CROSS-IMPACT METHOD

by

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CONTENTS

I HISTORY OF THE METHOD

The cross-impact method was originally developed by Theodore Gordon and Olaf Helmer in 1966. The method resulted from a simple question: can forecasting be based on perceptions about how future events may interact?

In their initial application of cross-impact principles, Gordon and Helmer developed a game for Kaiser Aluminum and Chemical Company in the mid 1960s called *Future.* The company produced many thousands of copies of the game and used them as promotional gifts in conjunction with its 100th anniversary. The game, which is long out of print, involved a series of cards, each depicting a single future event. The cards were given an *a priori* probability of occurrence, based largely on Gordon and Helmer's judgment. Then a die was rolled to determine whether or not, in the scenario that was being constructed, the event "occurred." In the game, the die was an icosahedron with numbers written on the faces to correspond to the probability that that face would be turned up. If the probability shown on the die face was equal to or greater than the event probability, it "occurred."

If an event occurred, the card was flipped over. On the back face of the card, the "cross impacts" were described: e.g., "if this event happens, then the probability of event 12 increases by 10 percent; the probability of event 53 decreases by 15 percent, etc." Brief reasons were given for the stated interactions, and a simple system was provided for keeping track of the evolving probabilities as the game progressed.

At the end of the game, one stack of cards represented events that had happened and another stack, events that had not. This scenario was, in fact, determined by chance, the predetermined probabilities and the cross impacts.

The game also provided players with the ability to "invest" in a favored item, simulating an R&D investment. This ability provided players a mechanism for exerting "policy," a means for them to bring about a desired future by thinking through possible cross impacts. The best strategy, for example, might be to invest in a secondary or tertiary event that would produce a favorable cross impact on the ultimately desired event.

Gordon and Hayward programmed the approach at University of California Los Angeles (UCLA, USA) in 1968. The conditional probabilities were expressed as impact coefficients and ranged from -10 to +10. The first programs played almost exactly like the *Future* game: events were chosen in random order, decided, and the probabilities of cross-impacted events then determined. One "play" was completed when all events were decided. (Gordon and Hayward, 1968) Then, in Monte Carlo[1] fashion, the process was repeated many times. The computer kept track of the number of

[1] "Monte Carlo" is the name of a technique that includes random chance in the forecast by including random sampling. It is often used in operations research in the analysis of problems that cannot be modeled in

scenarios that contained each event. This count of event "occurrences" was used to compute the final probabilities of the events, given their cross impacts.

The game appeared in many classrooms in the 70s, reworked to address the problems under study (e.g., urban crises). Gordon, Rochberg, and Enzer at The Institute for the Future experimented with a form of cross impact that included time series rather than "a slice of time" approach. Norman Dalkey used conditional probabilities in the matrix (1972). Helmer applied the approach to gaming (1972).

KSIM, a simulation technique developed by Julius Kane, was based on the expected interactions among time-series variables rather than events (1972). In this approach, Kane treated all of the variables as a percentage of their maximum value, and the cross impacts were used to adjust the variables in each time interval.

Turoff generated scenarios from the cross-impact matrix by assuming that events with probabilities less than .5 did not occur and those with probabilities equal to or greater than .5 did occur (1972). Duval, Fontela, and Gabus at the Battelle Institute in Geneva developed EXPLOR-SIM, a cross-impact/scenario approach (1974), and Duperrin and Gabus developed SMIC, a cross-impact approach that asks experts to provide initial, conditional occurrence, and conditional nonoccurrence probabilities and to form scenarios based on the cross-impact results (1974).

At The Futures Group, probabilistic systems dynamics was a joining of systems dynamics and a time-dependent version of cross impact, an approach first explored by John Stover in simulating the economy of Uruguay (1975).

A simulation method, called Interax (1980), that incorporated cross-impact concepts was developed by Selwyn Enzer at the University of California (USA). Ducos integrated Delphi and cross impact (1984).

Bonnicksen at Texas A&M University (USA), in a process called EZ-IMPACT, used the cross-impact approach in a workshop gaming application to explore policy options among contentious parties. His algorithm was based on Kane's approach.

