ZIRN Interdisciplinary Research Unit on Risk Governance and Sustainable Technology Development - University of Stuttgart

Cross-Impact Balance Analysis Guidelines - No. 1

Prior knowledge: none

Last update: May 30, 2014

Introduction to qualitative systems and scenario analysis using cross-impact balance analysis[1][2]

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Cross-impact balance analysis (CIB) offers a structured procedure for the derivation of plausible future developments in the form of rough scenarios and is based on qualitative judgements concerning cross-impact relations between fundamental system elements. CIB is particularly used when conducting analyses which, owing to their disciplinary heterogeneity and the relevance of "soft" system knowledge, do not permit the application of quantitative prognosis models and yet remain too complex for intuitive systems analysis. The following describes the basic characteristics of CIB and its application by expert groups.

1. Scenarios provide orientation for long-term planning

Scenarios are (Porter 1985):

> "...an internally consistent view of what the future might turn out to be - not a forecast, but one possible future outcome".

They are thus images of the future that provide a rough and yet consistent illustration of the basic development possibilities for an area – large or small - of interest, and which can therefore be used as a basis for planning. They do not focus on "... what will happen, but on what might happen" (Becker and List 1997). Scenarios have proven to be a particularly fruitful instrument in those areas where developments cannot be forecast, either owing to their complexity, their susceptibility to interference, or their dependence on human decisions.

The key to Porter's definition however is the demand for consistency. A scenario may reveal only one of many development possibilities; what however distinguishes it from an arbitrary concept of the future is the internal consistency of the assumptions made. Nevertheless this consistency remains hard to achieve the case of scenarios with a range of different assertion areas and complicated contexts allowing only qualitative analysis. As a result such a claim can only be asserted in a reproducible, informatively documented, and hence verifiable manner if an explicit and structured process is in place to promote the consistency of the scenario project.

A scenario-generating method developed to cater to these requirements and tested in numerous scenario projects is cross-impact balance analysis (CIB), described below. The aim of this introduction is to present the method's fundamental principle. For more detailed information on the theoretical background and the various application and analysis options please refer to those publications listed in the bibliography.

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[1] For information on CIB and handouts on applying the method see www.cross-impact.de

[2] Translated from German by Jucy James

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2. Cross-impact balance analysis

Cross-impact analysis is a group of methods designed to provide a rough analysis of cross-impacting social, political, technological, environmental and economic events (multi-disciplinary systems). The basic concept was developed within the context of *technology foresight* back in the nineteen sixties (Gordon and Hayward, 1968). Common to all CI methods is a systematic approach, which bases on assessments of the interdependencies of key system variables in pairs, thus producing a cross-impact matrix as the system description. Depending on the method used, different types of expert judgements are used and different algorithms applied in the analysis.

Owing to this focus on expert judgements, CI methods differ greatly from econometric or technology-based mathematical models. Generally, if theory-based mathematical models can be applied to the issue in hand, their use is to be preferred. The typical field of application for CI analyses occurs in cases where major aspects of the problem cross disciplines or can only be analysed qualitatively; instances in which restricting the problem to those aspects open to mathematical treatment would lead to inappropriate restriction of the problem's scope, thereby heightening the risk of inaccurate analysis (Godet 1983). Futurologist Olaf Helmer succinctly characterised the status of cross-impact analysis thus (Helmer 1981):

> "Cross-impact analysis represents a schema for collating and systemizing [...] expert judgments, so as to make it possible to construct a conceptual substitute, however imperfect, for a wished-for but nonexistent theory of how events affect one another in a multidisciplinary context."

