From Disability Income to Mega-Risks: Policy-Event Based Loss Estimation

by Amy S. Bouska, FCAS

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ABSTRACT

As new types of losses appear for which traditional "triangular" analysis in inadequate, different approaches must be used. This paper defines policy-event based loss estimation (PEBLE), which is being used primarily in developing natural disaster and toxic tort rates and loss estimates. Although PEBLE appears to be new, its history goes back to life and disability reserving. The paper provides a non-mathematical discussion of the components of PEBLE, its advantages and disadvantages, and some of the issues associated with its use. The paper also examines the compatibility of PEBLE with CAS practices and principles.

BIOGRAPHY

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Black box. Obvious. Tricky. Inevitable. Old hat. Many adjectives can be used to describe the models that are emerging as the primary tools for estimating losses arising from natural disasters and toxic torts, but "non-actuarial" is not one of them. The intent of this paper is to provide an expository (i.e., non-mathematical) discussion of policy-event based loss estimation in general, including some of the advantages, disadvantages, and issues in its application, and to try to place it in the context of actuarial principles and practices.

Definition

By "policy-event based loss estimation" (PEBLE) technique, we mean any technique, whether for purposes of ratemaking or reserving, that estimates losses by comparing event outcomes directly to the applicable individual policy terms in order to estimate the potential loss to the policy. Some further calculation with these estimates (e.g., addition of general expenses or IBNR) may be required before arriving at a final result. These techniques may be either deterministic or stochastic and frequently rely on external, non-insurance data. They offer an alternative to traditional actuarial analysis for types of losses that are not "triangularizable" and coverages that do not lend themselves to loss ratio ratemaking.

At its most basic level, PEBLE consists of two elements: (1) a loss event that might give rise to an insurance claim, and (2) the application of the terms of an individual policy to that loss event in order to determine the insured loss. This is done for all of the policies exposed to the loss event in order to estimate the total insured loss. In addition, different

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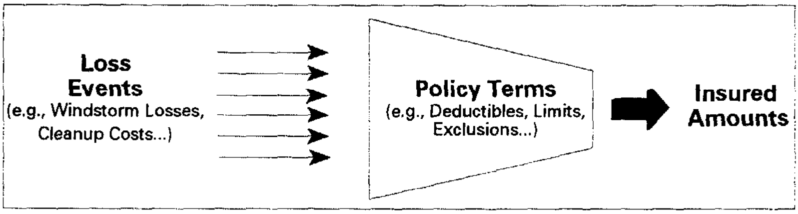
potential loss events might be used in order to better understand the variation in the total loss.



The PEBLEs with the highest property/casualty profiles at this time are the natural disaster models (e.g., windstorm or earthquake) and the toxic tort models (e.g., asbestos or pollution). However, they are also particularly useful for the analysis of auto warranty experience (see later).

PEBLEs are a form of collective risk model. As described by Roger Hayne in his 1989 paper,

> [t]he basic collective risk model approaches the question of the distribution of total reserves by modelling the claim process faced by an insurer. It considers the interaction between the distribution of the number of claims and the distribution(s) of the individual claims by calculating loss (or reserve) T as the sum
>
> $$T = X_1 + X_2 + \ldots + X_N,$$
>
> where the number of claims N is randomly selected, and each of the claims X_1, X_2, ..., X_N is randomly selected from claim size distribution(s). [1]

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[1] Roger M. Hayne, "Application of Collective Risk Theory to Estimate Variability in Loss Reserves," *PCAS* 1989, p. 78.

In a PEBLE, the claim size distribution of the collective risk model is replaced by the result of an explicit interaction of policy terms and exposures with external loss events.

In ratemaking, PEBLE is a pure premium approach rather than a loss ratio method. Assuming that sufficient care is taken in constructing the simulation sample (where simulation is involved) to adequately represent the tail of all of the relevant distributions, there is no need for credibility weighting against a broader average loss. The result is fully credible in the technical sense of the word.[2]

When Triangles Fail

Insurance policies are the proximate cause of insurance losses (without policies, would there be any losses?). Thus, it is reasonable to consider policies directly in the course of loss estimation. However, it is not always necessary, as the widespread and successful use of triangular methods clearly shows.

Strong implicit assumptions regarding both policy terms and loss events underlie triangular analysis methods, but they are rarely made explicit.[3] In particular, unless corrections or adjustments are made to the data, these methods assume a wide-ranging stability in both policies and losses. For example, if deductibles and/or limits change over time, historical report-to-report factors can mis-represent future development. Similarly, if the attributes of loss events or the handling of the resulting claims changes, analyses may be led astray.

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2 Michael A. Walters and François Morin, "Catastrophe Ratemaking Revisited (Use of Computer Models to Estimate Loss Costs)," Casualty Actuarial Society Forum Winter 1996, pp. 354-355.

3 "The basic objection to the simple methods is that they pay no regard to the theoretical foundations. Close examination will show that even apparently intuitive projections have some underlying model on which they are founded. .... (The chain ladder [triangular] method, for example, has been particularly subjected to such criticism.)" from the Claim Reserving Manual (2/89) of the UK Institute of Actuaries, p. D2.1.