Most recently, the cross-impact method has been applied to many research questions on a stand-alone basis or in combination with other techniques. Godet, for example, lists application of SMIC to subjects as diverse as aircraft construction, world geopolitical evolution, the nuclear industry

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closed form. In a Monte Carlo simulation, the values of independent variables are selected randomly and the equations in which these variables appear are run to achieve a single result. The process is repeated many times, perhaps thousands with the aid of a computer, each time with a new random selection of the values of the independent variables. This process produces a range of results of the dependent variables.

in 2000, and corporate activities and jobs to the year 2000 (Godet, 1993). Other contemporary examples include Brent Vickers in 1992 studying the European automobile industry, and Albert Schuler et al. studying the softwood lumber industry in Canada (1991). The threads running through all of this work is organized as follows:

- *Early exploration phase*: In initial attempts to collect judgments about the quantification of these interactions, researchers recognized that interactions among events constitute a powerful way to examine perceptions about the future.

- *Probabilistic phase*: How can the conditional probability questions be asked?

  When an expert is asked to provide judgment about the probability of an event, does he or she:

  (a) include the possibility of the cross impacts, *a priori*; or

  (b) are the events seen as standing alone?

  Given that each event has an initial probability of one sort or the other, and, given the possible occurrence or nonoccurrence of an event, the conditional probabilities provided by expert judgment must meet certain coherent limits. These limits can be calculated. If the judgments do not fall within the calculated limits, how should the matrix be adjusted?

- *Synthesis phase*: Cross impact can stand alone as a method of futures research (see Moritz, for example) or can be integrated with other methods to form powerful tools. When integrated, cross impact allows the introduction of perceptions about the future into otherwise deterministic methods (see Stover, and Enzer, for example). In addition, various methods of collecting judgments (e.g., Delphi, mailed questionnaires, interviews, etc.) have been used in conjunction with cross impact to simplify the data gathering process (see, in Godet 1993, the description of mailed questionnaires used in SMIC).

- *Application phase*: In recent years, the work on cross impact has shifted from "pure" methodological development to applications. Questions about the method remain, of course: how best to ask questions about conditional probabilities; is the method really convergent; how to handle noncoherent input from experts; how to integrate with other methods? But there is no doubt that cross-impact questions help illuminate perceptions about hidden causalities and feedback loops in pathways to the future.

II DESCRIPTION OF THE METHOD

The cross-impact method is an analytical approach to the probabilities of an item in a forecasted set. Its probabilities can be adjusted in view of judgments concerning potential interactions among the forecasted items. We know from experience that most events and developments are in some way related to other events and developments. A single event, such as the production of power from the first atomic reactor, was made possible by a complex history of antecedent scientific, technological, political, and economic "happenings." In its turn as a precedent, the production of energy from the first atomic reactor influenced many events and developments following it. Many apparently diverse and unrelated occurrences permit or cause singular events and developments. From this interconnected flow are ever-widening downstream effects that interact with other events and developments. An event without a predecessor that made it more or less likely or that influenced its form is hard to imagine - or to imagine an event that, after occurring, left no mark. This interrelationship between events and developments is called "cross-impact."

The first step in a cross-impact analysis is to define the events to be included in the study. This first step can be crucial to the success of the exercise. Any influences not included in the event set, of course, will be completely excluded from the study. However, the inclusion of events that are not pertinent can complicate the analysis unnecessarily. Since the number of event pair interactions to be considered is equal to $n^2 - n$ (where n is the number of events), the number of interactions to be considered increases rapidly as the number of events increases. Most studies include between 10 and 40 events.

An initial set of events is usually compiled by conducting a literature search and interviewing key experts in the fields being studied. This initial set is then refined by combining some closely related events, eliminating others, and refining the wording for others. The cross-impact analysis is simplified if the events are independent of one another.

Once the event set is determined, the next step is to estimate the initial probability of each event. These probabilities indicate the likelihood that each event will occur by some future year. In the initial application of cross impact and in some current applications, the probability of each event is specified, assuming that the other events have not occurred. Thus, the probability of each event is judged in isolation and the cross-impact analysis is used to adjust the initial probabilities for the influences of the other events.

In the other more elegant and frequently used approach, the initial probabilities assume that the experts making the probability judgments have in mind a view of the future that includes the set of events and their likelihoods'. Thus, in estimating the probability of each event, the possibility of the other events occurring is taken into account from the beginning. In effect, the events are already cross-impacted in the expert's mind. In this case, the cross-impact analysis is used to determine whether the judgments about initial and conditional probabilities are coherent. The completed matrix can show how changes (the introduction of new policies or actions, the unexpected occurrence of an event, etc.) would affect the probabilities of occurrence or nonoccurrence of the entire set of events.

