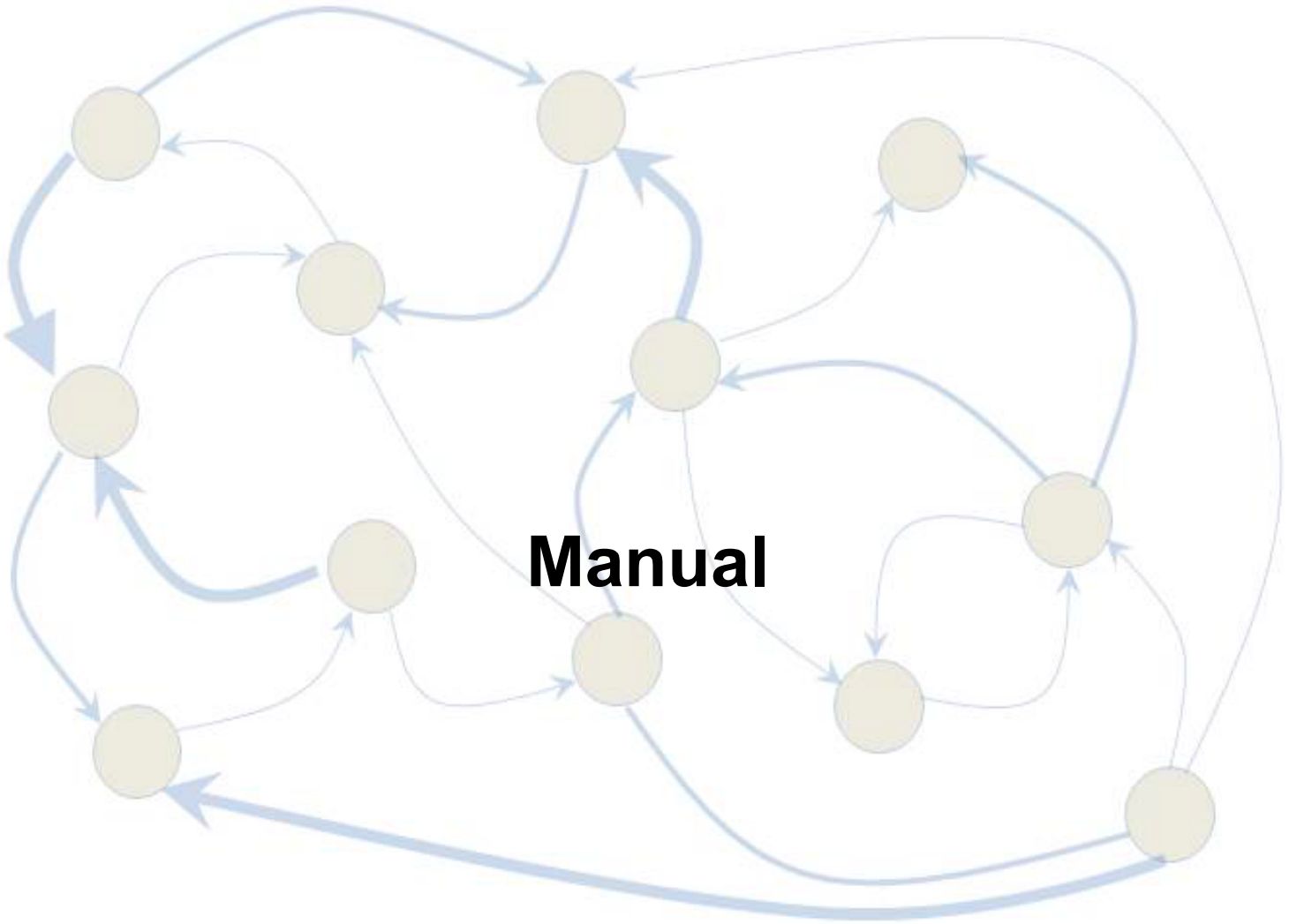
ScenarioWizard 5.1

Constructing Consistent Scenarios Using Cross-Impact Balance Analysis



Manual

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1 Preface

ScenarioWizard is designed for conducting a cross-impact balance analysis (CIB), which is a method of qualitative system and scenario analysis. CIB facilitates the construction of qualitative scenarios based on qualitative impact networks, i.e. based on qualitative knowledge concerning the mutual impact relations of a system's principal elements. Qualitative impact networks are used as a concept of system description in many disciplines, for instance, economics, energy policy analysis, technology foresight, innovation research, social sciences, management sciences, and health care analysis. CIB offers an approach for analysing such networks and understanding their behaviour.

CIB and *ScenarioWizard* were first developed from 2001 to 2003 at the Centre for Technology Assessment and developed further from 2004 to 2011 at ZIRN (Interdisciplinary Research Unit on Risk Governance and Sustainable Technology Development). In 2012, when ZIRN was integrated in ZIRIUS, the newly founded Research Centre for Risk and Innovation Studies of the University of Stuttgart, the mentoring of the CIB method was transferred to this organisation. Since 2001, the method and the software have been used, tested, and improved in many projects[1].

This manual only describes the technical aspects of using *ScenarioWizard*. It does not aim at explaining the methodological basis of CIB nor does it provide details on the different methods of data evaluation or the theoretical background of this form of analysis. However, a short introduction to the basic concepts of CIB is offered in Chapter 2, which also includes reference to a more comprehensive description of the CIB method. The CIB homepage www.cross-impact.org provides further information, references, and materials.

The most important addition in Version 5.1 is the implementation of a function for the graphical representation of the impact network that exist between the active variants of a consistent scenario (Impact Network Diagram, see Section 6.6). For other new features, see Appendix 3 "New functions".

The structure of this manual is as follows: Chapter 2 contains a short introduction to the CIB method. Far from being exhaustive, it provides a rough idea of the goals, approach, and possible products of a CIB analysis. Although the installation of the software is straightforward and uses standard Windows procedures it is briefly described in chapter 3. Chapter 4 takes you through a simple CIB analysis creating scenarios of the societal future of a fictitious country 'Somewhereland'. After having worked through this chapter, you will be able to assign the analysis steps described in Chapter 2 to the corresponding *ScenarioWizard* functions.

After this overview, the subsequent chapters describe the functions of the software in greater detail. Chapter 5 shows how to build up a project file (containing descriptors, descriptor variants, descriptor definitions, the cross-impact matrix, and comments on the cross-impacts) and how to modify and store it. Chapter 6 deals with *ScenarioWizard's* evaluation procedures designed to support the con-

[1] A bibliography can be found at www.cross-impact.org/english/CIB_e_Pub.htm

struction and understanding of scenarios, i.e. plausible and internally consistent combinations of descriptor variants. Chapter 7 shows how the user can customise the output formats and evaluation procedures of the software to meet his/her needs. Chapter 8 explains the Presenter mode. The Presenter provides several functions supporting the presentation and discussion of data and results of your CIB analysis. Chapter 9 describes the technical limitations of the data structures, which can be processed by *ScenarioWizard*. The topic of Chapter 10 is both a pleasure and an obligation. It acknowledges the support of the many scholars, colleagues, and friends who contributed in various ways to the development of the CIB and *ScenarioWizard*. Chapter 11 informs about the license regulations and the liability disclaimer regulating your use of the software. Finally, Chapter 12 contains a glossary, which might be a helpful guide through the jungle of technical terms that, unfortunately, also pervades this manual. The appendix contains descriptions of several data file formats and provides an overview of the new features of the program version 5.1.

2 Introduction to CIB

This chapter offers a short introduction to the basic concepts of CIB. Readers who are knowledgeable about CIB may prefer to skip this chapter. The method was published in 2006 in *Technological Forecasting and Social Change*[2]. A handbook on the CIB method has been published by Springer Nature in 2023[3]. A bibliography of the extensive body of publications about the method and its applications can be found at the CIB homepage (see http://www.cross-impact.org/english/CIB_e_Pub.htm).

2.1 Purpose of the CIB method

CIB is a method for analysing impact networks. The method uses qualitative insights into the relations between the factors of an impact network to construct consistent images of the network behaviour.

A typical application field of CIB is scenario analysis. The construction of scenarios frequently requires the examination of developments in many different fields (e.g. economic, political, social, or technological developments). Within different fields, well-established ideas about possible developments often exist (e.g. in the form of a favourable, neutral, and unfavourable forecast variant). However, the development of holistic scenarios requires identifying which combinations of these variants are promoted by the net of their interrelations. This systemic synthesis of isolated information to an overall picture in the context of a scenario analysis is the aim of the CIB analysis.

CIB is a special form of cross-impact analysis. Cross-impact methods are mostly used for analytical tasks that do not allow the use of theory-based computational models due to their disciplinary heterogeneity and the relevance of 'soft' system knowledge, but on the other hand, are too complex for a purely argumentative systems analysis.

The CIB-Lab of ZIRIUS supports the application of the CIB method by scientists, companies, or administrations through advice, cooperation, and various materials. Visit CIB's method homepage for more information.

[2] Weimer-Jehle W. (2006): Cross-Impact Balances: A System-Theoretical Approach to Cross-Impact Analysis. Technological Forecasting and Social Change, 73:4, 334-361.

[3] Weimer-Jehle W. (2023): Cross-Impact Balances (CIB) for Scenario Analysis - Fundamentals and Implementation. Springer Berlin, Heidelberg, New-York. DOI: 10.1007/978-3-031-27230-1

2.2 The CIB approach

The aim of the CIB analysis is the construction of plausible configurations of an impact network consisting of mutually supporting assumptions about the network states. CIB uses a pair-interaction system approach. The starting point is the identification of a set of factors ('descriptors') that characterise the system in a sufficient way for a qualitative system understanding. The relations between these descriptors are described by a net of influences (Fig. 2-1).

The impact relations may be one-sided or reciprocal. An arrow directed from descriptor D1 to descriptor D2 indicates an impact on D2, caused by D1. This means that, all other things equal, a change in the state of D1 will stimulate a change in the state of D2. As a whole, the system will tend to a configuration in which the web of influences is balanced in an internally consistent way. The impact network and its interdependencies can be described in a qualitative manner by a "cross-impact matrix".

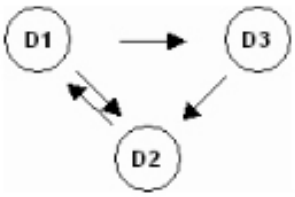


Fig. 2-1: A simple impact network.

2.2.1 Structure of a cross-impact matrix (CIM)

The construction of a cross-impact matrix will be explained with the help of a simple example. The example describes a fictitious country, 'Somewhereland', with six interdependent factors in the fields of politics, economy, and society. The steps of the CIB process are as follows:

1) Compile a list of the most relevant system factors ('descriptors').

In our example, literature research or expert interviews may lead to the following list of descriptors: A. Government, B. Foreign policy, C. Economy, D. Distribution of wealth, E. Social cohesion, and F. Social values.

2) Define a set of qualitative alternatives that characterise the possible states of descriptors.

In the example, we use

- ***'Patriots party', 'Prosperity party', and 'Social party'*** *as possible variants of the des. 'Government';*
- ***'Cooperation', 'Rivalry', and 'Conflict'*** *as possible variants of the descriptor 'Foreign policy';*
- ***'Shrinking', 'Stagnant', and 'Dynamic'*** *as possible variants of the descriptor 'Economy';*

- ***'Balanced' and 'Strong contrasts'*** *as possible variants of the descriptor 'Distribution of wealth';*
- ***'Social peace', 'Tensions', and 'Unrest'*** *as possible variants of the descriptor 'Social cohesion';*
- ***'Meritocratic', 'Solidarity', and 'Family'*** *as possible variants of the descriptor 'Social values'.*

3) Make a judgement about the impact of variant x of descriptor X on variant y of descriptor Y

(based on literature reviews, expert interviews, or other appropriate investigations). Express your judgement in a qualitative scale as follows:

-3: strongly restricting influence
-2: moderately restricting influence
-1: weakly restricting influence
0: no influence
+1: weakly promoting influence
+2: moderately promoting influence
+3: strongly promoting influence.

Only direct influences must be considered for these judgements. The resulting indirect influences will be automatically constructed by the algorithm.

In the example, we make the judgement that the occurrence of social unrest will strongly motivate many citizens of Somewhereland to retreat mentally into their closer social references: the family. The cross-impact of the variant 'E3 Social cohesion: Unrest' on the variant 'F3 Social values: Family' is set as +3.

This procedure results in a cross-impact matrix. Fig. 2-2 shows the matrix for our example. The row descriptor of a judgement section indicates the source of an impact, whereas the column descriptor shows the target of the impact. For example, the judgement section C_{EB} describes the impact of social cohesion on foreign policy.

Cross-Impact Matrix "Somewhereland"	A.Gov			B.FoP			C.Eco			D.W		E.SCo			F.SoV		
	A1 'Patriots party'	A2 'Prosperity party'	A3 'Social party'	B1 Cooperation	B2 Rivalry	B3 Conflict	C1 Shrinking	C2 Stagnant	C3 Dynamic	D1 Balanced	D2 Strong contrasts	E1 Social peace	E2 Tensions	E3 Unrest	F1 Meritocratic	F2 Solidarity	F3 Family
A. Government:																	
A1 'Patriots party'				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
A2 'Prosperity party'				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
A3 'Social party'				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy:																	
B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy:																	
C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth:																	
D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion:																	
E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
E3 Unrest	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values:																	
F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			

C_{EB}: A judgement section A judgement group C_{E3F3}: A judgement cell

Fig. 2-2: A cross-impact matrix (CIM).

Exercise: The cross-impact judgements in Fig. 2-2 are to be taken as examples. They express a possible view on the issue of societal development, but your opinion on some relationships might be different for your country. Prepare your own matrix, which expresses your personal judgements.

2.2.2 Detecting the inconsistencies of a scenario

The interdependencies shown in Fig. 2-2 constitute a net of impact relations expressed by the cross-impact matrix. They limit the space of plausible scenarios for the system state because a configuration chosen arbitrarily will in general contain contradictions to the 'rules' of the system. Contradictions are made visible by calculating the impact balances of a scenario. In Fig. 2-3, this is done for the scenario *S* = [A2 B1 C3 D1 E1 F1] (Government: 'Prosperity party', foreign policy: cooperation, econ-

omy: dynamic, distribution of wealth: balanced, social cohesion: social peace, social values: meritocratic). Summing up the highlighted rows gives the impact balances that summarise the influences affecting the descriptors. The scores of the impact balances, which correspond to the given scenario, are marked by arrows in the row 'Scenario assumptions'.

Cross-Impact Matrix 'Somewhereland'	A.Gov			B.FoP			C.Eco			D.W		E.SCo			F.SoV		
	A1 'Patriots party'	A2 'Prosperity party'	A3 'Social party'	B1 Cooperation	B2 Rivalry	B3 Conflict	C1 Shrinking	C2 Stagnant	C3 Dynamic	D1 Balanced	D2 Strong contrasts	E1 Social peace	E2 Tensions	E3 Unrest	F1 Meritocratic	F2 Solidarity	F3 Family
A. Government:																	
A1 'Patriots party'				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
A2 'Prosperity party'				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
A3 'Social party'				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy:																	
B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy:																	
C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth:																	
D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion:																	
E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
E3 Unrest	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values:																	
F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			
Scenario assumptions:	↓			↓			↓			↓		↓			↓		
Balances	0	3	-3	2	1	-3	-9	-1	10	-7	7	4	-1	-3	2	-1	-1
Maximum:		↑		↑				↑			↑	↑			↑		

The impact score of a variant

The impact balance of a descriptor

Fig. 2-3: Impact balance of a scenario.

In five cases (descriptors A, B, C, E, and F), the arrows indicate the maximum score of the descriptor impact balance (see arrows in the row 'Maximum'). Consider descriptor E (social cohesion) as an example. The impact balance of 'E. Social cohesion' is [+4,-1,-3], and the impact score of 'social peace' (the descriptor variant, which is assumed in scenario *S*) is +4. There is no higher impact score within the impact balance of this descriptor, and therefore, the assumption 'Social cohesion: social peace' is rated consistent. The reason behind this technical rating is that the scenario includes two

assumptions strongly working in favour of social peace: dynamic economic growth and balanced distribution of wealth. These impacts as a whole have considerably more weight than the scenario's single argument against social peace (social values: meritocratic). A comparable dominance of pro-arguments can be found in none of the other possible variants of the descriptor 'Social cohesion'.

The assumptions of the scenario are not working out for every descriptor, however. In one descriptor balance ('D: Distribution of wealth'), the arrow does not point to the maximum impact score and this indicates an inconsistency in the scenario. Scenario *S* assumes the variant 'balanced' for this descriptor, but this assumption is supported by none of the other scenario assumptions. The policies of Somewhereland's 'Prosperity party', the dynamic economic growth, and the meritocratic social values point towards the opposite assumption of strong contrasts in the distribution of wealth (see the cross-impact matrix). This means that the assumption 'balanced' does not comply with the pros and cons associated with the descriptor 'Distribution of wealth'.

Descriptor D violates the 'rules' coded in the cross-impact matrix. To avoid such violations, the states of the descriptors must show a well-balanced configuration that reflects the dual role of each descriptor as both impact source and impact target. The internal consistency of a scenario requires that every variant is chosen in such a way as to ensure that no other variant of the same descriptor is stronger supported by the combined influences of the other descriptors than the selected variant. In CIB, this is denoted as the principle of consistency. In Fig. 2-3, this principle is violated, and the shown scenario is inconsistent.

It should be mentioned that the switching of the inconsistent descriptor 'Distribution of wealth' does not automatically result in a consistent scenario. The variant of this descriptor then would correspond to the influences having an impact on it. However, new inconsistencies would arise in other places, caused by the changes in descriptor D. Impact nets are complex systems and usually, they are not easy to understand. CIB analysis, although a qualitative method, mirrors this fact.

Exercise: Try to guess a Somewhereland scenario without inconsistency before you read the next section.

2.2.3 Consistent scenarios

In our example (six interacting descriptors), 3*3*3*2*3*3 = 486 possible configurations exist. Checking all configurations by the method shown in Fig. 2-3 reveals that only 10 configurations are free of internal inconsistencies. The 10 consistent scenarios are grouped into six scenario families (scenario groups) and a title is assigned to each group interpreting and summarising the scene in each case:

Scenario-group I "Prosperity in a divided society"		Scenario-group II "Stop exploitation!"		Scenario-g. III "Cosy society"	Scenario-g. IV "Protectionism"	Scenario-group V "We against the others"			Scenario-g. VI "Society in crisis"
Ia	Ib	IIa	IIb			Va	Vb	Vc	
A. Government: -A2 "Prosperity party"		A. Government: -A3 "Social party"				A. Government: -A1 "Patriots party"			
B. Foreign policy: -B1 Cooperation	B. Foreign policy: -B2 Rivalry	B. Foreign policy: -B1 Cooperation			B. Foreign policy: -B2 Rivalry	B. Foreign policy: -B3 Conflict			
C. Economy: -C3 Dynamic				C. Economy: -C2 Stagnant					C. Economy: -C1 Shrinking
D. Distribution of wealth: -D2 Strong contrasts				D. Distribution of wealth: -D1 Balanced					D. Distribution of wealth: -D2 Strong contrasts
E. Social cohesion: -E2 Tensions		E. Social cohesion: -E1 Social peace							E. Social cohesion: -E3 Unrest
F. Social values: -F1 Meritocratic				F. Social values: -F2 Solidarity				F. Social values: -F3 Family	

Fig. 2-4: Consistent scenarios of Fig. 2-2.

The consistency of the single scenario in scenario group VI 'Society in crisis' is demonstrated in Fig. 2-5. All arrows of the row 'Scenario' mark the states of the maximum impact score in the respective impact balance. They coincide with the arrows in the row 'Maximum'. The state of each descriptor reflects the sum of all influences, which are caused by the other descriptors. In the case of contradictory influences, the stronger influences are decisive.

Large cross-impact matrices include too many possible configurations to be checked by hand. Even in the case of our example with 486 configurations, this would be a laborious task. A systematic exploration of the configuration space and identification of the complete set of consistent scenarios require the help of *ScenarioWizard*. Nonetheless, it is possible and instructive to test the validity of the resulting scenarios or the inconsistency of a rejected scenario manually. The possibility of testing the computer evaluations in an easy and understandable way can considerably enhance the credibility of the analysis results in the eyes of the involved persons and the users of the analysis.

It should be stressed that the application of CIB is not restricted to the issue of societal developments, which is used here only as an example. Typical descriptors in applied projects concern policy decisions, business strategies, environmental, social, or technological changes, and others.

Cross-Impact Matrix 'Somewhereland'	A.Gov			B.FoP			C.Eco			D.W		E.SCo			F.SoV		
	A1 'Patriots party'	A2 'Prosperity party'	A3 'Social party'	B1 Cooperation	B2 Rivalry	B3 Conflict	C1 Shrinking	C2 Stagnant	C3 Dynamic	D1 Balanced	D2 Strong contrasts	E1 Social peace	E2 Tensions	E3 Unrest	F1 Meritocratic	F2 Solidarity	F3 Family
A. Government:																	
A1 'Patriots party'				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
A2 'Prosperity party'				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
A3 'Social party'				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy:																	
B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy:																	
C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth:																	
D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion:																	
E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
E3 Unrest	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values:																	
F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			
Scenario assumptions:	↓			↓			↓			↓		↓			↓		
Balances	7	-4	-3	-5	2	3	5	2	-7	-1	1	-3	1	2	-2	-1	3
Maximum:	↑			↑			↑			↑		↑			↑		

Fig. 2-5: Impact balance of scenario VI.

3 Installation

System requirements

ScenarioWizard requires the following system features:

- A PC with Microsoft Windows 10 or higher (recommended);
- The software can also be operated with older Windows versions from Windows 7 onwards. However, it requires the Microsoft .NET Framework 4.7, which is not pre-installed by default on Windows versions older than Windows 10. If you receive an error message during installation on older Windows versions, you can download .NET Framework 4.7 free of charge from the Microsoft Download Center:

  https://www.microsoft.com/en-us/download

  ScenarioWizard versions designed for older Windows versions can be requested from scenariowizard@cross-impact.org.
- At least 10 MB free space on your hard disk;
- The software is optimized for operation with display scaling settings between 125% and 175%;
- A mouse or another pointer device is recommended;
- The CPU speed required depends on the size of the cross-impact matrices to be evaluated. A CPU speed of 1 GHz or more is recommended.
- The main memory size required depends on the size of the matrix under consideration. A maximum use of the data arrays enabled in *ScenarioWizard* (see Chapter 9.1) requires a main memory of approximately 650 MB. Typical project sizes use approx. 7–10 MB of main memory.

Installing and starting *ScenarioWizard*

Before you install the software, read the
End User License Agreement (EULA) in Chapter 11!

1. If you have installed older versions of the software on your computer, please deinstall it before proceeding.
2. Start the installation package *ScenarioWizard4Setup.msi* using the Windows function 'Start-Run' or Windows program 'File Explore'.
3. Follow the instructions of the installation program. Having completed the installation procedure, start *ScenarioWizard* using the Windows function 'Start-Run' or the Windows program 'File Explore' or the icon on the desktop.

Further information

Scenario studies may require confidentiality in certain cases. In order to allow users the greatest possible privacy when using the program, the *ScenarioWizard* is designed as offline software. This means that the software no longer accesses the Internet after installation (provided you refrain from including Internet links in the documentation texts of your project files) and the software can be operated offline permanently and without restriction.

On the other hand, the offline design of the software requires that there is no automatic update function. It is therefore recommended that you regularly visit the website www.cross-impact.org to check for new versions.

4 Getting started with *ScenarioWizard*

4.1 Overview

A qualitative system analysis using *ScenarioWizard* is conducted by sampling qualitative judgements about the mutual influences (the 'cross impacts') of the principal elements of a system, and by constructing plausible and consistent qualitative scenarios concerning the system's behaviour. The typical structure of a cross-impact analysis using *ScenarioWizard* is as follows:

- Generate a list of descriptors (relevant system elements) and their variants (possible states or developments): the 'analysis structure'.
- Enter the cross-impact data into this structure. The analysis structure and the cross-impact data together form the cross-impact matrix.
- Evaluate the cross-impact matrix by computing its solution set (consistent scenarios, weights, etc.).
- If appropriate for the aims of the analysis, carry out additional evaluations (frequency statistics, influence analysis, and transient analysis).
- Store data and results.

The following chapters describe how to perform the various stages of the process. All necessary functions can be accessed via the menu items and the buttons found in the different *ScenarioWizard* windows. The basic functions are also available using the buttons of the toolbar (Fig. 4-1). All functions may only be accessed if the necessary preparatory steps have been done. Otherwise, the menu items appear grey and their toolbar buttons are disabled. For instance, clicking the button 'Find consistent scenarios' on the toolbar is only effective if an analysis structure has been generated or loaded, and if cross-impact data have been provided.

A help function is also available. It may be accessed via the menu item *Info* – *Help* or the F1 key.

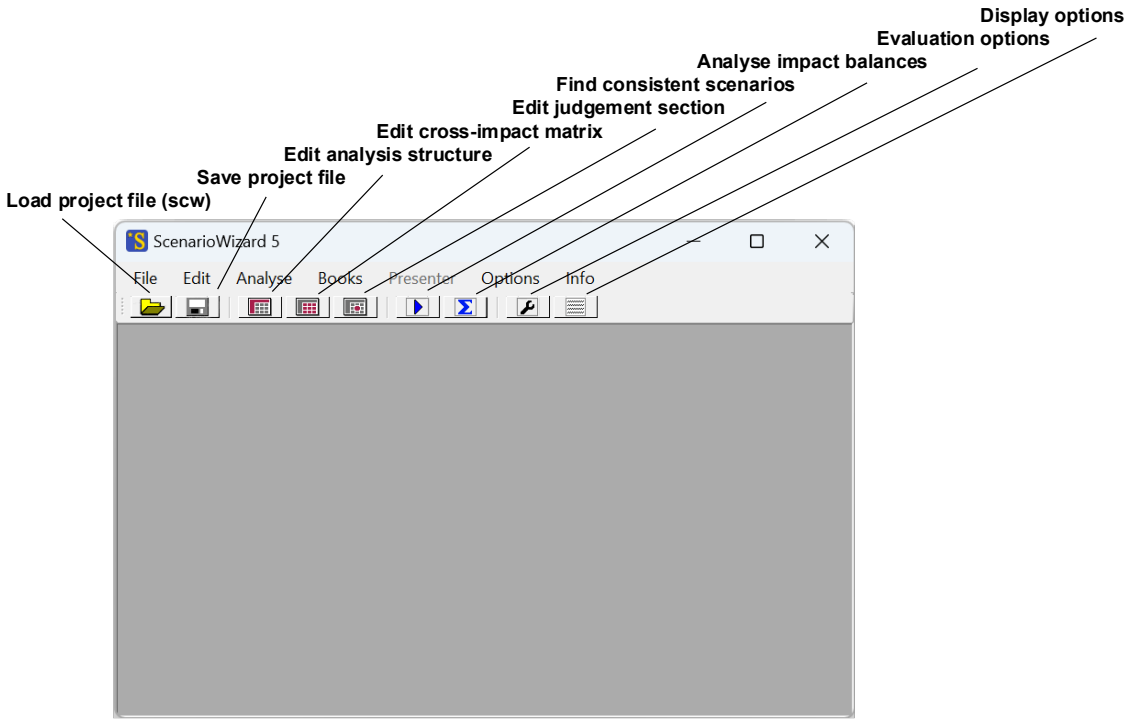


Fig. 4-1: Basic functions of *ScenarioWizard* found on the toolbar.

4.2 A simple step-by-step analysis

This chapter describes a simple analysis to show the principles and the typical way of working with *ScenarioWizard*. The analysis deals with the calculation of the consistent scenarios of Somewhereland, which is the example used in Chapter 2.

Step 1: The analysis structure

The first step of the analysis requires the definition of the descriptors and their variants (the 'analysis structure'). Sections 5.3 and 5.8 describe how to build up a new analysis structure using *ScenarioWizard* and how to fill the analysis structure with cross-impact data. This is not necessary in this exercise as a ready-to-use project file named 'Somewhereland_en.scw' is included in *ScenarioWizard's* installation package. The project file can be loaded using the menu item *File - Load...project file* or the button in the toolbar.

After loading the analysis structure, it can be displayed using the menu item *Edit - Analysis structure* or the button in the toolbar (Fig. 4-2). First, an inquiry is shown to confirm if the cross-impact

matrix shall be co-edited, because a modification of the analysis structure can request an appropriate restructuring of the cross-impact data. Click on the button ‘Yes’.

