sufficient, so this is what was used. However, they did look at a small sample of twelve-month profiles to check whether something important was being missed.

Data on bond indexes benchmarked investment return. In addition, Peterson and Arthur looked at the time series of insured members, competitor membership, inflation indices, and operating expense components (claims, underwriting, sales, etc.).

Harder: Risks. The only problematic variables were the potential and incurred losses. Insurance underwriters and premium rate setters collect a significant amount of detailed data and perform many calculations to do this for individual municipalities. Fortunately, this isn't always necessary for strategic modeling, where characteristics of many individual entities are represented only in the aggregate. What were needed were the aggregated losses for a large group of municipalities, not individual municipalities, but there were a variety of possible indicators and influences for the potential losses.

The Ventana team looked at all of the measurements collected by MIIA's actuaries, but most of them afforded no significant predictive value for aggregate losses. This was a surprise; this result raised a question about the usefulness of the data collected routinely, but the writ for modeling didn't extend to addressing underwriting and rating for individual municipalities. Only two key indicators emerged as necessary and sufficient to explain future losses for the model's aggregate financial representation, one for P&C (total municipality property value) and the other for workers' compensation coverage (total municipal payroll). The historical data for these variables were sufficient to estimate not only the total future loss but also the rate at which the losses would play out over time.

This pattern of "collateral analyses", looking at many types of information beyond what is used directly in the model, is common and increases confidence in the modeling process. The most important such analysis focused on market share.

Competitive dynamics

Dealing with competition for market share was central to the choices MIIA faced. There are many potential drivers, and many possible strengths of influence on market share. To evaluate service quality, Ventana reviewed the member survey forms that MIIA sent out to get feedback on the quality of its service. From market intelligence sources, Ventana examined the premium and loss histories on individual municipalities who had changed insurance providers. They reviewed the experience level of staff members, competitor intelligence, actuarial reports, and sales summaries. From these data they wanted to learn if there were discernible characteristics of the members who switched, in particular to make sure that the competitor hadn't found a way to segment the market or design an attractive offering that MIIA missed. What were the charac-

teristics of the public entities that switched insurers? Were some municipalities constantly shopping for the best price? Were those who left MIIA unable to take advantage of the discounts? Were those that switched in particular regions?

The information indicated that despite customer statements in the surveys, most didn't behave as if they were highly price sensitive. This is not uncommon; economists characterize this as the difference between "expressed preference" and "revealed preference". Few customers were 'shoppers', even though switching costs were very low. This investigation also helped validate as far as possible the assumptions that the competitor's book of business was roughly of the same quality as MIIA's book.

The immediate implication for modeling was that there was not a clear immediate need to represent competition for market share, and responding to relative pricing, as part of the model's internal dynamics, at least going forward in time from the present. By mid-November 1995, the work had progressed to the point of being ready to present initial simulation analysis, as well as reviewing the data and calibration process. The purpose of the meeting was both to clarify issues, and increase stakeholder buy-in. A relatively informal session, using live computer simulation, discussed some disconnects among logical assumptions, data and beliefs (specifically, about underwriting), and resulted in a directive to simulate the competitor explicitly, in particular the competitor's fast growing P&C business, given that the competitor's Worker's Compensation business was still embryonic. The model structure created for MIIA applied equally well to other lines of business and to the competitor. But the data and the parameters that characterize the competitor would be different: The same types of data used to characterize MIIA were not available for the competitor.

Characterizing the competitor from sparse data

Data availability is a common challenge, and there are common solutions. To skip ahead a bit, there are three distinct ways of estimating characteristics to arrive at a model that is hopefully "good enough", and systematic tests for whether the remaining uncertainty is "small enough to be good enough" to guide constructive decisions and actions.

(Graham 1980) classifies three realms of parameter estimation, based on the level of detail of information used relative to the level of detail of the model's variables. The model variables are, e.g., financial flows for all of MIIA's customers, aggregated, not on individual members. So information detail ***below*** this level would be on the multiplicity of each of the individual member public entities. More typically in system dynamics models, this is the realm of anecdotal information about how the system works from firsthand observers. Information detail ***at*** this level would be aggregated financial flows, or insured property values, with no further detail—classic time series. Information detail ***above*** the level of individual model variables would be the entirety of the other data, plus the full model structure. For the moment, this can be thought of as

inferring things about what is *not* seen from what *is* seen, plus knowledge of how variables interact, which is summarized in the model structure and known parameters. This is also referred to as *indirect measurement*[5] but more formally as maximum likelihood estimation.[6] Table 1 gives a preview of these three types of parameter estimation.

Realm of parameter estimation methods	Examples
Estimation from ***below*** the level of detail of model variables	MIIA member: • property values • payrolls • loss experiences Analysis of competitor's members showing comparability in incurred risk Analysis of customer policy switches
Estimation from ***at*** the level of detail of model variables	Competitor agent's investment returns (from insurance company's annual statements) Comparability analysis for loss profile and re-insurance cost
Estimation from ***above*** the level of detail of model variables • Here, indirect measurement via maximum likelihood estimation (a least squares fit of simulation to data)	Competitor operating expenses Competitor premium rates

Table 1. Methods for estimating parameters for the model of the competitor's finances. The use of all three methods left some, but not a lot, of uncertainty about parameter values for the competitor.