We all know the various techniques that have been developed to deal with many of these aberrations in the data. However, there are other problems that are not resolvable within a triangular format.

Triangular analysis relies on a continuing flow of large numbers of relatively small loss events, the emergence and payment patterns of which do not change materially (or change predictably) over time. The first and most obvious case when the method fails is when there have been few, if any, similar losses in the past and a new type of loss emerges out of nowhere, or, more commonly, out of a report on a television news show. An example of this might be a surge in suits after an exposé on possible side effects of vaccines. The recent significant increase in silicone breast implant claims following a few successful lawsuits and increased publicity is another example.

The emergence of these losses tends to be on a calendar-year basis, reflecting the elapsed time since the initiating event rather than the underlying occurrence. For example, after a TV program on vaccines (the initiating event), claims might be equally likely from a family with a child who was recently vaccinated as from one with a child who was vaccinated five years ago. If the "occurrence" for purposes of triggering the policy is the onset of disability following the vaccination, then the accident-year age of the policy is irrelevant, and only the time since the initiating event is important. In this case, history provides no guidance, since the same forces are acting on all accident years simultaneously. (See Appendix A.)

Even if the claims emerge relatively slowly over time, triangular analysis may still fail. This is frequently due to a lack of correlation between a discrete occurrence and the accounting for the loss. Asbestos-related bodily injury is an example of this type of loss. Asbestos claims did not emerge full-blown after a single initiating event; instead, claim activity increased gradually from the first claims in the early 1970s. In the case of mesothelioma, it could be argued that, if the accident date were defined as the date of first exposure to asbestos, then some triangularization might be possible after adjustment for changing levels of exposure. This is due to mesothelioma's relatively well-understood latency period and the fact that it is less subject to reporting manipulation than the other asbestos-related diseases (since it is a signature disease of asbestos exposure).

However, the courts have not been that kind to actuaries. Instead, they have generally allowed all policies from the date of first exposure to the manifestation of the disease to be triggered. In this case, the cost of a claim might be recorded in any year -- or spread across all of these years -- making report-to-report analysis meaningless. (See Appendix B for an example.)

Triangular analysis shines where the losses can be described as "high frequency and low severity." It becomes more difficult when the losses are "low frequency and high severity" (as might be the case for excess medical malpractice or other excess liability coverages). It fails completely when the losses are either very rare or have never occurred before. Most natural disaster modelling falls in this category, as the timespan of recorded claim activity may not be long enough to capture the full impact of the tail of the severity distribution.

Although the CAS Ratemaking Principles require that "consideration ... be given to ... prospective changes in claim costs, claim frequencies, exposures, expenses, and premiums,"[4] traditional methods may fail in the face of those prospective changes. This occurred in the analysis of potential claims from leaking underground storage tanks (LUST). In 1988, the US Environmental Protection Agency (EPA) published regulations with future effective dates regarding financial responsibility, release detection, and

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4 "Statement of Principles Regarding Property and Casualty Insurance Ratemaking (As Adopted May 1988)", CAS 1996 Yearbook, p. 239.

corrosion protection. The official effective dates varied with the tank owner's business, volume of throughput, and age of the tank; due to differences in enforcement at the state level, actual effective dates varied even more. All of these had the potential to affect claims activity to greater or lesser extents. For example, the installation of release detection devices could reasonably be assumed to create a surge in claim reporting activity as old leaks were discovered. In addition, once detection devices were in place and existing leaks had been dealt with, claim severity was expected to decrease, since more leaks would be detected before they spread widely. As a result of the many future changes, LUST ratemaking for most tank populations requires unusually intricate simulations in the PEBLE.

The Emergence of PEBLE Techniques

With the exception of the very infrequent loss situation, all of the above examples are of relatively recent origin. It might be argued that a visceral understanding of the potential for very infrequent natural disaster losses to occur is also a relatively recent phenomenon resulting largely from Hurricane Andrew.[5] Thus, it is hardly surprising that, if a new class of insured losses appears, techniques will be developed in order to deal with them appropriately.

The increasing popularity of PEBLEs also corresponds with the emergence of cheap computing power.[6] PEBLES are frequently (although not always) very machine intensive, requiring megabytes of RAM and gigabytes of storage to be practical. In earlier days,

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5 "[Andrew] awakened some larger companies to the fact that their reinsurance protection against catastrophes was far from adequate. (It's only when the tide goes out that you learn who's been swimming naked.)" (Warren E. Buffett, Berkshire Hathaway, Inc. 1992 Annual Report, p. 10.)

6 Stephen W. Philbrick, "Catastrophe Modelling – Taking the Country by Storm," TopCat News (March 1996), p.4.

computing power of this magnitude was limited to mainframes, and access to mainframes tended to be relatively limited and relatively expensive.[7] Future PEBLE expansion will no doubt evolve in step with the available desktop machine power.

PEBLEs and Principles

PEBLEs are compatible with the CAS loss reserving and ratemaking principles even though these principles were articulated in the context of US actuarial practice, which tends to rely on the historical development of insurance data.