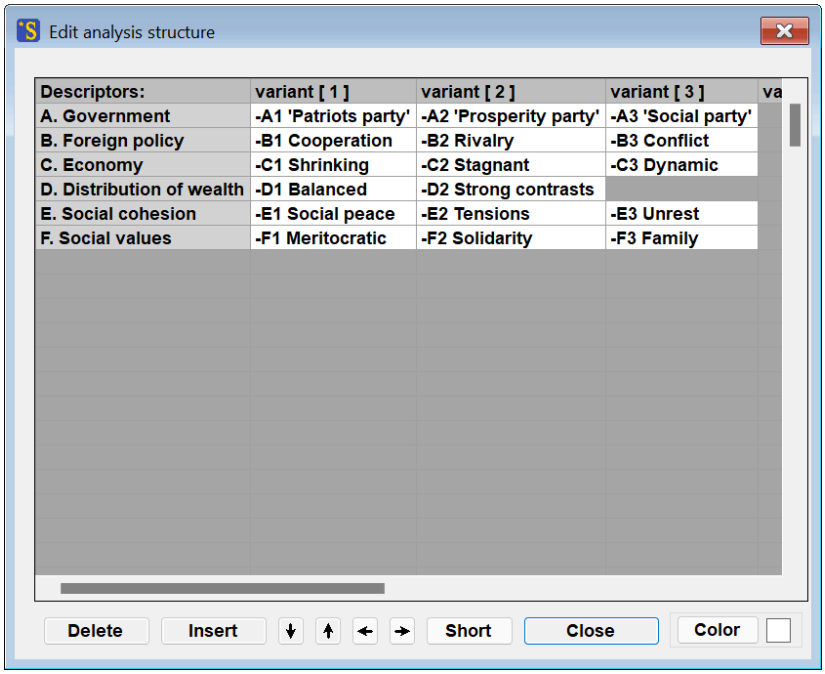


Fig. 4-2: Analysis structure of the Somewhereland exercise displayed in the structure editor.

In several program windows, *ScenarioWizard* uses abbreviations of the names of descriptors and variants. Therefore, the preparation of an analysis structure in the structure editor also includes the definition of short names of the descriptors and variants. However, this step can also be skipped in our exercise, because all necessary abbreviations are already included in the loaded project file. To display the abbreviations, press the button ‘Short’. The same button (now inscribed ‘Long’) can be used to switch back to the long names.

The structure editor can also be used to modify the analysis structure (see Section 5.6). This is not required now because the loaded project file fully represents the exercise Somewhereland. The structure editor can be closed now. Use the button ‘Close’ to this end.

Step 2: Cross-impact data

The next step in the analysis procedure is to enter the cross-impact data. They represent the mutual influences between the descriptors. This can be done using the ‘matrix editor’. The menu item *Edit - Cross-impact matrix* or the button  in the toolbar opens the matrix editor (Fig. 4-3). Again, it is not necessary to enter the data manually because the data of the exercise Somewhereland are provided by the loaded project file.

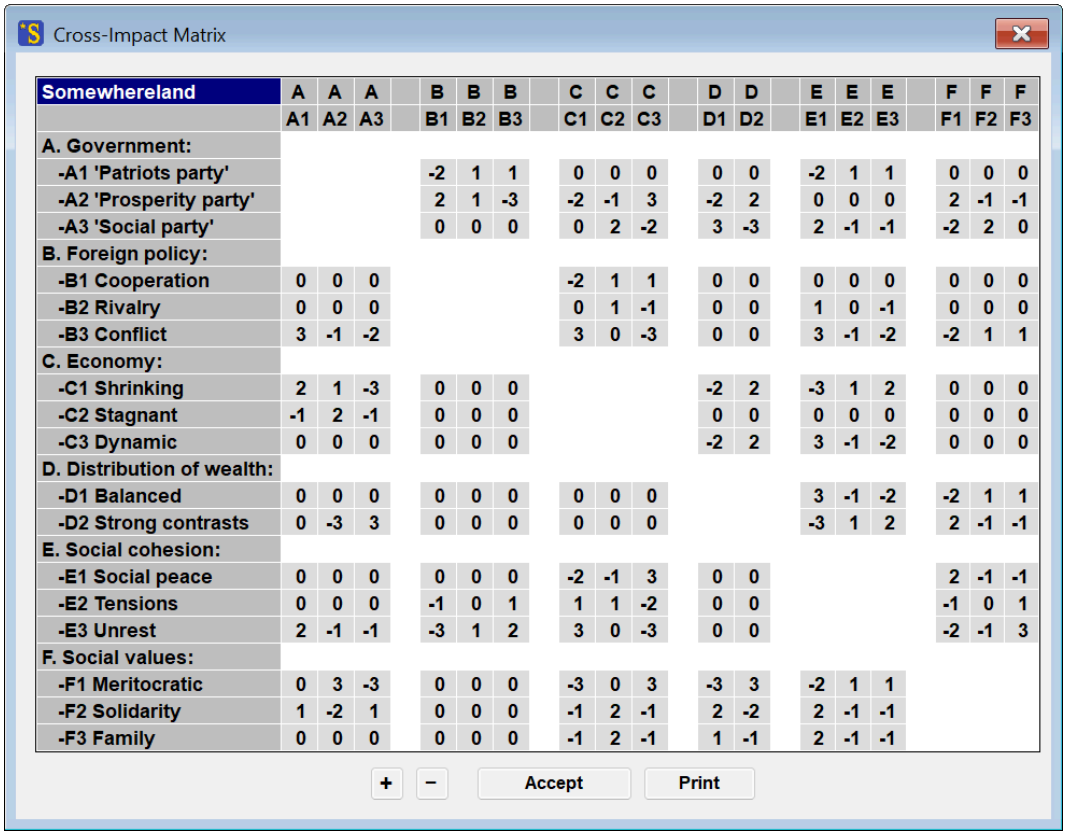


Fig. 4-3: The matrix editor.

Descriptors and their alternative variants are printed in long names in the left column of the matrix. In the head row, they are printed in short names (see step 1). The matrix editor can be used to enter or to modify cross-impact data. In our exercise, the loaded matrix matches perfectly with Fig. 2-2 and we can close the matrix editor by pressing the button 'Accept'.

Step 3: Calculation of consistent scenarios

Now that all data are available, the evaluation of the cross-impact matrix can begin. The calculation of the consistent scenarios following the method described in Chapter 2 is started by the menu item *Analyse - Consistent scenarios* or the button in the toolbar. The results of the calculation (the 'solutions of the matrix') are displayed in the protocol shown in

Fig. **4-4**.

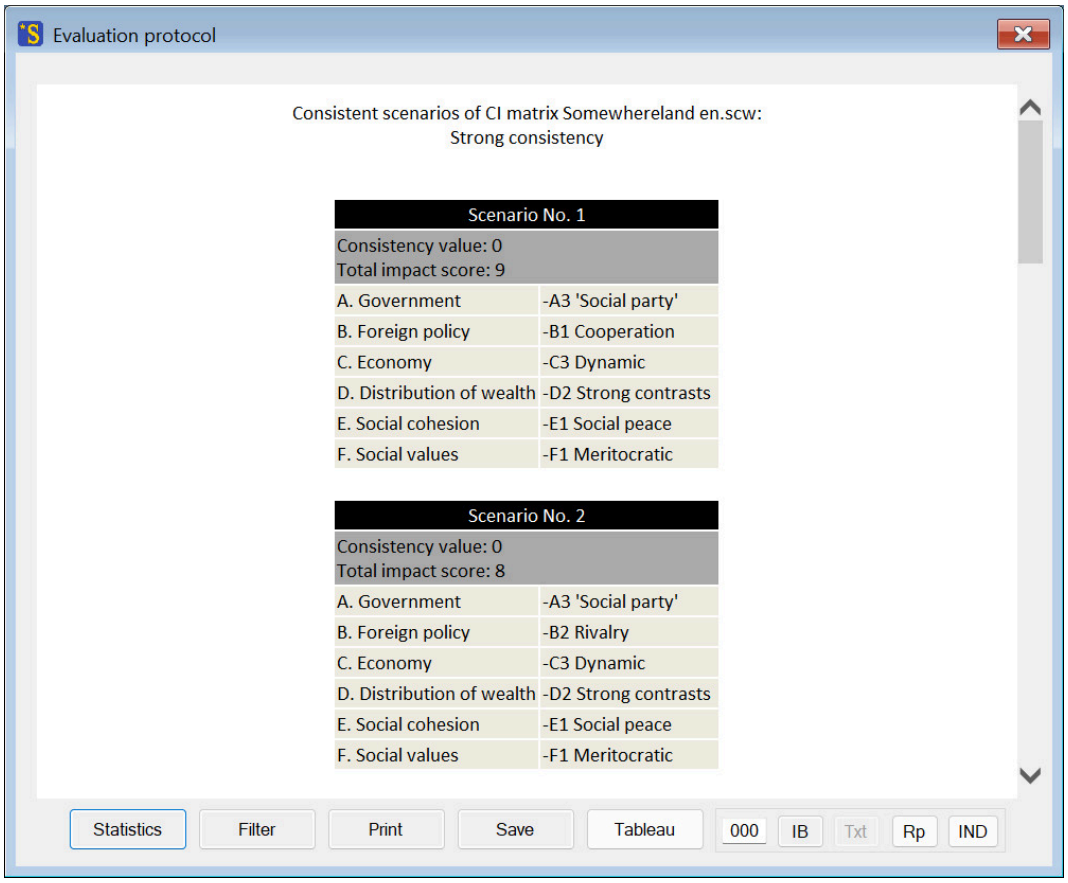


Fig. 4-4: Evaluation protocol displaying consistent scenarios.

The protocol shows the scenario IIA and IIB of the scenario tableau in Fig. 2-4. The other scenarios can be displayed using the scroll bar.

Step 4: Analysing the consistent scenarios

Using the input field between the 'Tableau', "WB" and 'IND' buttons in the evaluation protocol, a scenario can be selected for in-depth analysis by entering its number in accordance with the evaluation protocol. For example, pressing the "IND" button calls up a graphical representation of the impact relationships in the selected scenario, so that the logical relationships between the individual scenario elements and the reasons for the consistency of the scenario become visible. An 'Impact Network Diagram' for scenario no. 1 is shown in Fig. 4-5.

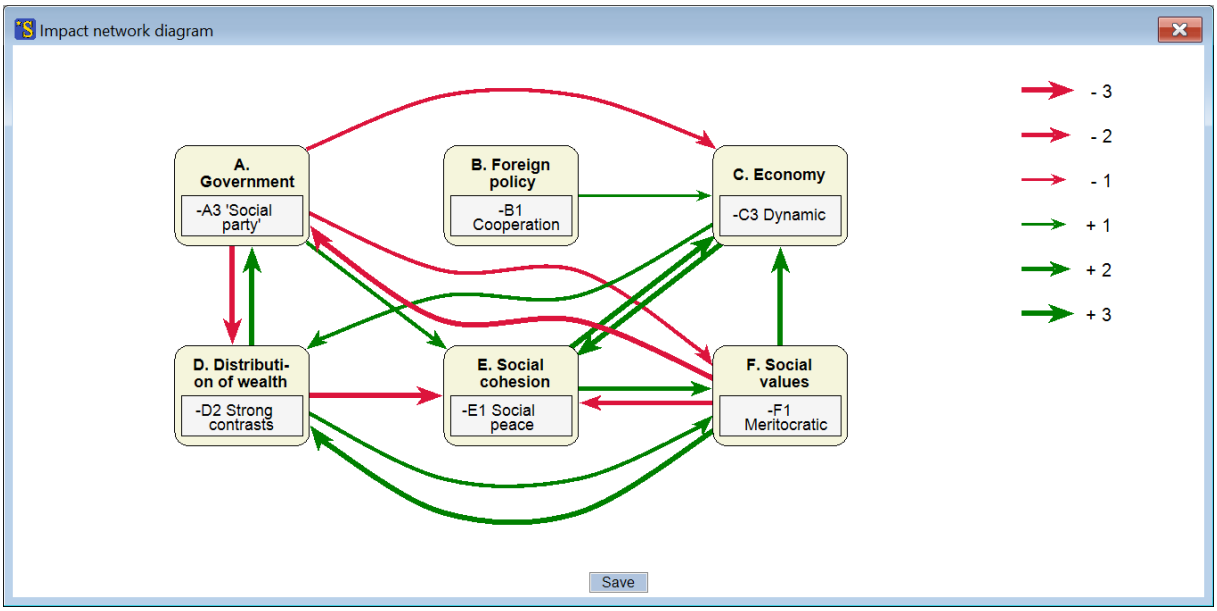


Fig. 4-5: An impact network diagram.

The calculation of the consistent scenarios is the core function of the CIB method. Further analysis procedures are described in Chapter 6.

The demonstration of the basic analysis of the exercise Somewhereland is completed now. Close *ScenarioWizard* by the menu item *File - Exit* or press the close button at the top right of the program's main window. The following chapters provide detailed information on several functions of the software.

5 Generating and handling a project file

Since program version 4, all input data necessary for conducting a CIB analysis are integrated and stored in a single project file (in earlier versions of the software, the analysis structure and the cross-impact data were stored in different files). The project files bear the extension .scw. The following sections describe the generation, handling, and use of project data and project files by *ScenarioWizard.*

5.1 Overview

ScenarioWizard project files contain the following data (some of them are obligatory, whereas some are optional for conducting an analysis):

1. Name of the project (obligatory).
2. Names and abbreviations of the descriptors and their alternative variants (obligatory).
3. Colour codes of the descriptor variants. For instance, colours can be used to express the normative desirability of the variants (optional).
4. Cross-impact data characterising the influences between descriptors (obligatory).
5. Explanatory text ('comments') for the descriptors and cross-impact data (optional).

Section 5.2 shows how an existing project file can be loaded and saved. Sections 5.3 to 5.10 deal with the process of building up a new project by defining an analysis structure (descriptors and their variants) and defining the cross-impact data. The remaining sections of Chapter 5 describe additional functions, e.g. the import and export functions of *ScenarioWizard.*

5.2 Loading and storing a project file

The first step of a cross-impact analysis using *ScenarioWizard* is either to load an existing project file or to generate a new analysis structure. An existing project file (scw file) is loaded using the menu item *File - Load...project file*. Upon starting *ScenarioWizard*, this is the only item available in the *File menu*, because all other items require the presence of an analysis structure.

Having clicked on *File - Load...project file*, a file selection window is shown. The window can also be opened by the button  on the toolbar. The loading of a new project file overwrites any

previously loaded or generated structure or cross-impact data. If there are unsaved structure data or cross-impact data in the workspace, a warning will appear before starting the loading procedure.

Once a new project file has been loaded, it can be used for modification and evaluation of the included data.

The menu item *File - Save ... project file* or the button in the toolbar stores the current state of the project data. The name and the location of the project file can be chosen via a file selection window. Existing files with the same name will be overwritten.

5.3 Generating an analysis structure

The first step of a cross-impact analysis using *ScenarioWizard* is either to load an existing project file or to generate a new analysis structure. In the case of a new project, the analysis structure must be generated. Use the menu item *Edit - Analysis structure* to generate a new analysis structure. This menu item opens the 'structure editor' shown in Fig. 5-1.

To avoid unclear data states, the menu bar remains inaccessible while the structure editor is open. The toolbar is also deactivated.

The newly opened sheet is prepared to accept the names of the first and second descriptor (light grey cells below the label 'Descriptors') and the names of their first states (white cells in the second column of the sheet). Enter the names.

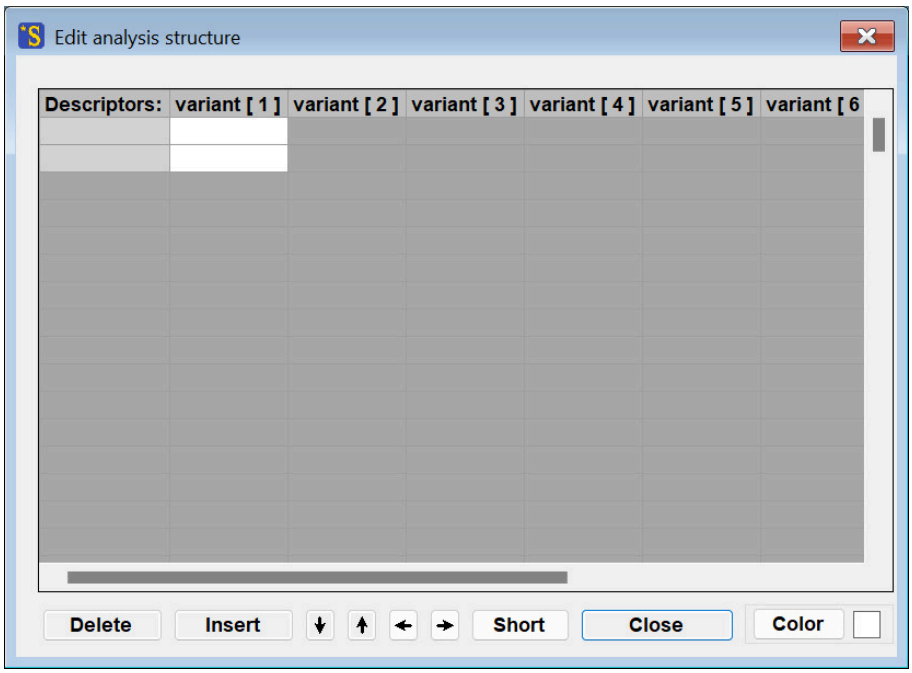


Fig. 5-1: Generating an analysis structure using the 'Structure editor'.

If required, click a variant name and then the ‘Insert’ button to expand a row and to generate a new cell for a further variant name of the same descriptor. Click the cell below the last descriptor name and then the ‘Insert’ button to expand the descriptor column and to generate a new cell for the name of the next descriptor. Repeat these steps until all descriptors and variants are specified. The column width will automatically adjust to the longest name in use inside a column. Note: Descriptors with only one variant are permitted (but descriptors without variants are not permitted). Once the analysis structure is completed the window looks as shown in Fig. 5-2.

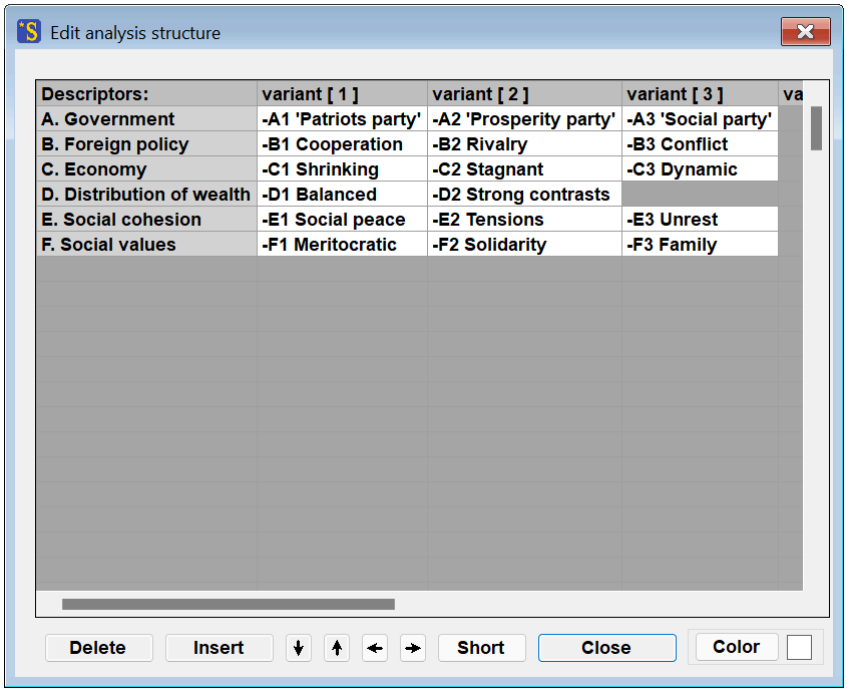


Fig. 5-2: Structure editor after the definition of descriptors and variants.

In addition to the names of the descriptors and variants (‘long names’), abbreviations (‘short names’) must also be defined. They are used in several program windows, e.g. as labels of the cross-impact matrix columns. The short names should be as short as possible to achieve compact representations, but they should also be as meaningful as possible to keep representations intelligible. Click the ‘Short’ button. The sheet with empty cells for all defined descriptors and variants is ready for the entry of short names. Click the same button (now named ‘Long’) to change back to the long names.

> The long names and short names of the descriptors and variants must not contain commas, semi-colons, or double quotation marks.

A double click on any point of the structure editor outside of the cell array generates a default set of descriptor and variant names for all empty cells. Descriptors are named as A–Z, their variants as A1, A2, ... B1, B2, ..., and so on. This function is available only for a maximum of 26 descriptors.

Having entered all short names and long names, the generation of the analysis structure is complete. The structure editor is closed using the 'Accept' button. The generated analysis structure is saved using the menu item *File-Save ... Project file* (this menu item becomes available after closing the structure editor) or the  button on the toolbar. The saved file can be loaded again in a later session.

5.4 Entering descriptor comments

The definitions of the descriptors and their variants can be entered into 'comment windows'. This is useful for documentation and as a base for judging interdependencies. The comment window of a descriptor is opened by clicking on the descriptor name (or on any of its variants) in the structure editor using the right mouse button. A small text window appears in which the comment can be entered or an existing comment can be modified (Fig. 5-3). The title of the comment window refers to the short name of the descriptor. After finishing the comment, the comment window can be closed using its close button. Double quotation marks (") are not permitted in comments and are automatically converted into single quotation marks once the comment window is closed.

A click on the title row of the table (containing the denominations 'Descriptors: Variant[1] Variant[2], ...') opens the comment window for general project information (e.g. project name, purpose of the analysis, project team, project publications, etc.).

Comments are optional and do not influence the scenario calculations. However, they are used for the automatic scenario report, if available (see Section 6.3).

All comments are integrated into the project file database and they will be stored and loaded when the project file is stored or loaded.

The menu item *Edit - Show comments* produces a compilation of all comments of the project (descriptor comments and cross-impact comments; see Sections 5.10 and 5.11). The compilation can be transferred into a word processor by copy and paste or it can be printed using the print button of the 'Show comments' window. Descriptors or judgement sections without comment are skipped in the compilation. The menu item *Edit - Show comments* is only available if at least one comment exists.

The comments of a project can be erased using the menu item *File - Reset ... Clear comments*. The analysis structure and the cross-impact data of the project remain unchanged by this command.

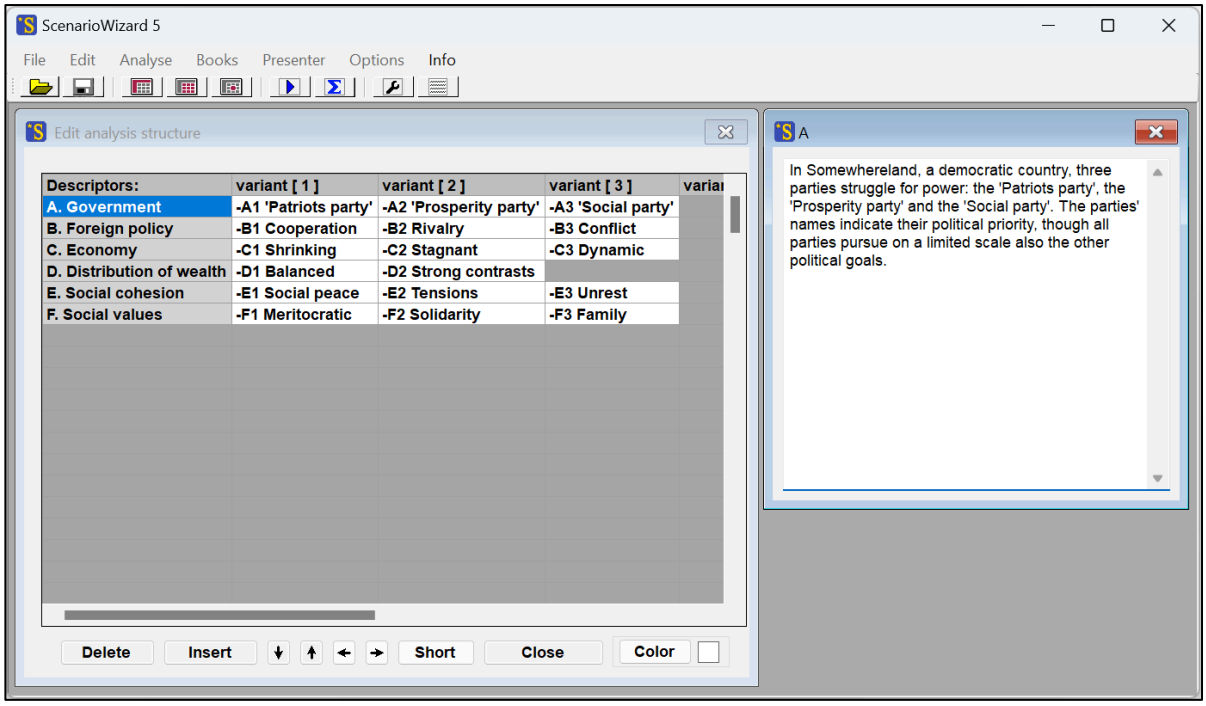


Fig. 5-3: The comment window. In this example, a comment on the descriptor 'A. Government' is displayed.

5.5 Assigning colours to descriptor variants

The colour selection button 'Colour' can be used to assign colours to the descriptor variants, e.g. to express their normative desirability by traffic light colours. Colour coding is optional and has no influence on the scenario calculations. However, colour coding is used in the scenario tableau (see Section 6.5).

To assign a colour to a descriptor variant, select a colour by pressing the colour selection button and choosing a colour. Double click on a descriptor variant and assign the selected colour to this variant. Fig. 5-4 shows a colour-coded analysis structure.

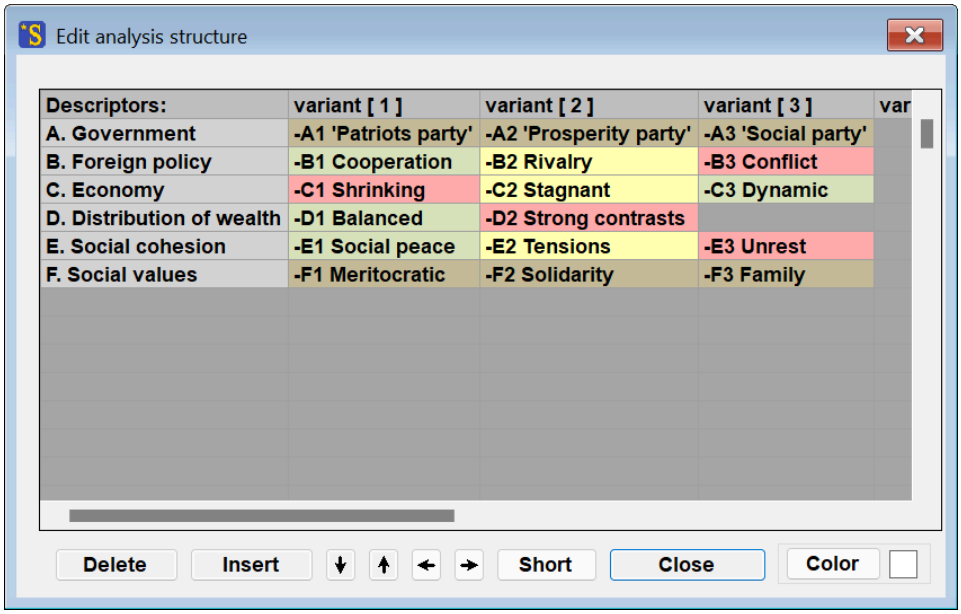


Fig. 5-4: A colour-coded analysis structure.

5.6 Editing an analysis structure

The structure editor can also be used to edit an existing analysis structure. To do this, select the menu item *Edit - Analysis structure*.

If any cross-impact data are present at that time, the program will ask whether the cross-impact matrix (CIM) should be co-edited (synchronised). The reason for this question is that a modification of the descriptor state list may have consequences on the cross-impact data structure. If the cross-impact matrix is co-edited, a deletion of a descriptor in the structure editor will automatically cause a deletion of the respective rows and columns in the cross-impact matrix. If the user changes the sequence of the descriptors or variants, co-editing means that the respective rearrangements will also be carried out in the cross-impact matrix, so that the correlations between names and data remain unchanged.

If the user rejects co-editing, the present cross-impact data are deleted by the program, thereby preventing a meaningless combination of structure and data. In this case, a descriptor variants list without connected cross-impact data will be edited by the structure editor.

Deleting descriptors or variants

To delete a descriptor, click the descriptor name in the descriptor list and click the ‘Delete’ button. After confirmation, the descriptor and its variants will be erased. If a cross-impact matrix is co-edited, the cross-impact data of this descriptor are also deleted. The succeeding descriptors move upwards, to preserve a connected list.