Below the level of model variables. Most of this effort went into estimating the magnitude of the competitor's incurred risks over time, first using MIIA's information on the property values, payrolls and loss experiences, and then analyzing the competitor's customers relative to those characteristics. Competitive intelligence yielded a list of the competitor's customers at four points in time, including the startup and the current membership. Earlier analysis had shown that the municipalities served by the competitor had the same risk characteristics as MIIA's members. The main difference between MIIA and the competitor's members were their numbers and sizes. So there was no aggregate information on the potential risks in insuring the competitor's members.

For example, for Worker Compensation insurance, the municipality payrolls for most of the competitor membership weren't available. (All that was known was the payroll size for customers who switched at the time they switched.) Since these payrolls were a matter of public record,

the data could have been collected, but it would take more time and effort than were available. Therefore, Peterson and Arthur looked for a surrogate variable for payroll that was easily obtainable.

About the only easily obtained variable with a logical connection to municipal payroll was the population residing in the competitor communities. Was this an adequate surrogate variable? To find out, a collateral analysis plotted population against payroll for each of *MIIA's* members. Fortunately, the plots showed a high correlation, and implied that at least for a large aggregate of customers, payroll could be inferred from population. In this way the competitor's incurred risk could be analyzed at a few points in time. Interpolation between these points gave the risk in the remaining years.

At the level of model variables. Data from the annual reports of the competitor's insurance company allowed estimation of the return on the competitor's cash and reserves. This was a reasonable estimate because the parent collected the income from all its subsidiaries and invested it. The data showed that the competitor had a moderate advantage over MIIA in this area, undoubtedly from the scale of its investment banking activity and greater flexibility in selecting investment instruments—as a nonprofit organization, MIIA had a conservative approach to its investment options, yielding an investment portfolio with less risk, which usually implies less return.

There were similar collateral analyses, to support the assumptions that MIIA and the competitor had the same: (a) loss profile per unit of incurred risk, and (b) ceded insurance cost (reinsurance) per claim.

Even with the surrogate risk input (population) and these assumptions, there were still several unknowns, e.g., competitor pricing rules and operating expenses. While MIIA had some information about these unknowns, most of its knowledge was either fragmentary or anecdotal. This is where the indirect measurement entered the model analysis.

Above the level of model variables. Regulatory submissions by the competitor showed three financial ratios, for three recent years: the expense ratio, the policy year combined ratio and the policy year loss ratio. These are standard measures used in the insurance industry to judge the financial health of an insurance company. The expense ratio is the operating expenses divided by the total premium collected from customers. Figure 4 shows a simulation compared to the data.

Alone, this fit is not a strong test of the validity of the model's parameterization of the competitor's premiums, operating expenses, etc. This fit is only a demonstration that the model structure and parameters are not substantially at odds with the data. Such fitting, however, contributes to later sensitivity testing, by substantially reducing the range of uncertainty about such parameters.

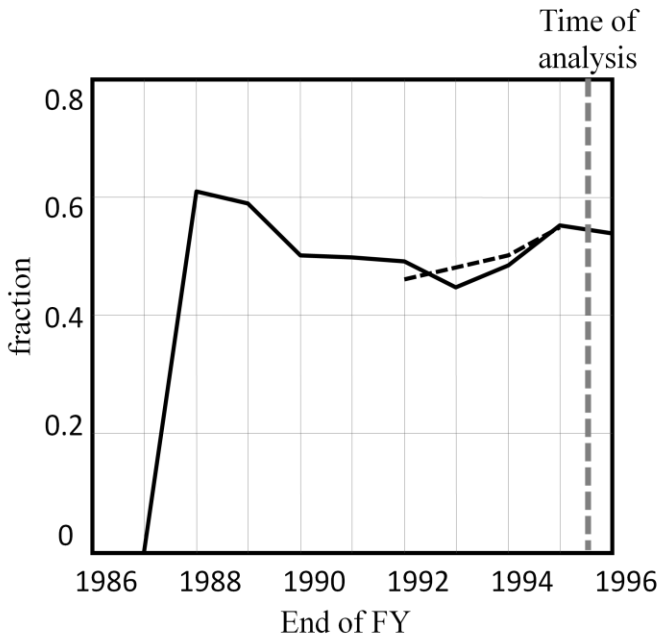

Figure 4. Simulated expense ratio for competitor P&C (solid line) versus data (dashed line). The parameters adjusted to maximize (likelihood) "fit" to this data were premium rates and operating expenses, simultaneous with fitting other data as well. Note that system dynamics parameter estimation does not require data for all points during the simulation. This calibration is the second-to-last step in dealing with uncertainty about the competitor's characteristics, the last being sensitivity testing.

The policy year data attempt to take time out of the picture when measuring financial performance. Simple cash flows mix investment returns based on accumulated premium payments of many years, mixed with the loss payments on policies both recent and long-standing.

So the policy year loss ratio divides the cumulative loss payments for claims arising in one particular policy year (regardless of when paid) by policy year premium receipts. It is a simple indicator for whether policies of that year made money in the longer run: A loss ratio of less than one implies that premiums more than paid for claims payments. Here, claims arising from the policy years of 1993, 1994 and 1995 were accumulated up to and including 1997. The bulk of claims are settled within a few years of the policy year, which makes the policy year ratios a reasonable, but not perfect, measure of financial performance.

Similarly, the policy year combined ratio takes a particular year in the past (the "policy year"), and measures the cumulative loss payments for claims arising in the policy year (regardless of when paid), plus operating expenses for that policy year, all divided by policy year premium receipts.