Individual experts may estimate the initial probabilities but, more commonly, groups of experts from the various disciplines covered by the events estimate them. Questionnaires, interviews, and group meetings can also be used to collect these judgments.

The next step in the analysis is to estimate the conditional probabilities. Typically, impacts are estimated in response to the question, "If event m occurs, what is the new probability of event n?" Thus, if the probability of event n were originally judged to be 0.50, it might be judged that the probability of event n would be 0.75, if event m occurred. The entire cross-impact matrix is completed by asking this question for each combination of occurring event and impacted event.

When the initial probabilities are estimated with reference to other event probabilities (that is, not considering each event in isolation), some additional information enters into the estimation of the impact matrix. For each event combination, there are limits on the conditional probabilities that can exist. A simple example can illustrate these limits. Suppose we consider two events, n and m: event n has a 50-percent chance of occurring in the next year, and event m has a 60 percent chance of occurring. Thus, out of 100 hypothetical futures, event n would occur in 50 of them and event m in 60. Obviously, events m and n would occur together in at least 10 of the futures.

In answer to the question in this case - "If event m occurs, what is the new probability of event n?" - our responses are limited. A conditional probability of 0 for event n is impossible. For example, if event n never occurred when event m occurred, the "overlap" of 10 combined occurrences would not be possible. The initial probability estimates specified that event n occurs in 50 percent of our hypothetical futures. Since this approach assumed that the estimate of 0.50 for the original probability of event n included a consideration of the 0.60 probability of event m, an inconsistency in judgments has occurred. Either the original probability estimate of event n does not actually take into account the 0.60 probability of event m, or the probability of event n given the occurrence of event m is not equal to 0. One of these judgments is incorrect, because it leads to an inconsistency. Only the participants in the analysis can decide which judgment must be changed. They may decide that the initial probability estimate for event n did not fully account for the expected influence of event m, or they may decide that their original estimate of the probability of event n, given the occurrence of m, was too low. In either case, they have learned something about events n and m because of the cross-impact exercise. This learning process that occurs while the cross-impact matrix is being estimated is one of the major benefits of performing a cross-impact analysis.

The calculation for a range of conditional probabilities that will satisfy this consistency requirement is easy. The initial probability of an event can be expressed as follows:

$$P(l) = P(2) \times P(1/2) + P(2c) \times P(l/2c) \qquad (1)$$

where:

P(l)	= probability that event I will occur;
P(2)	= probability that event 2 will occur;
P(1/2)	= probability of event 1 given the occurrence of event 2;
P(2c)	= probability that event 2 will not occur; and
P(1/2c)	= probability of event 1 given the nonoccurrence of event 2.

This expression can be rearranged to solve for P(1/2):

$$P(1/2) = \{P(l) - P(2c) \times P(l/2c)\}/ P(2) \qquad (2)$$

Since P(l) and P(2) are already known (the initial probability estimates) and P(2c) is simply 1 - P(2), only P(1/2) and P(1/2c), the conditional probabilities, are unknown. By substituting zero for P(1/2c) (the smallest value it could possibly have), the maximum value for P(1/2) can be calculated. Thus:

$$P(1/2) <= P(1)/P(2) \qquad (3)$$

Similarly, by substituting 1.0 for P(1/2c) (the largest possible value for P(1/2c), the minimum value for P(1/2) can be calculated:

$$P(1/2) <= \{P(1) - 1 + P(2)\}/ P(2) \qquad (4)$$

Thus, the limits on the new probability of event 1 given the occurrence of event 2 are:

$$\{P(1) - 1 + P(2)\}/P(2) <= P(1/1) <= P(1)/P(2) \qquad (5)$$

Using equation (5), we can now calculate the limits for the example previously used. If the initial probability of event n is 0.50 and event m is 0.60, the permissible values for the probability of event n given the occurrence of event m are 0.17 and 0.83. Or, if the probability of event n, given the occurrence of event m, is actually 1.0; then the initial probability of event n must be 0.60 or greater.