To delete a variant, click on the variant name. After clicking on the ‘Delete’ button and following confirmation, the deletion will be carried out. If a cross-impact matrix is co-edited, the cross-impact data of this variant are also deleted. After deletion, the succeeding variants in the list will move leftwards.

It is not possible to delete a variant if it is the only variant of a descriptor. Furthermore, it is not possible to shorten a descriptor list below a minimum number of two descriptors.

Moving descriptors or variants

The sequence of descriptors (or variants) can be changed by the arrow buttons of the structure editor. Click the descriptor or the variant to be moved. Each click on an arrow button moves the descriptor (or variant) one place upwards or downwards (to the left or to the right). If a cross-impact matrix is co-edited, the cross-impact data of the descriptor (or variant) will be moved simultaneously.

Changing names

Click the long name or the short name of the descriptor or the variant in question. Edit the name or enter a new name as desired. The long names and short names of the descriptors and variants may not contain any comma.

Adding new descriptors or variants

A new state cell in a descriptor's row will emerge if an existing variant of the same descriptor is clicked and the ‘Insert’ button is pressed after that. A new descriptor row will emerge if the cell below the name of the last descriptor is clicked and the ‘Insert’ button is pressed after that. If a cross-impact matrix is co-edited, appropriate rows and columns will be automatically inserted also in the matrix and filled with zeros. The new descriptor (or variant) can afterwards be moved to its designated place in the list using the arrow buttons. Adding of a new descriptor (or variant) is not possible if the number of descriptors (or variants) would exceed the maximum number (199 descriptors and 9 variants for each descriptor).

After pressing the ‘Accept’ button, the program enters the data of the structure editor into the workspace of *ScenarioWizard* and closes the window. The edited analysis structure should then be saved by saving the project file. Section 7.3 provides some hints on the use of the structure editor if the descriptor type option is selected.

5.7 Displaying an analysis structure

A descriptor variant list that has been created or loaded as part of a project file can be displayed in a column format using the menu item *Edit - Show analysis structure*. This is shown for the Somewhere-land example in Fig. 5 5.

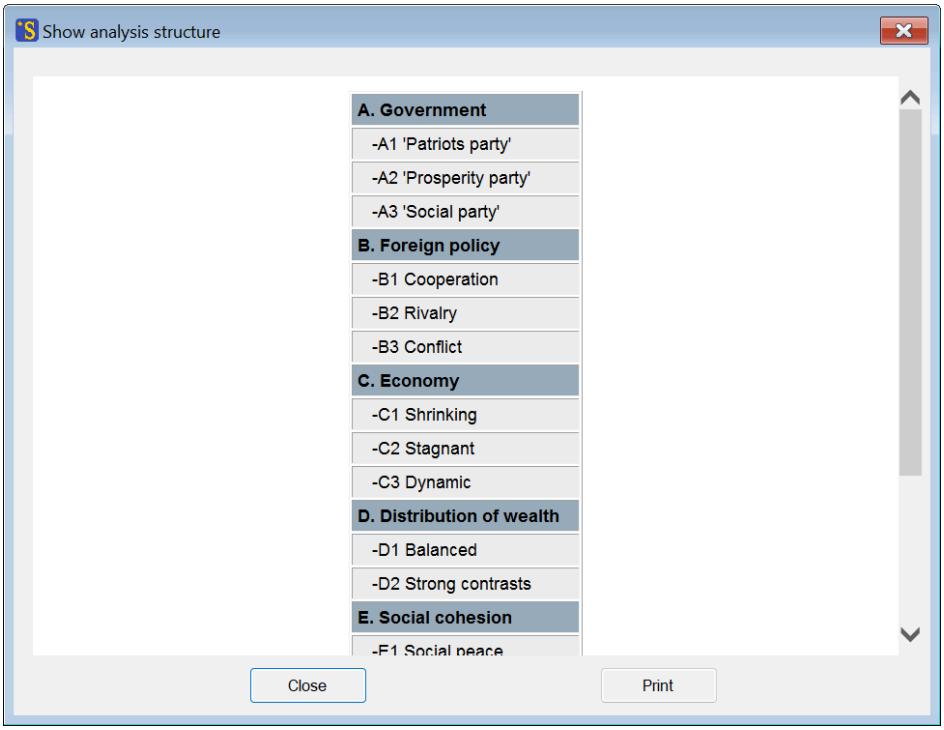


Fig. 5-5: Displaying a descriptor-variant-list (analysis structure).

This function is only available if a descriptor-variant-list has been created with the structure editor or a project file has been loaded. If colours have been defined for the variants, these are used for the display.

5.8 Displaying and editing cross-impact data using the matrix editor

The cross-impact matrix contains the cross-impact database of the project. It represents the interdependence of the descriptors in a qualitative manner. The menu items for loading and editing a cross-impact matrix are not available until an analysis structure has been defined (see Sections 5.2 and 5.3). *ScenarioWizard* offers two ways of entering and editing cross-impact data:

- The matrix editor displays a table representing the entire cross-impact matrix at once. Data can be entered or modified at any position of the matrix.
- The section editor displays only a single judgement section for data editing at once. This can be helpful to concentrate on the specific descriptor relationship under work.

All necessary steps can be done by both editor types. Basically, it is a matter of choice which editor is preferred by the user. This section describes the use of the matrix editor. The section editor is described in Section 5.11.

Choose the menu item *Edit - CI-Matrix* or press the button  on the toolbar to display a cross-impact matrix using the matrix editor. If no cross-impact data have been loaded before, an empty cross-impact matrix is displayed for the current analysis structure (Fig. 5-6).

While the matrix editor is open, all menu items are disabled (except for the menu item *Info*) to avoid the storage or evaluation of unconfirmed data. The toolbar is also deactivated.

Descriptors and variants appear with their long names in the first column of the matrix. In the first row, they are printed with their short names to save space and keep the size of the table small. Variant names are tabulated in the first column.

The blue cell at the top left of the matrix contains the name of the project file. If a new project is not yet stored, the cell is empty.

Enter cross-impact data by clicking on a cell and pressing the '+' ('-') button at the bottom of the matrix editor. Each click on the '+' ('-') button increases (or decreases) the cross-impact entry of the selected cell by one unit. The data can be entered also using the keyboard.

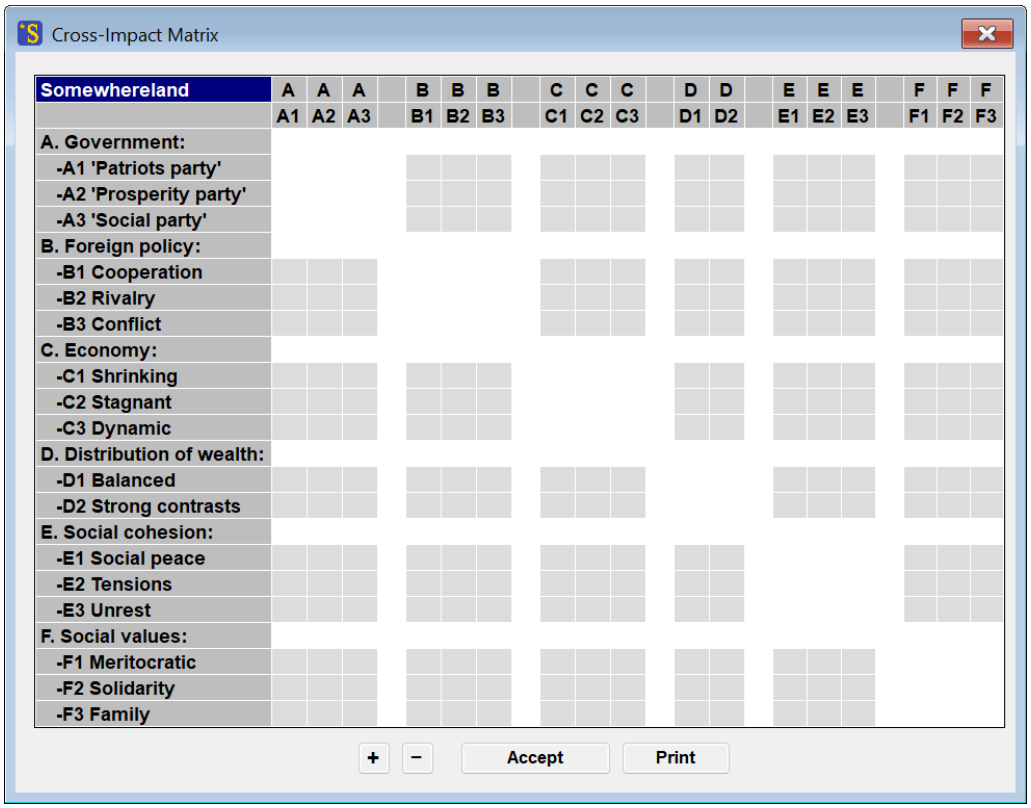


Fig. 5-6: An empty matrix editor ready for the input of cross-impact data.

Cross-impact values are usually interpreted in CIB as shown in Tab. 5-1. The variants in the rows are sources of influence, and the column variants are the targets of influence. If necessary, higher values than those quoted in Tab. 5-1 can be used to express very strong influences. Only direct influences are coded in the cross-impact matrix. The resulting indirect effects are automatically constructed by the CIB algorithm.

The matrix editor with cross-impact entries is shown in Fig. 5-7. The diagonal judgement sections remain empty in the case of regular cross-impact matrices (for extended cross-impact matrices see Section 7.1).

The user can change the font used to print the names of descriptors and states in the matrix editor (see Section 7.2). A small font helps display large matrices without scrolling. A large font is useful for projector presentations.

Tab. 5-1: Interpretation of cross-impact judgements considering the direct influence of state x on state y.

+3: strongly promoting influence
+2: promoting influence
+1: weakly promoting influence
0: no influence
-1: weakly restricting influence
-2: restricting influence
-3: strongly restricting influence

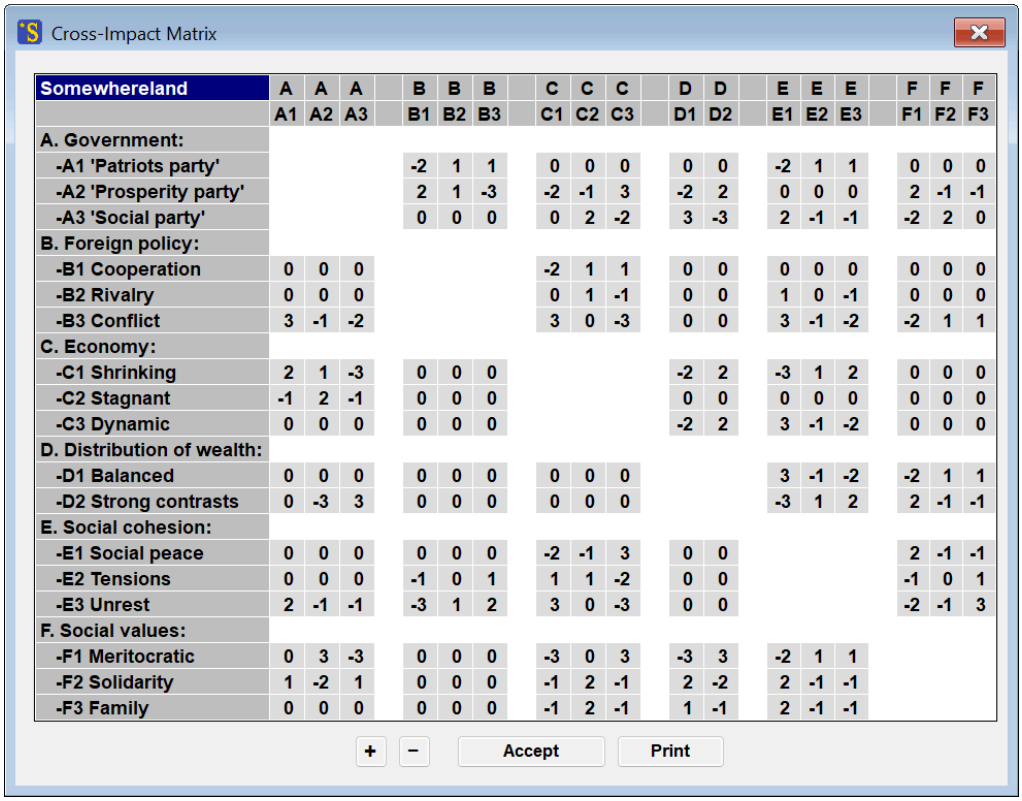


Fig. 5-7: Matrix editor filled with cross-impact data.

Printing

Use the ‘Print’ button to request a printer selection window and a printout of the cross-impact matrix. For a satisfactory printout, the printer needs to support the scalable ‘Arial’ font.

The printing of large matrices requires that the printer is able to print very small fonts. Selecting the landscape orientation in the printer selection menu helps to print out larger matrices. Depending on the abilities of the printer, the printout of a large matrix may also fail. Selecting a PDF printer in the printer setup, converting the matrix into a PDF file, and printing the PDF file may yield a better result in this case.

Accepting a cross-impact matrix

After pressing the ‘Accept’ button, the program enters the data of the matrix editor into the workspace of *ScenarioWizard* and closes the window. Closing the form by clicking on the matrix editor close button (upper right corner of the window) closes the window after acknowledgment of a warning notice without updating the *ScenarioWizard* workspace. All changes made in the matrix editor are lost.

After closing the matrix editor by pressing the ‘Accept’ button, the data of the matrix editor are available in the program's workspace and will be used by all evaluation procedures during the current session. However, the data are not stored permanently. If you want to use the data in a later session, you must store them using the menu item *File - Save...project file* or the  button in the toolbar before you finish the session and close *ScenarioWizard*.

The first opening of an empty cross-impact matrix displays the matrix editor with highlighted cells, but without zeros (this gives the user the opportunity to create and print easily a blank matrix form and fill it out by hand). To display the window of an empty matrix including zeros, close the matrix editor by pressing the ‘Accept’ button, and open the matrix editor again. Now all relevant fields will be filled with zeros.

Section 7.3 provides some hints on the use of the matrix editor if the descriptor type option is selected.

5.9 Bans

Bans (“absolute impacts”) are cross-impacts that not only make the occurrence of a certain development more difficult (as would be the case with a regular negative cross-impact), but absolutely rule it out. This allows impeding influences to be modeled that are considered to be so overwhelmingly strong that they cannot be compensated for by the promoting effects of other descriptors.

Bans can be stated in the matrix editor by entering an “X” in a cell instead of a cross-impact value. In Fig. 5 7, a ban was entered as an impact from E3 (unrest) to C3 (dynamic economy). This expresses the fact that dynamic economic development is not only made very difficult in the event of unrest (as expressed by the cross-impact -3 in the original Somewhereland matrix), but is considered completely impossible.

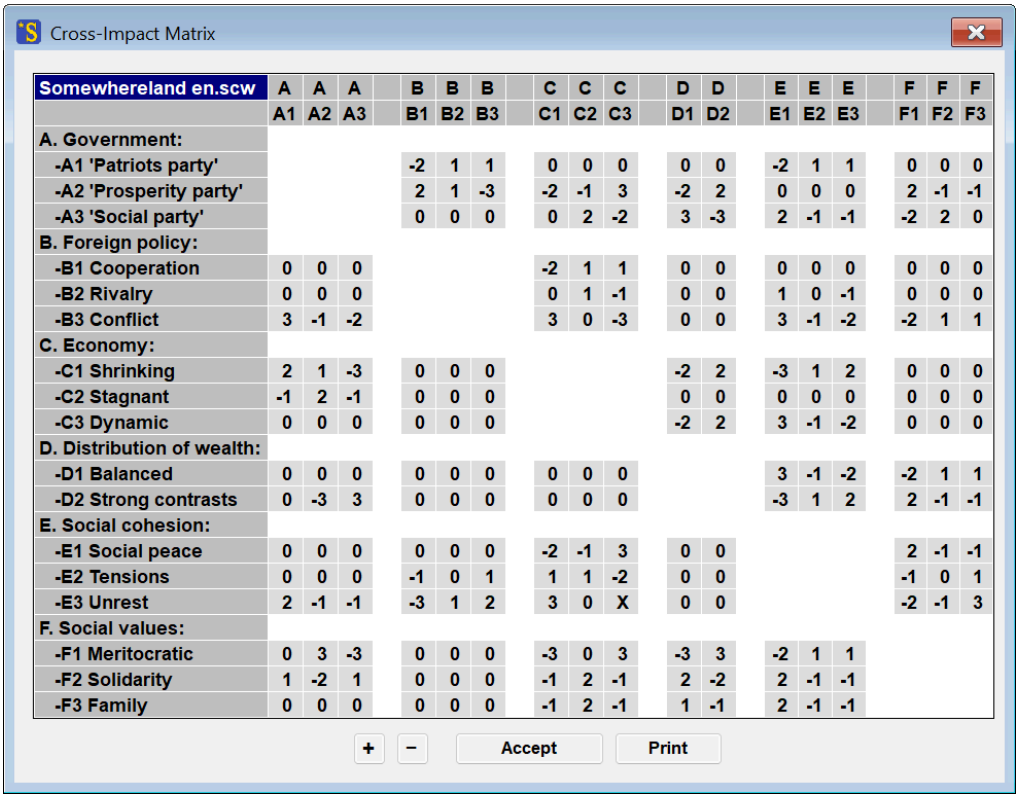


Fig. 5-8: Cross-impact matrix including a ban.

More than one ban can be used within a matrix. When calculating the consistent scenarios (see Section 6.4), bans are automatically taken into account. All bans entered are saved when the matrix is saved and are available again when the matrix is reloaded.

5.10 Entering cross-impact comments in the matrix editor

To explain the definition of the descriptors and the ideas behind the cross-impact judgements, the user can enter text into ‘comment windows’. This is useful for the documentation of the reasoning on which the analysis is based and makes it easier for discussing the analysis results with the target group of the analysis.

The comment window of a descriptor is opened by clicking on the descriptor name (or on any of its variants) in the left column using the right mouse button. A small text window appears in which the comment can be entered or an existing comment can be modified. The title of the text window refers to the short name of the descriptor. After finishing the comment, the text window can be closed using its close button. Double quotation marks (“) are not permitted in comments and are automatically converted into single quotation marks once the comment window is closed.

To enter a comment on the impact of descriptor x on descriptor y, click on any cell of the respective judgement section using the right mouse button.

A click on the blue cell at the top left of the matrix (containing the name of the project file) opens the comment window for general project information (e.g. project name, purpose of the analysis, project team, and project publications).

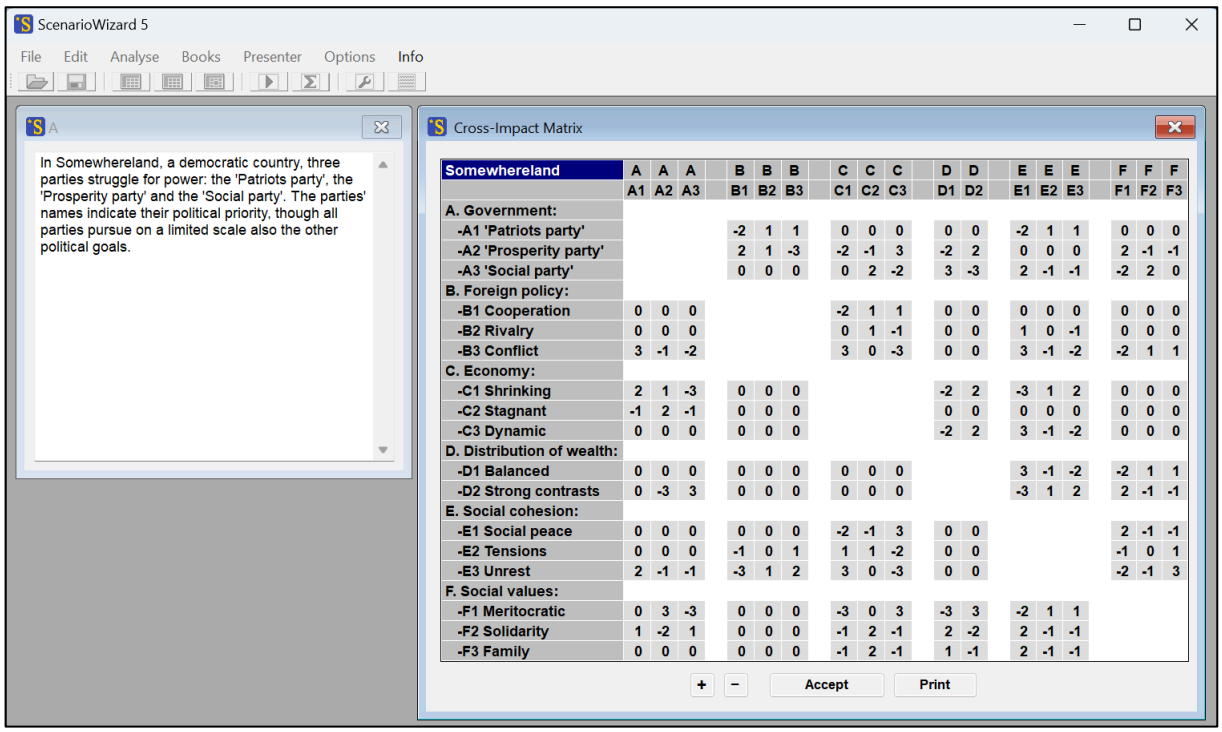


Fig. 5-9: The comment window. In this example, a comment on the descriptor ‘A. Government’ is displayed.

Comments are optional and do not influence the scenario calculations. However, they are used for the automatic scenario report, if available (see Section 6.3).

All comments are integrated into the project file database and they will be stored and loaded when the project file is stored or loaded.

The menu item *Edit - Show comments* produces a compilation of all comments of the project. The compilation can be transferred into a word processor by copy and paste or it can be printed using the print button of the window. Descriptors or judgement sections without comment are skipped in the compilation. The menu item *Edit - Show comments* is only available if at least one comment exists.

The comments of a project can be erased by the menu item *File - Reset ... Clear comments*. The analysis structure and the cross-impact data of the project remain unchanged by this command.

5.11 Entering and editing cross-impact data using the section editor

Cross-impact data can be entered and edited step by step using the 'section editor'. This editor only displays a single judgement section representing the impact of one descriptor onto another descriptor without displaying the entire matrix. The advantage of this editor type is that restricting the display to a single section helps to concentrate on the specific descriptor relationship under work.

The section editor is activated by the menu item *Edit - Cross-impact section* or by the  button in the toolbar. The editor can be opened only if an analysis structure has been generated or loaded before (see Sections 5.2–5.3). While the section editor is open, all menu items are disabled to avoid the storage or evaluation of unconfirmed data (except for the menu item 'Info'). The toolbar is also deactivated. Fig. 5-10 shows the section editor for the judgement section 'B. Foreign policy impacts on A. Government'.

The row descriptor (impact source) and the column descriptor (impact target) of the judgement section can be selected from the combo boxes 'Select row' and 'Select column'. The selection can be changed also by the arrow buttons below the combo boxes. It is also possible to click on the selection field of a combo box and to scroll through the descriptors by turning the mouse wheel.

The selected descriptors (brown background) and their variants (grey background) are shown below the combo boxes. The cross-impact data can be edited by clicking on a cell and entering a new value using the keyboard or the plus/minus buttons. Changes are stored in the *ScenarioWizard* workspace once a new judgement section is selected or the section editor is closed.

The width of the name labels adapts to the length of the names. If necessary, the width of the editor window is increased. Very long names may be displayed incompletely, however. In this case, the complete name of a descriptor or a variant can be depicted by clicking on the name label using the

left mouse button. While the mouse button is pressed down, the name label will be expanded to show the complete name. Once the mouse button is released, the name label shrinks to its normal size.

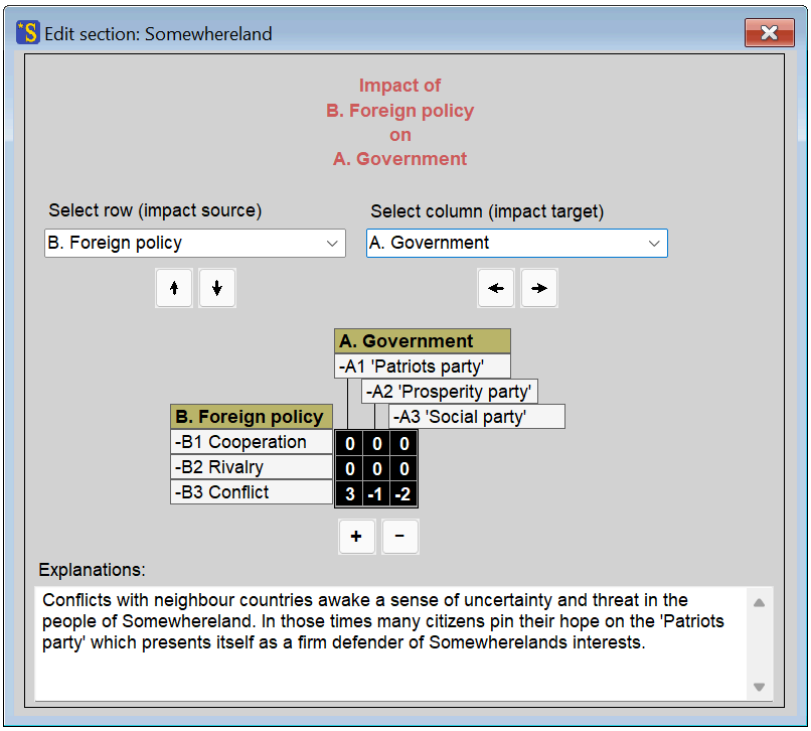


Fig. 5-10: Section editor displaying the judgement section ‘B. Foreign policy impacts on A. Government’.

When a diagonal judgement section is selected by the user, the section is printed in grey and no data entry is accepted. Diagonal judgement sections are accessible for entry only if the option ‘Diagonal elements’ (see Section 7.1) is activated.

Bans (see Section 5.9) can also be recorded in the sector editor using the “X” symbol and are displayed and saved accordingly.

Statements explaining the ideas behind the judgements can be entered into the text window ‘Explanations’ at the bottom of the section editor. The explanations are stored into the *ScenarioWizard* workspace once a new judgement section is selected by the user or the section editor is closed.

Displaying descriptor comments

Thinking about cross-impacts and delivering judgements need a proper awareness of the definitions of the involved descriptors. This is the reason why users are encouraged to formulate their defini-

tions of the descriptors and store them in ‘descriptor comments’ when building the analysis structure (see Section 5.4).

If descriptor comments are available, they can be used when working with the section editor. The height and width of the section editor window can be increased by clicking on the edge of the window and dragging while holding down the left mouse button. An extension of the window to the right makes the explanatory texts for the two involved descriptors visible, if such have been provided (Fig. 5-11). The descriptor comment windows are read-only windows. You can either use the structure editor (Section 5.4) or the matrix editor (Section 5.10) to edit the descriptor comments.

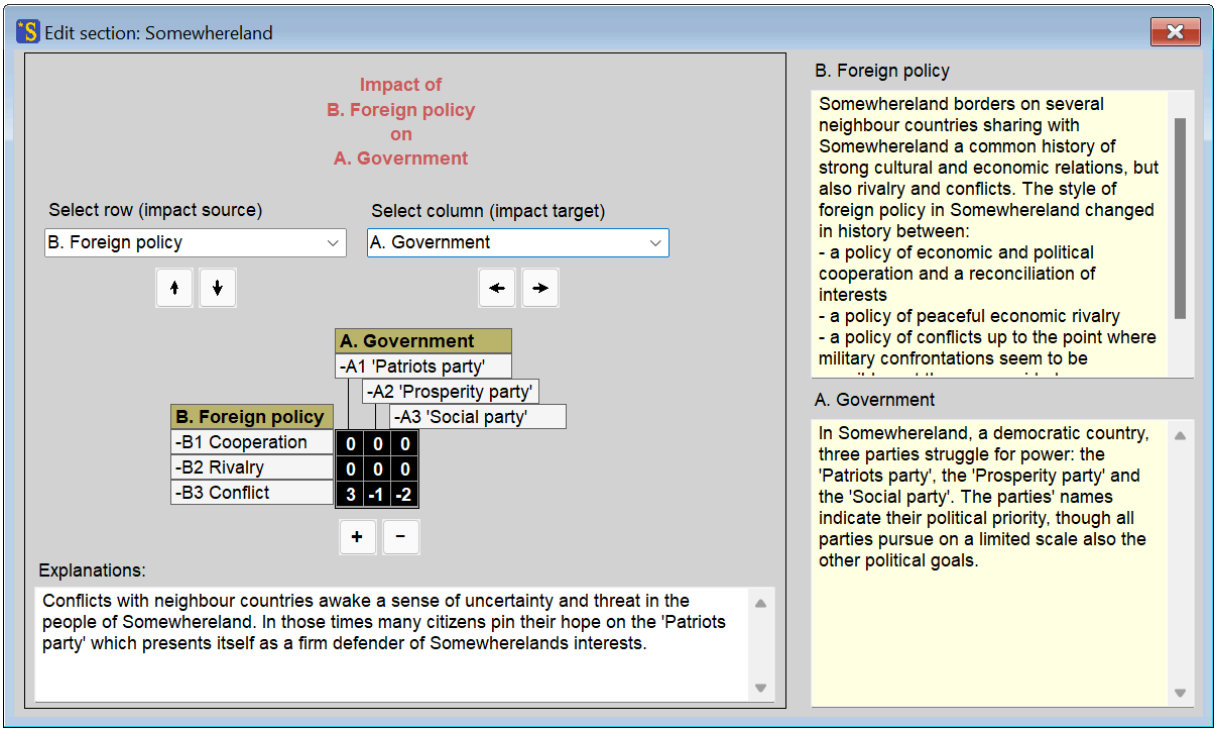


Fig. 5-11: Expanded section editor displaying the descriptor comments.