These ratios didn't say what the operating expenses and premium rates were, but they were 'indirect measurements' of them for the three years for which data existed. Added model equations for the expense and combined ratios effectively linked them to the unknown loss, premium and expense parameters in the model. Then, the unknown parameters of the competitor model could be estimated from the three pairs of ratios. More specifically, the estimated values for the unknown parameters had the highest possible likelihood of generating the measured ratios, using maximum likelihood estimation. Table 2 compares simulated policy year ratios to the data.

Competitor Policy Year Loss Ratio as of 1996			Competitor Policy Year Combined Ratio as of 1997		
Policy Year	Simulation	Data	Policy Year	Simulation	Data
1993	0.42	0.33	1993	0.87	0.79
1994	0.40	0.42	1994	0.91	0.92
1995	0.39	0.36	1995	0.95	0.91

Table 2. Policy Year Loss and Combined Ratios, measures of the competitor's financial performance for policies and claims of a particular year, with claims accumulated until the "as of" year. Like the fit of the expense ratio in Figure 4, the fit here is the best obtainable with the data and model structure at hand, but far from perfect. The value of such fitting is the significant reduction in uncertainty about the competitor's premiums and costs.

Picking the best possible parameters given the model structure is not the same as proving the model was adequate. The paucity of data made statistical checks of the model fairly weak. Nonetheless, the indirect measurement significantly reduced the uncertainty about a central pair of strategic questions: Was the competitor truly offering very low premiums? (Yes), and had he found a way to dramatically reduce cost, to be a financially strong competitor despite the low premiums? (No).

Competitor's hidden weakness allows safe policy

A second meeting between the Ventana and MIIA teams reviewed findings and recommendations. The fundamental dynamics are shown in Figure 5, which in the later presentation to the MIIA Board of Directors was captioned "Today's Prices are Unsustainable". The current premium rates were insufficient to maintain cash and reserves in the face of the profile of future losses implied by present base of policy-holders.

Notice that in 1996, even when the competitor had captured most of the P&C market, and insured roughly twice as much property as MIIA, the cash and reserves available to settle claims were much smaller than MIIA's. This is a natural consequence of very low pricing. Given the

low pricing at the time, both MIA and the competitor both run out of reserves. But the competitor never had a period of higher prices, so the competitor runs out of reserves far sooner than MIIA would. The emperor's clothes weren't looking quite as impressive.

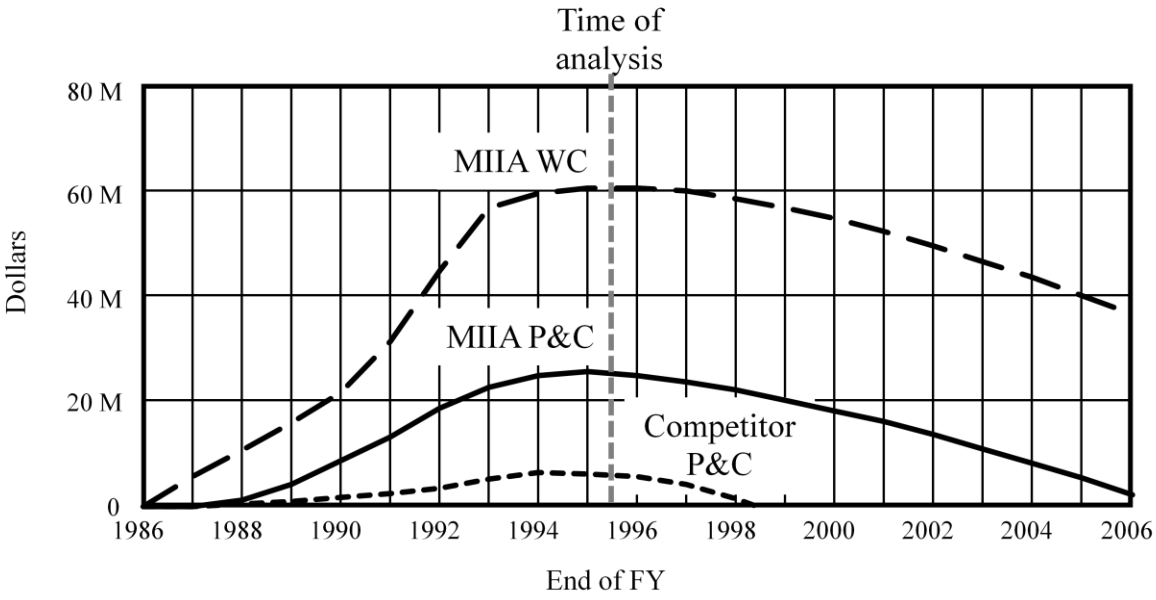

Figure 5. Cash and reserves under a no-growth scenario, with current (late 1995) premium rates (very low), for MIIA Worker Compensation (long dashed line) and Property and Casualty (solid line) and the competitor's P&C (short dashed line). This scenario has the competitor's cash and reserves running dry in early 1999, at which point MIIA still had substantial financial reserves. MIIA could win a price war. The "emperor had no clothes".

The conclusion that the competitor's reserves were quite low is the key result of indirect measurement. Direct data were not available, but a trajectory and magnitude like that shown in Figure 5 are the only ones that are consistent with the extant data and the known structure of financial relationships.[7]

As in the first meeting, much of the second meeting was done with live simulations. The MIIA team seemed well-familiarized with the material, and discussion and simulation were lively. Indeed, one person suggested an extreme condition test that revealed a hidden flaw in the model formulation.

Several aspects of the model-based analysis surprised Corcoran and his modeling team. The unsurprising result was that MIIA's planned insurance premium rates were too low to: (a) support the long-term health of the company, and (b) maintain long-term stability in the municipal insurance market. Third-party actuaries had announced this before Ventana started work; Ventana had only confirmed it.