The CAS Loss Reserving Principles state that:

> An actuarially sound loss reserve for a defined group of claims as of a given valuation date is a provision, based on estimates derived from reasonable assumptions and appropriate actuarial methods, for the unpaid amount required to settle all claims, whether reported or not, for which liability exists on a particular accounting date. .... *Selection of the most appropriate method of reserve estimation is the responsibility of the actuary.* [Emphasis added.][8]

The CAS Ratemaking Principles are even more explicit:

> A number of ratemaking methodologies have been established by precedents or common usage within the actuarial profession. *Since it is desirable to encourage experimentation and innovation in ratemaking, the actuary need not be completely bound by these precedents.* [Emphasis added.] .... Historical premium, exposure,

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7 Of course, PEBLEs were done on mainframes. However, the wide availability of powerful and relatively inexpensive PCs widens the potential pool of model developers and users.

8 "Statement of Principles Regarding Property and Casualty Loss and Loss Adjustment Expense Reserves (As Adopted May 1988)," CAS 1996 Yearbook, pp. 231 and 236.

> loss and expense experience is usually the starting point of ratemaking. This experience is relevant if it provides a basis for developing a reasonable indication of the future. Other relevant data may supplement historical experience. *These other data may be external to the company or to the insurance industry and may indicate the general direction of trends in insurance claim costs, claim frequencies, expenses and premiums.* [Emphasis added.][9]

The importance of the underlying policy terms is clearly recognized by the Statement of Principles Regarding Property and Casualty Loss and Loss Adjustment Expense Reserves. One of its important "Considerations" is: "A knowledge of the general characteristics of the insurance portfolio for which reserves are to be established also is important. Such knowledge would include familiarity with policy provisions that may have a bearing on reserving, as well as deductibles, salvage and subrogation, policy limits and reinsurance."[10] (The Ratemaking Principles include a similar consideration on p. 239.)

Generic Description

In its most basic form, PEBLE consists of comparing an event outcome to the applicable policy terms in order to produce an estimate of the insured loss.

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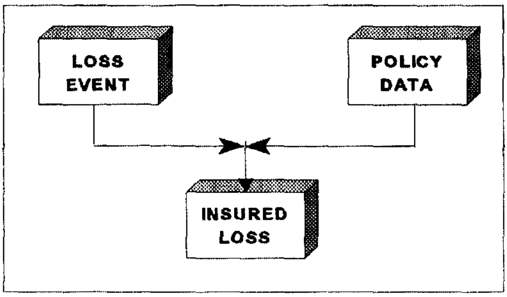
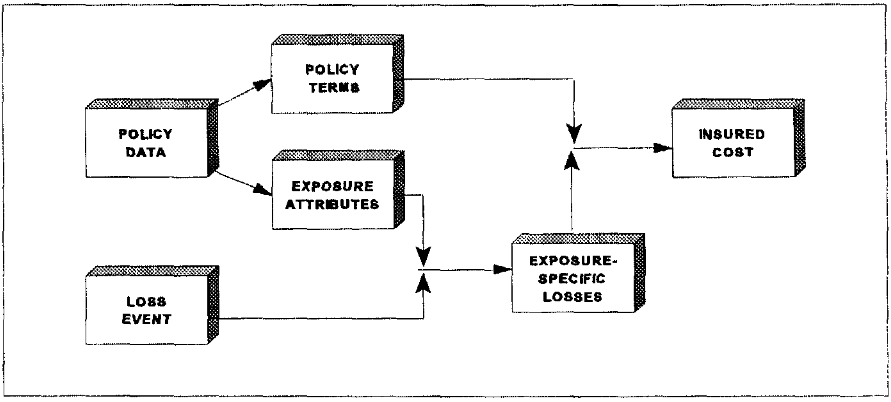
9 "Ratemaking Principles," p. 238.

10 "Loss Reserve Principles," p. 232.



However, in addition to the policy terms, the policy database usually supplies information on the attributes of the exposure (e.g., location, name of insured) that interact with the characteristics of the loss event to generate an exposure-specific loss amount. (In catastrophe models, this is called the damage module.) It is the comparison of this amount to the policy terms that determines the insured cost.



The relative size and complexity of the various modules depend on the loss peril being modelled. In natural disaster models, the event and loss amount modules are much more complex than the insured cost module; in pollution models, the opposite is true. The relationship reflects both the level of understanding of the loss event and the issues in policy allocation. In hurricane modelling, a great deal of meteorological information regarding past storms and storm behavior is available, along with engineering data on damageability, while the allocation of losses to policy is relatively simple due to the discrete nature of the loss. On the other hand, information regarding the underlying cost of pollution cleanups and its distribution among insureds is still developing and comparatively limited. The relative simplicity of the pollution loss event module is more than offset by the intricacy of the allocation module, which must be constructed to deal with multiple potential allocations across multiple years.