The font size of the section editor window can be modified by changing the font size setting in the output options (Section 7.2). This makes it possible to select a larger font size for presentations or for online expert surveys in video conferences with screen sharing to enable all participants to read the form easily.

5.12 Standardisation

Standardisation means that the sum of each judgement group (one line within a judgement section) should be zero. Standardisation is not necessitated by the mathematics of CIB, but it enhances the comprehensibility of the data and the results. Users are free to decide if they wish to apply standardisation or not. If standardisation shall be applied, *ScenarioWizard* provides two tools to support the application of the standardisation rule:

Check standardisation

The menu item *Edit - Standardisation ... Check standardisation* instructs the program to check the standardisation of all judgement groups. In this procedure, the program checks the data and highlights all judgement groups found with invalid standardisation. If the matrix contains only correctly standardised groups, no cells are highlighted.

Execute standardisation

The menu item *Edit - Standardisation ... Execute standardisation* enables a standardisation of the currently loaded cross-impact matrix to be performed. *ScenarioWizard* first checks whether a standardisation is necessary. If this is the case and a security query is confirmed, the whole matrix is multiplied by a suitable integer number. Afterwards, the mean value of each judgement group will be subtracted within this group. These calculations obey the invariance laws of CIB. They therefore result in a standardisation without changing the set of consistent scenarios and their weights.

Bans (see Section 5.9) are not included in the standardization operations.

The menu item *Edit - Standardisation* is only available if an analysis structure and a cross-impact matrix have already been defined.

5.13 Factor multiplication

The menu item *Edit - Factor Multiplication* multiplies the entire cross-impact matrix by a uniform factor. The factor can be a positive or negative number. The factor can also be a non-integer number (decimal character: point). In this case, the calculated cross-impact values are rounded to integer numbers and the standardisation of a matrix may be cancelled. Fig. 5-12 shows the query for the multiplication factor.

Because of the invariance laws of CIB, the multiplication of a cross-impact matrix with a positive integer number does not affect the solution of the matrix. Factor multiplication by a non-integer number with rounded results may however, as a consequence of rounding, change the solution set of a cross-impact matrix.

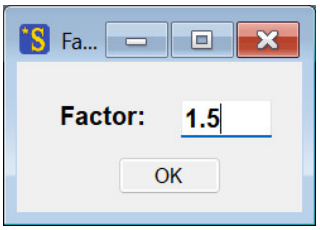


Fig. 5-12: Entering a factor for matrix multiplication.

A negative factor inverts all impact relations. The resulting cross-impact matrix thereby describes a completely different system and leads to totally different solutions.

In ensemble mode (Section 6.9), all cross-impact matrices of the ensemble are multiplied by the specified factor.

Factor multiplication is useful in practical situations, for example, if the user wants to refine the judgement scale in the course of cross-impact data sampling. A factor multiplication of 2 for example creates a new space for intermediate values when judging impact strength.

Bans (see Section 5.9) are not included in the factor multiplication and remain as such.

The menu item *Edit* - *Factor Multiplication* is only available once an analysis structure and a cross-impact matrix or an ensemble have been defined.

5.14 Transposition

The menu item *Edit* - *Transpose* transposes the current cross-impact matrix. This is equivalent to an inversion of the causal relations in the system: impact sources will be impact targets and vice versa.

	D1	D1	D1		D2	D2	D2		D3	D3	D3
	a	b	c		a	b	c		a	b	c
D1:											
a					-1	3	-2		0	0	0
b					3	-3	0		-3	1	2
c					0	0	0		0	-1	1
D2:											
a	-3	0	3						-2	0	2
b	2	-3	1						-3	3	0
c	3	-1	-2						1	1	-2
D3:											
a	0	0	0		-2	1	1				
b	-1	1	0		-2	-1	3				
c	2	-3	1		1	0	-1				

	D1	D1	D1		D2	D2	D2		D3	D3	D3
	a	b	c		a	b	c		a	b	c
D1:											
a					-3	2	3		0	-1	2
b					0	-3	-1		0	1	-3
c					3	1	-2		0	0	1
D2:											
a	-1	3	0						-2	-2	1
b	3	-3	0						1	-1	0
c	-2	0	0						1	3	-1
D3:											
a	0	-3	0		-2	-3	1				
b	0	1	-1		0	3	1				
c	0	2	1		2	0	-2				

Fig. 5-13: A cross-impact matrix (left) and the transposed matrix (right).

In ensemble mode (see Section 6.9), all cross-impact matrices of the ensemble are transposed.

The 'Transpose' function can be used to decompose a cross-impact matrix into its symmetric and antisymmetric parts. When transposed, a matrix usually loses its standardisation.

The menu item *Edit - Transpose* is only available an analysis structure and a cross-impact matrix or an ensemble have been defined.

5.15 Generating a random matrix

The menu item *Edit - Random Matrix* creates a cross-impact matrix with random cross-impact data. The procedure only works for analysis structures with not more than five variants for each descriptor.

As a first stage, a list of possible judgement groups is generated. All groups, which use judgements in the range of -3 to +3 and obey the standardisation rule, are taken into consideration. In the case of a judgement group with two variants, seven possible groups exist. In the case of three variants, there are 37 possible groups. In the case of five variants, the number of possible groups is equal to 1,451.

Before the random matrix is created, you have to enter the desired degree of connectivity for the matrix. Values between 0 and 1 are accepted. A connectivity of 0.6 would mean that around 60 % of the judgment sections would be filled with random data and around 40 % of the judgment sections would remain empty. The specified connectivity is only approximately maintained, as the decision as to whether a specific section is filled with data or remains empty is also random.

The random matrix is then generated by choosing a group from this list randomly for every judgement group of the matrix. Equal probabilities are assigned to all listed members.

The menu item is only available if an analysis structure has been defined, but no cross-impact data have yet been entered or loaded.

Random matrices are useful, e.g. for demonstration and research purposes.

5.16 Exporting a cross-impact matrix

The menu item *File - Save ... export* exports the current cross-impact matrix into an HTML file. In this file, the matrix is represented in a formatted fashion, ready to be used for documentations or printouts. Because many programs offer an import function for HTML files, the 'Export' item enables the user to pass a matrix into a word processor, spreadsheet, or presentation software. In the case of MS Office, it is advisable to import the HTML file first into Excel and to copy the imported table into Word or PowerPoint. The indirect import via Excel leads to a better result. For example, the matrix in Fig. 5-7 is converted by the export function as shown in Fig. 5-14.

Bans (see Section 5.9) are represented by an "X" symbol in the exported matrix.

The menu item *File - Save … export* is not available until a descriptor state list has been defined. Furthermore, 'Export' is not available while *ScenarioWizard* is in the ensemble mode (see Section 6.9).

	A			**B**			**C**			**D**		**E**			**F**		
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	E1	E2	E3	F1	F2	F3
A. Government																	
-A1 'Patriots party'				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
-A2 'Prosperity party'				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
-A3 'Social party'				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy																	
-B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
-B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
-B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy																	
-C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
-C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
-C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth																	
-D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
-D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion																	
-E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
-E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
-E3 Unrest	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values																	
-F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
-F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
-F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			

Fig. 5-14: Matrix generated by 'Export' function.

5.17 Importing a cross-impact matrix

The menu item *File - Load ... import* imports a CSV-formatted cross-impact matrix. The menu item is only available once a matching project file has been loaded (see Section 5.2). The import function reads the cross-impact data of the CSV file, but the names of the descriptors and states of the loaded project file remain unchanged. If there are unsaved cross-impact data in *ScenarioWizard*'s workspace, a warning will appear before starting the import procedure.

To be ready for import, a CSV file must show a specific structure. The requested structure corresponds to the usual structure of a cross-impact matrix (see Fig. 5-14) and is shown in Appendix 3. However, it is not necessary for the user to deal with these conditions. Exporting a cross-impact matrix using *ScenarioWizard*'s export function (see Section 5.16), loading the exported file into MS Excel or another suitable spreadsheet application, editing the cross-impact data using the spreadsheet application, and saving the spreadsheet as a CSV file (separator: comma or semicolon) generate automatically a valid CSV file suitable for import.

This procedure proves useful for expert surveys if persons without access to *ScenarioWizard* are asked to contribute to a CIB analysis by giving their cross-impact judgements. Exporting a cross-impact matrix containing only the analysis structure without cross-impact data and loading the exported file into a spreadsheet provide a suitable blank form, which can be distributed to the experts. Saving the completed spreadsheets as CSV files and importing the CSV files into *ScenarioWizard* avoid the efforts and possible errors of a manual data entry.

A valid import requires that

- the number of descriptors and variants of the current project data in *ScenarioWizard*'s workspace must match the number of descriptors and variants of the imported CSV file;
- the long and short names of the descriptors and their variants stored in the CSV file must follow *ScenarioWizard*'s conventions, i.e. the names must not contain commas (,), semicolons, or double quotation marks (“).

Otherwise, the import may terminate with an error message or it may result in corrupted cross-impact data.

Once the CSV file was generated, ensure that the spreadsheet application is closed before you start *ScenarioWizard*'s import function. Otherwise, the CSV file might be linked to the spreadsheet application and access to the CSV file is denied. In this case, *ScenarioWizard* produces an error message and terminates the import procedure.

5.18 Workbooks

'Workbooks' generated by *ScenarioWizard* are HTML documents showing the cross-impact matrix divided into its judgement sections. They comprise a compilation of 'sheets', each of them displaying a single judgement section in the style of the 'Section Editor' (see Section 5.11).

Workbooks can be generated for empty cross-impact matrices (i.e. after generating or loading the analysis structure but without entering cross-impact data into the matrix). This type of workbook is intended, for instance, to be used as blank forms in expert interviews (Fig. 5-15).

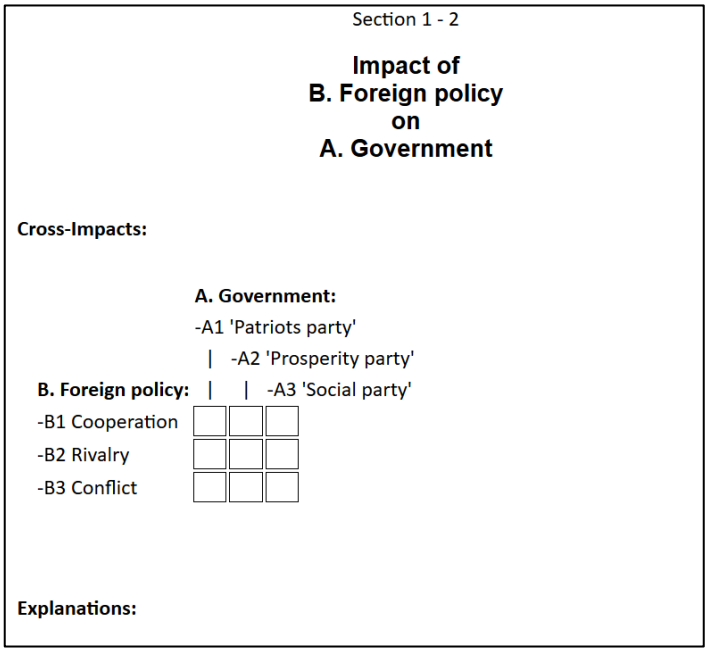
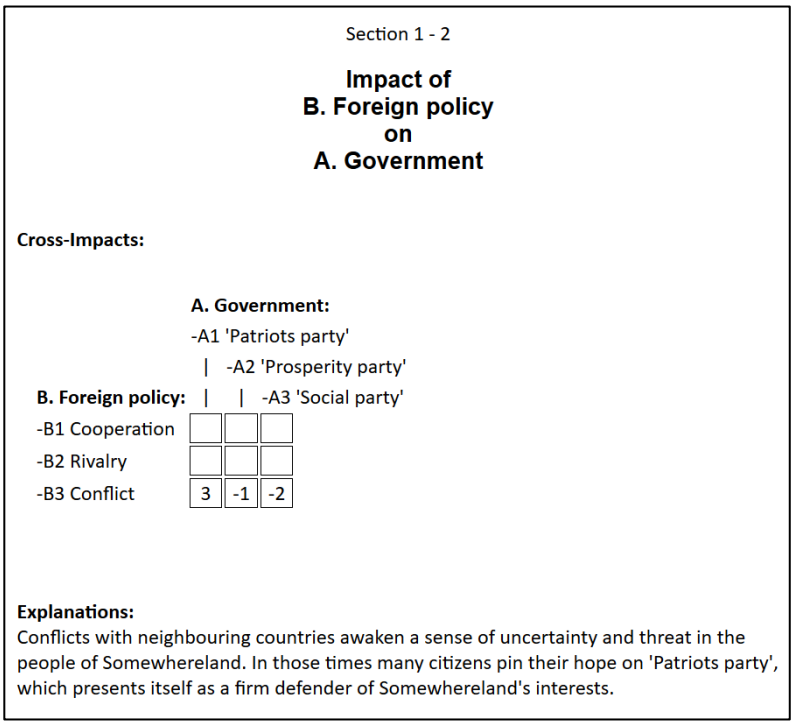


Fig. 5-15: Workbook sheet of an empty matrix to be used as a blank form.

Workbooks can be generated also for completed matrices. This workbook type is used for supporting the review and discussion of the cross-impact judgements documented in the completed matrix (Fig. 5-16). Zero judgements cells are left empty for the sake of greater clarity.



Section 1 - 2

Impact of
B. Foreign policy
on
A. Government

Cross-Impacts:

	A. Government: -A1 'Patriots party'	-A2 'Prosperity party'	-A3 'Social party'
B. Foreign policy: -B1 Cooperation			
-B2 Rivalry			
-B3 Conflict	3	-1	-2

Explanations:
Conflicts with neighbouring countries awaken a sense of uncertainty and threat in the people of Somewhereland. In those times many citizens pin their hope on 'Patriots party', which presents itself as a firm defender of Somewhereland's interests.

Fig. 5-16: Workbook sheet containing cross-impact data and text.

There are two variants of workbooks available. In *workbooks sorted by cols*, each workbook chapter represents one column of the cross-impact matrix, e.g. all impact *on* a descriptor. Within the chapter, each judgement section of the column starting from above is shown in its own workbook sheet.

In *workbooks sorted by rows*, the opposite is true: each workbook chapter represents one row of the cross-impact matrix, e.g. all impacts exerted by a descriptor. Within the chapter, each judgement section of the row is shown in a separate sheet (starting from the left side).

Using a workbook sorted by cols means studying a descriptor focusing on its role as an impact target. On the other hand, using a workbook sorted by rows has the purpose of studying a descriptor in its role as an impact source. Fig. 5-15 and Fig. 5-16 are extracted from a workbook sorted by cols. 'Section 1-2' is the second sheet of the first chapter. The first chapter deals with all impacts exerted *on* the descriptor 'A. Government'. The second sheet of chapter 1 shows the impact of descriptor 'B. Foreign policy' on 'A. Government'.

Workbooks are generated using the menu item *Books - Workbooks sorted by cols* or *Books - Workbooks sorted by rows*. These menu items are available only after an analysis structure is generated (see Section 5.3) or a project file is loaded (see Section 5.2). Generating the workbook of a large matrix can take several minutes because the workbook might contain several hundreds or thousands of

pages. Once the generation of workbook is completed, an input form is shown requesting the file name and storage location.

Workbooks are generated in HTML format because this format offers a broad variety of possible uses. The workbooks can be displayed directly by a browser but also printed into a PDF file using the print function of the browser. The workbook contains line breaks between the sheets. The line breaks are inactive when the workbook is displayed by a browser but become active once the workbook is converted into a PDF file.

Workbooks have the following structure:

- Table of contents. The items of the table of contents are linked and the respective chapters and sheets can be accessed by a mouse click.
- Chapter 0: This chapter contains the descriptor essays (if available).
- Chapter 1 to Chapter D (number of descriptors). Each chapter is structured as follows:
    - The first page of the chapter shows a list of all impact sources (respective impact targets) dealt with in the chapter. All impacts to which any data are assigned are marked by [■].
    - One page ('sheet') for each impact showing the respective judgement section.

A special type of workbook is generated when the 'workbook' function is used in the *ScenarioWizard* ensemble mode. This case is described in Section 6.10.

5.19 Displaying project information

The menu item *Info - Project information* provides some basic information about the current project. The following data are listed:

- Name of the project file (if defined).
- The project description (if specified; see Section 5.10).
- The number of descriptors.
- The total number of all descriptor variants.
- A statistic on the number of variants per descriptor.
- Number of configurations (number of ways to combine the descriptor variants).
- Number of judgement sections and the share of empty sections.
- Number of judgement cells and their judgement statistics.
- List of primary or secondary autonomous descriptors (if any; see Section 12).
- List of primary or secondary passive descriptors (if any; see Section 12).

This menu item is available only after loading or building up a project.

6 Evaluating a cross-impact matrix

Having specified the descriptor state list and the cross-impact data, the evaluation of the defined qualitative system model may begin. The evaluation aims at determining the credible combinations of qualitative descriptor states, so that these 'scenarios' are compatible with the insights expressed by the cross-impact data.

The evaluation procedures of the *Solve* menu item are only available if a descriptor state list and a cross-impact matrix have already been defined.

6.1 Calculating an Active-Passive Diagram

A system grid is a simple tool for assessing the role of the descriptors in the analysed system. The descriptor assessment is a widely used preparation step for the actual scenario construction process. The general procedure to prepare a system grid is to calculate the sum of all impacts exerted by a descriptor ('active sum') and to calculate the sum of all impacts exerted onto a descriptor ('passive sum').

CIB offers a straightforward approach to this type of analysis. As a measure of the impact of descriptor A on descriptor B, the average of all absolute values within the respective judgement section is defined. The active sum of a descriptor is then calculated by summing up all impact measures within the descriptor's row. Correspondingly, the passive sum of a descriptor is calculated by summing up all impact measures within the descriptor's column. By plotting all descriptors in a diagram, the passive sum serving as x coordinate and the active sum serving as y coordinate yields the "active-passive diagram", referred to partly as a "system grid".

ScenarioWizard's menu item *Analyse* - *Active-passive diagram* generates the active-passive diagram of the current project. This analysis is available as soon as cross-impact data are defined by loading a project file or entering cross-impact data into the matrix editor. The active-passive diagram of Somewhereland is shown in Fig. 6-1.

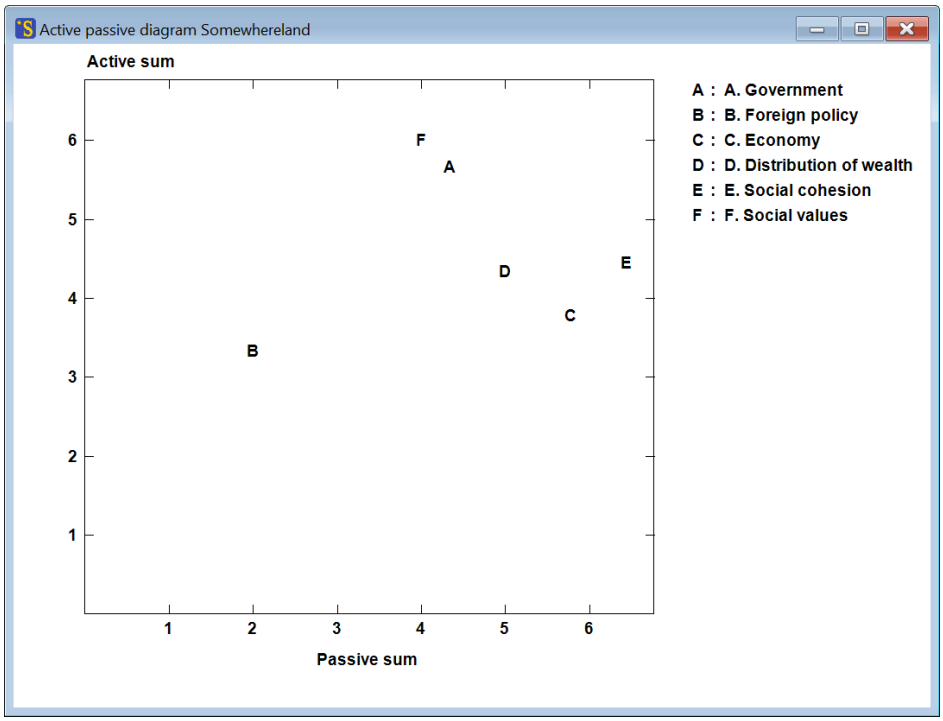


Fig. 6-1: Active-passive diagram of Somewhereland.

All descriptors are plotted in the diagram using their short names. Descriptors at the top left of the diagram (none in this example) are interpreted as descriptors able to control a system in an effective way. Descriptors at the bottom right of the active-passive diagram (none in this example) can be understood as dependent descriptors following the guiding of other descriptors without too much influence on the events in the system. Descriptors settling the top right domain in the diagram are descriptors exerting strong influence on the system and, at the same time, sensing strong influence. This type of descriptors is usually connected with the potential emergence of complex system behaviour.

However, the active-passive diagram, being based only on an analysis of direct impacts, is a rather simple assessment method. The results should be interpreted as helpful, but provisional conclusions. A deeper understanding of the descriptor's role in the system, reflecting the direct influences as well as the indirect influences and the context sensibility of impact effects, should include a scenario-based analysis.

6.2 Analysing the impact balances of a scenario

The heart of the CIB method is the assessment of the internal consistency of a scenario by calculating its impact balances (see Section 2.2.2). They are derived by inserting the scenario assumptions into the cross-impact matrix showing if one or more scenario assumptions are at odds with the other parts of the scenario, or if there are no contradictions between the scenario assumptions and the scenario can be assessed to be internally consistent.

The calculation of the impact balances can be done by calling the menu item *Analyse - Impact balance* or pressing the Σ button in the toolbar. The impact balance form is available only after a project is loaded or built up using the structure editor and the matrix editor or sector editor (see Sections 5.3 and 5.8).

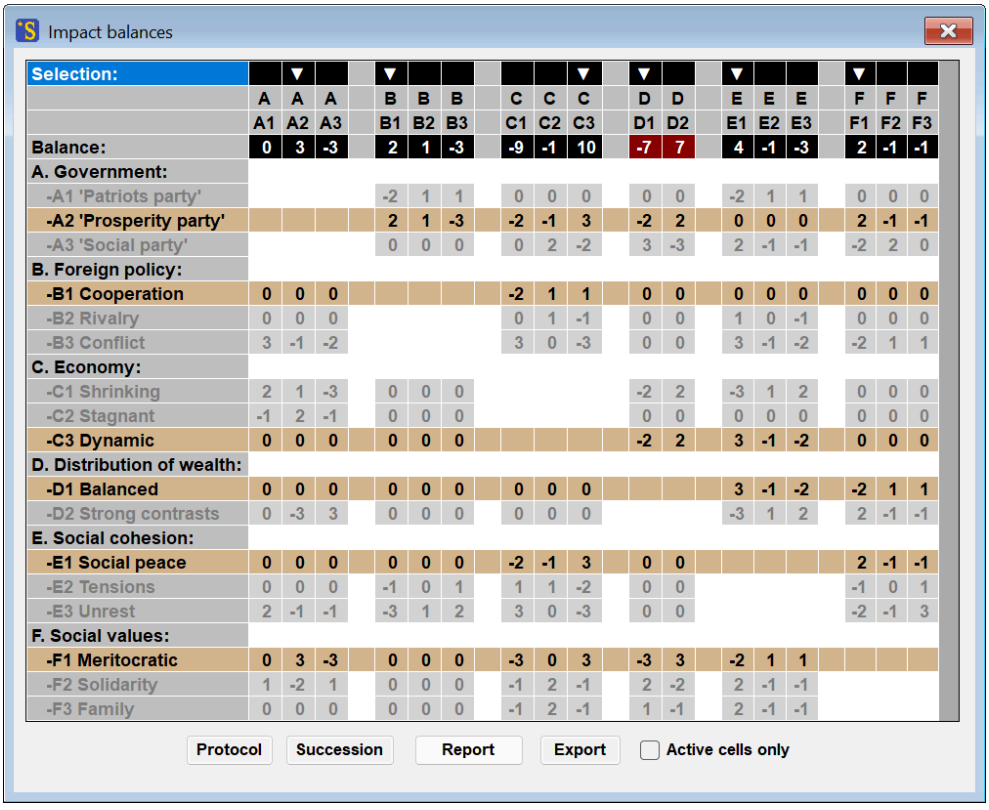


Fig. 6-2: Form for calculating the impact balances of a scenario.

The form displays the cross-impact matrix. In the row ‘Selection’ at the top, the user can select the variants for each descriptor, thus defining the scenario under investigation. The selected variant is marked by an arrowhead. When the form is opened, the first variant of each descriptor is selected as a default setting. In Fig. 6-2, the scenario

z = [A2 B1 C3 D1 E1 F1], i.e.

Government: ‘Prosperity party’, foreign policy: cooperation, economy: dynamic, distribution of wealth: balanced, social cohesion: social peace, social values: meritocratic

known from the CIB introduction in Section 2.2.2 is selected. In the matrix, all rows representing the selected descriptor variants are highlighted. The sum of all highlighted rows yields the impact balances of the scenario. It is displayed in the row ‘Balance’ (third row). After each change in the selection, the highlighting of rows and impact balances are updated. If a descriptor is ‘forced’ (see Section 6.8), its impact balance is not displayed because the impact balance of a forced descriptor is meaningless.

CIB rates an impact balance as consistent if the impact sum of the selected variant is not surpassed by the impact sum of another variant of the same descriptor (see Section 2.2.2). Inconsistent impact balances are printed on a red background in the row ‘Balance’. In Fig. 6-2, this is the case for descriptor ‘D. Distribution of wealth’.

The form ‘Impact balance’ can be used to identify in an easy way which parts of a scenario contribute to the consistency (or inconsistency) of a scenario assumption. Fig. 6-2 reveals that the scenario assumption ‘Distribution of wealth: balanced’ is assessed as inconsistent because three other scenario assumptions contradict this statement (i.e. they contribute to the negative impact sum of the assumption D1): the economy-oriented policy of the government, dynamic economy, and meritocratic social values.

To avoid unclear data states, the menu bar remains inaccessible while the impact balance form is open. The toolbar is also deactivated.

The impact balance form offers several services to support the tracking of internal connections of a scenario. These services are described in the following.

Impact diagrams

Selecting a descriptor’s impact balance (row ‘Balance’ of Fig. 6-2) by a mouse click and then clicking with the right mouse button call a diagram displaying all impacts on the selected variant of the respective descriptor. Fig. 6-3 shows the impact diagram of descriptor variant ‘E. Social value: meritocratic’ in scenario [A2 B1 C3 D1 E1 F1]. The diagram depicts the promoting impacts (green) and the hindering impacts (red) on a certain scenario assumption (yellow) under the conditions of the scenario selected in the impact balance form.

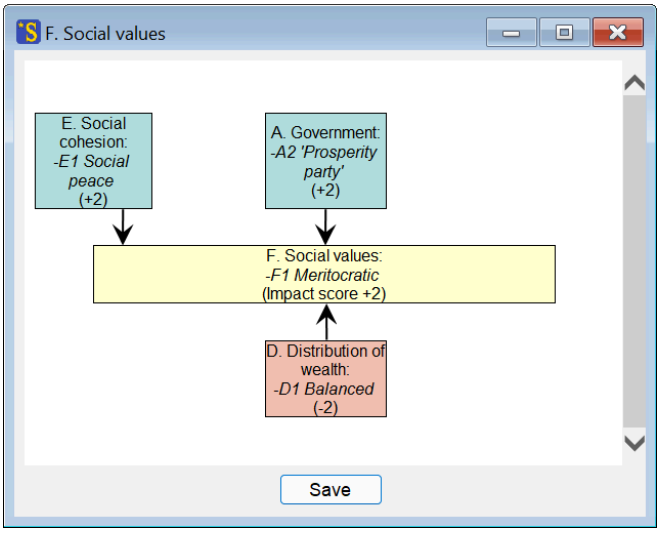


Fig. 6-3: Impact diagram of descriptor variant 'F. Social value: meritocratic' in scenario [A2 B1 C3 D1 E1 F1].