Yet, the model afforded a benefit. It made it particularly easy to understand this result and its implications. At planned prices, it would take many years for MIIA's position to erode significantly, unless it tried to match the recent workers' compensation offering of its competitor. This was easy to see in simulation experiments with different pricing strategies, illustrated in Figure 6.

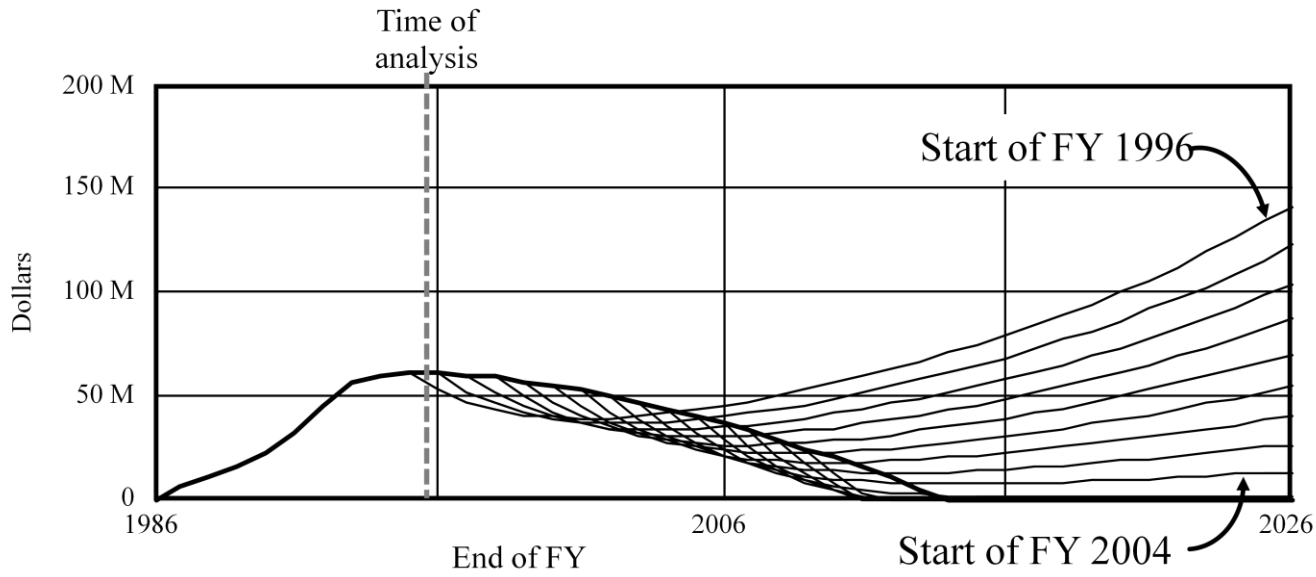

Figure 6. Simulation of cash and invested reserves for MIIA Worker Compensation (WC) insurance, assuming no growth, starting modest price increases at (2 percent per year) various times. Note the time scale, 20 years longer than Figure 5. The thick line shows MIIA WC running out of reserves at about 2010 if price increases started in late 1995. The lowest thin line showed that MIIA could have postponed starting (fairly modest) price increases as late as 2004. Very modest price increases sufficed to keep reserves in place, and a decision to raise WC premium rates needn't have been taken immediately. Sensitivity testing (of both behavior and policy improvement) is the fourth and last method of dealing with uncertainties in characterization of the system.

Table 3 summarizes similar experiments with the other insurances, and for different assumptions about growth rate.

	MIIA WC	MIIA P&C	Competitor P&C
No growth	2004	2003	(1987)
10% / year growth	2002	2002	(1987)
20% / year growth	2001	2001	(1987)

Table 3. When premium rates must start increasing to avoid running out of cash and reserves. For the competitor to have avoided this through moderate price rises, they would have had to start almost a decade earlier (i.e. not to have started a price war at all). For MIIA, from the time of the analysis in late 1995/early 1996, there was plenty of time—years—in which to raise its prices.

In effect, if new customers are piling into the business, with new losses and new premium rates too low to cover them, the stock of reserves built up from an era of higher prices gets eaten through more quickly. Higher growth, then, would move the crisis point earlier, when premium rates had to start to rise. Nonetheless, at the time of 1995/1996, the last day of reckoning was a long way off for MIIA. And even very modest yearly price increases had dramatic effect on the trajectory of cash and reserves.

The competitor's position was very different. Indeed, the surprising result was that the competitor was nearing an *in extremis* condition. The aggressive, driven, and clever competitor had a business that was likely to collapse in the near future, in less than a handful of years. Even growing at an implausibly high rate and almost completely taking over the P&C market could postpone the day of reckoning only a year or two—at which time MIIA would still be solvent and open for business. Similar experiments with other parameters did not change the basic picture: The competitor almost certainly couldn't stay in business. The only possible escape was to dig themselves out of the hole by starting immediate large yearly price increases, resulting in prices higher than those MIIA could be sustaining. But for such large premium hikes, loss of customer base counteracts the cash flow boost from higher premiums. In essence, the competitor had started a Ponzi scheme.

The insurance industry has characteristics that make it susceptible to Ponzi scheme-like behaviors. Insurers collect money up front in anticipation of future losses. Suppose a company elects to price its insurance policies well below the ultimate losses that it must pay, but these losses appear over several years. The low premium rate will attract customers. As more and more of them take advantage of the low prices, the insureds provide the premiums to pay the shortfall in the earlier insurance policies. As long as the company grows fast enough, the losses will never catch up with it.

