Interactive Future Simulations (IFS)™
Theory and Computational Method

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Interactive Future Simulations (IFS)™ is an analytical method of generating scenarios using Bayesian probabilities and cross-impact analysis as a model for considered expectations and for simulations of logically consistent possible conditions in the future. The method employs a software program that originated at the Battelle Memorial Institute (Battelle) in the 1980s.

The IFS method relies heavily upon expert judgments that are made explicitly in a rigorous manner and subject to peer review. Because the inputs are made into a laptop computer, values may be changed, simulated, and update whenever necessary.

The IFS method requires the following inputs:
1. A topic question
2. Descriptors (trends, issues, and factors) as elements of the model
3. Alternative states, or outcomes, for each descriptor. Each alternative state is assigned an *a priori* probability of occurrence by the target date in the future.
4. Cross-impact values arrayed in a cross-impact matrix.

Scenario analysis begins with a topic question that provides focus for everything that follows. A typical topic question consists of the following parts:
- A focus topic or descriptor
- A way to measure or define the topic descriptor
- A geographical scope
- A time frame, or target date in the future.

For example, a topic question might be "What will likely be SUV sales, as measured in US dollars, in South America by the year 2017?" Often there will be a follow-up question that provides a normative foresight that is desired by the scenario analysis, such as "And what do we need to do to achieve a 25% market share of those SUV sales?" Every scenario analysis should have a goal identified at the beginning of the inquiry; the goal made be an input to a pending business decision or background to gain broad foresight into possible alternative futures.

The identification of descriptors (trends, issues, factors, variables, or elements), their alternative outcomes (states), and their *a priori* probabilities of occurrence by a target date in the future are determined by expert judgment subject to peer review and modification with the availability of new information. Expert judgment is the product of knowledge about past trends and present conditions and expectations for the future based on intuition of potential changes, both great and small.

The descriptors can be identified through expert focus groups, surveys of experts, and interviews. A sampling of expert judgment is necessary to get a broad range of opinions and to balance out individual biases. Descriptors may be demographic , social, economic, consumer behavioral, political and regulatory, demographic, technological. They can be virtually any trends, issue, factor, or variable directly relevant to the topic question.

A typical set of descriptors ranges from 8 to 18. The IFS software program will accommodate as many as 24 descriptors, but that is usually too large a set to interpret. There is also the risk of over-specifying the model by putting in too many descriptors that are redundant of each other.

A person is assigned the task of preparing a written narrative (white paper or essay)for each descriptor. A descriptor white paper should contain the following parts:

- Definition of the descriptor
- Why it is important to the topic question
- Trends, background, and current information
- Expectations for the future – the identification and justification for 2, 3, or 4 alternative states (outcomes) by the target year and an *a priori* probability of occurrence for each
- References
- First cut at cross- impacts with all the other descriptors
- Names and dates for drafting, editing, and reviewing of the white paper.

An example of a descriptor with alternative states and probabilities may be as such:

1. U.S. economic growth

a. high range (annual average >5%)	0.20
b. middle range (annual average 2.5%-5%)	0.45
c. low range (annual average <2.5%)	0.35

The *a priori* probabilities should be based on trends and reasoned expectations for the future in the judgment of the expert who prepared the descriptor white paper. Probabilities must be reviewed by other experts and changed according to new circumstances. In addition, probabilities may be changed for performing sensitivity analysis ("what if…then").

The IFS computational approach is based on Bayesian probabilities and statistical calculations. The initial, judgment-based probabilities are *a priori* in the sense that they are intuitive approximations used as a starting point for calculating *a posteriori* probabilities resulting from new information.

The *a priori* probabilities placed on alternative states for each descriptor will sum to 1.0. Each *a priori* probability reflects a degree of uncertainty about a future outcome. New information will adjust the *a priori* probabilities for each descriptor so that the result will be that one alternative future will have an *a posteriori* probability of 1.0 (it will occur) and the alternatives states for each descriptor will have *a posteriori* probabilities of 0 (will not occur). Occurring and non-occurring descriptor sets are organized into scenarios. Alternative scenarios happen when at least one occurring descriptor state differs from another set (scenario).

One form of new Information in the IFS computational approach takes the form of cross-impact values in the cross-impact matrix. The matrix contains all the descriptors and their alternative states on each axis. The procedure is to go down each column from left to right and to determine how the occurrence of each descriptor state (as though its probability were set to 1.0) would likely change the a priori probabilities of all other descriptor states.

(New information may also be included in the method by changing *a priori* probabilities, changing cross-impact values, and introducing disruptive events, which are new descriptors with a hypothetical single state with an *a priori* probability of 1.0 with impacts, but not impacted by, other descriptors in the matrix).

A cross-impact matrix is a type of model. We are not literally modeling the future, but actually modeling our judgments and expectations for the future based on available information and our intuition. Although we are using expert judgment, assumptions that may be implicit in other models become explicit and subject to peer review in a cross-impact matrix. As a model, a cross-impact matrix can be reviewed, revised, and updated. A cross-impact model is a way to integrate many trends into sets of alternative futures. It can produce many alternative scenarios of identically occurring descriptor states rather than just one forecast.

Cross-impact values are index values that reflect the judgment of how one descriptor impacts another. A positive impact means that if one descriptor state were to occur ("new information"), then it is expected to increase the *a priori* probabilities that other descriptor states will also occur. A zero means that there is no direct cause-and-effect relationship or there is no net impact. A negative impact means that the impact of one makes the probabilities of other states less likely to occur in the future.