Because most are, PEBLEs are often assumed to be stochastic, but this is not necessarily true, as can be seen from their use in disability income reserving (see later). A stochastic PEBLE allows explicit consideration of process variance. This is especially important when the policies under consideration have high attachment points. In this case, the use of a deterministic average loss may seriously understate the potential average exposure to the higher layers. Implementation of the win factor in a pollution analysis as a deterministic multiplier rather than a stochastic culling of losses retains the correct average loss but understates the variability.[11]

[11] A pollution win factor decides whether the insured wins its coverage case against its insurer or not. It can be implemented as a multiplier of the pre-win factor loss (after allocation to layer) or as a random selector of losses to be completely removed (culled) from the results because coverage was denied. While the latter is more realistic, the former decreases the number of trials needed to reach a stable average for high layer coverages without changing the expected mean.

The distinction between deterministic and stochastic can be somewhat arbitrary: Although technically deterministic, the output of an asbestos model that is run for all possible values of underlying limits is indistinguishable from a model that is stochastic over that variable.

Stochastic PEBLEs need to address the intertwined issues of tails and number of trials. Especially when continuous (as opposed to empirical) distributions are used for some variables, care must be taken to run enough trials that the tails of the distributions are adequately sampled. Depending on the shapes of the distributions, a stable mean result may appear before the tail results are fully explored. Stratified sampling may be warranted, especially if the potential variability of the results is as important as the average result.

Loss Events

As noted above, modelling of loss events may be relatively straightforward (e.g., sampling from a single cost distribution) or very complicated (e.g., simulation of the attributes of a hurricane). In most cases, this module relies on work done outside of the insurance industry, for example, by meteorology researchers, by EPA contractors, or by the medical community (in the case of silicone breast implants).

Where multiple loss events are involved, one must consider correlations among the events. For example, hurricane paths within a single year may exhibit a clustering effect, having a greater tendency in that year towards moving up the US east coast versus moving into the Gulf of Mexico. Liability-based losses frequently occur in a "feeding frenzy" pattern, with a series of successful suits each increasing the likelihood that more suits will be filed.

Another important characteristic of the liability-based loss events is the "propensity to sue" adjustment. People whose homes have been blown away rarely neglect to file a claim, but even in cases of mesothelioma, where a significant award is virtually certain, not everyone will file a suit. Factors affecting the propensity to sue are not well understood, so it is usually incorporated as a simple multiplier, perhaps differing across broad types of exposure.

Underlying Losses

The underlying losses (i.e., exposure-specific losses before application of policy limits, deductibles, and other terms) are created by the interaction of the attributes of the loss event and the attributes of the exposure. This interaction may affect either frequency, severity, or both. For example, a hurricane will create different underlying losses depending on a dwelling's building materials. Likewise, the same hurricane will affect similarly constructed buildings differently depending on their locations, since one may be further from the coast and the average windspeed may have decreased by the time the storm reaches the inland structure.

Although it is sometimes said that trailer parks attract tornados, it is rarely argued that high-priced dwellings selectively attract hurricanes. On the other hand, it is reasonable to assume (but difficult to quantify) that larger petrochemical corporations will be exposed to more dumpsites than smaller ones. Similarly, certain types of manufacturing (e.g., petrochemicals) can be reasonably assumed to have exposure to more waste sites on average than, say, clothing manufacturers. Clearly, the larger manufacturers of asbestos-containing products are attracting more bodily injury claims than the smaller companies. Thus, frequency, as well as severity, can be a function of the exposure.

Like the loss event module, the underlying loss module frequently incorporates non-insurance expertise and/or data concerning, such as structural damageability, the differential effects of various types of asbestos, or EPA information regarding the PRP status of various corporations.

Insured Losses

The insurance module applies the terms of the applicable policy or policies in order to determine the insured loss. Since most actuaries are familiar with the operation of policy limits and deductibles (attachment points), this would seem to be relatively straightforward. Even in the case of natural disaster models, this view neglects the fact that usable individual policy data (or even exposure profiles) has only recently become widely available. Reinsurers and rating agencies have been instrumental in forcing insurers to develop the required exposure databases.

The problem of policy data availability is even worse in the case of latent toxic torts, where the policies in question may have been written before company operations were computerized. In addition, like all other records, policy data is routinely purged. Where available, policy data on old policies is likely to be incomplete or poorly recorded (e.g., as text fields). In these cases, some policy limits and/or attachment points will have to be simulated. It is important to note that the estimated losses may be very sensitive to both the average and the distribution of these policy terms. Before extensive simulation is used for policy terms, the possibility of completing the data should be explored.

In the case of liability-based exposures, estimation of insured losses from exposure-specific losses is difficult even if perfect policy data has been supplied. The estimation must take into account the possibility of different allocations across multiple years with widely variant policy terms, as well as the possibility that coverage will be denied. The latter is particularly important in estimating pollution losses. Even where an allocation to year has been selected, interaction of occurrence and aggregate limits and deductibles, differing expense treatments, drop-down clauses, and other common policy terms can require complicated programming.

Simplified Cases

The most basic PEBLE of reported claims is the total of the claim department's case reserves. On the other hand, the definition does not require that a policy-based loss estimate developed from another source be a case reserve. For example, a PEBLE might rely on completely simulated loss events (e.g., hurricane modelling) or simulated attributes for known loss events (e.g., pollution reserving). In these cases, the resulting loss estimates would not be appropriate for use as case reserves even though they are on a policy-by-policy basis and appear to be the functional equivalent of case reserves. PEBLEs as discussed in this paper are not expert systems for the claim department and are not intended to replace claims adjusters.