As shown by the model of MIIA's competitor, its pricing was too low to sustain it over the long term. In the short run, its rapidly growing business base had disguised the problems that would emerge over the slightly longer term. Fortunately for MIIA, the easy pickings for the competitor were fast disappearing. The higher cost commercial competitors were gone. The competitor now faced a marketplace of low-cost, nonprofit MIIA. Although there never was a definitive "base run" that predicted a specific future, it was clear from the simulation experiments that within a small number of years, the ruthless managing general agent would either have to raise prices significantly or exit the business--"burn book". The emperor really had no clothes.

With reasonable pricing policies, MIIA had the invested assets to last for a decade. It was in no real danger; it just looked like it. The right strategy was to stick to its original charter and act as a rate stabilizer in its served market. If some members left due to great premium rates elsewhere, this wasn't awful. Most likely, these customers eventually would be back -- grateful for the stability and rationality provided by the nonprofit company.

The group discussed Ventana's investigations into customer switching behavior, and the apparent lack of significant sensitivity to modest premium price differentials and changes.

The group also needed to explain the motives for the competitor's actions. Why would he engage in what appeared to be a doomed strategy? Was he naive? Or was he thinking that he could drive all of his competitors out of business and raise prices before the hens (losses) came home to roost? After all, he had already driven all but one competitor (MIIA) out of the P&C market in Massachusetts. Given his apparent strategy, how did his reputation as a ruthless competitor help him? At the other extreme, could he have perceived MIIA's market responses as threatening his own survival, causing him to lower price more than he wanted? This is an "Arms Race" scenario in which the perceptions of the competitors cause escalation of arms spending (here, low premium rates) that is in no country's ultimate interests. The weak market signaling in the marketplace made this a possibility. Each of these questions was discussed in the context of the model and data.

By the end of the meeting, the group had addressed almost all the issues, but again there was an extreme conditions test failure on a type of insurance coverage for the competitor's Worker Compensation (which MIIA was considering adopting) called an *aggregate deductible option.* The formulation was fixed, and the results didn't change appreciably. Again, the value of active client participation was confirmed.

With the MIIA and Ventana teams convinced that this competitor / emperor really had no clothes, it was time to take these results to MIIA's Board of Directors.

Safe policy and good results

A month later (18 January 1996), Ventana made a presentation to the Board of Directors. The presentation was very well received. The company's board of directors was particularly satisfied because the perspective afforded by the modeling was much deeper than they normally got. It was clearer because the board understood the company's performance in the context of the industry structure and the dynamic relationships among variables. After a Ventana presentation, several board members stated that they felt they were now in a much better position to advise the Chief Operating Officer (Corcoran) on strategy and insurance policy.

Corcoran and MIIA decided to announce a 2 ½ percent price rise in P&C insurance for the following municipal fiscal year (which runs July 1 through June 30 in Massachusetts), and not match its competitor's new offering on workers' compensation. It is important to realize that the change in pricing policy did not result only from a single, succinct presentation, confidently delivered to the MIIA Board of Directors, even though it explained the mystery of how the competitor could offer such low rates. Several other factors were in play, collectively perhaps more important in motivating the Board than the Ventana presentation as such:

The conclusions were consistent with the messages from MIIA's external advisors. Extensive analysis had strongly implied that if MIIA had followed the competitor's pricing model in the past, it would be in significantly poorer financial shape now. By implication, using that pricing model for the future would be a Bad Idea. These results were never substantively challenged; they just didn't go all the way to answering the questions of what MIIA should be doing and when.

The simulator was demonstrably consistent with the available data. In many cases, it was the same data used by the external advisors, and the MIIA working group of industry-experienced executives saw that consistency demonstrated. Moreover, the available data included not just the data that entered directly into parameter values used by the model, but data used for the "collateral analyses" of the appropriateness of model assumptions, in particular about the comparability of MIIA's and the competitor's respective clients.

The respected MIIA working group had visibly given the simulator the "twice over". The same group had familiarized themselves in with the relatively straightforward logic of the simulation, and suggested and criticized simulations. They had seen misunderstandings of data, and formulation errors (albeit minor) in model equations corrected, and the analyses rerun. The analysis resulted from a respectable process, which they had witnessed through two iterations.

The competitor continued his aggressive pricing practices, and in July 2000 the insurance company whose policies he was selling had completely withdrawn from the municipal business. The insurance company would continue honoring claims originating from the insured period, but wouldn't allow renewal of any policies. By that point the competitor agency had found another

insurance company willing to have their P&C insurance sold. They, too, give the agency some latitude (with a "Managing General Agent" (MGA) status), but with less ability to offer low premium rates and more restrictive coverage. Then in 2002 that insurance company went into voluntary rehabilitation, where the insurer lacks assets to settle claims (or is coming close to that condition), and the state insurance regulator compels the insurer to show how they can rehabilitate the situation, or continue on into liquidation. During the rehabilitation period, claims payments were suspended. The company eventually was placed into liquidation and cities and towns had to access the state guarantee fund to receive payment for outstanding claims with a limitation of $300,000 for claimant liability. Its extensive use of MGA program business and heavy reliance on reinsurance were thought to be the root causes for their financial difficulties. Municipalities turned to MIIA for P&C insurance, whose market share rose precipitously, as shown in Figure 7 below. The competitor agency continued to be in business, but with much less capacity in the public entity P&C business.