Impact diagrams can be drawn up to a maximum number of 10 active impacts. A black-and-white printout of the diagram can be generated in the window's context menu (click with the right mouse button on the window to call its context menu). Furthermore, the diagram can be stored into an HTML file using the 'Save' button.

Succession

Scenario succession is a CIB procedure to find a consistent scenario. The succession starts with an initial scenario, computes the impact balances by summing up the cross-impacts of all rows of the scenario, and switches all descriptor states to the states of the maximum impact score within every descriptor impact balance. Such procedure is repeated until it yields a consistent scenario (or a cycle, i.e. a repetitive series of scenarios). Once a consistent scenario is found, it does not change under the application of additional iteration steps.

Choose an initial scenario by clicking on the appropriate descriptor variants in the 'Selection' row before starting the scenario succession (when the window is opened, the first variant of each descriptor is selected as a default setting). The rows of the selected variants are highlighted in the matrix. Every change in the selection also updates the highlighting of rows and impact balances in the row 'Balance'.

Click the 'Succession' button to switch all descriptor states to the states of the maximum impact score within a descriptor's impact balance in accordance with the CIB scenario succession rules. Row and impact balance highlighting is also updated. The result is shown in Fig. 6-4 (see below for the 'Succession protocol'). The window is now ready for the next step.

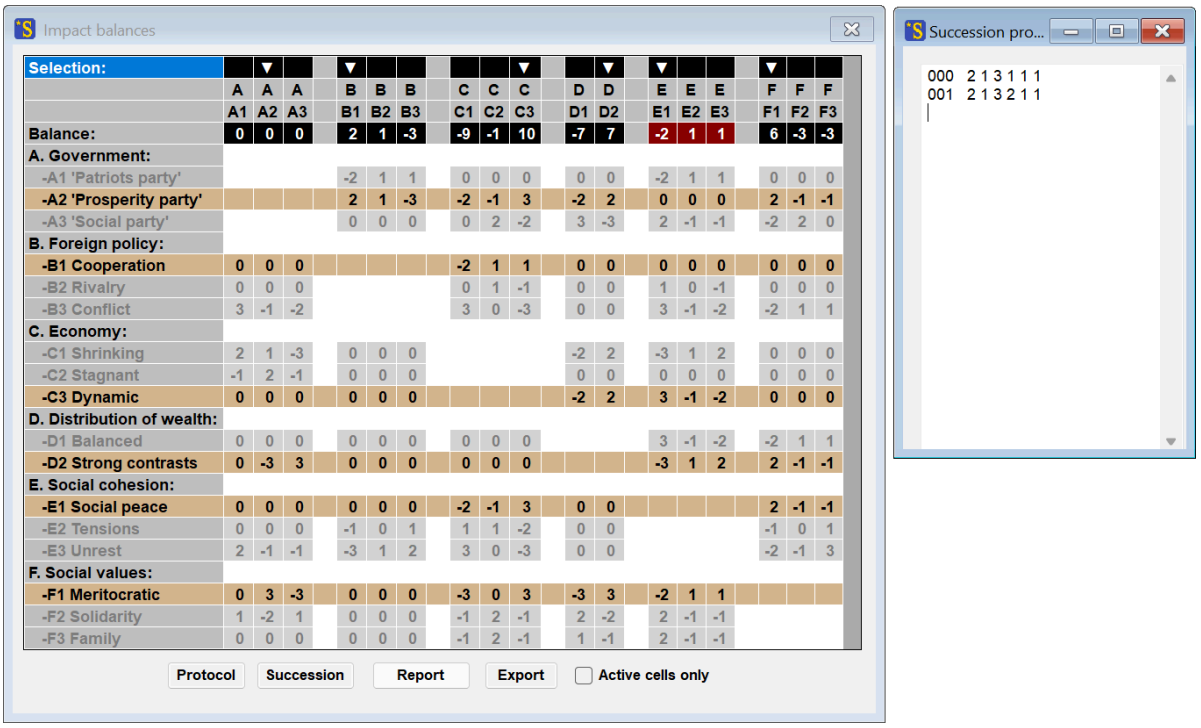


Fig. 6-4: The window ‘Impact balances’ (Fig. 6-2) after application of one succession step.

The succession procedure is iterated by clicking the ‘Succession’ button repeatedly. This leads to one of two possible results: i) after a few steps, there are no more changes in the scenario, i.e. a consistent scenario has been found; ii) after a few steps, the sequence of scenarios begins to repeat itself, i.e. a scenario cycle has been found.

In the example, a consistent scenario is found after two iterations. This is shown by the fact that the scenario code in the protocol window is repeated from the third step onwards and no impact balance is marked in red in the impact balance form.

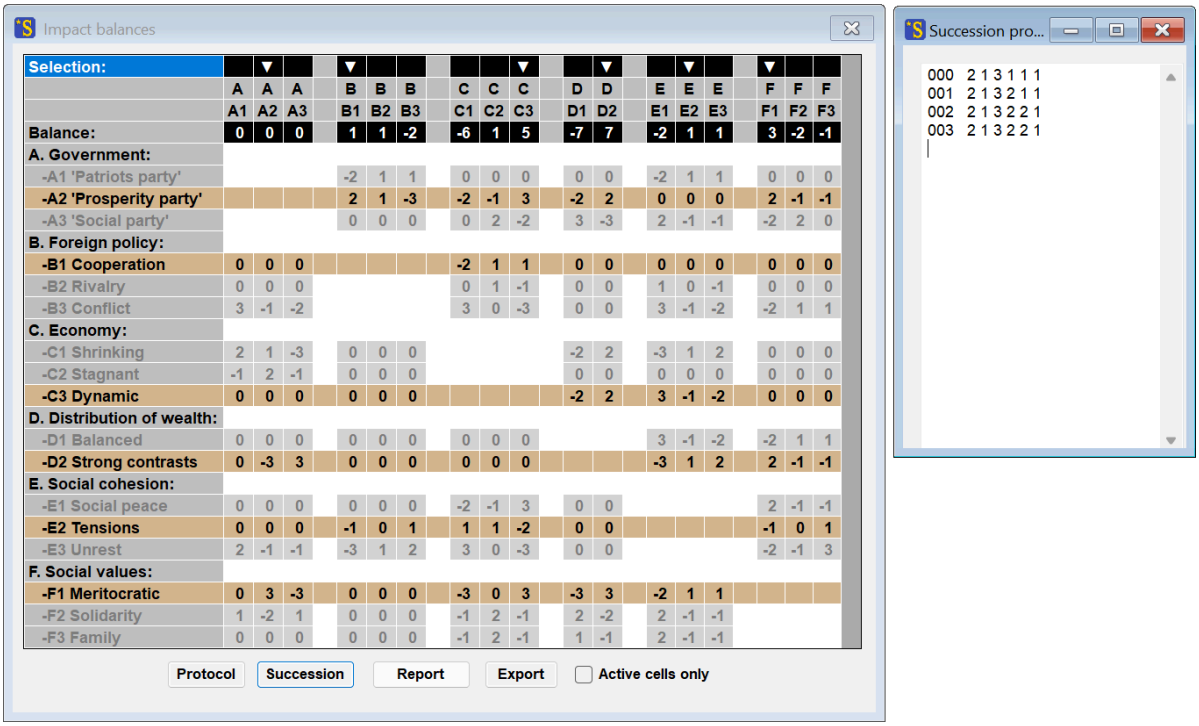


Fig. 6-5: Achieving a consistent scenario through iterating the succession procedure.

If the matrix possesses only one solution (one consistent scenario or one cycle), every succession will lead to this solution after a sufficient number of steps, no matter which initial scenario is chosen. If the matrix possesses more than one solution, the choice of the initial scenario dictates which solution will emerge from the succession. The probability that an initial scenario chosen arbitrarily will lead to a specific solution can be calculated by dividing the attractor weight of the solution (see Section 7.1) by the sum of the attractor weights of all solutions.

Protocol

The 'Protocol' button opens a listing of the succession. The scenarios of the succession are printed in lines using the coded format (see Section 7.2 for an explanation of the 'coded' scenario representation). The protocol will be reset once the 'Impact balance' window is reopened or if a new initial scenario is selected by clicking a descriptor variant in the 'Selection' row.

Report

The 'Report' button generates a scenario report on the current scenario as set in the 'Selection' row. The 'Report' function is described in detail in Section 6.3.

Export

The 'Export' button prints the current cross-impact matrix, the selected variants, and the resulting impact balances into an HTML file. The data shown in Fig. 6-4 will be stored as shown in Fig. 6-6.

	A			B			C			D		E			F		
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	E1	E2	E3	F1	F2	F3
A. Government																	
-A1 'Patriots party'				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
-A2 'Prosperity party'				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
-A3 'Social party'				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy																	
-B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
-B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
-B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy																	
-C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
-C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
-C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth																	
-D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
-D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion																	
-E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
-E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
-E3 Unrest	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values																	
-F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
-F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
-F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			
Balance:	0	**0**	0	**1**	1	-2	-6	1	**5**	-7	**7**	-2	**1**	1	**3**	-2	-1

Fig. 6-6: HTML export of Fig. 6-4.

The inverted balance cells refer to the selected descriptor variants.

This type of depiction is useful for the analysis of the sources of consistency or inconsistency of a descriptor, and useful for improving the understanding of the internal logic of a consistent scenario or the shortcomings of an inconsistent scenario.

Similar to exported cross-impact matrices (see Section 5.16), exported impact balance data can be imported not only by HTML browsers, but also by various standard application programs, e.g. MS Excel.

Active cells only

Activating the checkbox ‘Active cells only’ compresses the form ‘Impact balances’. For this purpose, only the rows and columns of the selected variants are displayed and all other cells are hidden, resulting in a scenario-specific (‘reduced’) cross-impact matrix. In this matrix, the promoting influences are marked in green and the inhibiting influences in red (Fig. 6-7).

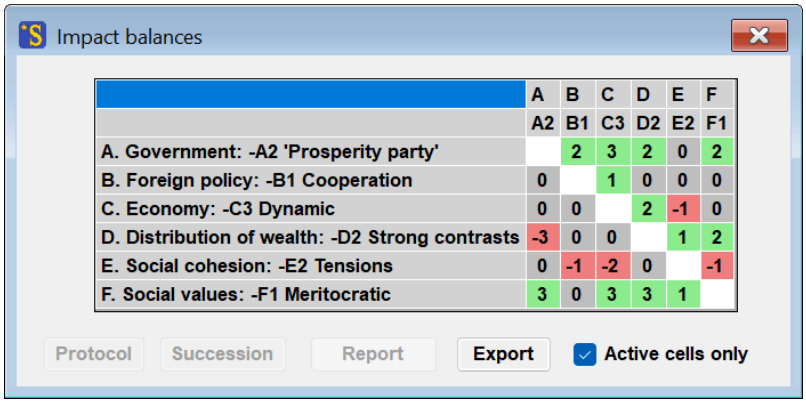


Fig. 6-7: The reduced cross-impact matrix for the consistent scenario [A2 B1 C3 D2 E2 F1].

The logical relationships in the scenario are now easy to recognize, since it is now possible to read off from the green entries in the columns of the reduced matrix for which reasons the column variant occurs in the scenario.

A click with the left mouse button on the reduced cross-impact matrix generates a scenario-specific active-passive diagram. It plots the row sums of the positive (green) values of the reduced matrix against the respective column sums.

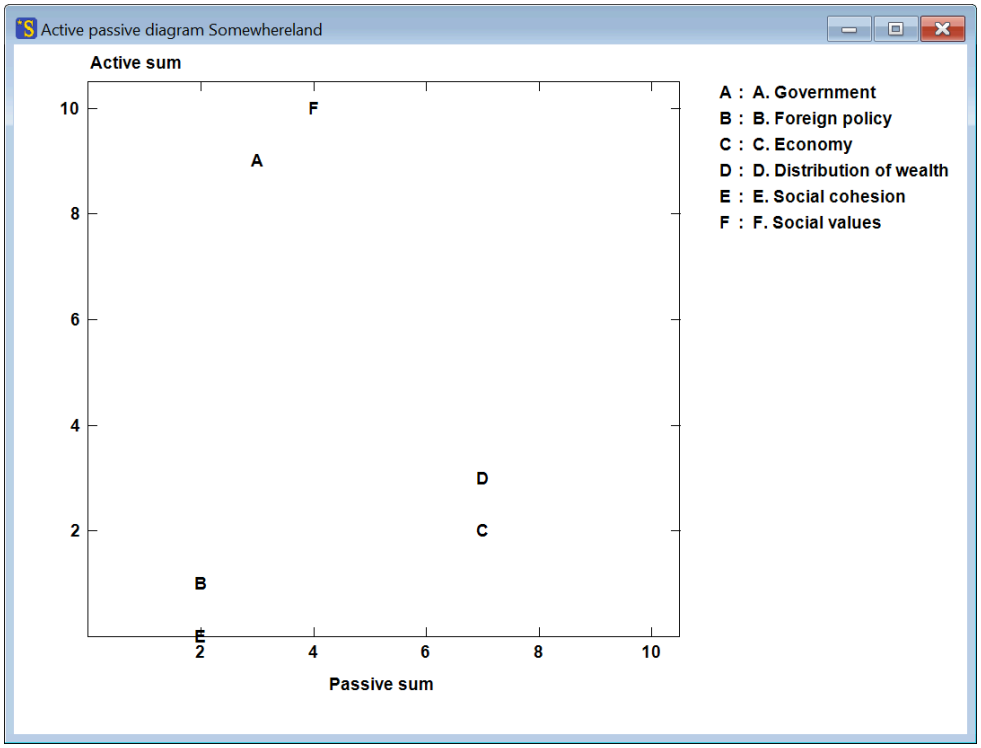


Fig. 6-8: Scenario-specific active-passive diagram.

In contrast to the generic active-passive diagram described in Section 6.1, the specific active-passive diagram describes the special influence relationships responsible for consistency in a concrete scenario. The comparison of the generic diagram with the specific diagram reveals whether descriptors in the examined scenario take on a role in the system that deviates from the general case. For example, the comparison between Fig. 6-1 and Fig. 6-8 shows that descriptor "E. Social cohesion" is to be regarded generically as a descriptor of medium influence strength, but in the scenario [A2 B1 C3 D2 E2 F1] ("Prosperity in a divided society", cf. Fig. 2-4) it is exceptionally an exclusively driven descriptor that cannot bring its influence potential to bear under the conditions of this scenario.

Deactivating the checkbox restores the original state of the form, showing the active as well as inactive columns and rows.

6.3 Generating an automatic scenario report

The ‘Report’ button in the impact balance window (see Section 6.2) and the ‘Rp’ button in the evaluation protocol ‘Consistent scenarios’ (see Section 6.4) start the automatic generation of a scenario

report. The report discusses the plausibility of the scenario assumptions and compiles the pros and cons for each assumption. If available, the descriptor and cross-impact comments (see Section 5.10) will be integrated in the report to support the argumentation. The report shows the following structure:

Project information

If available, the general project information (see Section 5.10) opens the report. If no general project information is entered into the comment database, this section is skipped.

Scenario topic

This section lists the comments defining the descriptors provided that comments are available for at least one descriptor. Otherwise, the section is skipped.

Scenario overview

The scenario under consideration is documented in the section 'Scenario overview' by listing the assumed variant for each descriptor. Inconsistent descriptors, forced descriptors, and autonomous descriptors are marked in the list by colours. Fig. 6-9 shows this section in the case of the scenario displayed in Fig. 6-2.

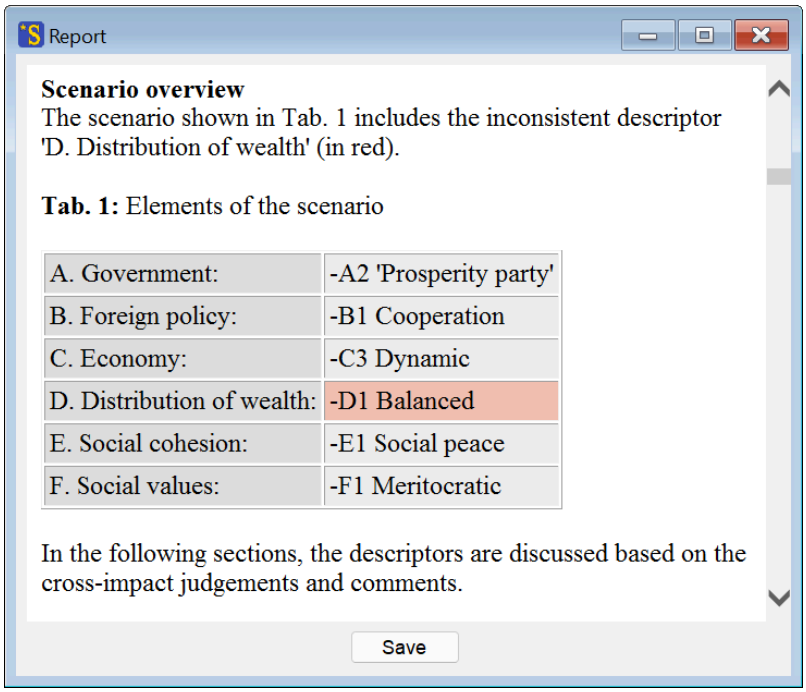


Fig. 6-9: The 'Scenario overview' section of an automatic report.

Descriptor consistencies

In a series of sections, the assessment of descriptor consistency shown in the 'Scenario overview' section is backed by comparing the supporting influences and the contradicting influences on the selected variant for each descriptor. In the case where comments on the cross-impacts are provided, the comments will be integrated into the discussion. The influences on the selected descriptor variants will be visualised by impact diagrams, provided that there are not more than 10 active impacts.

In the case of a consistent descriptor, the list of supporting and contradicting influences on the selected variant (pros and cons list) is compared with respective lists for all other variants of the same descriptor. According to the CIB principles, consistency is proved if none of the other variants shows a more convincing pros and cons list than the selected variant (measured by the impact sum) (see Fig. 6-10 and Fig. 6-11).

In the case of an **inconsistent descriptor** (marked in red in the 'Scenario overview' section), the pros and cons list of the selected variant is confronted with the respective list of an alternative variant of the same descriptor showing a better balance of pros and cons, thus disproving the consistency of the scenario assumption for the respective descriptor.

Forced descriptors and descriptors that are not the target of any impact ('autonomous descriptors') are skipped in this section because the question of consistency is meaningless in these cases.

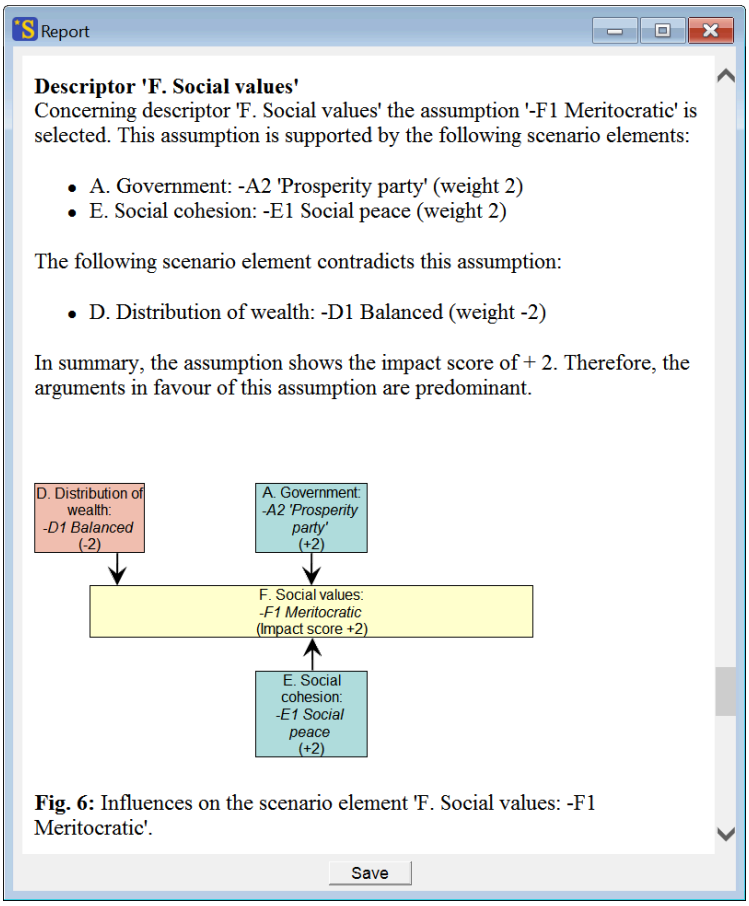


Fig. 6-10: Comparing the supporting and hindering influences on a scenario element.

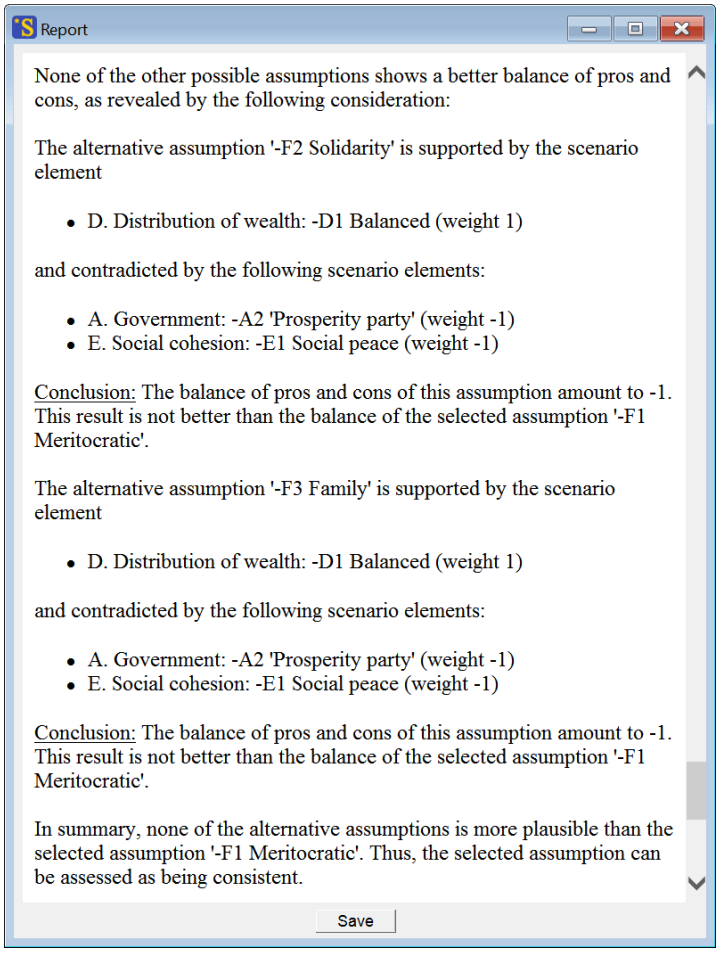


Fig. 6-11: Continuation of Fig. 6-10: proving the consistency of a scenario assumption by showing the inferiority of all alternative assumptions.

Firmness of scenario assumptions and conclusions

After the discussion of the basal question of whether a descriptor is consistent or inconsistent, the amount of consistency is now scrutinised as an indicator of the firmness of the scenario assumptions. The consistency measure of a descriptor is defined as the difference between the impact balance of the selected descriptor variant and the highest impact balance of all alternative variants of the same descriptor, thus expressing (if positive) the superiority of the selected descriptor variant. In the section ‘Firmness of scenario assumptions’, the descriptors and their consistency measure are listed and sorted by consistency.

The last section of the report (‘Conclusions’) summarises the scenario discussion, formulates a short assessment of the scenario, and mentions some scenario peculiarities, if necessary.

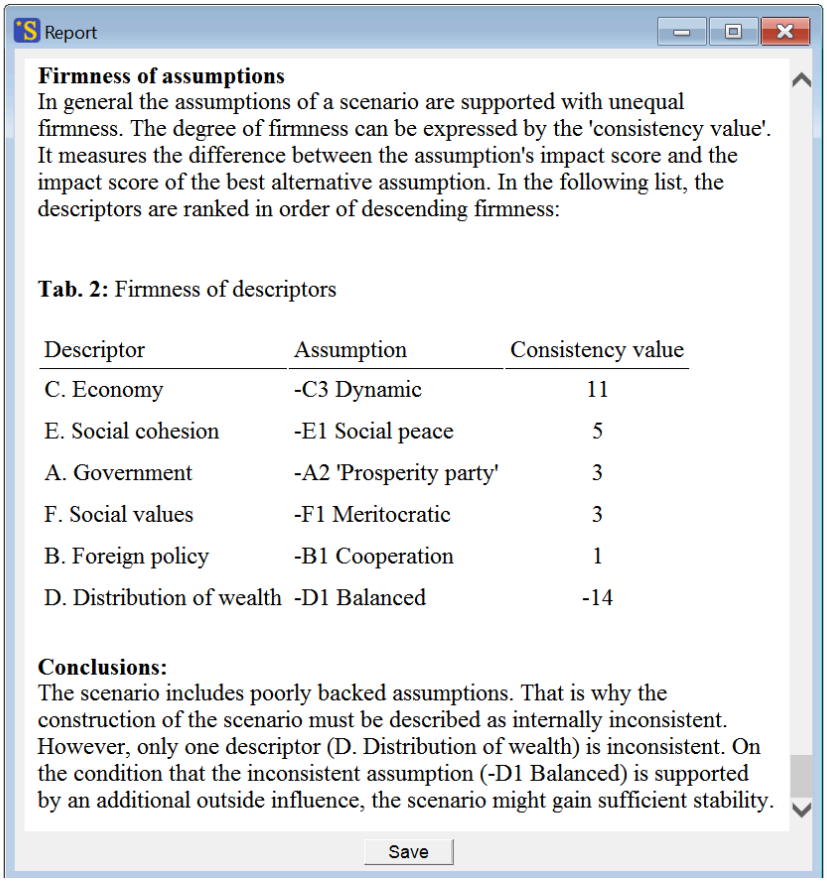


Fig. 6-12: The sections 'Firmness of scenario assumptions' and 'Conclusions' of an automatic scenario report.

6.4 Computing consistent scenarios

The computation of consistent scenarios is the basic evaluation in CIB analysis. Each consistent scenario is a bundle of mutually supporting assumptions. Consistent scenarios are calculated using the menu item *Analyse - Consistent Scenarios* or the button on the toolbar.

A progress bar displays the course of the calculation. The evaluation of small cross-impact matrices (e.g. with 10 descriptors) is carried out within a few seconds. The computation of large matrices (e.g. with 20 descriptors) can take several minutes to hours, depending on the performance of the computer.

Once the calculation is completed, an evaluation protocol appears. It displays all computed consistent scenarios. Fig. 6-13 shows the evaluation protocol of the example in Fig. 5-7.

The first line of the evaluation protocol displays the name of the evaluated matrix and the consistency mode used ('Strong consistency' is the default setting. Other consistency modes are described in Section 7.1). In the case of the option 'Volume weights' or 'Attractor weights' (see Section 7.1, default: deactivated), a line indicating the weight type follows. In the case of the option 'Attractor weight', the succession mode is also printed (default setting: 'Global succession'; see Section 7.1).

Then, a printout of the consistent scenarios follows. In this case, 10 consistent scenarios exist. Each scenario report starts with a header (in the case of the default output option; for other output options, see Section 7.2). It contains the current number, weight (only in the case of activated weight calculation, default: deactivated), consistency value, and total impact score (the sum of the impact scores of all selected states of a scenario) of the scenario. In the case of the option 'Max. inconsistency' and a maximum inconsistency value > 0 (see Section 7.1), the header is completed by the number of inconsistent descriptors. Then the descriptor variants that together form the suggested combination are listed.

