A Systems Dynamics Approach to Business Interruption Risk

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The commercial property insurance industry has become increasingly alarmed over the risks involved in insuring business interruption. Business interruption coverage is designed to cover the foregone profits and extra expense incurred following an insured loss. Coverage is provided until the insured has recovered to pre-loss levels, thus a BI loss could potentially go on for years. Due to business reengineering practices such as "just-in-time," the potential exposure has grown substantially in recent years. A recent example is a large Japanese automaker, which had a loss in Feb. 1997 estimated to be in the neighborhood of $320 million. Decreased inventory levels, sole-sourcing, and reduced make-up capacity are a few of the risk factors which have been accentuated by just-in-time changes. Complex interdependencies between various locations within companies produce a "ripple effect" when a loss occurs. When a loss does occur, a company will attempt to minimize the effect of the loss, including shifting manufacturing to the products with the highest profit margins (when this is prudent) and buying materials on the market to honor sales contracts. The business interruption loss is calculated as the lost profits which would have been made, according to forecasted sales, as well as any extra expense involved in trying to mitigate the effect of the original loss, up until the time at which the company has rebuilt the capacity to sell at the forecasted levels.

It is perhaps not surprising then, after taking all of these factors into account, that the commercial property insurance industry has not had a good method of predicting the expected BI loss in the past. To determine the *expected* BI loss, one would also need to have accurate estimation of probabilities associated with the frequency and severity of losses as well as downtimes and recovery periods following a loss. Often the underwriter will investigate the *Maximum Foreseeable Loss* scenario, that is, a "worst case" scenario, which is in fact not the absolute worst case in which everything is lost, but rather a scenario which is assumed to only occur if all protection systems fail - generally a loss whose probability of occurrence is quite small, usually .01 or less on an annual basis. These MFL studies are fine, except that they only represent one point in the whole probability distribution of BI losses. After the MFL study, the mathematical basis for pricing insurance rates falls apart considerably, with one perhaps taking a small fraction of this MFL as the desired premium, with no appeal to the actual probability distribution involved.

A Systems Dynamics Approach

In order to develop a better model, a natural approach is to try to build a model which would simulate the same processes that are used when evaluating a BI loss, in order to estimate the probability distribution of BI loss. That is, a model of the company is built which simulates product flow or cash flow, taking into account inventory levels (if they even exist after just-in-time practices have taken their toll,) interdependencies between locations, make-up capacity, seasonal demand, and market share. Once a working model has been built and validated, losses may be introduced at various locations, each loss having its own probability distribution for frequency and severity of loss, length of downtime (the time period during which no recovery can be made) and recovery period. The resulting BI loss is then calculated for each loss scenario. Typically, thousands of scenarios must be made in order to simulate over the whole range of the distributions involved. The simulated BI losses can then be examined to get an idea of the overall shape of the BI probability distribution (this same idea has been explored independently (Arthur, 1996.)) The incorporation of probability distributions as well as the focus on developing an "accurate" model for the flows, makes this application of systems dynamics different from applications where the emphasis is on the power of the model as a decision-making tool (Forrester, 1961.)

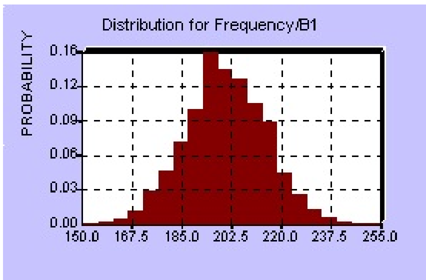
An Example

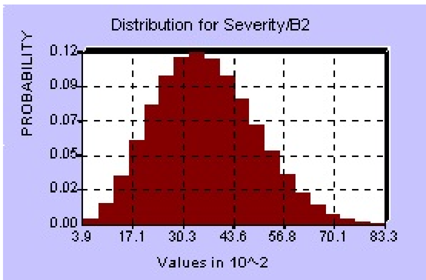
The following example is real, and concerns a nationwide product distribution system. Although the system is relatively simple in comparison with other possible systems, the data was available, and the customer had a potentially large BI risk which was not felt to be well understood, so it was a good candidate for the model. There are five main distribution centers in the USA, at which the product flows in and is sent to its destination by way of a vast network of handling centers and trucking operations. There is no transfer of product between the five centers, thus no interdependency. If one center should become inoperable, the other centers could accommodate the added demand and would eventually take up the overflow by hiring more workers. Even if the largest center were to go down, there would be an initial loss of profits from inability to deliver the product, but after the third week all of the product would be distributed, hence most of the BI cost would be in the form of extra expense due to new hires and overtime. Due to the vastness of the trucking and handling operations, it was not felt necessary to include these smaller facilities in the model. The market is very fickle, as prices are competitive, hence market share represents an important feedback mechanism in the model. Following a major loss, an advertising campaign would begin, in order to gain back lost market share, and the model allows for this effect of advertising.