Cross-impact balance analysis (CIB) is a cross-impact analysis variant that emphasises transparent, discourse-compatible, analysis logic, the avoidance of input variables that are difficult to estimate, a high degree of flexibility and versatility of application, and an analysis algorithm based on systems theory. The concept is a response to the forty years scientists have spent working with this family of methods and analysing its strenghts and weaknesses. The method was introduced by Weimer-Jehle (2001, 2006) and has been used in a series of practical applications within a range of different contexts and the experience gained used to develop the method still further. Practical applications have included the structural consequences of political intervention in the power industry, the promotion of innovation processes, socio-environmental syndrome phenomena within sustainability, and the development and analysis of framework scenarios in preparation for mathematical model-assisted systems analysis (Förster 2002, Förster and Weimer-Jehle 2003, Förster and Weimer-Jehle 2004, Aretz and Weimer-Jehle 2004, Weimer-Jehle and Fuchs 2006, Schweizer 2007, Renn et al. 2007, Fuchs et al. 2008).

The process starts from an interdependency-oriented viewpoint on systems. First it is necessary to define a set of system variables ("descriptors") with which the system can be adequately described for the purpose of obtaining a qualitative understanding. Relations between the descriptors are described by a network of influences (Fig. 1).

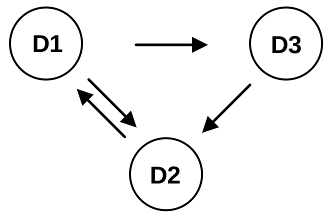

Fig. 1: The impact network of a simple system.

An impact arrow from descriptor 1 to descriptor 2 indicates that descriptor 1 impacts on descriptor 2, i.e. under otherwise identical conditions a change in the state of descriptor 1 causes a change in the state of descriptor 2. The system as a whole tends towards states which reflect the double role of each descriptor as both impact source and impact target.

The following simple example is intended to demonstrate the process. The example takes the development of personal opinions among a group of initially undecided individuals on an issue of common interest. Some group members are mutually acquainted; the personal opinion of each person is influenced to a greater or lesser extent by the opinion of the acquaintance. The process is as follows:

1) Create a list of all relevant influence factors ("descriptors").

In the example these are the group members who mutually influence each other's opinions. The example presents 5 individuals: Tom, Lisa, Paul, Katja and Max.

2) Determine the key qualitative states in which the impact factors may find themselves.

The example deals with the development of personal opinions in response to a specific question. In the simplest case the individuals can either be in a state of "Agreement" (abbreviation: +), "Neutral" (abbreviation: 0) or "Disagreement" (abbreviation: -). This scale could be refined further without any difficulty.

3) Ascertain by studying appropriate literature, expert interviews, or other suitable research findings what would be the impact on state x of factor X if factor Y were in state y. Express these as qualitative judgements:

- -3: strong inhibiting influence
- -2: inhibiting influence
- -1: slightly inhibiting influence
- 0: no influence
- +1: slightly promoting influence
- +2: promoting influence
- +3: strong promoting influence[4].

Please note that only direct influences are specified. Any indirect influences arising from the process are established independently by CIB during the subsequent analysis.

In the example it is possible that Katja's agreement with a statement could exert a strong influence on Tom to agree as well (+3 is therefore selected as the cross-impact of the state "Katja: Agreement" on the state "Tom: Agreement").

Complete these steps and the result is a "cross-impact matrix". Table 1 shows this matrix for the example described.

[4] If stronger impacts need to be expressed the scale may also be expanded.

Tab. 1: A cross-impact matrix with 5 descriptors. The cell values describe the impact of a row state on a column state. $C_{25}(1,3)$=-2 reveals for example that Lisa's agreement is likely to inhibit any disagreement by Max.

	1.Tom			2.Lisa			3.Paul			4.Katja			5.Max		
	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-
1.Tom															
+				0	0	0	0	0	0	0	0	0	1	0	-1
0				0	0	0	0	0	0	0	0	0	0	0	0
-				0	0	0	0	0	0	0	0	0	-1	0	1
2.Lisa															
+	0	0	0				0	0	0	0	0	0	2	0	-2
0	0	0	0				0	0	0	0	0	0	0	0	0
-	0	0	0				0	0	0	0	0	0	-2	0	2
3.Paul															
+	0	0	0	0	0	0				2	0	-2	0	0	0
0	0	0	0	0	0	0				0	0	0	0	0	0
-	0	0	0	0	0	0				-2	0	2	0	0	0
4.Katja															
+	3	0	-3	2	0	-2	2	0	-2				0	0	0
0	0	0	0	0	0	0	0	0	0				0	0	0
-	-3	0	3	0	0	0	-2	0	2				0	0	0
5.Max															
+	2	0	-2	1	0	-1	-3	0	3	0	0	0			
0	0	0	0	0	0	0	0	0	0	0	0	0			
-	-2	0	2	-1	0	1	3	0	-3	0	0	0			