Once the cross-impact matrix has been estimated, a computer program is used to perform a *calibration* run of the matrix. A run of the matrix consists of randomly selecting an event for testing, comparing its probability with a random number to decide its occurrence or nonoccurrence, and calculating the impacts on all the other events due to the occurrence or nonoccurrence of the selected event. Impacts are normally calculated using odds ratios. To apply the odds ratio technique, the initial and conditional probabilities of the events are converted to odds, using the following relationship:

$$\text{Odds} = \frac{\text{Probability}}{1 - \text{Probability}} \qquad (6)$$

The impact of event m is then calculated as the ratio of the odds of event m given event n to the initial odds of event m. Thus, the cross-impact matrix shown in Figure 1 (below) would become the matrix shown in Figure 2 when odds are used in place of probabilities. The ratio of the new odds to the initial odds is used to define the event impacts. Thus, the occurrence of event 2 causes the likelihood of event 1 to go from odds of 0.33 to 1.50. The odds ratio expressing the occurrence impact of event 2 on event 1, therefore, is 1.50/0.33 = 4.5. Figure 3 shows the entire odds ratio matrix corresponding to Figures 1 and 2.

The Probability of this Event Becomes:

If This Event Occurs	**Initial Probability**	**1**	**2**	**3**	**4**
Event 1	0.25		0.50	0.85	0.40
Event 2	0.40	0.60		0.60	0.55
Event 3	0.75	0.15	0.50		0.60
Event 4	0.50	0.25	0.70	0.55	

Figure 1. Cross-Impact Probability Matrix

The Odds of this Event Become:

If this Event Occurs	Initial Odds	1	2	3	4
Event 1	0.33		1.00	5.67	.67
Event 2	0.67	1.50		1.50	1.22
Event 3	3.00	0.18	1.00		1.22
Event 4	1.00	0.33	2.33	1.22	

Figure 2. Cross-Impact Odds Matrix

The Odds of this Event are Multiplied

If this Event Occurs	Initial Odds	1	2	3	4
Event 1	0.33		1.50	1.90	0.67
Event 2	0.67	4.50		0.50	1.20
Event 3	3.00	0.55	1.50		1.50
Event 4	1.00	1.00	3.50	0.41	

Figure 3. Occurrence Odds Ratios

A nonoccurrence odds ratio matrix also can be calculated from the information in the occurrence matrix in Figure 1. Again, using equation (1):

$$P(1) = P(2) \times P(1/2) + P(2c) \times P(1/2c) \qquad (1)$$

The probability of event 1 given the nonoccurrence of event 2, P(1/2c), can be determined. From these probabilities, the nonoccurrence odds ratios can be calculated just as the occurrence odds ratios are calculated.

Once the odds ratios have been determined, the calculations proceed as follows:

1. An event is selected at random from the event set.

2. A random number between 0.0 and 1.0 is selected. If the random number is less than the probability of the event being tested, the event is said to occur. If the random number is greater than the event probability, the event does not occur.

3. If the event (event j) occurs, the odds of the other events occurring are adjusted as follows:

   New odds of event i =
   (initial odds of event i) x (occurrence odds ratio of event j on event i)

   If the event does not occur, the same calculations are made but the nonoccurrence odds ratios are used.

4. Steps 1, 2, and 3 are repeated until all the events have been tested for occurrence.

5. Steps 1 through 4 (which represent one play of the matrix) are repeated a large number of times.

6. The frequency of occurrence of each event for all runs of the cross- impact matrix determines the new probability of that event.

If the initial event probabilities were estimated in isolation, that is assuming that cross impacts were not part of the picture, the event probabilities obtained after the cross-impact procedure produces new estimates of event probabilities that take into account the interrelationships among the events. The matrix produced in this way can then be used to test the sensitivity of the event probabilities to the introduction of a new event, to the changes in initial probability (simulating an R&D investment, for example), or to changes in event interactions (simulating, for example, a policy that changes the consequence of an event).

If the initial event probabilities were estimated assuming that all other events are possible, the calibration probabilities obtained after the cross-impact procedure may be quite similar to the initial probabilities. In this case, differences between the initial and the final probabilities can be viewed as resulting from inconsistencies in judgments and the omission of higher order combinations. The cross-impact exercise produces new estimates of event probabilities that simply account for the higher order interrelationships among the events, as before.

At this stage in the analysis, the cross-impact matrix is ready for sensitivity testing or policy analysis. Sensitivity testing consists of selecting a particular judgment (an initial or a conditional probability estimate) about which uncertainty exists. This judgment is changed, and the matrix is run again. If significant differences occur between this run and the original run, the judgment that was changed is apparently an important one. Thus, expending more effort in making that particular judgment may be worthwhile. If no significant differences appear, that particular judgment probably is a relatively unimportant part of the analysis.