MIIA's results were as benign as the analyses implied they would be. In an update to the MIIA Board in August 1996, Corcoran noted that the P&C line had *gained* ten new members at that point. From 1997 to 1998, MIIA lost one public entity as a P&C member, net. Every year before and after until 2009, membership increased, as shown in Figure 7:

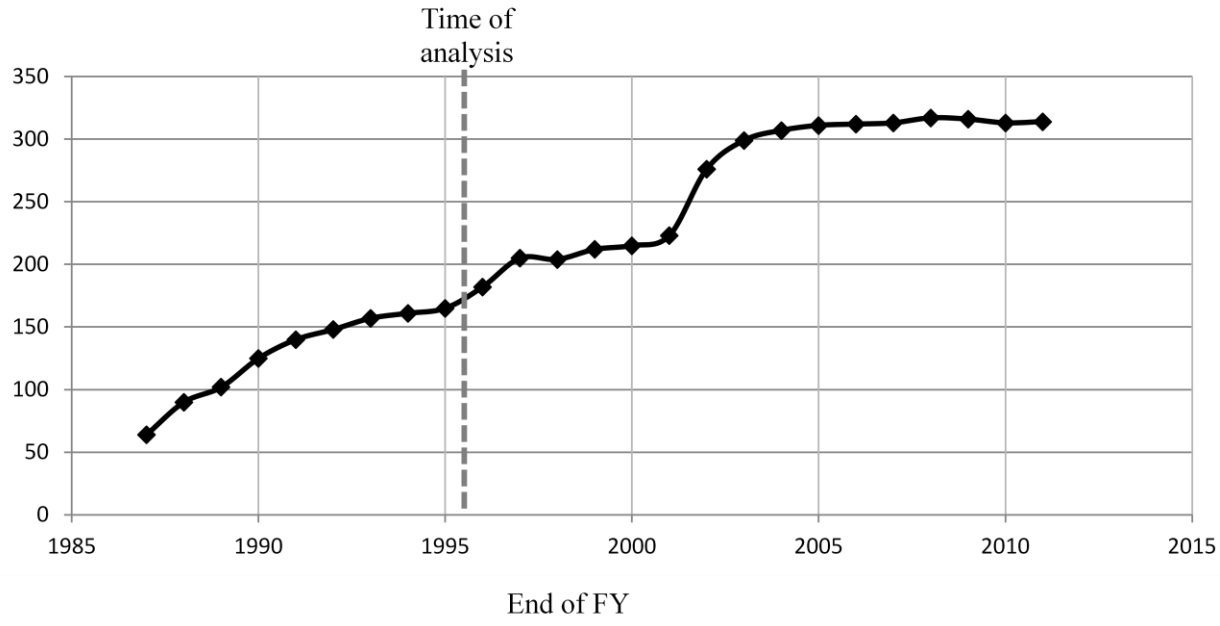

Figure 7. Number of public entities with MIIA P&C policies ("members"). Membership continued modest growth MIIA moved away from cut-rate pricing in 1996—certainly there was no wholesale loss of market share. Membership surged 2001-2003 after the competitor's insurance company went into liquidation. In effect, MIIA won the price war by opting out of it, with sustainable pricing.

MIIA has continued to offer P&C insurance at reasonable rates to the pool of members. Figure 8 shows an approximating index of premium rates, obtained by dividing premium revenues by full value of property insured.

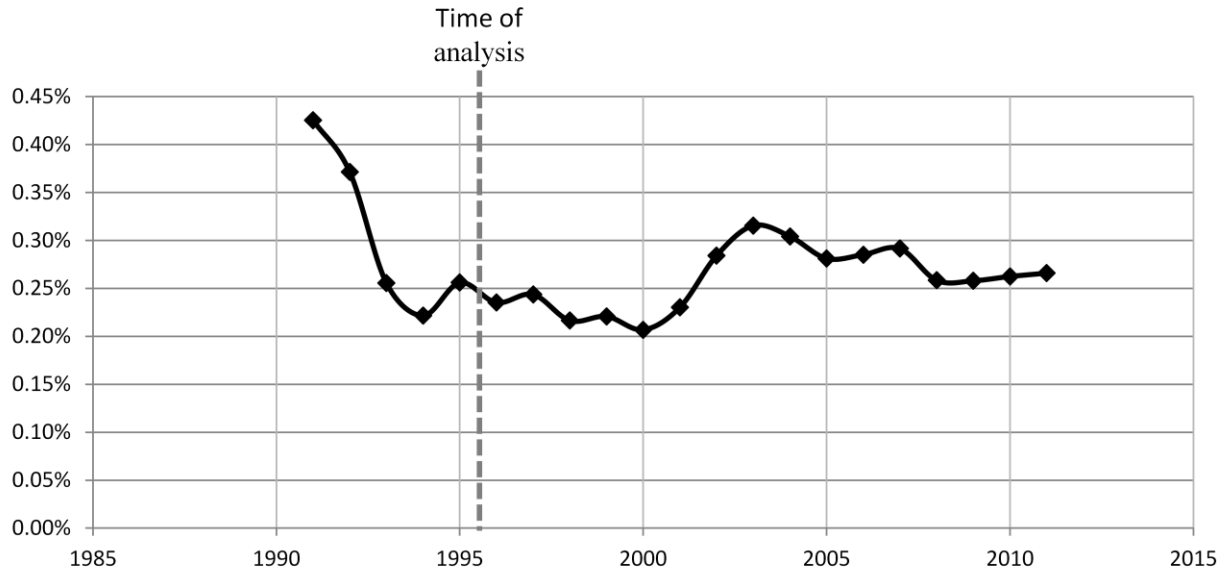

Figure 8. Index of MIIA P&C premium rates (all P&C premium income divided by property values insured). Except for the transient increases 2000 through 2003 responding primarily to external events (including 9/11 terrorist attacks increasing the price of reinsurance), MIIA has been able to maintain reasonably stable premium rates.