C_{43}: judgement section — judgement group — $C_{25}(1,3)$: judgement cell

It is assumed that Tom and Lisa are not acquainted. Hence no direct influence exists between these two individuals and the judgement sections C_{12} and C_{21} are both zero. Tom and Katja on the other hand know each other. Tom likes Katja and her opinion exerts considerable influence on him. Unfortunately this is not mutual (C_{41} contains strong cross-impacts, C_{14} only zeros). Paul consistently shows a strong tendency to adopt a stance that is opposed to Max's opinion. Lisa takes note of Katja's opinion, however only in those instances when Katja agrees with a statement. Max is influenced by Tom and Lisa, however in case of doubt the balance tips in favour of Lisa's opinion.

These relations, along with the others shown in tab. 1, describe a network of influence that is represented by the cross-impact matrix. They severely restrict the scope of possibility, since in general a random configuration of opinions (a "scenario") will contain contradictions to the group "rules". Such contradictions may be made visible by calculating the "impact balances" of a scenario. Tab. 2 illustrates this for the scenario z = [-,-,+,-,-] (Tom and Lisa disagree, Paul agrees, Katja and Max disagree).

The impact balances are calculated by marking the lines that belong to the assumed state of the scenario under examination and then adding up the marked lines in columns. This allows us to balance all impacts that would have an effect on the individual states should the people involved hold the opinions assumed in scenario z.

Tab. 2 reveals the impact balances of Tom, Lisa, Paul and Max to be of such a nature that the opinions adopted by these individuals in scenario z demonstrate the highest impact totals in the different impact balances. Tom's impact balance, for instance, is [-5,0,+5] and the opinion adopted by Tom in scenario z ("-", i.e. disagreement) produces an impact total of +5 (no higher value exists in this impact balance). The descriptor "Tom" is therefore regarded as *consistent* for the purposes of CIB. The obvious reason for this analysis is that Tom's opinion is impacted by Katja and Max (as revealed by the cross-impact matrix). Since both tend towards disagreement, Tom's attitude of disagreement is the only plausible ("consistent") assumption. Common sense and formal verification go hand in hand: the dominating opinion of the influencing persons receives the impact sum with the most cross-impact points.

With Katja things are a little different. In scenario z the attitude adopted by Katja was one of disagreement. But the only person she is known to be influenced by (Paul) agreed with the statement! If scenario z were to prove correct, Katja would have flouted the "rules" of the group. The scenario therefore assumes that Katja is *inconsistent* (she does not comply with the specified cross-impact matrix rules). This inconsistency is immediately recognisable from the impact balance (comp. tab. 2): the impact score for Katja's assumed attitude in scenario z is -2 and this is not the highest value within the impact balance (the highest value would have +2 for a position of agreement).

Tab. 2: Impact balances for the inconsistent scenario z = [-,-,+,-,-]. The states of this scenario have been marked using grey shading and arrows above the impact balances (see line "States"). The CIB principle of consistency demands that the state arrows for all descriptors must point to the highest impact total within an impact balance (see arrow in the "Maxima" line). If – as in the case under examination – this is not the case for every descriptor, the scenario is rejected as inconsistent.