Going beyond the hands-on area of case reserves to the actuarial domain, it may appear that PEBLE is something new. However, PEBLE is actually very old, as it was and is the primary method for setting disability income reserves. In this case, the event module is reduced to the known duration-to-date of a disability-inducing event that has already occurred. The attributes from the policy database that combine with this to estimate the underlying loss cost (referred to as the probability of recovery) are age at disability, type of contract, and elimination period (deductible). This is then combined with the net present value of the policy benefits and multiplied by the probability of claim denial to calculate the reserve. In the case of life insurance reserves, the event module is reduced to a certainty.

Not surprisingly, tabular reserving for workers' compensation can be described in essentially the same way.

The derivation of increased limit factors (ILFs) and much of reinsurance analysis can also be considered to be somewhat simplified PEBLEs. Here, the loss module is simplified to the empirical or fitted distribution of underlying losses for the line of business under consideration. The attachment point and limit of the coverage are part of the ILF analysis, although these techniques do not generally reference individual policies. This is in contrast to the "new" PEBLEs, which are distinguished by the use of individual policy terms from an entire book of exposures, as opposed to the use of a generic attachment point or limit (e.g., "all losses greater than $25,000 and less than $1,000,000").

These PEBLE applications have very simplified loss event modules and few steps between the event and the result. The fact that they are entirely uncontroversial highlights two of the primary sources of unease about the "new" PEBLEs: their use of intricate, non-insurance based loss event modules; and their implementation through "black box" computer programs.

Issues in Using PEBLEs

There are several issues that are inherent in the use of PEBLEs and may lead to some reluctance to accept the result of the modelling. These include:

<u>External Processes and Data</u>

Much of the discomfort with respect to PEBLEs is concentrated in the loss event module. There are two reasons for this. First, loss event modules are frequently based on data developed outside of the insurance industry. Second, PEBLEs tend to deal with types of losses about which there is relatively little information, regardless of the source.

The actuarial literature does not deal with firewall movement in off-center automobile crashes, the relationship of central pressure to windspeed in Atlantic hurricanes, the demographics of drywall installers, or the migration of contaminant plumes in groundwater. We are not disadvantaged by the first of these omissions due to the abundance of private passenger claim data, but the others are emerging as more important. This creates two problems: (1) We have to rely on experts in other technical fields in developing our estimates. If we rely on incompetent "expert" advice, our estimates may be biased or completely wrong even if the insurance section of the model is completely correct. If it is very technical, the flaw may be invisible. (2) Because of the amount of (the frequently quite technical) outside material that must be studied, understanding of the relevant issues tends to be concentrated within the actuarial profession. This limits the number of actuaries who can deal knowledgably with a given issue; more importantly, it restricts the number who can usefully critique the work of the practitioners and contribute to the expansion of knowledge of the problem.

The expertise issue is a problem especially if there is relatively little hard data or experts disagree widely. This is the case, for example, with the estimation of future LUST discovery patterns. By definition, the 1998 regulations have never been implemented before. Anecdotal information can be gathered regarding the likely number of recalcitrant tank owners who are still not in compliance with earlier technical regulations but will bring their tanks into compliance in 1998 (and therefore discover leaks then). However, this sort of "soft" data is often a function of the source and should be viewed in the context of other related data.

In addition to non-actuarial expertise, significant amounts of external data may be required, the collection and maintenance of which can be both time-consuming and expensive. The data may not be practically arranged and, even where the original data source is considered to be reliable, the required "massaging" may introduce errors. To the extent that the data was not originally developed for modelling purposes, it may be inappropriate, biased, or incomplete. If claims have been reported, claims specialists can be a valuable and familiar source of information. However, the claims reported to date may be an inadequate sample from the universe of possible events. In the case of future changes in the external environment, reported claims may be unrepresentative of the future population.

"Black Box"

As Greg Taylor noted with respect to regression models, PEBLEs do not "... have the 'hands on' nature characteristic of methods based on age-to-age factors, for example, with which actuaries tend to feel at ease. There is a feeling of abstractness and loss of control .... "[12] Because of the "black box" nature of most PEBLEs, this reaction is well founded.

Actuarial standards of practice require that an actuarial report provide sufficient documentation that another actuary can replicate the work and confirm the conclusions. This is a problem when several hundred lines of computer code and multiple random number generators separate the input and output. The problem is exacerbated when the details of the model, the external data, and even some of the parameter selections are considered by the modeler to be proprietary.

While no standards for this situation are in place, pragmatic responses have emerged. Second opinions and methodology reviews are common. Assuming that the computer

[12] Greg C. Taylor, "Regression Models in Claims Analysis I: Theory," *PCAS* 1987, p. 354.

programs are correct (see later), the descriptions of them are accurate and sufficiently complete, and broad ranges for the parameters are supplied, experienced practitioners can generally reach an opinion regarding the likely overall appropriateness of the result. This is particularly true if a "benchmark" output or other information (e.g., survival ratios) is available. However, this is clearly an area that will require further attention as the use of PEBLEs and other intricate computer models such as dynamic financial analysis (DFA) become more widespread.