The index of premium rates continues to go *down* after 1996, even though P&C premium rates were increased. This is due to a wrinkle in the structure of MIIA's P&C coverage. Property losses are self-insured by the MIIA membership. But another form of casualty liability, professional liability, is insured through a regular insurance company. From presentation materials at a Board meeting in August 23 1996: "MIIA's rates for the property & casualty pool coverages actually went up. [But] This increase was more than offset by a rate decrease in our sponsored professional [liability] coverage program."

The large increase after 2001 is predominantly due to a significant increase in reinsurance costs following the 9/11 terrorist attack: MIIA's reinsurance costs rose around 300 percent over 3 years. Also, the surge in new membership caused by the competitor's final withdrawal from the market was priced according to risks, and the premiums for the new members were actuarially higher. Finally, the very modest price rises started in 1996 needed to continue for several years to come back up to actuarially sound levels.

The resolution of the competitive threat allowed MIIA to change its relationship with its customers. It had the financial security to institute several programs where a city could get immediate

premium reductions by implementing better risk management practices. And MIIA's finances are now governed less by business management issues and more by insurance issues, such as stress tests (for, e.g. weather disasters, or failure of reinsurers).

Conclusions

Dynamic modeling reveals otherwise-hidden information. The title of this paper deliberately alludes to the story of the emperor's new clothes, because the consensus appearance of almost unstoppable market share gains turned out to be just the opposite. Some form of revelation is common in dynamic modeling. By analogy, consider beachcombing. Beachcombers who use just their eyes will pick a beach clean of interesting objects. No more surprises. But a beachcomber using a different methodology, like a metal detector, is working some virgin territory. There are more interesting things to be found.

The power and the pain of using data in dynamic modeling is that the simulator is a single integrated consistency test. All of the information about cause and effect, all of the information about parameter values must in the end be consistent with all of the information about behavior, within the limits of being adequate to the purpose. The (moderate) pain happens because at first, there will be discrepancies, and the discrepancies need to be tracked down and resolved. This is the scientific method.

The power of using data in dynamic modeling happens because former certainties turn out not to be what they were once thought. This happens on several levels. At the tactical level, the model calibration process reveals flaws in understanding both the real system (often incompleteness of cause and effect relations) and the data (where what was thought to be measured isn't what actually is measured). It may be a surprise that that model flaws and data flaws happen with roughly equal frequency.

More importantly, at the strategic level, decision-makers' understanding of behavior turns out to be incorrect, at least in terms of what cause and effect linkages are most important. Executives may have different ideas about what the most important drivers of performance are, or what the causes of past or present crises were. From these, they often draw different conclusions about what the best strategy should be. This is a common source of uncertainty or disagreement.

Simply piling up more facts—the typical result of "in-depth studies"—is not sufficient to resolve such differences. An expert subjective judgment based on examination of 10,000 facts is still a subjective judgment, and one person's judgment can easily differ from another's. Moreover, in a complex situation amid the myriad pressures of everyday life, the most salient causes and facts may not be recognized or inferable by anyone. This is the situation that phrases like "counterintuitive systems" or "the law of unintended consequences" characterize. The facts need to come together in one place to be weighed against one another, and that is what testing a simulator

against extensive data does. That is what allows discovery of hidden information and implications.

Sustainable strategies need dynamic analysis. A for-profit business in MIIA's markets and facing the competitive threat that MIIA faced may very well have said "well, cities and towns are getting cheaper insurance from that competitor. We'll maximize returns to our shareholders by pulling out." Indeed, many insurers did exactly that, which caused enormous problems for cities and towns. Sudden and unexpected costs, coupled with political restraint on taxes mean that they get to choose what to cut to stay in budget—Police? Teachers? Which constituencies to shortchange?

But MIIA is *only* in business as a service to cities and towns (and other public entities). Corcoran says "our job is to be invisible (except for support of risk management); cities should be able to focus not on insurance but their core services: teaching, policing, recreation, and the things that matter to people."

A significant part of what MIIA provides is dependability—confidence that next year's premiums will be much like last year's, and that reserves are sufficient to keep that insurance available (and claims settled) year after year. Beyond being simply an insurer that won't leave the market, MIIA has also stabilized the market; it is no longer a viable strategic option for competitors to attempt to drive all other insurers from the market via low prices, in the hope of then charging high premium rates. MIIA has the financial reserves needed to outlast such attacks, and so they are much less likely to happen in the first place.

Attaining such sustainability will often be difficult, especially in an environment competing with purely profit-maximizing entities. Issues of sustainability almost always seem to have long-term benefits arising from short-term costs, and paying those short-term costs often seems prohibitive when competing with entities that are operating for the short-term. At the outset, MIIA was apparently faced with two bad choices: Either raising premium rates and going out of business (whereupon the competitor could raise premium rates), or fighting and eventually winning a bruising price war and then itself needing to sharply raise premium rates afterwards to rebuild reserves. Neither choice did cities and towns any favors—both would subject them to large changes in premium rates. It took dynamic analysis and the revelation of the weakness of the competitor's finances to justify stepping back from the short-term issues of the price war to give cities and towns the sustainability they need.

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Wikipedia 2012b http://en.wikipedia.org/wiki/Abductive_logic, accessed 16 March 2012.