	1.Tom			2.Lisa			3.Paul			4.Katja			5.Max		
	+	0	-	+	0	-	+	0	-	+	0	-	+	0	-
1.Tom:															
+				0	0	0	0	0	0	0	0	0	1	0	-1
0				0	0	0	0	0	0	0	0	0	0	0	0
-				0	0	0	0	0	0	0	0	0	-1	0	+1
2.Lisa:															
+	0	0	0				0	0	0	0	0	0	2	0	-2
0	0	0	0				0	0	0	0	0	0	0	0	0
-	0	0	0				0	0	0	0	0	0	-2	0	2
3.Paul:															
+	0	0	0	0	0	0				2	0	-2	0	0	0
0	0	0	0	0	0	0				0	0	0	0	0	0
-	0	0	0	0	0	0				-2	0	2	0	0	0
4.Katja:															
+	3	0	-3	2	0	-2	2	0	-2				0	0	0
0	0	0	0	0	0	0	0	0	0				0	0	0
-	-3	0	3	0	0	0	-2	0	2				0	0	0
5.Max:															
+	2	0	-2	1	0	-1	-3	0	3	0	0	0			
0	0	0	0	0	0	0	0	0	0	0	0	0			
-	-2	0	2	-1	0	1	3	0	-3	0	0	0			
States:			↓			↓	↓					↓			↓
Balance:	-5	0	5	-1	0	1	1	0	-1	2	0	-2	-3	0	3
Maxima:			↑			↑	↑			↑					↑

Impact score of the "Lisa: Agreement" state

Impact balance of the "Katja" descriptor

Impact balances are therefore a clear and simple means of determining at which specific points a hypothetical scenario will conflict with the rules specified. A "perfect", wholly self-consistent scenario will contain no inconsistencies of the nature described above. In other words, the arrows in the "States" line in tab. 2 would always point to the states with the highest impact sums within the impact balance (as a borderline case, a tie with the highest impact total is acceptable). In the scenario examined in tab. 2 this is not the case. It contains one inconsistent descriptor and this is reason enough to reject the entire scenario as inconsistent.

Furthermore it is not enough to convert the inconsistent descriptor “Katja” with the aim of obtaining a consistent scenario. Although Katja’s opinion would then tally with the influences impacting on her, the changed influences now issuing from Katja would produce new inconsistencies somewhere else. Influence networks are complex structures and generally difficult to grasp; their treatment within CIB is a succinct expression of this fact despite the qualitative and simplified approach.

The CIB principle of consistency formalises the terms plausibility and consistency to the extent that they can be automated using a computer program[5]. Otherwise it would be necessary to “guess” at hypothetical scenarios until one was finally found to be consistent. Using CIB the process is much simpler. All possible combinatorial scenarios can be automatically scanned and the generally small number of scenarios that are completely without contradiction, i.e. consistent, can be selected. Since an analysis of typical size involves more descriptors than the example and therefore thousands or millions of combinatorial scenarios, it would be impossible to record and analyse every conceivable scenario without formalising the terms of consistency and plausibility. The simplicity of the plausibility definition on which the CIB method is based is the price paid for being able to scan all the possibilities completely.

In the example involving five individuals under influence, 3·3·3·3·3 = 243 possible combinational scenarios exist. The scanning process and the application of the test step demonstrated in tab. 2 reveal that in this case only two scenarios are consistent. These are:

a) [0,0,0,0,0]: all group members remain undecided.

b) [-,+,-,-,+]: Lisa and Max agree, all others disagree.

The consistency of the second scenario is demonstrated in tab. 3. The arrows marking the scenario states above the balance line all point to the highest impact totals for the different impact balances. The opinion of each group member tallies with the total of influences received from all the other group members. In the case of contradictory influences it is the stronger impact that that proves the deciding factor.

It should be emphasised that the CIB method is not only limited to the analysis of the development of personal opinions within groups. This example serves solely as illustration. Typical descriptors in application projects previously mentioned have included policy-making, corporate strategy, environmental change, as well as social or technological change. Box 1 contains a few examples of typical descriptors used in multi-disciplinary cross-impact analyses.

Tab. 3: Impact balances for the consistent scenario z = [-,-,+,-,-].