Policy testing is accomplished by first defining an anticipated policy or action that would affect the events in the matrix. The matrix is then changed to reflect the immediate effects of the policy, either by changing the initial probabilities of one or more events or by adding a new event to the matrix. A new run of the matrix is then performed and compared with the calibration run. The differences are the effects of the policy. Often unexpected changes result. When this happens, the changes can be traced back through the matrix so that the chains of causality that led to the unexpected changes can be determined and the effects of the policy understood. Used in this way, the cross-impact matrix becomes a model of event interactions that is used to display the effects of complex chains of impacts caused by policy actions.

III HOW TO DO IT

Suppose a study of the future of the chemical industry was in progress. In the course of the study, a list of important future events is generated. One part of that list might include the following events:

1. The use of plastics in transportation vehicles and construction expands six fold from 1992.

2. Increased governmental intervention in the process of innovation results from demands for consumer protection and pollution control.

3. Chemical theory progresses to the point where much of chemical research can be done through computer calculations rather than actual experimentation.

4. The chemical industry expands into textiles and clothing through the development of nonwoven synthetic fabric.

5. Chemical companies realize a declining return or rising investment in conventional research.

The first step in using these events in a cross-impact analysis is to estimate initial probabilities for the events. Experts, recognizing that all of these events are possible and interact, might provide the following probabilities:

Event	Probability of Occurring by 2000
1.Use of plastics expands six fold	0.15
2.Increased governmental intervention in innovation	0.20
3.Chemical research performed on computers	0.25
4.Chemical industry expands into textiles	0.10
5.Declining return on conventional research	0.20

The next step is to estimate conditional probabilities. In this step, a matrix similar to Figure 4 is constructed. Each cell of the matrix represents the answer to the question, "If event x occurs, what is the new probability of event y?" For example, the first completed cell of the first row of the matrix contains the new probability of event 2 given the occurrence of event 1. Thus, the question answered here is, "If the use of plastics in transportation and construction increases six fold (event 1), what is the likelihood of increased governmental intervention in the innovation process resulting from the demand for consumer protection and pollution control (event 2)?" Since the increased use of plastics is likely to increase demand for consumer protection and pollution control, event 2 should be somewhat more likely than initially estimated (0.20) if event 1 occurs. Thus, we might judge that the new probability of event 2 becomes 0.30, if event 1 occurs.

		The Probability of This Event Becomes				
If This Event Occurs	Initial Probability by 1985	1	2	3	4	5
1. Use of plastics expands six fold	.15		.30	.25	.10	.15
2. Increased governmental intervention in innovation	.20	.10		.35	.07	.40
3. Chemical research performed on computers	.25	.15	.20		.15	.05
4. Chemical industry expands into textiles	.10	.15	.25	.25		.15
5. Declining returns on conventional research	.20	.25	.15	.50	.20	

Figure 4. Sample Conditional Probability Matrix

Since the influences of the events on each other were included in the initial probability estimates, this judgment must now be tested for consistency with the initial probabilities. Using equation 5 and the probabilities of events 1 and 2, we see that the limits on the conditional probability of event 2, given event 1, are 0.0 and 1.00. Thus, no problem is presented by the judgment of 0.30 for the probability of event 2, given event 1.

In a similar fashion, the entire matrix is completed. The next task is specifying policy or sensitivity tests to be run with the matrix. In this case, we may wish to know the effect on the other events if event 3 (use of computers for much chemical research) occurs. Thus, one test would be performed by assigning a probability of 1.0 to event 3 and rerunning the matrix. A second test might be performed to test the sensitivity of the events to event 2 (increased governmental intervention in the innovation process). These tests are shown below:

TEST OF OCCURRENCE OF EVENT 3

Event	Initial Probability	Test Probability	Final Probability	Change
1	.15	.15	.14	-.01
2	.20	.20	.20	.00
3	.25	1.00	1.00	.00
4	.10	.10	.12	.02
5	.20	.20	.13	-.07

TEST OF SENSITIVITY OF EVENT 2

Event	Initial Probability	Test Probability	Final Probability	Change
1	.15	.15	.13	-.02
2	.20	1.00	1.00	.00
3	.25	.25	.30	.05
4	.10	.10	.09	-.01
5	.20	.20	.29	.09

Thus, if event 2 were to occur, the principal consequence would be an increase in the probability of event 6, from 20 percent to 29 percent. We have, in effect, written a small scenario in this example.