To asses the probability distributions involved, the MFL study provided a benchmark, that is, one point on the BI distribution, and some assumptions had to be made about the actual shapes of the various distributions at each center. It should be mentioned that these assumptions, perhaps more than anything else, can have a dramatic influence on the resulting BI distribution. Each center has four distributions associated with it, so in all there were 20 probability distributions involved. The five centers were assumed to behave independently of each other, since they are spread out across the country, however there is probably some weak dependence, since the overflow from one center could increase demands on the other centers and affect their distributions as well. Below are diagrams of the distributions for the first center and the distribution for BI resulting from the model.

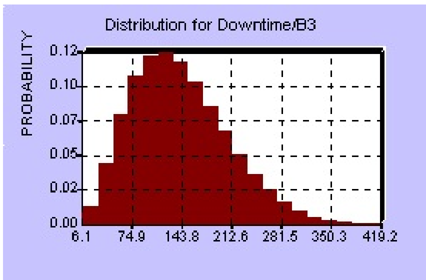
Center A:

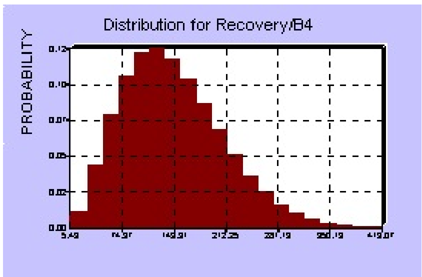
Frequency of Loss (years between losses) Severity of Loss (% of sorting capacity lost)



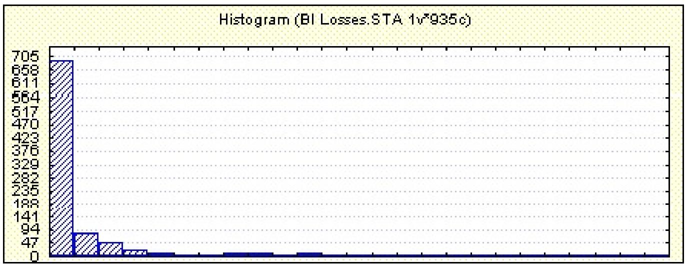


Downtime (days) Recovery Period (days)





Twenty such distributions were used as random inputs into the model, and the resulting BI computed over many simulations. The shape of the BI distribution appears below.



Conclusion

Once a convincing prototype model was initially completed, the next objective was to work with a few specific customers, collect the data, and try to then determine a general approach to determine the BI risk for all customers. The quest for product-line data has been frustrating, since many companies think in terms of net sales rather than net production, and hence do not keep track of this data. In the example above, product-line data was publicly available, but still did not differentiate by type of product, hence it represents more of an average product flow. Efforts in collecting financial flow data have been more fruitful, but still require diligent investigation with regard to interdependency flows and make-up capacities. Another problem exists in that companies are subject to change, so that the original model must be continually updated by someone competent in using systems dynamics software. Because companies typically do not try to estimate probabilities of losses, they often have no clue of how likely a particular scenario is, nor how they would specifically cope with such loss scenarios, thus it is difficult to get a good idea about the loss distributions involved. Because of the amount of time required to collect data, create a model, and keep it up to date, this particular approach does not seem to be a feasible option for all of our customers at this time. It may be more reasonable to try to develop a less sophisticated model which would apply to most customers, using financial information, while developing sophisticated systems dynamics models for the customers who pose the highest potential risk. The process of data collection in itself has proved to be an enlightening experience for the customer as well as the insurer, and questions relating to interdependency, make-up capacity, seasonality, and likelihood of loss will continue to be part of the service to our customers.

References

Arthur, W.B., Eberlein, R.L., 1996, Sensitivity Simulations*, Proceedings of the 1996 International Systems Dynamics Conference*, Vol. 1, P. 44, Cambridge, MA

Forrester, J. W., Industrial Dynamics, 1961, MIT Press, Cambridge, MA