Notes

[1] Drawn extensively from Ventana Systems, Inc., 1966 internal memorandum "Case Study: Assessing Competitive Pricing Strategy—Insurance Industry.", and from Ventana Systems, Inc., 1966, "Analysis of Current Competitive Environment & MIIA's Response" presentation slides. Used by permission.

[2] For readers not familiar with system dynamics: It is a professional and academic discipline created in the late 1950s at the Massachusetts Institute of Technology by Jay Forrester and many other contributors. It uses computer simulation and the constructs of feedback control theory to represent complex systems in corporations, markets, economies, and ecologies—systems whose behaviors and responses to interventions are often counterintuitive (Forrester 1971a). Initially known as industrial dynamics (Forrester 1961), it was applied in the US urban crisis of the 1960s (Forrester 1969), and most widely known, world economic growth (Forrester 1971b, Meadows *et al.* 1972 and 1974). (The latter application was almost as widely misunderstood (Meadows, Meadows and Randers 2004)).

The System Dynamics Society (http://www.systemdynamics.org/) was formally organized in 1983 as a professional society for academics and practitioners, and sponsors conferences and chapters, and a highly-cited, peer-reviewed journal, the *System Dynamics Review*. The discipline of system dynamics has progressed to the point where it is commonly used in settlement of some types of legal disputes (Cooper 1980, Stephens, Graham and Lyneis 2005). As of 2002, system dynamics was taught at over 70 colleges and universities around the world, including Massachusetts Institute of Technology, London Business School, London School of Economics and many others.

[3] There was, and is, little extant system dynamics work on the insurance industry. There was a brief flurry of activity in the late 1980s, using a gaming form of dynamic model of automotive claims settlement to train claims managers at the Hanover insurance company (Moissis 1989, Senge 1990, pp. 325-335 etc., Senge and Sterman 1992). That effort carried on as a more generalized approach to service quality management, e.g. (Oliva and Sterman 2001). It was not particularly relevant for MIIA's situation. Since then there have been several isolated efforts: (Doman et al. 2000) studied growth management in life insurance, (Akkermans and Van Oorschot 2004) and related studies focused on formulation of a balanced scorecard. That work carried on into balanced scorecards for other industries. (Franco 2005) and (Taylor 2008) seem to round out the extant work.

[4] The MIIA modeling used parameter estimation from information below the level of detail of model variables in an unusual way. Usually, model-building makes extensive use of first-hand system observer's anecdotal information, as described in (Sterman 2000 Ch. 14). The MIIA model used extensive analysis of the insurances of individual cities, towns and other public entities. This is a by-product of the simplicity of the model and the primary focus on financials.

[5] The classic example of indirect measurement is inferring the existence and position of Neptune from observations of Uranus, and then doing the same for Pluto from observations of Neptune

and Uranus. An extreme example in system dynamics is two former CIA officers estimating heroin imports into the United States—something obviously not measurable (Gardiner and Shreckengost 1987).

[6] Using model structure and other parameters to indirectly measure unknown parameters indirectly touches on several very technical areas. This is the realm of multiple-equation econometric regression. This is also the realm of a somewhat parallel body of mathematical tools arising from engineering control theory, described in the system dynamics community as Full-Information Maximum Likelihood (estimation using) Optimal Filtering (FIMLOF) (Schweppe 1973; Peterson 1975, 1980). This functionality is available in the Vensim simulation package (http://www.vensim.com/software.html). For the domain of dynamic systems, FIMLOF makes practical what is otherwise prohibitively difficult: rigorously estimating parameter values from data that is incomplete (not available for some, even many, variables) and corrupted. (Heuristically, if everything depends on everything else, it shouldn't be possible to estimate parameters that are too much different from the true values.) Moreover, if the dynamics are dominated by responses to known inputs (as opposed to unknown and random inputs), FIMLOF can be shown to be equivalent to fitting a normal simulation to the available time series data with a particular form of weighted least squares. That was the case for the MIIA model.

[7] Although this paper couches the inference process in terms of indirect measurement and maximum likelihood estimation, the more general characterization of this type of logic is *abductive logic*, abductive being from the Latin for "pulling in" (Wikipedia 2012b). It is logic that "pulls in" conclusions in a way that is different from deductive or inductive logic. Abductive logic in effect says "this is the only conclusion that fits with all these other facts." Abductive logic is obviously weak when dealing with small numbers of facts: "The lawn is wet. Therefore it rained" is the classic *post hoc ergo propter hoc* fallacy. (There might be a sprinkler system that just finished.) But when there are a large number of facts with which the conclusion must be consistent, there is much less "wiggle room" in terms of possible conclusions. Much of the drawing of conclusions from archeology implicitly uses this logic. As Sir Arthur Conan Doyle said through Sherlock Holmes said, "When you have eliminated the impossible, whatever remains, however improbable, must be the truth".

In the quantitative realm, abductive reasoning is closely related to confidence bounding: Given model assumptions and a body of data, what is the range of results within which we are, e.g. 95% confident that the true values lie? In the realm of dynamic modeling, this is the origin of *fit [to data]-constrained Monte Carlo analysis* (Graham, Choi and Mullen 2002; Graham, Moore and Choi 2002). This method varies model parameters (which can include those that change the effective causal structure) randomly, to get a simulation outcome, but eliminates from the samples the simulations that don't produce an acceptable fit to the time series data. This gives a statistical distribution of outcomes, given the available data. The cited papers give an example where requiring fit to data significantly reduced the uncertainty of the outcome.