Cross-impact values are based on a judgment of a direct (primary, not derivative) cause-and-effect impact.

The impact values range from +3 to -3.

The IFS algorithm begins with each descriptor state in turn set to 1.0 and to 0. So, the total number of simulations (or single, sequentially calculated scenarios) will equal twice the number of total descriptor states. For example, if there were 15 descriptors in the model with each having three alternative states, then the total number of states will be 45 and the total number of simulations will be 90. The formulas that convert the cross-impact values to numbers and that adjust the *a priori* probabilities up or down according to the cross-impact values are deterministic in that they always calculate the numbers the same way. There are no random number generation and Monte Carlo simulations. This approach guarantees that changes in results due to changes in inputs are indeed caused by the changes in the inputs and not in internal random number calculations.

Once the IFS algorithm calculations set an *a priori* probability to 1.0 or 0 it is set. The algorithm continues to recalculate all *a priori* probabilities according to the formula until one state of each descriptor reaches 1.0.

The formulas are as follows:

CV = Impact + 1, where CV is the coefficient value of a cross-impact value, and where the Impact is greater than or equal to 0.

CV=1/Impact + 1 when the impact is less than 0

The cross-impact index value corresponds to the following coefficient values (CV):

-3	¼
-2	1/3
-1	½
0	1
1	2
2	3
3	4

The coefficient is used in the following formula:

NPi = Pi x CV/1-Pi + (Pi x CV)

Where NPi = the new (adjusted) probability of descriptor state i
CV = the coefficient value
Pi = the old (a priori) probability of descriptor state I (with I = 1, 2, 3, N descriptor states in the matrix)

This formula is based on basic Bayesian probabilities and says that ODDS = Pi/1-Pi and Pi = ODDS/1 + ODDS. It also says that NEW ODDS = ODDS x CV.

If NEW ODDS + ODDS x CV, then NEW ODDS = (Pi/1-Pi) x CV.

A derivative formula is NPi = Pi x CV/1-Pi + (Pi x CV).

The following table may be helpful:

Cross-Impact Index Value	*CV*	*NPi =*	*NPi when Pi = 0.5*
-3	¼	P/4-3P	0.20
-2	1/3	P/3-2P	0.25
-1	½	P/2-P	0.33
0	1	P	0.50
1	2	2P/1 + P	0.67
2	3	3P/1 = 2P	0.75
3	4	4P/1 + 3P	0.80

The software organizes the resulting scenarios into clusters of single scenarios having exactly the same results (occurring and non-occurring states for the descriptors). The computer displays the frequency of each scenario cluster, or simply "scenario." The frequency as a percentage of all single scenarios is a type of *a posteriori* probability of occurrence in the future. For example, scenario Type I may have a frequency of 10, Scenario Type 2 may have a frequency of 8, Scenario Type 3 may have a frequency of 4, etc. Relative to each other, Scenario Type 1 is the most likely scenario to occur in the future, and Type 2 is less likely to occur than Type 1 but twice as likely to occur as Type 3.

IFS cross-impact models and scenarios can be interpreted in at least three ways:

1. As a predictive model with a hierarchy of scenarios foretelling what scenarios are more likely than others (given certain preconditions and inputs into the model)

2. As a normative model, with a “most desired” scenario, whether it is likely to occur or not, showing what outcomes must occur for desired outcomes to also occur
3. As a simulation model to play with to learn what inputs are expected to produce what results, thereby learning “from the future” what actions may produce what results in the future.

Each company or organization using the IFS method should draw its own implications for future decisions. Scenarios can provide valuable foresights for the following practical purposes:

- To estimate the unarticulated voice of the customer and to anticipate future consumer behavior, demand, and value when customers cannot tell you what they will likely do in the future
- To estimate future sales or income as a basis for calculating potential returns on investments in the future using alternative scenarios rather than customary financial and statistical projections
- To identify potential business strategies that appear to have good chances to produce desired results in the future
- To assess risk in a broad, semi-qualitative way for future investments, including R&D programs

The present IFS method and supporting software program were developed at Battelle in Columbus, Ohio, in 1998. At that time an older version of the software program was reprogrammed to be compatible with Microsoft Windows. The reprogramming also included some improvements to the earlier method.

In the 1970s, Battelle collaborated with the business school at the University of Southern California to develop an approach to generating scenarios that was based loosely on systems dynamics, modeling and simulation, Bayesian probabilities, and the cross-impact method that had earlier been developed at the RAND Corporation of Santa Monica, CA. The method that emerged from this collaboration was known as BASICS (standing for Battelle scenario inputs to corporate strategy). The BASICS mathematics and original mainframe software program originated with the Battelle laboratory in Geneva, Switzerland. Idea generation methods for the specification of the model and for making collective expert judgments were developed at the Battelle laboratory in Frankfort, Germany. The first BASICS scenario studies appeared as group programs in 1980.

In 1986, the Battelle laboratory in Columbus, Ohio, programmed the first personal computer version of the BASICS software. It was called BASICS-PC. It was used for over 50 major projects and many more lesser efforts and feasibility demonstrations from 1986 to 1998, when it was reprogrammed and renamed Interactive Future Simulations (IFS). The present version of the IFS software is the same one that was developed in 1998. The software program is the intellectual property of Battelle and is available through license agreements.

References:

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