	1.Tom +	1.Tom 0	1.Tom -	2.Lisa +	2.Lisa 0	2.Lisa -	3.Paul +	3.Paul 0	3.Paul -	4.Katja +	4.Katja 0	4.Katja -	5.Max +	5.Max 0	5.Max -
1.Tom:															
+				0	0	0	0	0	0	0	0	0	1	0	-1
0				0	0	0	0	0	0	0	0	0	0	0	0
-				0	0	0	0	0	0	0	0	0	-1	0	+1
2.Lisa:															
+	0	0	0				0	0	0	0	0	0	2	0	-2
0	0	0	0				0	0	0	0	0	0	0	0	0
-	0	0	0				0	0	0	0	0	0	-2	0	2
3.Paul:															
+	0	0	0	0	0	0				2	0	-2	0	0	0
0	0	0	0	0	0	0				0	0	0	0	0	0
-	0	0	0	0	0	0				-2	0	2	0	0	0
4.Katja:															
+	3	0	-3	2	0	-2	2	0	-2				0	0	0
0	0	0	0	0	0	0	0	0	0				0	0	0
-	-3	0	3	0	0	0	-2	0	2				0	0	0
5.Max:															
+	2	0	-2	1	0	-1	-3	0	3	0	0	0			
0	0	0	0	0	0	0	0	0	0	0	0	0			
-	-2	0	2	-1	0	1	3	0	-3	0	0	0			
States:			↓	↓					↓			↓	↓		
Balance:	-1	0	1	1	0	-1	-5	0	5	-2	0	2	1	0	-1
Maxima:			↑	↑					↑			↑	↑		

[5] A basic version of the appropriate software *ScenarioWizard* is available for download (Weimer-Jehle 2007).

Box 1: Examples of descriptors typically used in multi-disciplinary cross-impact analyses

- political descriptors, which describe for instance whether a particular resolution will be passed or not;
- environmental descriptors, which reveal for instance whether a certain environmental indicator is likely to rise, stagnate or fall;
- economic descriptors, which characterise a business strategy for instance in terms of whether it focuses on diversification or a return to the core business;
- technological descriptors, which show for instance whether a certain technology is still likely to be in the innovation phase by a certain year, whether it will be realised in pilot projects, conquer niche markets or penetrate the market as a whole;
- sociological descriptors, which assess for instance whether social values are likely to shift in the direction of individualism and personal responsibility, or social integration and solidarity.

The CIB process used to create consistent qualitative scenarios is thus made up of three steps:

1. A qualitative systems representation is produced by selecting the key impact factors (descriptors) and identifying their main qualitative states.
2. A knowledge base is compiled for the system under examination and the knowledge formulated with reference to the mutual interdependencies of the impact factors in the form of cross-impacts.
3. All possible scenarios are systematically scanned (using analysis software) and those scenarios in complete agreement with the knowledge base (consistent scenarios) are selected.

The method described automatically ensures that in addition to the direct impacts between descriptors, all indirect impacts (i.e. those communicated through one or more intermediate stages) are also taken into account. The fact that CIB also takes indirect impacts into account is evidenced in the example above by the fact that in the consistent scenarios there is a correlation between the opinions of Tom and Paul, although the two are not acquainted with each other and can therefore only influence each via a third party (C_{13} and C_{31} are zero, nevertheless the opinions of Tom and Paul are always identical). Especially in the case of large, complex systems, indirect impacts can acquire a level of influence that is considerable and hard to assess without the help of additional aids. The ability of CIB to take indirect impacts into account is therefore essential to the method's claim of providing assistance in understanding complex systems behaviour.

3. The use of CIB by expert groups

Generally CIB is used to analyse multidisciplinary systems in which "soft knowledge" plays a significant role and which as a result are unsuited to conventional mathematical systems analysis. In some cases, the necessary knowledge base may be compiled by literature research. Frequently it must be acquired by consulting experts, however. In the later case a variety of methods may be used in the process. One typical approach is to appoint a team of experts that reflects both the transdisciplinary nature of the issue and the often divergent assessments concerning key problem areas. The expert team attends a number of workshops, during which the tasks described in Box 2 are typically worked through. Expert teams made up of approximately 5 – 12 members have proved optimum. Smaller groups are frequently unable to represent the necessary disciplinary breadth and the range of opinion that is being aimed for. In larger groups on the other hand it can be difficult to create a fruitful climate of discussion.