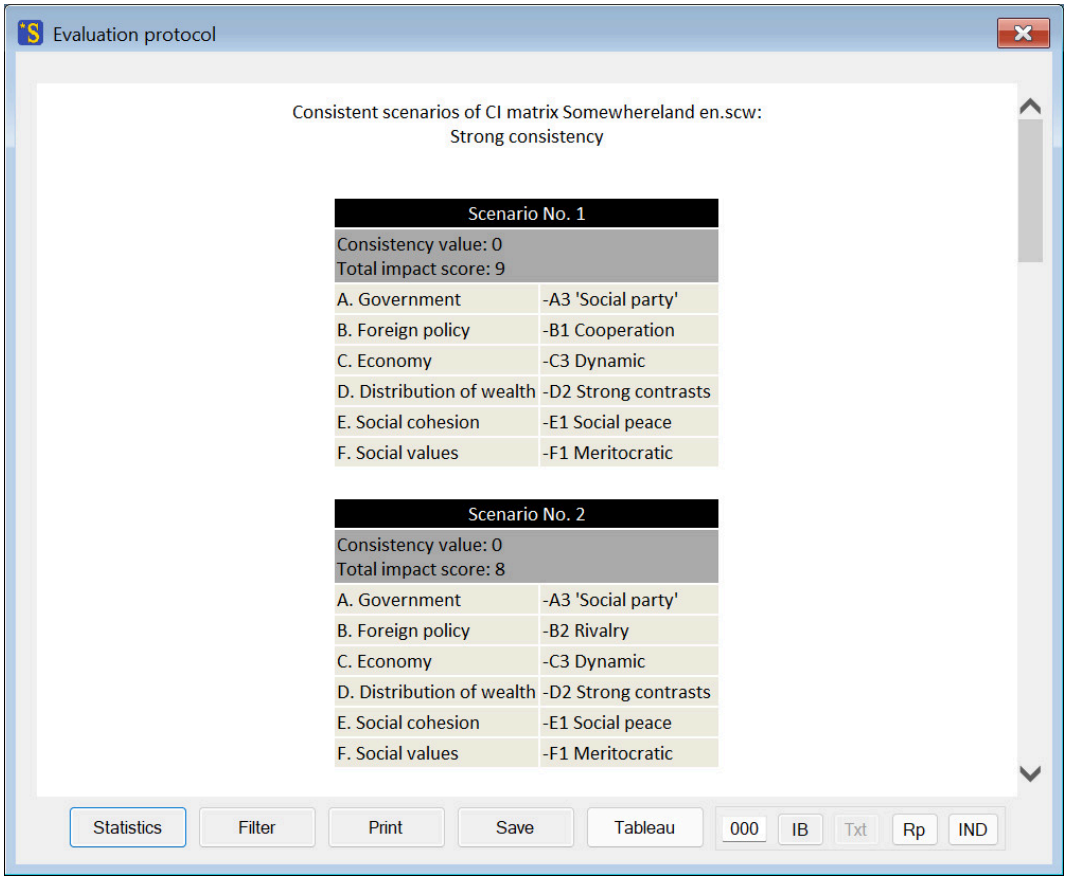


Fig. 6-13: Evaluation protocol for the consistent scenario calculation.

The scenario list with full descriptor and variant names (“long names”) is only printed in the protocol up to a maximum scenario number of 200. For larger scenario lists, the short names are used for the list output. For scenario lists with more than 1000 scenarios, only the scenario count is output. However, also in this case, the scenarios are available in the main memory for carrying out the analyses described below.

Regulating the number of scenarios

The number of scenarios (10 in the case of Somewhereland) is a result of the specific pattern of descriptor interdependencies in a system. Depending on the interdependencies, the number of scenarios may be very high or very low. It is even possible that the evaluation yields no scenarios.

If the evaluation yields too few or even no scenarios, the user should consider reducing the consistency threshold applied by the evaluation procedure. This can be done step by step by increasing the evaluation parameter ‘Max. inconsistency’ until the required number of scenarios is obtained (see Section 7.1). However, the internal logic of the scenarios will become weaker if this parameter is increased, and a careful consideration of the balance between both goals, i.e. achieving the desired number of scenarios and securing the scenario quality, is necessary.

The evaluation protocol window contains the following buttons:

Statistics

The interpretation of solution sets with many consistent scenarios can be aided by the calculation of descriptor variant frequencies in the scenario list. The ‘Statistics’ button is used for this purpose. It opens the window shown in Fig. 6-14.

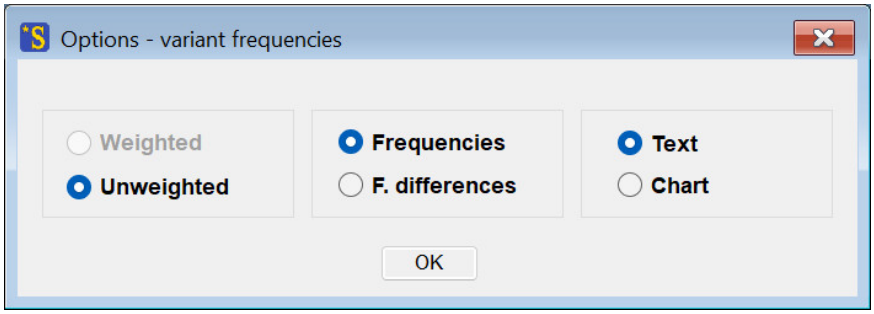


Fig. 6-14: Options for the calculation of variant frequencies.

Use this window to specify whether in calculating descriptor variant frequencies, the consistent scenarios are to be weighted using their weights (available only if the weight calculation option is selected) or counted with equal weights.

The ‘Frequencies’ option leads to the direct calculation of frequencies.

The ‘F. differences’ (Frequency differences) option requires that a calculation with the ‘Frequencies’ option has already been performed. The ‘F. differences’ option then calculates the differences between the actual frequencies and the frequencies of the previous calculation. This option is useful, e.g. to gain a clear picture of the effects of changes to the cross-impact data.

The ‘Text’/‘Chart’ option controls the way the results are depicted. In ‘Text’, the calculated frequencies are attached at the end of the evaluation protocol as a table (Fig. 6-15). In ‘Chart’, the results are presented in a bar chart (Fig. 6-16).

In the textual output of the frequency values, there is also a count of the proportion of the variants present in the matrix that are used in the scenarios, and which variants are vacant, i.e. do not occur in any of the scenarios (in the example, however, there are no vacant variants. However, this is not the rule).

The options window must be closed with the ‘OK’ button to store the selected options and to start the frequency calculations. According to the selection of options, the results will either be printed in the evaluation protocol or displayed in a newly opened graphics window. The evaluation protocol reappears once the graphics window has been closed by clicking the ‘Close’ button (top right corner of the window).

It is also possible to use the ‘Statistics’ button repeatedly, e.g. to obtain an initial text output of the frequencies as part of the protocol and to create a subsequent graphical view of the frequency data.

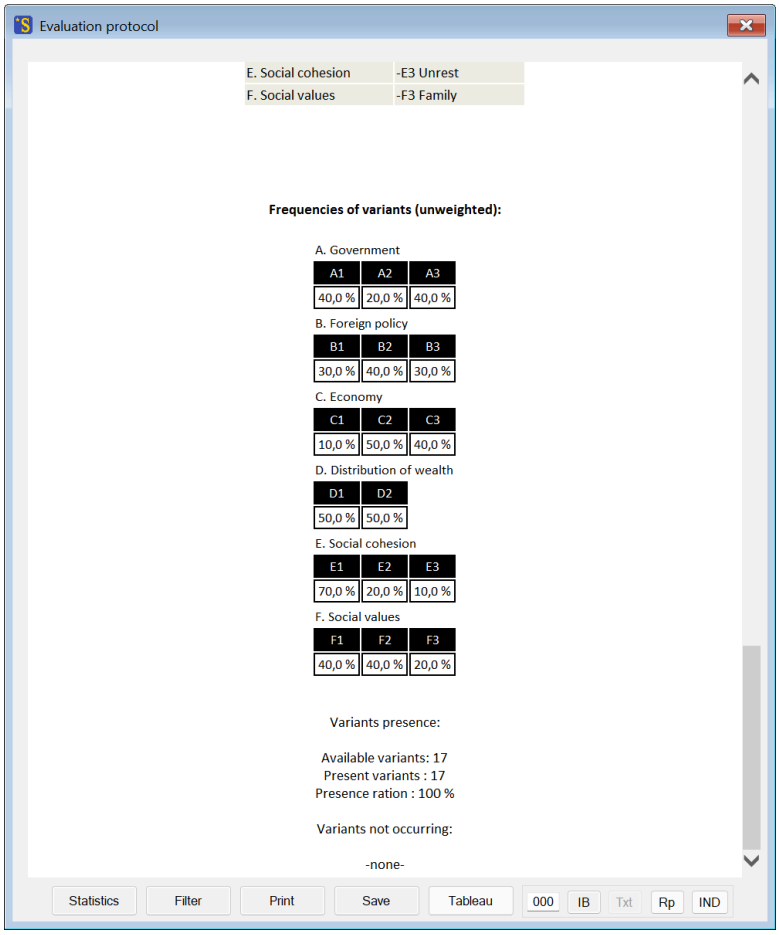


Fig. 6-15: Output of variant frequencies in the evaluation protocol.

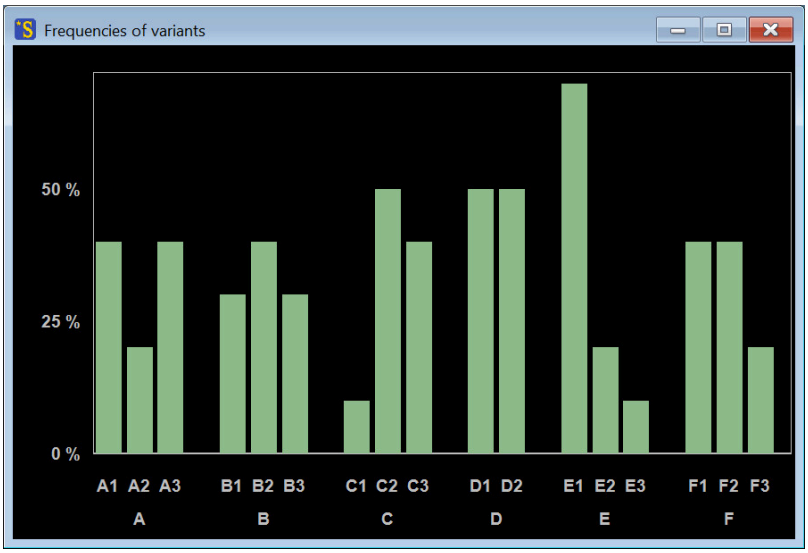


Fig. 6-16: Bar chart of unweighted variant frequencies. Short names of descriptors and variants are used for labelling (see Section 5.3).

As an example of the use of the option ‘F. differences’ (Frequency differences), we investigate the role of social values in Somewhereland. First, we calculate the frequencies by using the ‘Frequencies’ option in Fig. 6-14 (choose options: Unweighted/Text). Next, we open the matrix editor (see Section 5.8) and erase all impacts in the rows belonging to descriptor ‘F. Social values’. This corresponds to the hypothesis that social values have no impact on the development of Somewhereland. Then, we recalculate the consistent scenarios and variant frequencies, but now using the option ‘F. differences’ (choose option: Unweighted/Graphics).

As a consequence of this hypothesis, Fig. 6-17 shows which descriptor variants appear more frequently (or rarely) when compared with the baseline calculations.

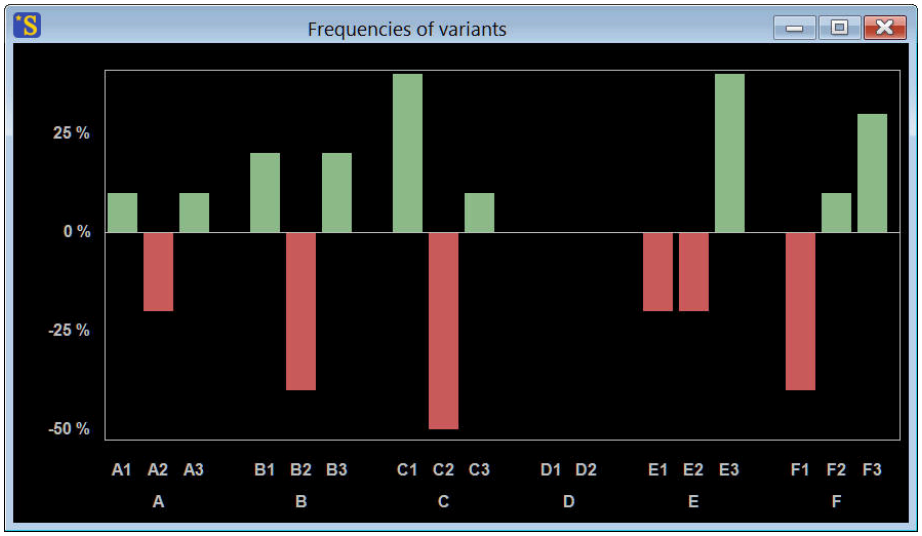


Fig. 6-17: The option ‘F. differences’ shows the changes in variant frequencies resulting from a modification of the cross-impact matrix.

Filter

Click on the ‘Filter’ button to apply a filter to the list of solutions in the evaluation protocol. Only solutions containing certain descriptor variants will be displayed. The filter conditions can be specified in a filter form, which will show up after the ‘Filter’ button is pressed (Fig. 6-18).

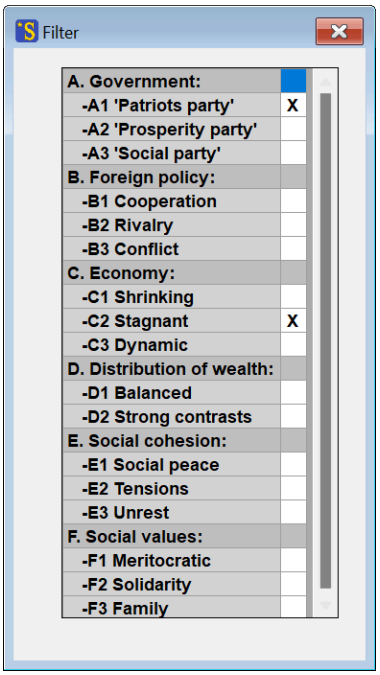


Fig. 6-18: Filtering the solution list.

The filter shown in Fig. 6-18 specifies that scenarios are displayed only if they include both 'A. Government: A1 Patriots party' and 'C. Economy: C2 Stagnant'. A filter condition can be specified for each descriptor. It is also possible to select more than one variant for a descriptor. In this case, all scenarios showing one of the selected variants are accepted ('or' condition).

Clicking a variant already selected will undo the selection of this variant. The solution list is updated after each click on the filter form.

All functions of the evaluation protocol (Statistics, Print, Save, and Tableau) can be applied to the filtered solution list as long as the filter form is active. Closing the filter form will cancel all filter conditions and the original solution list will be displayed.

Print

Click on the 'Print' button to open a printer selection window and to send the displayed evaluation protocol to the selected printer.

Saving

Click on the 'Save' button to open a file selection window for saving the list of consistent scenarios. The suffix of the file name is .sl. A saved SL file can be reloaded later using the menu item *File - Load - Solution Set*.

An SL file stores the consistent scenarios in coded syntax. The SL file of the cross-impact matrix shown in Fig. 5-7 contains four scenarios and has the following structure:

```
$ ScenarioWizard 2.0
Solution set
 10
" 3 1 3 2 1 1",0,0,0,9
" 3 2 3 2 1 1",0,0,0,8
" 2 1 3 2 2 1",0,0,0,17
" 2 2 3 2 2 1",0,0,0,15
" 3 1 2 1 1 2",0,0,0,18
" 1 2 2 1 1 2",0,0,0,9
" 3 2 2 1 1 2",0,0,0,19
" 1 3 2 1 1 2",0,0,0,14
" 1 3 2 1 1 3",0,0,0,12
" 1 3 1 2 3 3",0,1,0,21
```

The *ScenarioWizard* signature is followed by a line that characterises the file as an SLM file. Then, the number of stored scenarios follows. After an empty line, one line is added for each scenario. Each scenario is encoded by a string with the state numbers of the descriptors. The line ends with the combinatorial weight of the scenario.

ScenarioWizard uses an extended SLM data structure since the program version 3.2. SLM files created by older program versions cannot be loaded any longer. If necessary, old SLM files should be regenerated by a recent program version.

IB / Txt / Rp / IND

The buttons ‘IB’ (impact balances), ‘Txt’ (text), ‘Rp’ (report), and ‘IND’ (Impact network diagram) support a closer look at a scenario. Select a scenario of special interest and enter its number in the textbox to the left of the ‘IB’ button. Click the ‘IB’ button to open the impact balance window (see Section 6.2). The form will be set according to the selected scenario and the scenario impact balances are displayed.

Click the ‘Txt’ button to open a window showing the full text representation of the selected scenario. This function is helpful when the output options ‘Code’ or ‘Short name’ are used because these options generate only a reduced representation of the scenarios (see Section 7.2). The ‘Txt’ button is disabled if the output option ‘Long text’ is activated.

The ‘Rp’ button generates an automatic scenario report on the selected scenario. This function is described in detail in Section 6.3.

The 'IND' button delivers an impact network diagram of the selected scenario. It illustrates the influence relationships between the descriptors in the selected scenario. More information about the IND-Function provides Section 6.6.

The buttons ‘IB’, ‘Txt’, ‘Rp’, and ‘IND’ do not work if a number smaller than 1 or larger than the number of scenarios is entered in the textbox.

If the number of combinations of a matrix (the product of the number of states of all descriptors) exceeds 9.22×10^{18}, then an evaluation ‘consistent scenarios’ using the evaluation option ‘complete’ (see Section 7.1) is not possible. In this case, a warning is displayed and the evaluation is terminated. Use the evaluation option ‘Monte Carlo’ to solve matrices with a higher number of combinations.

6.5 Generating a scenario tableau

The ‘Tableau’ button of the evaluation protocol generates a table showing the consistent scenarios in the columns and their respective descriptor variants in the rows. To emphasise the similarities between scenarios, neighbouring cells with concurrent variants are merged. If colours are assigned to the descriptor variants while building up the analysis structure in the structure editor (see Section 5.5), the colours are used also in the scenario tableau. The 10 consistent scenarios of Somewhereland and the colour coding shown in Fig. 5-4 yield the tableau in Fig. 6-19.

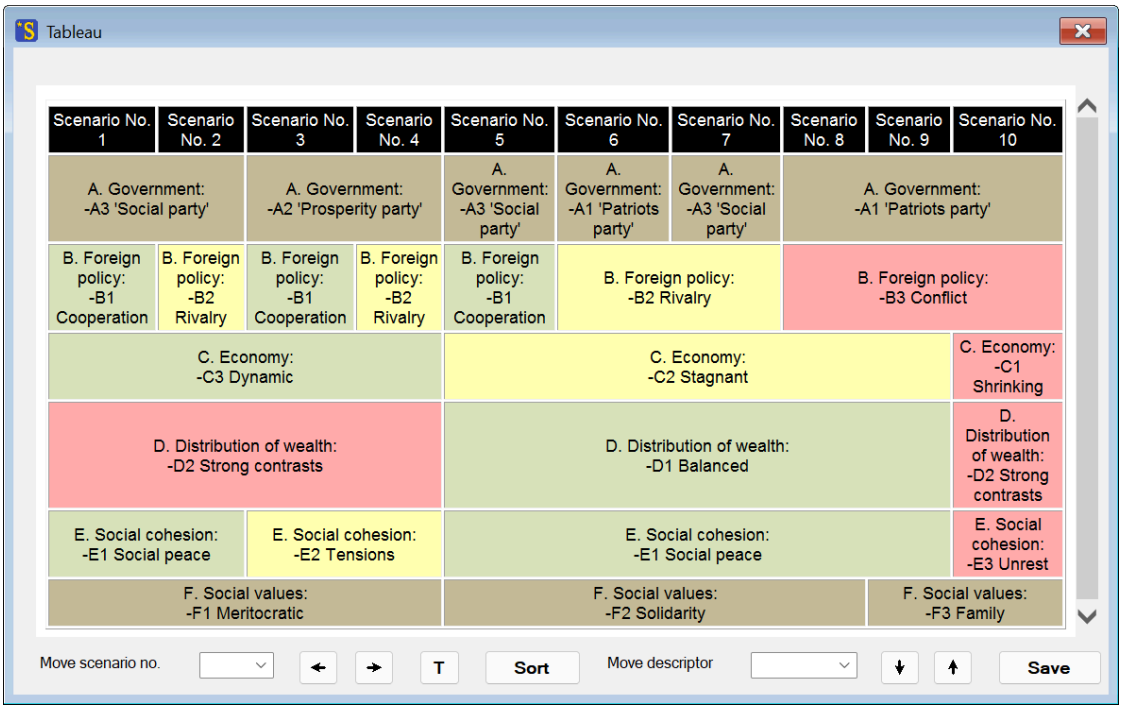


Fig. 6-19: Unsorted tableau of Somewhereland’s consistent scenarios.

Sorting

Full benefit of the tableau function is gained only if the scenarios are sorted in a way that exhibits 'scenario families' by grouping similar scenarios. The scenarios can be moved in the tableau to align them in a meaningful way. Select the number of the scenario to be moved in the combo box 'Move scenario no.' and press the right/left arrow buttons.

The 'Sort' button offers an alternative to the manual sorting of the scenarios. 'Sort' executes an automatic sorting using a heuristic, which strives for merging as much cells as possible. However, the automatic sorting acts only formally and is not able to include aspects of content. It is advisable to complete the sorting by manual action. Fig. 6-20 shows an example of a sorted tableau. This tableau was also used in Fig. 2-4 of the CIB introduction in Chapter 2.

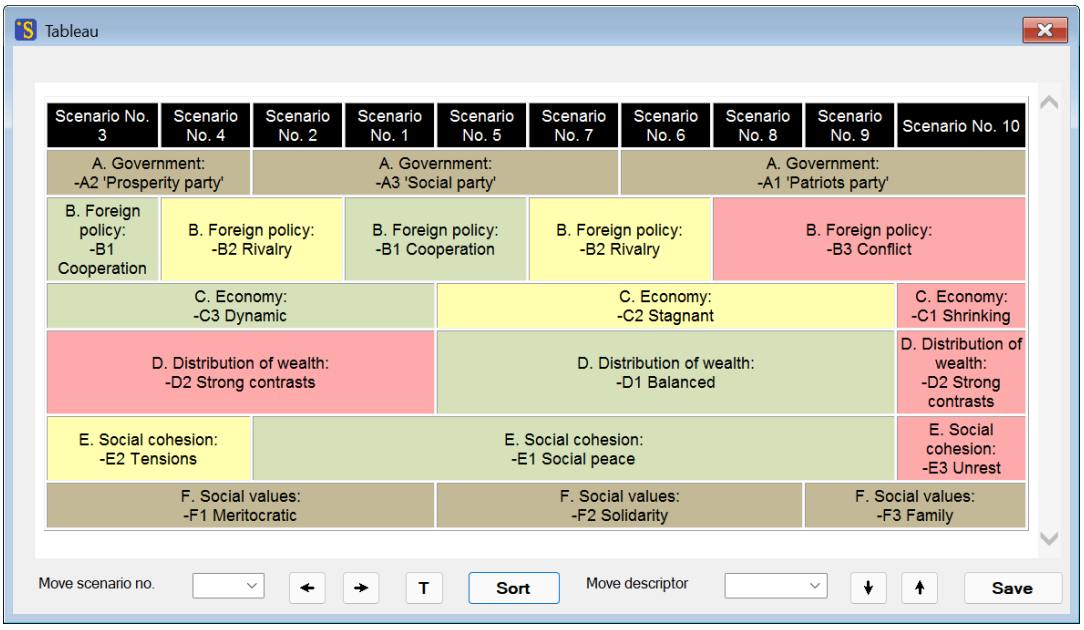


Fig. 6-20: Sorted tableau of Somewhereland's consistent scenarios.

The combo box 'Move descriptor' and the up/down arrow buttons can be used to change the sorting of descriptors. For example, placing influential descriptors on the top of the tableau and passive descriptors on the bottom can depict the cause–effect structure of the scenarios and enhance the logical readability of the tableau. According to Fig. 6-1, the descriptor 'F. Social values' is possibly a candidate to be moved to the upper part of the tableau.

Another approach to sort descriptors is to group covariant descriptors to emphasise 'syndrome behaviour' in the system. In the tableau of Somewhereland, this is not necessary because the only co-

variant descriptors (descriptors ‘C. Economy’ and ‘D. Distribution of wealth’) are already neighbouring descriptors.

The application of the up/down arrow buttons changes the sorting of descriptors only in the scenario tableau window. The analysis structure defined by the structure editor (see Section 5.3) remains unchanged.

Scenario titles

The form ‘Tableau’ can be used to assign titles to the scenarios. Select the scenario to be titled in the combo box ‘Move scenario’ and press the ‘T’ button. An input box will be displayed at the top of the tableau form. Enter the scenario title and press the ‘OK’ button on the right side of the input box. A new title row at the top of the scenario tableau emerges, showing the newly defined scenario title. The same function can also be used to edit an existing scenario title.

For neighbouring scenarios with identical titles, the title boxes are merged. This can be used to define scenario groups in the tableau.

When the ‘Tableau’ form is closed, *ScenarioWizard* registers all scenario titles in the evaluation protocol. In protocols using the output format ‘Code’ (see Section 7.2), the titles are displayed at the end of each line. In protocols using the output formats ‘Short name’ or ‘Long name’, the titles are shown in the header of each scenario section. The titles will be stored when the solution list is saved using the ‘Save’ button of the evaluation protocol. They are available again after reloading a solution list (Section 6.4, paragraph ‘Saving’).

The scenario tableau is built up as an html table. This offers the opportunity to format the scenario titles by including html tags in the title text. For instance,
 will generate a line break in the title and text enclosed by .... will be printed in bold letters.

Printing and storing the tableau

The tableau can be stored in html format by pressing the ‘Save’ button. A black and white printout of the tableau can be generated via the window’s context menu (click with the right mouse button on the tableau to open its context menu).

6.6 Impact Network Diagram

Impact network diagrams (also referred to as influence diagrams) graphically depict the influence relationships within a scenario. They show how the active variants of the scenario interact with each

other according to the cross-impact matrix and lead to the self-stabilisation of the scenario in a consistent scenario[4]. Impact network diagrams thus promote an understanding of the logical 'functioning' of the scenario and at the same time reveal the forces that work against the existing configuration in the scenario.

The impact network diagram of a scenario can be requested from the evaluation protocol by entering the list number of the selected scenario in the number input field at the bottom right of Fig. 6-13 and then pressing the IND button. For example, entering the value 3 in the number input field of the evaluation protocol in Fig. 6-13 stands for the Somewhereland scenario [A2 B1 C3 D2 E2 F1]. Then pressing the IND button produces the graph shown in Fig. 6-21.

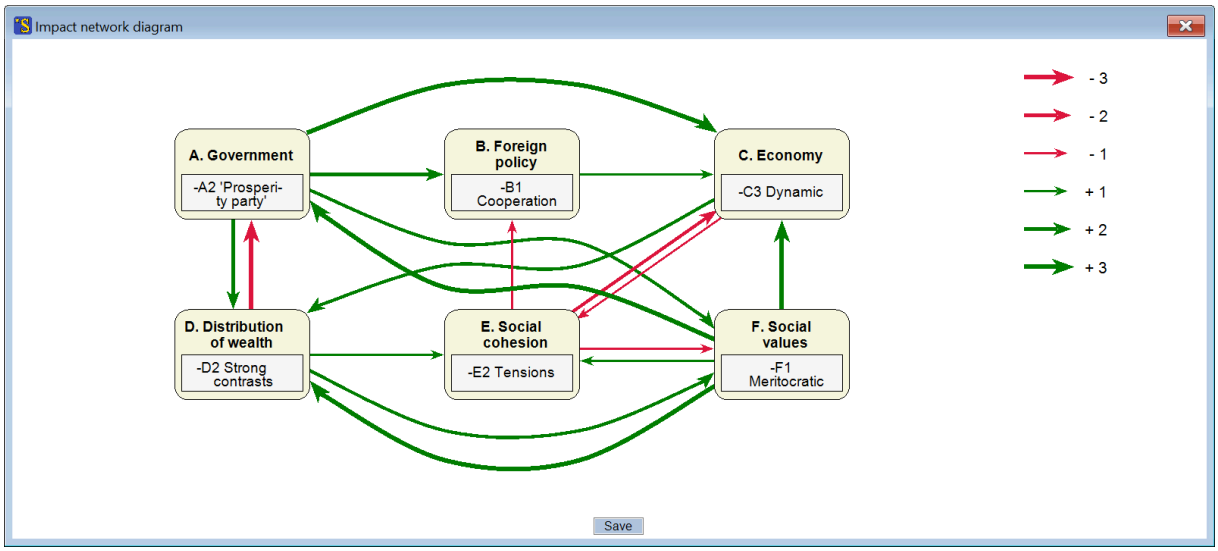


Fig. 6-21: Impact Network Diagram of the consistent Somewhereland scenario no. 3.

With the help of the impact network diagram, it can be quickly recognised in this case that, for example, the cooperative foreign policy is driven exclusively by the economy-oriented government policy and that this trend is subject to resistance due to social tensions, while other trends, such as the trend towards strong contrasts in prosperity, are driven forward in a much more multi-causal and at the same time less controversial manner. Among other things, such considerations can be used to discuss which components of a scenario are most likely to lead to destabilisation.