Validation and Usability

The use of any model, including PEBLEs, raises issues of validation and usability, where "validation" is only possible if losses of the type modelled have occurred, as is the case for natural disaster models.

Components of the model can and should be tested separately against individual events and for reasonableness overall. Validation should include consideration of the credentials of the outside sources used.[13] After the component parts of a model have been tested, it can be set to estimate the losses from a single storm with parameters matching a recent storm (to avoid significant changes in exposure) and the results compared to the actual losses. Because every event is unique, it is important to avoid over-calibration of the model.[14]

It is possible that the current review of catastrophe models by state regulators may provide additional guidelines for model validation.

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13 Walters and Morin provide a validation checklist in their Appendix C.

14 Karen M. Clark, "A Formal Approach to Catastrophe Risk Assessment and Management," *PCAS* 1986, p.87.

When PEBLEs are used for classes of losses that have not yet occurred or are likely to change significantly in the future, validation is not possible, and usability is the best that the actuary can achieve. In this case, the credentials of outside sources can be reviewed and their input independently confirmed, if possible. The overall structure of the model can be reviewed by others knowledgable in the field. Claims or legal specialists in the modelled type of loss are helpful for this step. While they frequently are unable to supply full distributions for the various parameters, they can provide insights on the distributions developed by the actuary.

Estimates are often needed where information is very sparse, but data-free analyses make actuaries nervous. The issues are whether the ranges of the parameters are sufficiently narrow to allow some analysis to proceed, and whether the true uncertainty in the resulting estimate can be conveyed to the end user. If the uncertainty is clearly disclosed, even in the absence of technical confidence intervals, sophisticated end users frequently find meaningful ways to incorporate the information. For example, acquisitions of property/casualty insurers generally proceed even in the face of wide ranges of estimates of potential toxic tort exposures.

In the end, the decision regarding the usability of a given model is subjective and rests ultimately with the decision maker. The question of when the input and output ranges become sufficiently refined to be "usable" is a function of the intended use. For example, the range of results may be so wide that, in the user's opinion, the loss is not "estimable" in the sense of FAS 5, even though the model provides important information in scenario comparisons. Alternatively, the results may be partly usable. This was the case in 1992-93, when the SEC began to indicate to insurers that, even if the upper end of the potential pollution losses could not be estimated, it was the SEC's opinion that reasonable low estimates could be formed (and it was the SEC's *a priori* expectation that, for exposed companies, zero was not a reasonable low estimate).

In evaluating usability, it is important to remember that PEBLEs do not need to reproduce individual case reserves exactly (or, in some cases, even remotely) in order to be either usable or valid. Storms and courts of law are both fickle, and PEBLEs are intended to provide reasonable aggregate loss estimates, not replicate micro-scale behavior.[15]

Quality Assurance

There are well-developed quality-assurance and de-bugging techniques for computer programs, in which most actuaries are completely untrained. This introduces yet another reliance on outside expertise and a significant interface problem. The model may do exactly what the programmer wants, but is that what the actuary wanted? This is not a new problem, although the intricacy of the models increases the risk.

Specific applications may require adjustments to the model. However, this tinkering tends to introduce errors into the code. One way to reduce this is to hardcode as little as possible, parameterize everything, and make the parameter files the responsibility of the user. To the extent that changes "on the fly" are required, Murphy's Law is always in force, and only continuing reasonableness checks can provide the necessary control.

Parameterization

It is possible to over-parameterize a PEBLE model. This stems from trying to closely replicate either actual losses or the details of the loss process as it becomes better understood. In both cases, the resulting model can become too sensitive and too intricate. Clearly, all major components of the ultimate loss should be included and refined over time. However, the fine line at which "better" becomes "too much" is not always clear.

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[15] Walters and Morin, p. 369.

There is a tendency to assume that model variables are independent. However, the goal of avoiding an overly sensitive model should not deter recognition that some of the selected variables may be correlated (e.g., wall thickness and tank capacity in underground tanks). If two variables are included and the correlation is considered significant, the model will have to be structured to link the two variables in order to rule out unrealistic outcomes.[16]

The issue of parameterization is closely linked with the issues of usability and cost. In the context of statistical models, Steve Philbrick notes that:

> [g]enerally speaking, increasing sophistication of the model produces more accurate results. The selection of an appropriate model for a particular problem requires deciding whether the increased accuracy of the more complex model justifies the increased costs associated with it. Furthermore, in many situations, the available data may be sparse or subject to inaccuracies. In these instances, a simple model may be preferred because the accuracy of results will not be materially improved by the use of a more complex model. .... There may be a need to explain the loss projection process to people without extensive actuarial or statistical training. Although techniques should not, in general, be dictated by the sophistication of the audience, if competing models produce almost identical results, the ease of explanation of one may be an important consideration.[17]

[16] In his 1995 discussion paper, Sholom Feldblum makes the point that, in some cases, "... individual factors are strongly correlated one with another, [and so] only a relatively small group of possible 'simulated' outcomes are realistic." He concludes that, in these cases, scenario testing is more appropriate and informative than stochastic modelling. (Sholom Feldblum, "Forecasting the Future: Stochastic Simulation and Scenario Testing," CAS 1995 Discussion Paper Program, p.158.)