Box 2: Typical form of cross-impact analysis as occurs during expert discourse

1) Formulation of analysis aims, definition of system limits, agreement on general assumptions.
2) Selection of descriptors and states. Preparation of "descriptor essays", describing the descriptors and their states, sketching their definitions, their significance to the system under examination, and their development trends. Possible disruptions may also be selected, with which the resilience of the scenarios produced can be tested.
3) Specification of cross-impact judgements. The judgements must be reached on the basis of discussion. Both the judgements and the underlying reasons in their favour are recorded to aid the subsequent interpretation of analysis results. Significant disagreement concerning interrelations is documented.
4) The qualitative system model thus created – the cross-impact matrix – is analysed using the CIB method. Differences of opinion arising during the judgement discussion are picked up on in the form of variant analyses.
5) The results are discussed by the experts and the logic of the scenarios produced are critically assessed using the initial reasons for the different judgements. In sound cases judgements may be revised. The experts may also commission more in-depth analyses.
6) Once checked and if necessary improved, the cross-impact matrix is analysed again.
7) The group of experts interprets the analysis results, formulates them in terms of the aims defined at the outset and makes recommendations concerning their application.

The method is bested suited to application in instances featuring some 5 – 15 descriptors and 10 – 50 descriptor states. The lower limit is defined by the fact that smaller systems can generally be analysed mentally. Clear demarcation does not exist, since the limits of mental analysis vary from person to person and are also determined by the particular characteristics of the system under analysis, e.g. the degree of interconnection within the impact network. The upper limit is of a practical nature: the number of expert judgements required increases quadratically with the number of states and thus finally reaches the limit of what is actually discussible. Moreover in larger matrices it becomes increasingly difficult for the experts to maintain the necessary overview concerning the relative weighting of the judgements.

It is unusual for calculation time to have a limiting effect on the analysis. Nevertheless a matrix with 15 descriptors, each with 4 states, will produce more than 1 billion possible combinational scenarios, all of which require scanning and checking.

4. Possible benefits of qualitative systems analysis using CIB

The immediate result of a CIB analysis is the identification of consistent configurations ("scenarios") within a network of interdependent factors. The method in itself, however, can instruct those involved in approaching problem analysis in a structured manner and therefore often leads to a deeper appreciation of the issue. The possible benefits described in Box 3 contribute to this.

Box 3: Benefits of cross-impact analysis using the CIB method

- Those involved often acquire a new appreciation of the system – by having to specify explicitly their personal interpretation of system links using cross-impact judgements and provide convincing arguments in their favour while facing up to the opinions of others.
- The assertion of prejudices, the pursuit of hidden agendas, and the proposal of tactical judgements that aim to produce a specific result is made more difficult by the discussion of supporting arguments within the peer group. The discussion of supporting arguments may therefore be regarded as a quality precaution designed to filter out judgements proposed on the basis of inappropriate motivation.
- On the other hand the method also identifies which system elements and relations provoke reasonable dissent among the experts. This insight frequently produces just as fascinating results as the share of the judgement process on which all the experts agree.
- By producing system assessments at the level of interrelation patterns and allowing the automatic construction of associated indirect system effects, a division of labour is achieved between the human and the method which benefits from the strengths of both and avoids the weaknesses: recognising patterns is a known cognitive human strength, the simultaneous tracking of many interconnected yet individual processes a pronounced weakness (as observed for instance in management game experiments).
- The cross-impact matrix produced by expert discourse is in itself an initial stand-alone result of the analysis process, and may therefore also be used irrespective of the scenario generation: e.g. to produce graphic illustrations of the system or for reflection processes concerned with the occurrence of feedback loops.
- The transparent analysis logic of CIB avoids "black box" results: after the analysis it is possible to trace the acceptance or rejection of a scenario back to the judgements reached and the arguments on which they were based, thereby allowing subsequent discussion and checking of the results. CIB's transparency prevents experts from feeling alienated from the results obtained with their assistance, as commonly occurs in the case of complicated mathematical computations only understood by specialists. The experts therefore tend to identify more readily with the results, making their task of interpretation and recommending subsequent action easier.