IV STRENGTHS AND WEAKNESSES

The cross-impact method forces attention to chains of causality: x affects y; y affects z. If the input to a cross-impact matrix falls outside of acceptable probabilistic bounds, or if the result of a cross-impact run is surprising, then the researcher is forced to reexamine his or her view of expected reality. The method shares this attribute with other approaches to simulation modeling.

However, the collection of data can be fatiguing and tedious. A ten-by-ten matrix requires that 90 conditional probability judgments be made. A 40-by-40 matrix requires that 1,560 judgments be made. The chances for falling asleep before completion are high.

Furthermore, this method assumes that, somehow and in some applications, conditional probabilities are more accurate than estimates of *a priori* probabilities; this is unproved.

Nevertheless, the disaggregation required by the method is usually illuminating. Inserting a cross-impact matrix into another model often adds power to that model by bringing into its scope future external events that may, in the limit, change the structure of the model (see Stover, for example). This integration also provides a means of testing sensitivity to changes in probabilities of future events and contemplated policies, an important consideration in planning studies.

V SAMPLES OF APPLICATIONS

By conducting an on-line search of the ABI/Inform data base, two recent applications of the cross impact were found. Quoting from the copywritten ABI/ Inform abstracts:

Authors: Vickers, Brent
Article: Using GDSS to Examine the Future European Automobile Industry
Journal: *Futures,* Oct. 1992

The group decision support system (GDSS) called DELAWARE incorporates the Delphi method and cross-impact analysis to provide a computer-assisted interactive approach to communication and decisionmaking. In an experiment undertaken in July 1990 at the Battelle Memorial Institute in Geneva, Switzerland, DELAWARE provided a select group of panelists from Geneva and Frankfurt, Germany, with the capability to communicate and refine their estimates about the business environment of the European automobile industry toward the year 2000. With the assistance of DELAWARE, panelists were quickly able to acquire an understanding of some important issues that could affect the future of the industry. The GDSS could be used in conjunction with verbal discussions to optimize the group's collaborative process.

Authors: Schuler, Albert; Thompson, William A.; Vertinsky, Ilan; Ziv, Yishi
Article: Cross Impact Analysis of Technological Innovation and Development in the Softwood Lumber Industry in Canada: A Structural Modeling Approach
Journal: *IEEE Transactions on Engineering Management;* Aug. 1991.

A central problem facing the softwood lumber industry in Canada is the declining quality of logs. The potential for technological innovations that may help alleviate the problem are examined. A simulation model of the North American softwood lumber industry was developed to forecast the effects of technological innovations. The model was formulated with two competitors, the United States and Canada, supplying one market. Two broad classes of technological innovations were identified as processing innovations and product innovations. Comparative forecasts were made of the consequences of three technological investment strategies, and comparisons were conducted for six environmental scenarios. A mixed strategy of investment in both processing and product technologies was identified as the best approach for the Canadian softwood lumber industry to maintain profitability and market share in the markets in which it competes with U.S. producers.

Godet (1993) presents detailed descriptions of two cross-impact/scenario studies carried out in France. The first, performed in 1974 by SEMA for the Paris Airport Authority, was designed to examine events that could affect air traffic at Paris airport in the time period 1974-1990. The second, conducted by SEMA and Economia in 1977, deals with nuclear power.

VI FRONTIERS OF METHODOLOGY

While cross impact began its life as a stand-alone method, using either a game format or a computer Monte Carlo approach, major applications have involved the use of the cross-impact method in combination with other techniques. One of the most promising combinations has been the marriage between cross impact and simulation modeling. The use of cross-impact approaches in games is also interesting and potentially important and can be developed further.

Research is still needed on the way experts judge probability. The cross-impact method involves judgments about conditional probabilities: are these disaggregated judgments easier to make, or more accurate?

Cross-impact studies focus on interactions between pairs of events. Yet, in the real world, the important interactions may involve not only pairs but triplets and higher-order effects. If such interactions were to be included, however, the complexity of judgment collection would grow tremendously.

New methods of collecting judgments may improve the efficiency of the method. The SMIC reflects one such approach using questionnaires. In addition, one could imagine, for example, a computer program that would systematically pose questions about causality from which the conditional probabilities would be mathematically derived. Furthermore, this interactive judgment collection system could link the cross impacts directly into a simulation model.

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