MICA
Minerals Intelligence Capacity Analysis

FACT SHEET

Cross Impact Analysis (CIA)

Scope (conceptual model & main characteristics)

Cross-impact analysis (CIA) is a methodology developed originally by Theodore Gordon and Olaf Helmer in 1966 to help determine how relationships between events would impact resulting events and reduce uncertainty in the future (Gordon, 1994). This group of methods aims to monitor the impact of interactions between a set of projections, when those interactions may not have been taken into consideration when individual futures were produced. CIA was originally developed as a card game, where each card described an event (in economic and business development) and where the probabilities that a certain event may take place were determined using hexagondodekaedral dice. The cards also contained informations on cross-impacts and estimates of their probability to occur.

Developing a CIA thus consists initially in developing a catalogue of processes and events, complemented by an assessment of their respective cross-impacts. This catalogue can be developed in a variety of ways, including expert opinion, delphi surveys, focus groups, etc. For certain types of analyses, Features, Events, and Processes (FEP) databases may already exist. Once the catalogue has been developed, 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 CIA 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 CIA is used to adjust the probabilities for the influences of the other events. A certain bias may occur due to 'experts' judging probabilities may unconsciously already considering cross-impacts. 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. These new, conditional events are bounded in their probabilities by the probabilities of the initiating events. 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. The calculation for a range of conditional probabilities that will satisfy this consistency requirement is easy and involves mainly multiplying the respective probabilities. A matrix of conditional probabilities is developed in this way (see Gordon, 1994), for a description of the procedure). However, the collection of data can be tedious. A ten-by-ten matrix requires that 90 conditional probability judgments be made, 40-by-40 matrix requires that 1,560 judgments be made. The calculations are performed with the aid of a computer.

Once the matrix has been developed, it can be used for e.g. testing the sensitivity of the system to policy decisions focusing on particular elements of the matrix.

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, e.g. a System Dynamics 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.

Range of relevant applications or topics

CIA can be used as an exploratory or a normative method, i.e. either the possible overall outcomes a range of interacting events can be studied, or it can be used as a risk analysis to scope which interacting factors can influence the route towards a desirable future. It can be applied to any kind of topic.

Data needs, databases

The (semi-)quantitative character of the method derives from the estimation of likelihoods for certain events to occur. These likelihoods or probabilities can be derived from statistical analysis or be based on expert judgements.

Model used (if any, mathematical, geological…)

- **Statistical evalutations of certain events to occur.**
- **Statistical package that can calculate the cumulated probabilities over a matrix of factors.**

System and/or parameters considered

CIA can be applied to systems of any kind.

Time / Space / Resolution /Accuracy

Theoretically there are no limits to the temporal or spatial domains.

Practical limits are given by the need to provide realistic initial estimates for the probability of all the events that are assumed to occur. This may limit the size of the matrix.

Indicators / Outputs / Units

Outputs will be a matrix of aggregated probabilities, that indicates critical paths and critical events.

Treatment of uncertainty, verification, validation

Verification can be provided to some degree by treating historic cases. However, in most instances the available data on the factors and their interaction may not be sufficient.
Validation will be only possible retrospectively.
In most practical cases the uncertainty of probabilities will introduce a large errorbar into each matrix element, so that it will be difficult to arrive at unique solutions.

Main publications / references

Gordon, T.J. (1994): Cross Impact Method.- United Nations University Millennium Project, 25 p., http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.202.7337&rep=rep1&type=pdf (accessed 30.06.16)

Related methods

SWOT Analysis

Trend Impact Analysis

System Dynamics Modelling

Operational tools

Not applicable.

Key relevant contacts