The 'Save' button at the bottom of the window allows you to save the graphic as a png file. The resolution of the graphic file is adaptive and increases with the number of descriptors.

[4] Cross-Impact Balances (CIB) for Scenario Analysis - Fundamentals and Implementation, by W. Weimer-Jehle. Springer Berlin, Heidelberg, New-York (2023).

Impact network diagrams are a graphical representation of the reduced cross-impact matrix (see Section 6.2, paragraph 'Active cells only'). The scenario shown as an example in Fig. 6-21 corresponds to the scenario used in Fig. 6-7 to demonstrate the reduced cross-impact matrix.

Impact network diagrams are particularly illustrative when they are created for the scenarios of small or moderately interconnected medium-sized matrices. For larger and highly interconnected matrices, there are frequently so many influence relationships between the active variants that the diagrams are difficult to interpret, unless they are completely unreadable due to their high information density. Fig. 6-22 shows the impact network diagram of a scenario of a medium-sized, averagely densely interconnected matrix. Even here, the legibility of the diagram is limited as a consequence of the information density. The demonstration example deals with the opinion formation of a social group of 15 people who are striving to reach an opinion on a controversial issue under mutual influence.

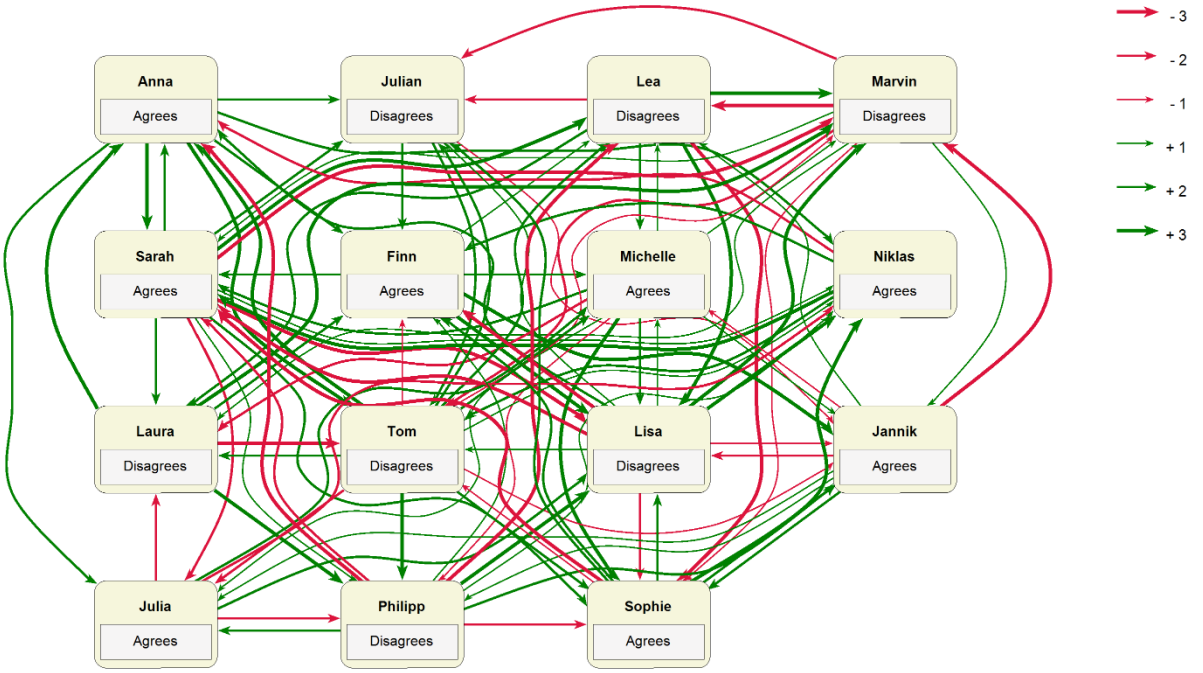


Fig. 6-22: Information vs. readability: Impact network diagram of a medium-sized, averagely interconnected matrix.

To handle diagrams with a high information density, the IND function allows you to view the impact network step by step using focus descriptors. When clicking on a descriptor name, only the arrows that go to or from the selected descriptor are displayed in colour. All other arrow connections are greyed out. Clicking on the descriptor name 'Sarah', for example, produces the illustration shown in Fig. 6-23. In focus mode, even complex impact networks can be easily understood in step-by-step fashion.

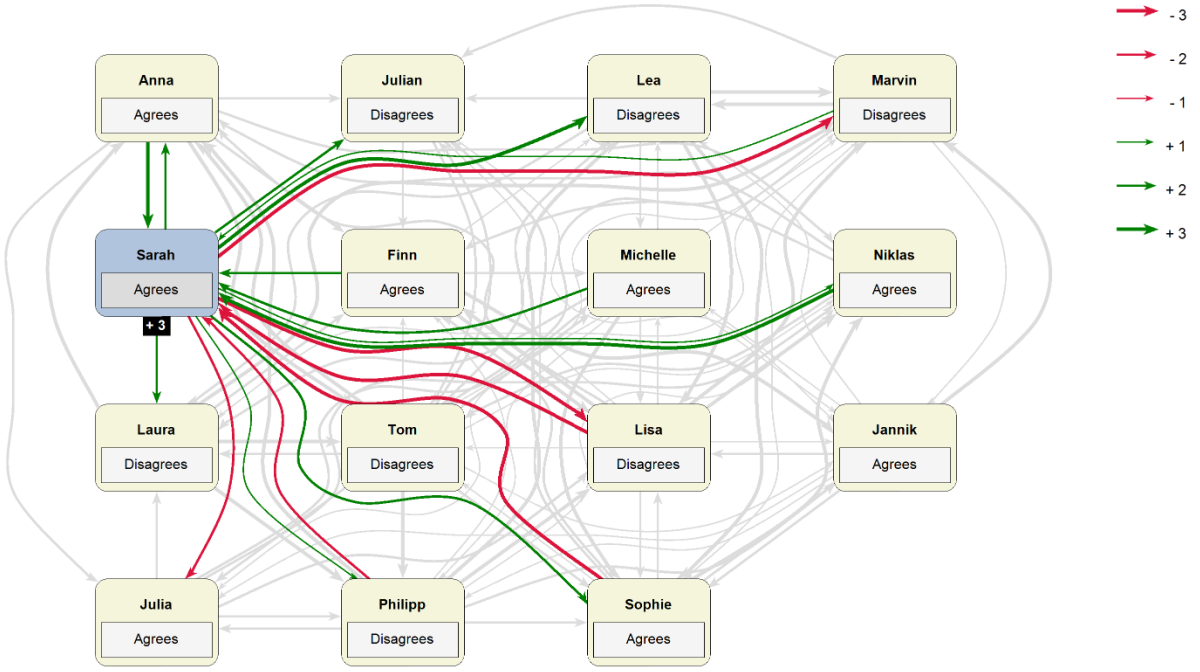


Fig. 6-23: Impact network diagram with a focus descriptor.

A second click on the selected descriptor name cancels the focus mode. A click on the name of another descriptor switches the focus to the other descriptor.

In focus mode, the impact network diagram illustrates the embedding of the selected descriptor in the impact network. The embedding reflects the fact that, according to the CIB philosophy, the variants that are best adapted to their environment are active in consistent scenarios. This is expressed by the impact sum, which is given as the balance of the strength values of all incoming arrows in the black box below the focus descriptor, in the example with the value +3.

The impact network diagram in focus mode can be used to demonstrate the consistency of the focus descriptor, i.e. to show that the alternative variants of the focus descriptor in the given network state are unable to achieve higher impact sums (provided the scenario under investigation is actually consistent). To do this, we click on the variant name of the focus descriptor (“Agree” in the case of Fig. 6-23) and thereby cause the variant for this descriptor to switch from “Agree” to “Disagree”. The result is the image shown in Fig. 6-24. It can be seen that the changed variant attracts more negative impacts and therefore achieves a significantly lower impact sum, i.e. it is less well adapted to the state of the network.

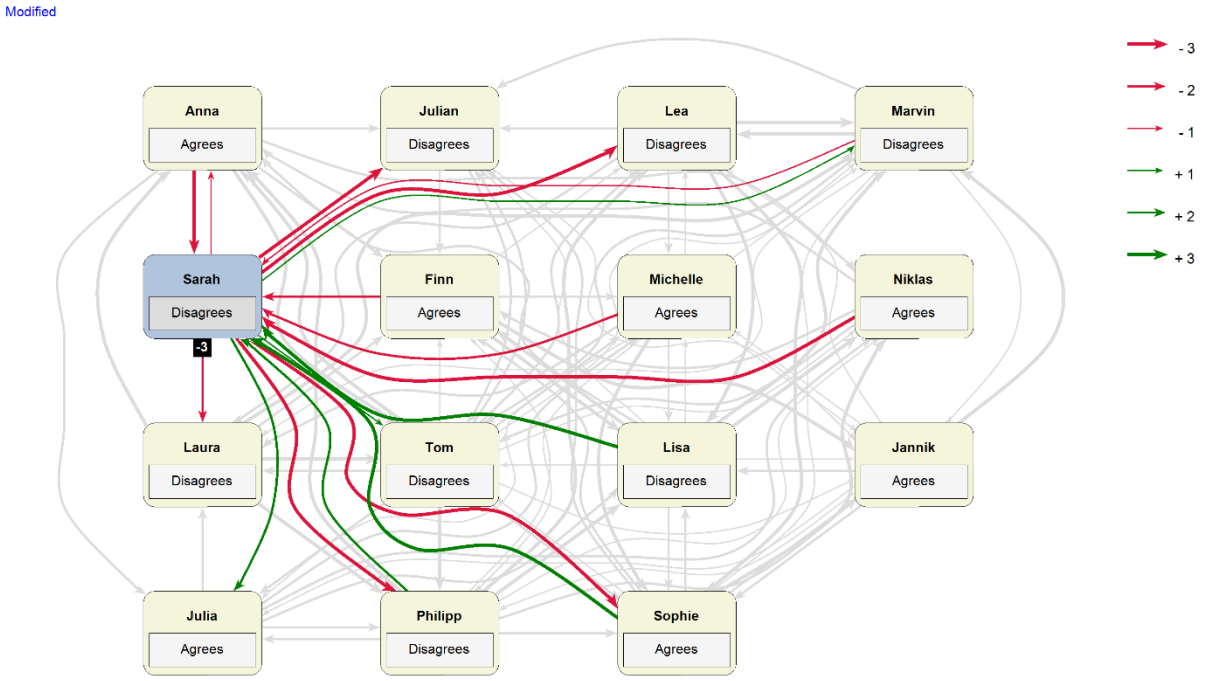


Fig. 6-24: Switching the descriptor variants by clicking on the variant name.

The fact that the scenario shown no longer corresponds to the original scenario is indicated at the top left by the note 'Modified'. The switching of descriptor variants is not restricted to the focus descriptor and the focus mode of the Impact Network Diagram function. It can generally be used for all descriptors.

6.7 The Selection Manager

The numbers of consistent scenarios resulting from a CIB analysis vary; some matrices yield only a few or even no perfect consistent scenario. Other matrices produce more solutions than required for the purpose of the analysis. In the latter case, a scenario selection has to take place. This can be done manually. However, a useful alternative in the case of large scenario numbers is a selection (or preselection) by formal procedures. In the *ScenarioWizard* three selection procedures are implemented that can create a scenario selection according to different criteria.

The Selection Manager can be activated by the menu item *Analyse - Selection Manager*. The menu item is available only while the evaluation protocol is open after calculating consistent scenarios or loading a solution set.

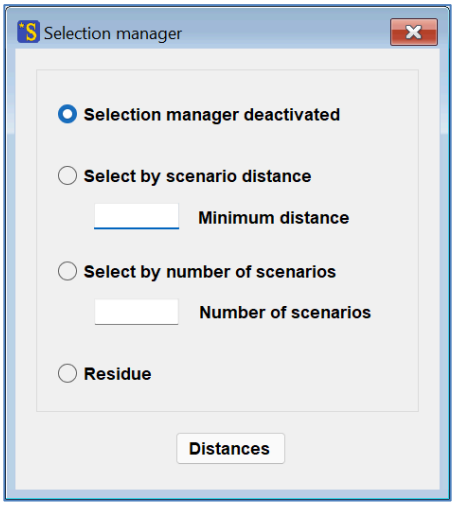


Fig. 6-25: The Selection Manager window.

After starting the Selection Manager window, the option 'Selection manager deactivated' is preselected. The Selection Manager is not active and the evaluation protocol displays the unmodified scenario list. For starting a selection, the user can choose between three modes of selection:

1) **Minimum distance:** Enter a number *n* into the text box 'Minimum distance' and click on the option 'Select by scenario distance'. Then a scenario list is displayed, each of them differing at least in *n* descriptors from each other scenario of the list. The larger the 'Minimum distance' parameter chosen, the smaller the number of scenarios that can satisfy the selection condition.

2) **Number of scenarios:** Enter a number into the text box 'Number of scenarios' and click on the option 'Select by number of scenarios'. The requested number of scenarios is displayed in the evaluation protocol. The more scenarios requested, the lower the differences between the scenarios in the selection.

3) **Residue:** Here, the heuristic chooses the scenarios for the selection in such a way that all variants that are represented in the complete scenario set also appear at least once in the selection. Although the 'residue' is usually much smaller than the complete scenario set, it ensures that no descriptor variants are 'lost' during the selection process. The size of the residue depends on the details of the scenario set and can therefore not be specified by the user.

The first two selection procedures work according to the principle of scenario diversity ('min-max selection', Tietje 2005[5]). The third method does not primarily strive for *scenario* diversity, but for a concise representation of the original *variant* diversity of the full scenario set.

[5] Tietje O. (2005) Identification of a small reliable and efficient set of consistent scenarios. European Journal of Operational Research 162, 418-432

All selection procedures are reversible, i.e. the selection modes and conditions can be changed in any manner causing an expansion or contraction of the selection list. Change the entry in the text box and press the ENTER key for applying a change in the selection condition.

Fig. 6-26 and Fig. 6-27 show the selection of Somewhereland scenarios resulting from selection mode ‘Select by scenario distance’ and ‘Minimum distance 3’, i.e. each scenario in the selection list has a minimum distance of 3 from other scenarios in the list. This results in a selection of 5 scenarios. Choosing the selection mode ‘Select by number of scenarios’ and entering ‘5’ into the text box ‘Number of scenarios’ would result in the same list.

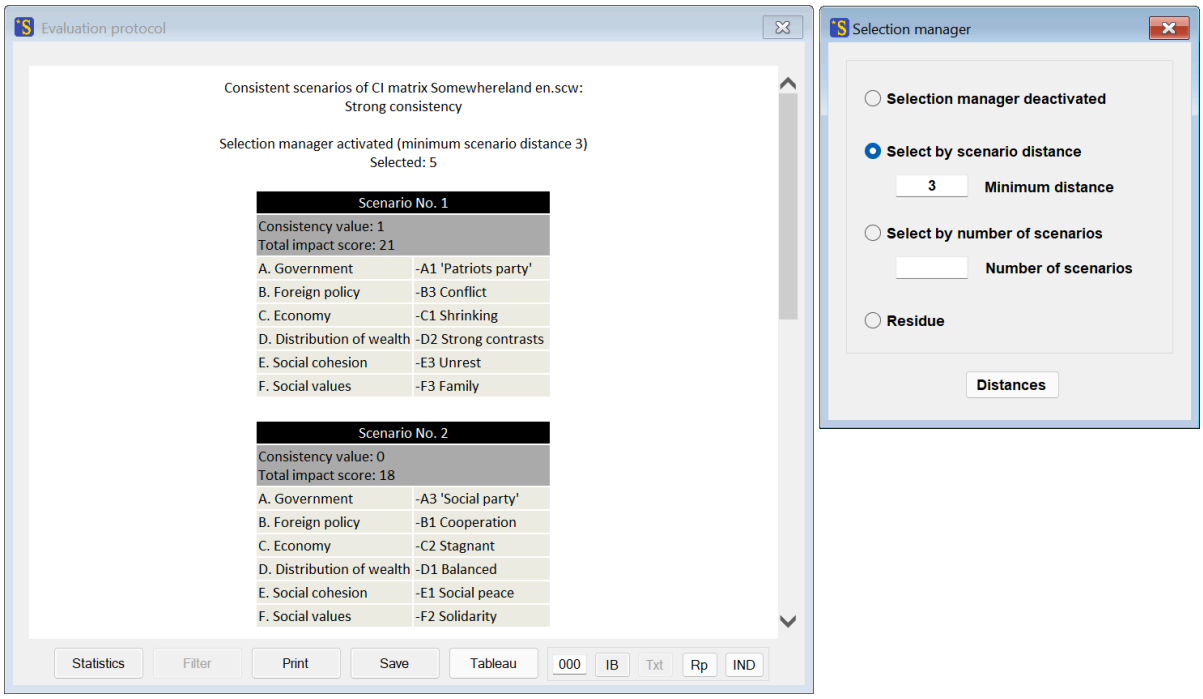


Fig. 6-26: Selection of Somewhereland scenarios resulting from selection mode ‘Select by scenario distance’ and ‘Minimum distance’ = 3.

Scenario No. 1	Scenario No. 2	Scenario No. 3	Scenario No. 4	Scenario No. 5
A. Government: -A1 'Patriots party'	A. Government: -A3 'Social party'	A. Government: -A2 'Prosperity party'	A. Government: -A3 'Social party'	A. Government: -A1 'Patriots party'
B. Foreign policy: -B3 Conflict	B. Foreign policy: -B1 Cooperation		B. Foreign policy: -B2 Rivalry	B. Foreign policy: -B3 Conflict
C. Economy: -C1 Shrinking	C. Economy: -C2 Stagnant	C. Economy: -C3 Dynamic		C. Economy: -C2 Stagnant
D. Distribution of wealth: -D2 Strong contrasts	D. Distribution of wealth: -D1 Balanced	D. Distribution of wealth: -D2 Strong contrasts		D. Distribution of wealth: -D1 Balanced
E. Social cohesion: -E3 Unrest	E. Social cohesion: -E1 Social peace	E. Social cohesion: -E2 Tensions	E. Social cohesion: -E1 Social peace	
F. Social values: -F3 Family	F. Social values: -F2 Solidarity	F. Social values: -F1 Meritocratic		F. Social values: -F3 Family

Fig. 6-27: Scenario table for the selection with minimum distance D=3.

The principle of the residue is illustrated in Fig. 6 25. Three of the ten Somewhereland scenarios are sufficient to provide a representation by occurrence in at least one scenario for each of the 17 descriptor variants represented in the complete scenario set.

Scenario No. 1	Scenario No. 2	Scenario No. 3
A. Government: -A1 'Patriots party'	A. Government: -A2 'Prosperity party'	A. Government: -A3 'Social party'
B. Foreign policy: -B3 Conflict	B. Foreign policy: -B2 Rivalry	B. Foreign policy: -B1 Cooperation
C. Economy: -C1 Shrinking	C. Economy: -C3 Dynamic	C. Economy: -C2 Stagnant
D. Distribution of wealth: -D2 Strong contrasts		D. Distribution of wealth: -D1 Balanced
E. Social cohesion: -E3 Unrest	E. Social cohesion: -E2 Tensions	E. Social cohesion: -E1 Social peace
F. Social values: -F3 Family	F. Social values: -F1 Meritocratic	F. Social values: -F2 Solidarity

Fig. 6-28: Residue of the full set of ten Somewhereland scenarios.

The "Distances" function

A click on the "Distances" button starts a calculation of the distances between the scenarios printed in the evaluation protocol and opens a window in which the results are displayed. For n scenarios, n(n-1)/2 scenario pairs can be compared in this way and a distance value can be calculated in each case. As a first result, a frequency distribution of the distance values found in this way is displayed in the newly opened window. If the number of scenarios does not exceed 300, a detailed table of the

distance values for the scenarios follows. In the title row and column the scenario numbers are given, which are compared for each cell value. Fig. 6-29 shows the results for the full scenario set of Somewhereland, i.e. with the selection manager disabled. The results can be saved as an html file by pressing the "Save" button.

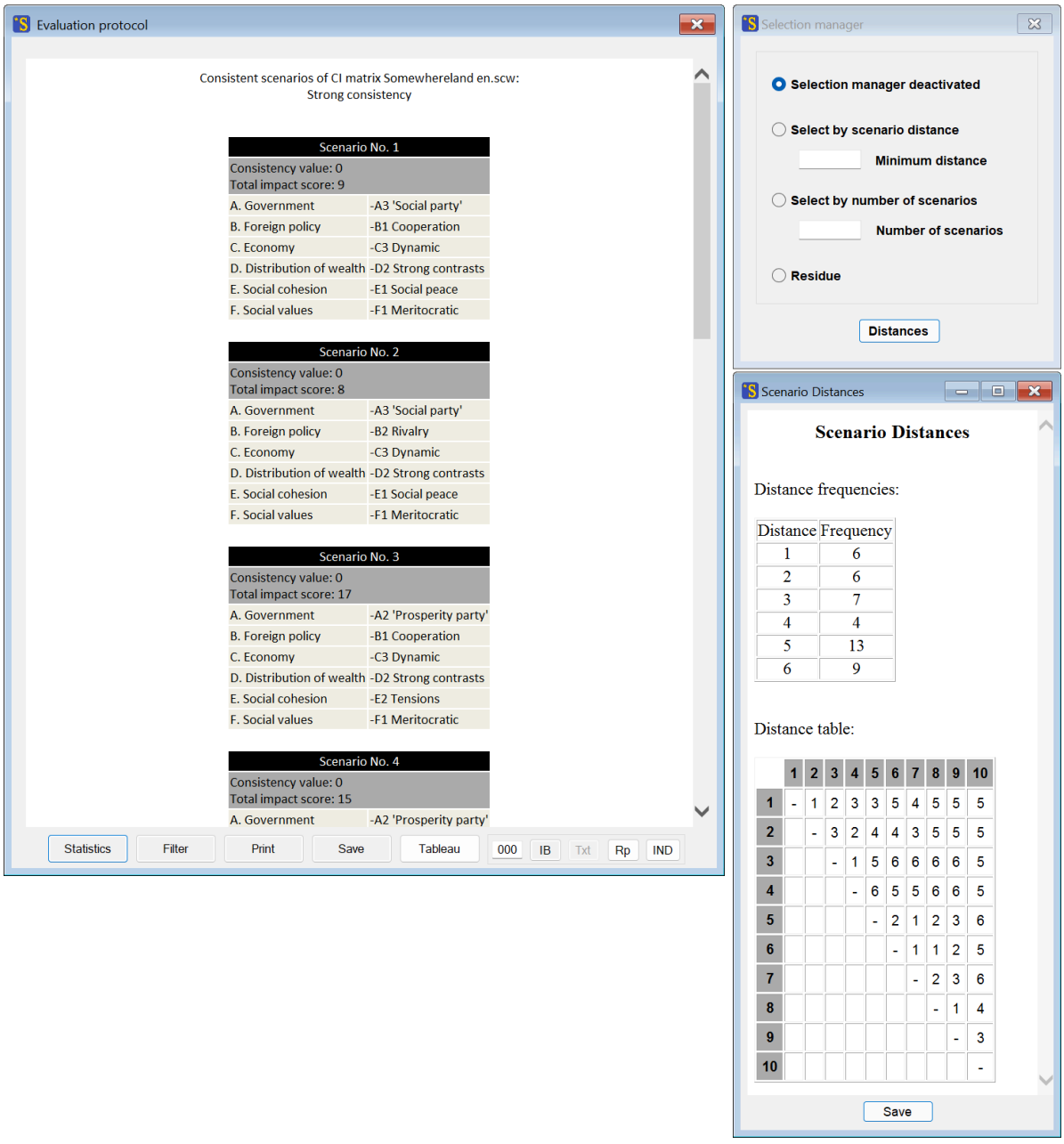


Fig. 6-29: Distance values for the scenarios of the evaluation protocol.

Pressing the "Distances" button after performing the scenario selection with minimum distance D=3 shown in Fig. 6-26 demonstrates that the selection heuristic fulfils its promise: As can be seen in the distance table in Fig. 6-30, the group of five selection scenarios is composed in such a way that no distance values below 3 occur any more.

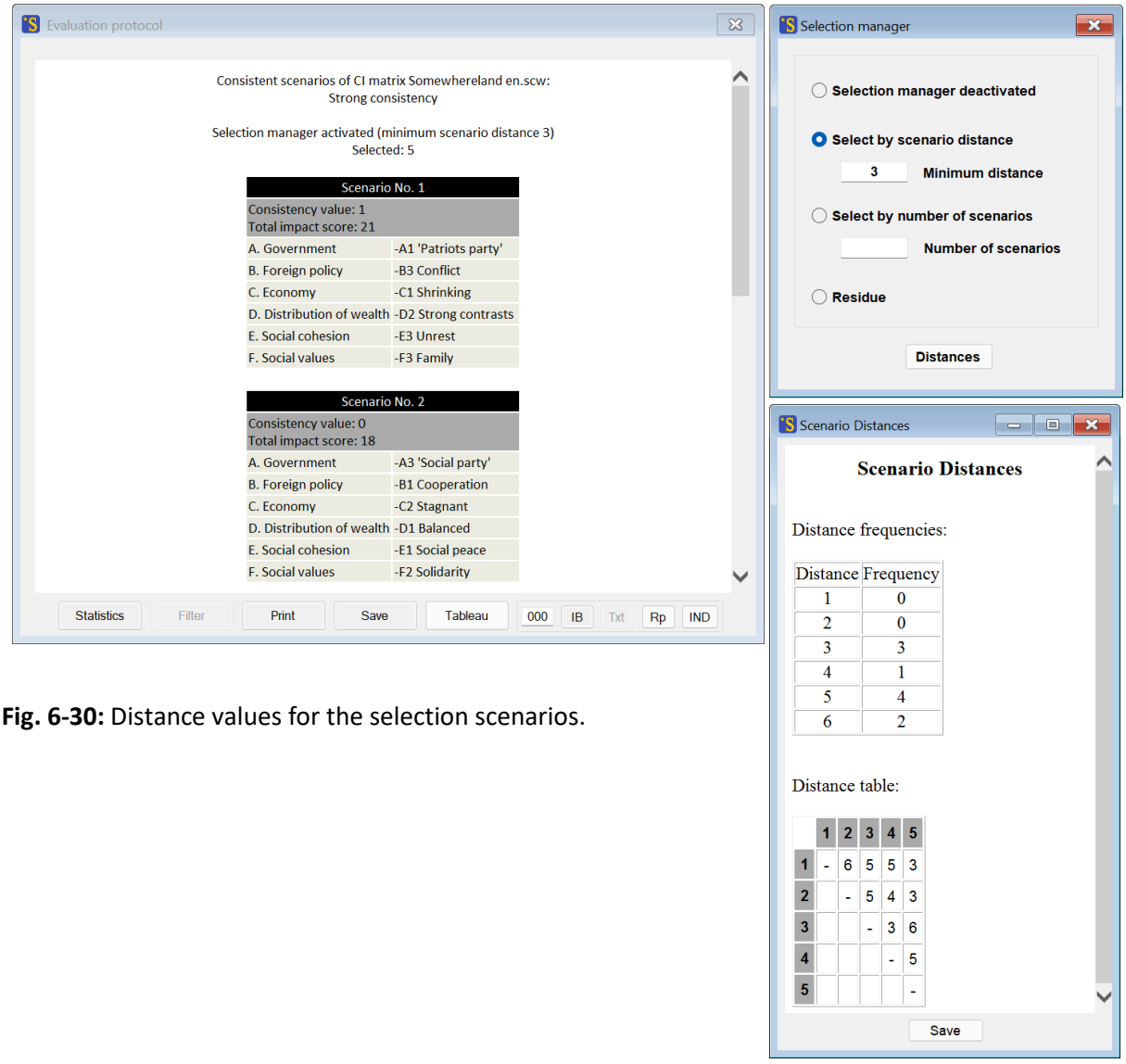


Fig. 6-30: Distance values for the selection scenarios.

Hints

As long as the Selection Manager window is active, the function ‘Calculate consistent scenarios’ is disabled. The respective menu item and shortcut are activated again once the Selection Manager window is closed.

The Selection Manager is not available when *ScenarioWizard* is in ensemble mode (Section 6.9) or if the evaluation option ‘Calculate cycles’ is activated (Section 7.1).

The Selection Manager can be used in combination with the 'Filter' function of the evaluation protocol (see Section 6.4). In this case, filtering has priority, i.e. the original scenario list will be filtered first according to the filter conditions specified in the filter form, and the result of the filtering will be the object of the selection procedure following the directives of the Selection Manager window.