Consistent scenarios are the immediate result of cross-impact matrix analysis. In many cases they are also the aim of the project, providing an adequate foundation for developing courses of recommended action or strategy. If required however the CIB method can also furnish numerous secondary analyses with which issues can be investigated in depth. See Box 4 for a selection.

5. Summary

Qualitative systems analysis using CIB supports the development of multidisciplinary scenarios as a method that generates internal consistent scenarios.

The sensible application of an analytical approach and the appropriate interpretation of the results also requires a conscious appreciation of the method's limitations. It is important to consider that owing to the discrete status subdivision of the descriptors only rough scenarios can be produced. Moreover the description of the relationship between two for the most part highly aggregated impact factors using cross-impacts always requires a degree of generalisation; the latter is usually only capable of reflecting the complexity of the real relationship to a limited extent. Furthermore, despite the inclusion of quality assurence measures in the expert solicitation process, it is not possible to obtain complete objectivity based on expert judgements, although group processes produce at least intersubjective judgements.

Nevertheless, the strengths of CIB make the method an effective tool. Its advantages include the fact

- that CIB is able to work with qualitative insights and use them to create a comprehensive image of the system. This obviates the need to exclude key problem areas for which only "soft" knowledge is available from the analysis of the system – a frequent cause of blunders during research about the future (Godet 1983);
- that CIB can be used during expert discourse – something which is frequently necessary in the case of multidisciplinary issues in order to collate all the information needed;
- that CIB, by virtue of its comprehensive scanning approach, conducts a complete check on all conceivable scenarios and thereby, rather than producing a prognosis, defines a field of options, thus occasionally revealing surprising developments, which in the case of an intuitive scenario construction might easily be overlooked.
- that despite being rooted in systems theory, CIB manages – thanks to its intelligible analytical basis – to avoid alienating results and experts on the one hand from users without a degree in mathematics on the other. This also produces less scepticism on the part of those involved when it comes to using a computer for the analysis, since all the PC does is take over the multiple application of a checking procedure that everyone understands and which every individual can double-check using paper and pencil – i.e. whether a scenario recommended by the computer is indeed consistent, or why a scenario which appears accurate at an intuitive level has been discarded as inconsistent by the computer.

Box 4: Selected secondary analyses using CIB

- Ranking of all possible combinatorial scenarios according to relative consistency (i.e. according to their compatibility with the cross-impact judgements) and combinatorial weight (the frequency with which development trajectories result in the various scenarios).
- Statistical rates of occurrence with reference to states in the consistent scenarios (preferred and suppressed states).
- Correlations between the behaviour of different descriptors.
- The effect of an assumed external impulse on one or more states and its impact on state statistics (impulse effect analysis).
- Inverted impulse effect analysis: which descriptors are best intervened with when looking to achieve a desired state?
- Sensitivity analysis and "critical cells". How does the uncertainty of cross-impact judgements affect the assessment of scenarios as consistent and inconsistent? Which sectors in the cross-impact matrix are particularly crucial and must therefore be considered with especial care?

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The series “Cross-impact balance analysis guidelines” provides information and assistance for the implementation of scenario and systems analyses using the CIB method. In addition to a description of the basics and information on the method’s background the series also includes instructions on its application, procedural descriptions and sample analyses. Publications to date:

No.	Title	Requirements
1	Introduction to qualitative systems and scenario analysis using cross-impact balance analysis	none
2	Bibliography	no. 1
*3**	*Sample instructions for experts on issuing cross-impact judgements*	*no. 1*
4	Key figures used in the analysis of CIB scenarios	no. 1

** in preparation*