[17] Stephen W. Philbrick, "A Practical Guide to the Single Parameter Pareto Distribution," *PCAS* 1985, pp. 45-46.

The British Institute of Actuaries states the tradeoff even more bluntly: "A trap to avoid is clearly that of indulging in mathematical sophistication for its own sake, without regard to the business needs."[18]

Cost / Benefit

PEBLEs tend to be expensive to develop and maintain. In deciding whether to use a model of this type, an insurer needs to weigh the cost against the benefits (e.g., improved management information, better rating). Cost/benefit analysis should also be applied to the source of the model. A large insurer may find it advantageous to build their models in-house, as this may generate greater internal acceptance. Because of the resource commitment required, however, smaller companies may prefer to use the model of an outside vendor that is able to amortize the development costs over several users.

Updates

After a PEBLE model has been completed and put into use, the question of updating both the model and individual results (e.g., Texas windstorm rates) arises. Cost considerations frequently create a certain inertia in this process, but, in some cases, updates are clearly indicated.

The first of these is significant change in the exposed business. This might include changes in underwriting guides (e.g., beachfront property becomes acceptable), policy terms (e.g., replacement cost instead of actual cash value coverage), or reinsurance (e.g., treaty attachment points are increased). Interestingly, even "old" exposures are subject to this sort of change as commutations and policy buyouts become more common.

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18 Institute of Actuaries, p. D2.2.

The second is significant change in the loss process or an important parameter, requiring changes in the structure of the model or revised parameter selections. This category might include notable external events, such as the enactment of Superfund reform, collapse or expansion of the Georgine asbestos settlement, or new information on global climate change. The changes can also be gradual, as, for example, claims handling practices or court decisions evolve over time. In the latter case, the point at which a "usable" model becomes "unusable" and an update is required may be not be clear.

The third clear reason to update is the availability of significant new data, even in the absence of other changes. This is especially true of the "old" toxic tort exposures, where there is frequently an on-going process of data entry in the claims department, including both new claims and additional data on known claims.[19]

Advantages of PEBLEs

Despite the difficulty of developing them, PEBLEs have important advantages even when other methods (such as claim department case reserving) are available. These include:

- Clarity – Although the details are frequently obscure, the overall structure of most PEBLE models is generally intuitive and easily communicated. This is not always the case with statistical or even triangular analysis. Unlike statistical techniques,[20] every part of a PEBLE model has a real world analog.

- Better understanding of the loss process -- Constructing the model inevitably improves understanding of the problem. This contributes to better management of

19 Reconciliation between reviews can be very difficult in this case, as the revisions may include changes to the prior data (different names, dropped claim records, etc.).

20 Taylor, p. 359.

the exposure and improvement in the estimation process. In addition, since all PEBLE models for a given exposure are attempting to measure the same process, this is likely to lead to convergence of results from different models.

- Documentation of changes – Unlike the diffuse (but more accurate at an individual exposure level) process of case reserving, PEBLEs facilitate documentation of overall changes. For example, a change in the estimated costs of Superfund sites might lead to adjustments in hundreds of case reserves. While clearly documented at the individual file level, these are difficult to compile and explain in aggregate.

- Scenario testing -- What if a force 5 hurricane hit New York? What if the New Jersey Supreme Court decided to impose a manifestation allocation on all sites with coverage litigation in New Jersey? PEBLE models can provide valuable insights on alternative scenarios. This may be true even if significant uncertainty remains in the estimates.[21]

- Understanding variation – Creating the distributions to be used for the parameters in stochastic models forces explicit consideration of the potential range of variability and the skewness in the distributions. The resulting variability in the output can be checked for reasonableness against intuitive expectations, recognizing that past experience may not always provide an adequate indication of potential outliers.

Virtually every discussion of stochastic models makes note of their usefulness in estimating process risk. Less attention is paid to the measurement *and*

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21 A similar situation is noted by James Stanard and Russell John in the introduction to their paper on "Evaluating the Effect of Reinsurance Contract Terms" (*PCAS* 1990, p. 2): "In many reinsurance pricing situations it is not possible to determine a 'correct' *absolute* price without making a large number of tenuous assumptions. However, it is often advantageous to make some general statements about *relative* price adequacy. By *relative* price adequacy we mean statements ... such as ... Deal #1 is better than deal #2."

communication of either parameter risk or model specification risk.[22] The former can be partially attacked by the brute force method of testing multiple versions of each parameter or creating a "meta-model" that randomly selects a distribution for each parameter and then runs the model. However, the worst outcomes may arise from an unsuspected (and therefore untested) correlation between two variables. Due to the cost of model construction, it is likely that, in the absence of "duelling models," model specification risk will remain untested.

More Examples

As noted earlier, PEBLE is also useful in the analysis of auto extended warranty, where the length of the warranties and the turnover of car models prevents the accumulation of a sufficiently long period of relevant historical data. In his paper on these models,[23] Roger Hayne notes that "[t]he primary value of these emergence models is that they can provide insight as to relative loss differences under various situations. ... These models can also be useful in providing insight into the influence of various factors on the overall cost...."[24]

PEBLE applications are not restricted to the examples above. The variety of auto no-fault implementations led to the development of PEBLE-based comparisons in the 1993 paper by Herbert Weisberg and Richard Derrig.[25] The authors specifically note the need for

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22 Roger M. Hayne, "A Method to Estimate Probability Levels for Loss Reserves," Casualty Actuarial Society Forum, Spring 1994, Volume One, pp. 299-300.

23 Roger M. Hayne, "Extended Service Contracts," *PCAS* 1994, pp. 243 - 302.

24 Hayne, *PCAS* 1994, p. 268.

25 Herbert I. Weisberg and Richard A. Derrig, "Pricing Auto No-Fault and Bodily Injury Liability Coverages Using Micro-Data and Statistical Models," Casualty Actuarial Society Forum Special Edition 1993 Ratemaking Call Papers, pp. 103-153.

additional data on both the underlying loss process (i.e., the injured claimant) and its characteristics relative to the policyholder.

Workers compensation has drawn two PEBLE analyses in papers by Venter and Gillam,[26] and Graves.[27]

Many more PEBLEs are in use but have not been documented in the literature. These include models for residual value insurance, mortgage insurance, a stochastic implementation of Chuck Berry's paper on retro reserves,[28] and a super-PEBLE DFA model.

Regardless of how inexpensive desktop computing power becomes, It is unlikely that PEBLEs will ever be the approach of choice for most actuarial problems. However, where the past is an inadequate guide to the future, PEBLE may be the best -- or the only -- method available. When looking out of the back window of the car doesn't work,[29] build a virtual highway.

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26 Gary G. Venter and William R. Gillam, "Simulating Serious Workers' Compensation Claims," Casualty Actuarial Society 1986 Discussion Paper Program, pp.226-258.

27 Gregory T. Graves, "On Pricing Multiple-Claimant Occurrences for Workers' Compensation Per-Occurrence Excess of Loss Reinsurance Contracts," Casualty Actuarial Society 1990 Discussion Paper Program, pp. 217-236.

28 Charles H. Berry, "A Method for Setting Retro Reserves," *PCAS* 1980, pp. 226-238.

29 "An insurance company is just like a car with a fogged-up windshield. The president is steering, ..."

Sudden Initiating Event

Incremental Reported Claim Counts

AY	12 mos	24 mos	36 mos	48 mos	60 mos	72 mos
1990	0	1	0	3	60	30
1991	1	0	2	60	30	
1992	0	4	80	40		
1993	2	30	15			
1994	40	20				
1995	60					

Initiating event occurs in late 1993.
Assume no claims are reported after 1995.

Cumulative and Final Reported Claim Counts

AY	12 mos	24 mos	36 mos	48 mos	60 mos	72 mos
1990	0	1	1	4	64	94
1991	1	1	3	63	93	
1992	0	4	84	124		
1993	2	32	47			
1994	40	60				
1995	60					

Report-to-Report Factors

AY	12-24	24-36	36-48	48-60	60-72	72-84
1990	-	1.00	4.00	16.00	1.47	
1991	1.00	3.00	21.00	1.48		
1992	-	21.00	1.48			
1993	16.00	1.47				
1994	1.50					
1995						
Indicated Factors	6.17	6.62	8.83	8.74	1.47	
Correct Factors	1.00	1.00	1.00	1.00	1.00	

Note: Claim amounts are entirely fictional and are not intended to represent a particular type of loss.

Appendix A

Multiple Occurrence Years

Claim #1 Incurred Loss ('000)*

AY	12 mos	24 mos	36 mos	48 mos	60 mos	72 mos
1990	0	0	0	0	20	20
1991	0	0	0	20	20	
1992	0	0	20	20		
1993	0	20	20			
1994	20	20				
1995	0					

Total Incurred Loss ('000)

AY	12 mos	24 mos	36 mos	48 mos	60 mos	72 mos
1990	0	0	30	30	50	50
1991	0	30	30	50	50	
1992	30	30	50	50		
1993	0	20	20			
1994	20	20				
1995	0					

Claim #2 Incurred Loss ('000)*

AY	12 mos	24 mos	36 mos	48 mos	60 mos	72 mos
1990	0	0	30	30	30	30
1991	0	30	30	30	30	
1992	30	30	30	30		
1993	0	0	0			
1994	0	0				
1995	0					

Report-to-Report Factors

AY	12-24	24-36	36-48	48-60	60-72	72-84
1990	-	-	1.00	1.66	1.00	
1991	-	1.00	1.66	1.00		
1992	1.00	1.66	1.00			
1993	-	1.00				
1994	1.00					
1995						
Indicated Factors	1.00	1.22	1.22	1.33	1.00	
Correct Factors	1.00	1.00	1.00	1.00	1.00	

** Both claims are assumed to be correctly reserved when first reported. Claim #1 ($100,000) is reported in 1994 and recorded in AY 90-94; claim #2 ($90,000) is reported in 1992 and recorded in AY 90-92.*

Note: Claim amounts are entirely fictional and are not intended to represent a particular type of loss.