6.8 Forcing descriptor variants

The menu item *Edit - Force variant* enables the user to select one variant out of the list of variants for one or more descriptors. In the course of all subsequent evaluation procedures, the selected variants will be forced, i.e. an additional impact that stabilises the forced variants will be assumed. Forced variants will be strictly maintained therefore, no matter which impacts may be exerted on this descriptor by the other descriptors. Forced variants are used in CIB to simulate strong external interventions. The forcing process is reported in the evaluation protocol by a code in the heading. For example, the code 'Forced states: 1 0 0 0 0 0' in a Somewhereland evaluation protocol indicates that the first state ('A1 Patriots party') of the first descriptor ('Government') is forced.

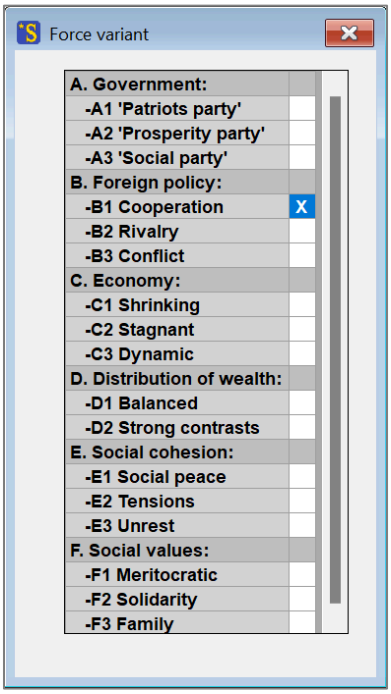


Fig. 6-31: Window for the forcing of variants.

In Fig. 6-31**,** one state is selected (B. Foreign policy: B1 Cooperation) by a mouse click on the framed cell. Selected variants can be defined for more than one descriptor, but only one variant can be selected to each descriptor. A selection can be cancelled by a further click on the selected cell.

As a consequence of forcing, the set of solutions changes. Obviously, only consistent scenarios bearing the feature 'B1 Cooperation' can now exist. All other descriptors are organised according to the newly adjusted net of impacts.

When calculating a scenario's inconsistency, its total impact score, or the number of inconsistent descriptors, the calculation skips all descriptors with forced variants because a descriptor's inconsistency is irrelevant if a dominant external force is present.

All selections are only valid while the 'Force variant' window is open. Closing the window resets all selections. The selection is taken into account by all evaluation procedures (consistent scenarios, impact balances, and ensemble solutions) as long as the 'Force variant' window stays open. The menu item *Edit - Force variant* is available only if an analysis structure and a cross-impact matrix have been defined before.

6.9 Ensemble evaluations

A system may be represented by more than one cross-impact matrix. This can be the case if different experts are asked to design a qualitative model of the system under consideration, and each of them codes his/her model as a separate CIM. The elicitation of different expert opinions is a suitable procedure to get a broad view on a system and to obtain information about the judgement uncertainties. A set of cross-impact matrices, each of them about the same system, is called a 'matrix ensemble'. Discrepancies between the members of the ensemble express judgement difficulties or indicate a dissent of expert opinions. *ScenarioWizard* provides several procedures to handle matrix ensembles.

Defining an ensemble

Having defined an analysis structure, the menu item *File - Load ... Ensemble* becomes available. The menu item opens the window shown in Fig. 6-32.

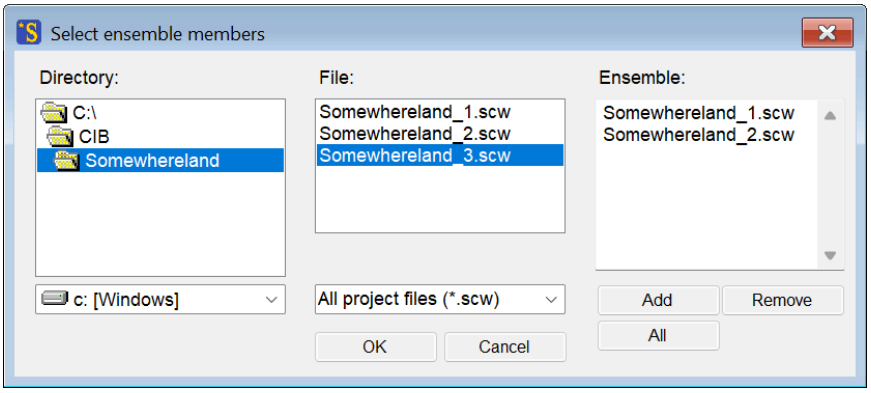


Fig. 6-32: File selection window for compilation of an ensemble.

After the selection of a folder, all SCW files stored in this folder are displayed in the file list in the centre of the window. Click on a file to mark it and then click the 'Add' button. The file will be added to the ensemble list on the right side of the window. A double-click on a filename will also add the file to the ensemble list. The 'All' button will add all displayed files to the ensemble. Mark a file in the file list (not in the ensemble list!) and click the 'Remove' button to remove a file from the ensemble.

In some application cases, the data of some files can be more reliable than the data of other files. In order to account for this, it is possible to add a file twice or more times to the ensemble to increase its weight in the ensemble evaluations.

After completing the ensemble, press the 'OK' button to close the window. *ScenarioWizard* now loads all selected scenarios. If the selection contains one or more unsuitable SCW files (e.g. if the number of descriptors or variants does not match), the loading procedure will be terminated and an error message will be displayed. The file selection window must be reopened and the file selection repeated.

Comment text of the ensemble matrices about cross-impacts are accumulated in the ensemble sum matrix. Comment text of the ensemble matrices about descriptors are not accumulated because it is assumed that the entire ensemble is based on the same set of descriptors. Instead, the descriptor comments of the last member of the ensemble are imported.

Once the loading procedure has been successfully completed, *ScenarioWizard* changes its internal operation mode to 'ensemble mode'. In this mode, several menu items that are irrelevant to ensemble evaluations are disabled. On the other hand, several ensemble specific menu items are now enabled.

If the 'Select Ensemble Members' window is closed using the 'Cancel' button, no ensemble will be defined. The system will revert to normal operation mode. Any previously defined ensemble will also be cancelled. On the other hand, previously loaded project files are not cancelled and can be re-accessed as required.

Ensemble sum

The menu item *Edit - Ensemble sum* calculates the sum of the cross-impacts of all ensemble members for each cell. After that, the operation mode of the program reverts to normal mode. The user can display and edit the calculated matrix of sum values and the usual evaluation procedures can be executed.
Because of the invariance laws of CIB, a matrix of sum values possesses exactly the same solutions as the corresponding matrix of mean values (which may contain non-integer values). The use of the matrix of sum values makes it possible to construct mean value scenarios and to avoid non-integer cross-impact values.

If necessary, the mean value matrix can be calculated by the menu item *Edit - Factor Multiplication* by multiplying the sum values by the factor 1/n (see Section 5.13; n is the number of ensemble members). However, the derived values are rounded numbers, and the matrix may lead to somewhat different solutions than the sum value matrix.

The menu item *Edit - Ensemble sum* is available only if an ensemble has already been defined using the menu item *File - Load ... Ensemble*.

Ensemble dissent

The menu *Edit - Ensemble dissent* provides two evaluations to depict the differences between the members of an ensemble:

The evaluation **Standard deviation** calculates the standard deviation of the cross-impacts of all ensemble members for each cell. The standard deviations will be rounded and they will be collected in a new matrix. The program then terminates the ensemble mode and reverts to normal mode. The dissent data can now be displayed, saved, and printed as an ordinary cross-impact matrix. By so doing, it is easy to see in which sections of the matrix the greatest disagreements occur.

The evaluation **Sign deviation** checks for each cell if the sign of the cross-impact judgements differ between the members of the ensemble. This would be a hint towards a fundamental dissent. The result of the evaluation indicates for each cell how many members propose a sign different from that chosen by the majority. For instance, if three members choose a positive value, two members choose a negative value, and one member judges the cross impact to be zero, the evaluation will report a value 2 for this cell.

Although the dissent data are collected in a cross-impact matrix form, they are not cross-impact data. It makes no sense to execute evaluation procedures with these data or to apply other procedures reserved for cross-impact matrices. Some menu items are therefore disabled after calculation of the ensemble dissent. Once the dissent analysis has been completed and the dissent data stored (if necessary), a system reset can be executed to revert to the normal mode (menu item *File - Reset ... ScenarioWizard*; see Section 7.4).

The menu *Edit - Ensemble dissent* is available only if an ensemble has already been defined using the menu item *File - Load ... Ensemble*.

Ensemble scenarios

Being in the ensemble mode, the menu item *Analyse - Consistent Scenarios* or the button  on the toolbar starts an evaluation of the consistent scenarios of the ensemble members. First, a query appears (Fig. 6-33). The query is concerned with the conditions governing the selection of consistent ensemble scenarios.

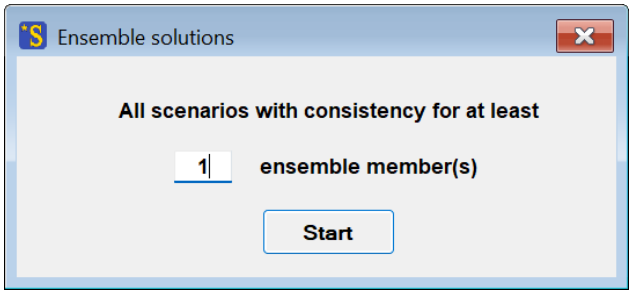


Fig. 6-33: Ensemble condition query for selection of consistent ensemble scenarios.

In the following evaluation, the complete scenario space is investigated. A scenario is selected as a solution only if it is a consistent scenario for at least the number of members specified in the query as shown Fig. 6-33. Suppose an ensemble has 3 members. If 3 is entered in Fig. 6-33, a scenario will only be selected if it is a consistent scenario for each ensemble member. On the other hand, if 1 is the entry in Fig. 6-33, the evaluation will report every consistent scenario of every ensemble member. Click the 'Start' button to begin the evaluation. An example of this evaluation is shown in Fig. 6-34.

The protocol heading records the members of the ensemble, the ensemble condition for the evaluation, and the consistency mode setting (see Section 7.1). Beneath are printed all selected scenarios in coded format. The choice of the output option discussed in Section 7.2 does not affect this protocol. The list provides the following information:

- The current number of the scenario.
- The scenario in coded format (see Section 7.2 for the interpretation of the code).
- The 'consistent members' (at the end of the line): the ensemble members for which the scenario is consistent. The number of consistent members is at least as high as the ensemble condition specified in Fig. 6-33.

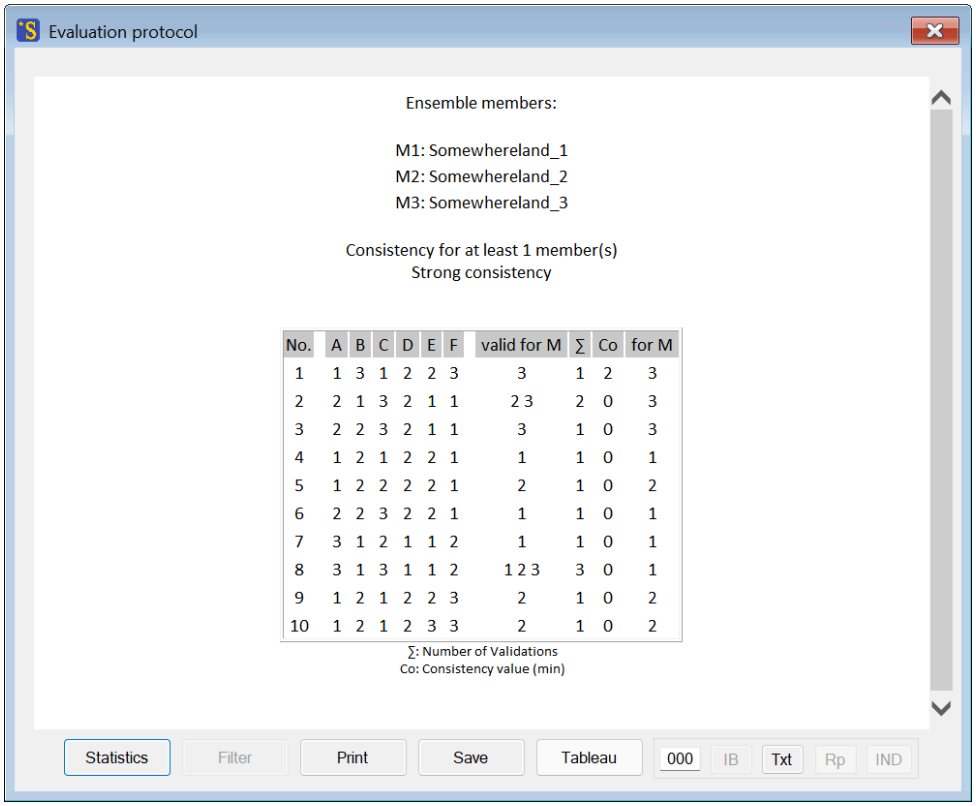


Fig. 6-34: Evaluation protocol of the menu item *Analyse - Ensemble Solutions*.

- The member number of the 'critical member': The critical member is the one among the consistent members, for whom the scenario has the greatest inconsistency. If more than one consistent member share the highest inconsistency, the consistent member with the lowest member number will be indicated. The critical member information is only relevant if non-zero inconsistencies are permitted (see Section 7.1).
- The maximum inconsistency of the scenario within all 'consistent members'. The maximum inconsistency is no higher than the inconsistency threshold that was specified in the 'Evaluation options' window (see Section 7.1).
- The 'weight' of the scenario. This ensemble weight should not be confused with the volume weight or the attractor weight (see Section 7.1). In the frame of ensemble analysis, the weight of a solution is defined as the number of consistent members. The weight of an ensemble solution is not smaller than the ensemble condition specified in Fig. 6-33.

Increasing the ensemble condition will increasingly restrict the set of solution scenarios to 'consensus scenarios'. In the given example of three ensemble members, an ensemble condition of 3 will result in one consensus scenario (Fig. 6-35). It can occur that there is no general-assent scenario. In this case, the scenarios with the highest weights may be considered to be the most relevant scenarios.

As with ordinary evaluation protocols, ensemble evaluation protocols can be printed, solution lists can be saved, and descriptor variant frequencies can be computed. Note that weighted calculations of variant frequencies will use the ensemble weights, not volume or attractor weights. Ensemble weights will also be used for saving solution lists (SL files; see Section 6.4).

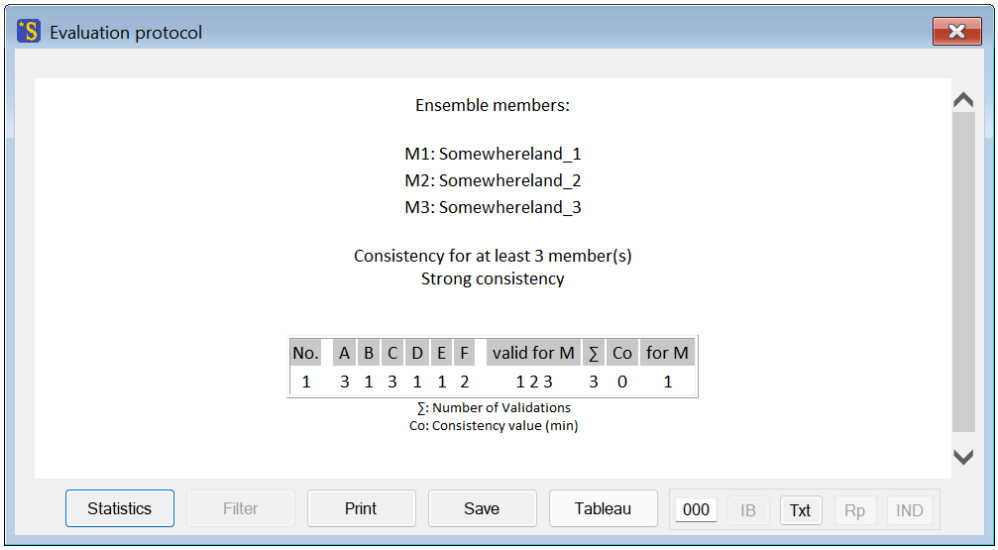


Fig. 6-35: A shared scenario (a scenario consistent for all ensemble members, 'consensus scenario').

Save scenario list

The solutions of the ensemble evaluation can be stored in an SL file by pressing the 'Save' key in Fig. 6-34 and reloading in a further session by the menu item *File - Load … Solution set*. The file contains the following data:

- the numbering of each scenario
- the scenario (coded format; see Section 7.2)
- the 'ensemble weight' of the scenario (number of ensemble members allowing this scenario)
- the worst (highest) inconsistency value of the scenario within all ensemble members allowing this scenario (0 if the option 'Max. inconsistency' and a maximum inconsistency value > 0 are not applied; see Section 7.1)
- two meaningless zeros.

If the number of combinations of a matrix (the product of the number of states of all descriptors) exceeds 9.22×10^{18}, then an ensemble evaluation using the evaluation option 'complete' (see Section 7.1) is not possible. In this case, a warning is displayed and the evaluation is terminated. Use the evaluation option 'Monte Carlo' to solve matrices with a higher number of combinations.

6.10 Ensemble mode and workbooks

The menu function *Books - Workbooks ...* generates HTML documents showing the cross-impact judgement sections and their textual explanations in an organised way to ease expert enquiries and discussions about the cross-impact judgements as described in Section 0. When called while the Ensemble Mode of *ScenarioWizard* is active, the 'workbook' function generates a special type of workbook. The purpose of 'ensemble workbooks' is to depict differences between expert opinions and judgement dissent in a clear way. For this purpose, all judgement sections of an ensemble concerning a certain impact relation are printed in columns on one page to facilitate the comparison between the judgements and explanations stored in different matrices. A simple example comprising three ensemble members and featuring three different expert opinions about the influence of 'Government' on 'Economy' in Somewhereland is shown in Fig. 6-36. However, also ensembles comprising two members or more than three members can be documented in ensemble workbooks.

Section 3 - 1

Impact of A. Government on C. Economy

Expert 1:

A. Government:	**C. Economy:** C1 Shrinking	C2 Stagnant	C3 Dynamic
A1 'Patriots party'			
A2 'Prosperity party'	-2	-1	3
A3 'Social party'		2	-2

Explanation:
Only a government focused on economic issues will succeed in boosting all economic growth potentials. A government focused on social issues might neglect economic growth potentials in favour of a policy of economic justice. No specific orientation of economic policy is expected from a government run by the 'Patriotic party'.

Expert 2:

A. Government:	**C. Economy:** C1 Shrinking	C2 Stagnant	C3 Dynamic
A1 'Patriots party'			
A2 'Prosperity party'	-2		2
A3 'Social party'	-2		2

Explanation:
Also a government focused on social justice is interested in economic growth in order to improve public wealth and it may succeed in boosting economic growth by stimulating domestic demand. Therefore, the overall effect of a 'Social party's' economic policy in terms of GDP growth could be similar to the effects of a 'Prosperity party's' one, although the instruments would be different. No specific orientation of economic policy is expected from a government run by the 'Patriots party'.

Expert 3:

A. Government:	**C. Economy:** C1 Shrinking	C2 Stagnant	C3 Dynamic
A1 'Patriots party'	-2	1	1
A2 'Prosperity party'	-2	-1	3
A3 'Social party'		2	-2

Explanation:
Only a government focused on economic issues will succeed in boosting all economic growth potentials. A government focused on social issues might neglect economic growth potentials in favour of a policy of economic justice. However, also a government run by the 'Patriots party' would make efforts to avoid a poor economic development because economic weakness would undermine the political and military strength of Somewhereland.

Fig. 6-36: Depiction of diverging expert opinions in an ensemble workbook.

The ensemble workbook will list all judgement sections containing cross-impact data or text for at least one ensemble member. Judgement sections without data or text for any ensemble member will be skipped. The file names of the ensemble members are used for the column titles (Expert 1, Expert 2, and Expert 3 in Fig. 6-36). Similar to ordinary workbooks (see Section 0), ensemble workbooks can be generated in two formats: sorted by cols or sorted by rows (use menu items *Books - Workbook sorted by cols* and *Books - Workbook sorted by rows*).

6.11 Statistics

The menu item *Analyse - Statistics* provides three evaluations. *ScenarioWizard* explores the space of all possible scenarios, checks the consistency of each scenario, and computes the statistics of their inconsistencies, the statistics of the total impact score, and the bias statistics of the cross-impact data. The results are displayed in a window shown in Fig. 6-37.

Inconsistency statistics

How often every inconsistency value appears is indicated, as well as how many scenarios show an inconsistency higher or lower than this value. The sum of these three numbers is equal in every line and indicates the number of possible scenarios.

If the evaluation option 'Max. inconsistency' is chosen (see Section 7.1), the inconsistency statistics are useful when selecting the inconsistency limit parameter.

Total impact score statistics

The display of the total impact score statistics is similar to the inconsistency statistics. How often every total impact score value appears is indicated, in the same way as how many scenarios show a total impact score higher or lower than this value. Again, the sum of these three numbers is equal in every line and indicates the number of possible scenarios.

The total impact score statistics support the interpretation of the total impact score data of the consistent scenarios (see Section 6.4).

Statistics of the index values

If evaluation data is available for the descriptor variants (see Section 6.15), then a statistic follows at this point which indicates for each index value how frequently it occurs and how high the cumulative frequency above and below this value is. The sum of all three values is again the same in each line.

The index statistics support the classification of the index values of the consistent scenarios (see Section 6.15).

List of matrix column sums

To calculate the column sum of a descriptor variant, all cross-impact values listed in the column of this variant in the cross-impact matrix are added. Thus, the column sums are not a characteristic of a particular scenario, but are characteristics of the matrix itself. High positive (or negative) column sums indicate that the descriptor variant in question has a particularly good (or bad) starting position for finding its way into a consistent scenario. High values for the column sum are also often associated with biases (see below).

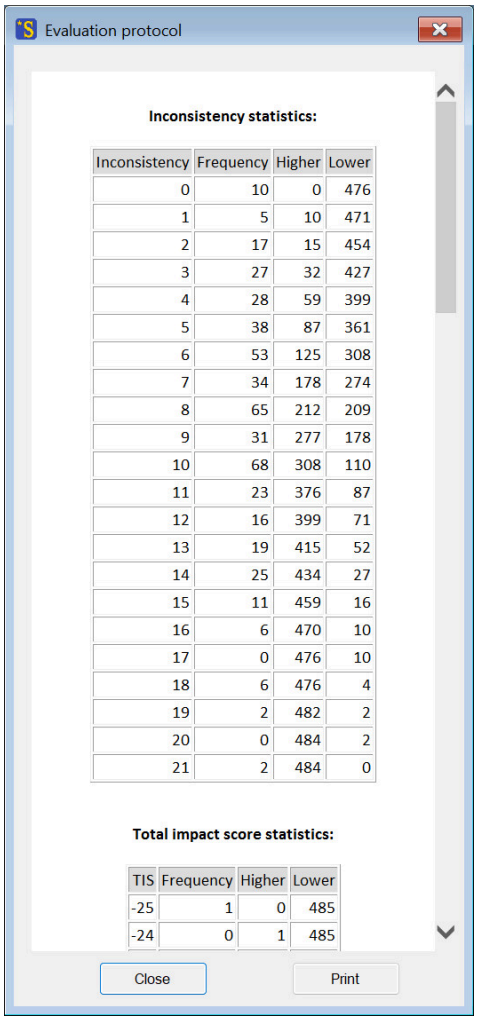


Fig. 6-37: Results of the *Analyse - Statistics* evaluation.

Bias statistics

A descriptor is biased if the maximum impact score of a randomly chosen scenario is assigned more frequently to some descriptor variants than to others. This is a consequence of the choice of the cross-impact judgements in the descriptor column in question, not a result of the systemic interplay with the other descriptors. In extreme cases, an unfavourable choice of judgements may completely disable a descriptor variant (‘forbidden variant’), no matter how the cross-impacts in the other descriptor columns are chosen.

The bias statistics indicate how often a descriptor variant reaches the maximum impact score when all possible scenarios are applied to the descriptor. Moderate bias is nearly inevitable and tolerable. Strong bias and forbidden variants should motivate to reconsider the respective descriptor judgements.

The row sums of the bias statistics may exceed 100% because different variants of a descriptor may share the same maximum impact score for some scenarios.

If the number of possible combinations of the evaluated matrix (product of the number of variants of all descriptors) exceeds 3 million, the software automatically switches to a Monte Carlo evaluation mode to limit the calculation time and the statistical data is based on 1 million randomly drawn variant combinations. In this case, a note is displayed in the results protocol. The result values (with the exception of the still exact column sums) are then to be understood as approximate values, and the distribution values are therefore not given in absolute figures but as percentages. If necessary, the default value of 1 million random combinations for the Monte Carlo evaluation can be changed in the Evaluation Options form (see Section 7.1) by activating the Monte Carlo option and entering the desired number of random combinations.

The menu item *Analyse - Statistics* is available only if an analysis structure and a cross-impact matrix have already been defined or a project file has been loaded.

6.12 Pathway analysis

The function 'Pathway analysis' identifies and displays first-order indirect impact pathways between two descriptors. A first-order indirect impact pathway establishes an influence from descriptor A to B via one intermediate descriptor C, i.e. descriptor A exerts an influence on descriptor B via an impact chain A -> C and C -> B. Path analysis can help to understand why certain descriptors may affect another descriptor even if there is no direct impact relation between both descriptors. In the case of existing direct impacts, indirect impacts may strengthen or counteract the direct impact.

Pathway analysis can be accessed via the matrix editor (see Section 5.8). Use the left mouse button to double-click on the matrix cell representing the direct impact for which the first-order indirect impact data are requested. *ScenarioWizard* opens a text window titled 'Pathway analysis' and displays the list of indirect impact pathways (if any). Fig. 6-38 shows a pathway analysis of the matrix cell C1–B3 of the Somewhereland matrix, i.e. all first-order indirect impacts of C1 (shrinking economy) on B3 (conflictual foreign policy) are listed.

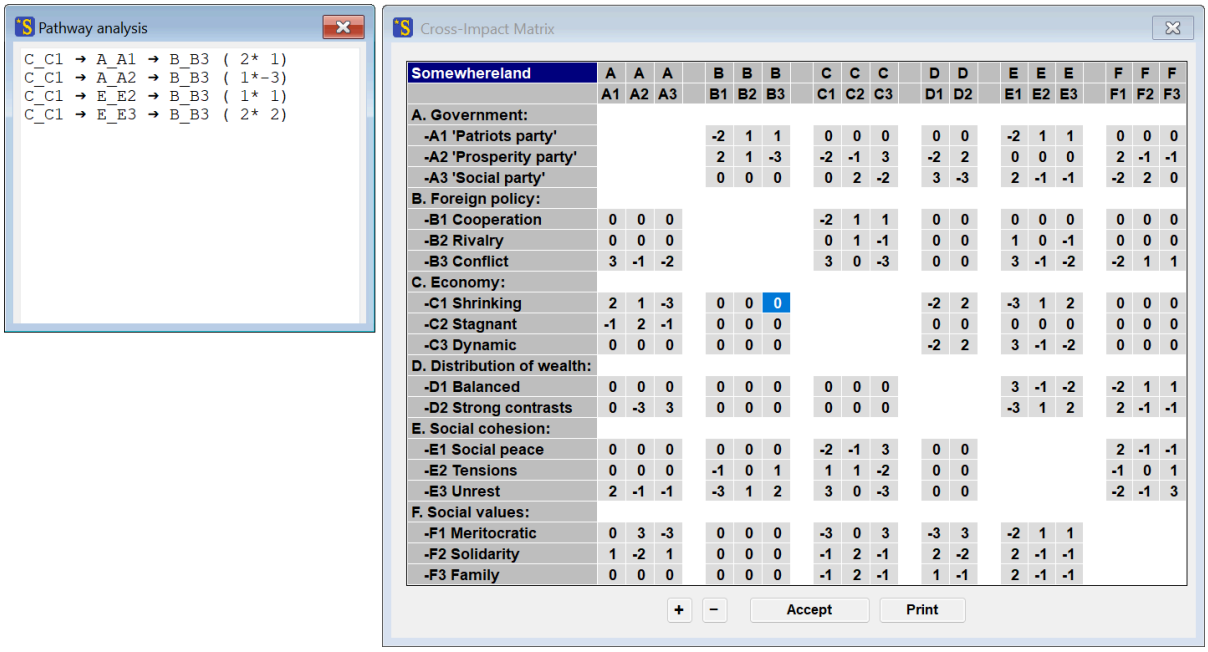


Fig. 6-38: Pathway analysis in the matrix editor.

The pathways are printed using the format

`Impact source → Intermediate descriptor and variant → Impact target (S1*S2)`

The impact source is the starting point of the indirect influence. The impact source exerts a direct impact of strength S1 on the intermediate descriptor, as recorded in the cross-impact matrix (first segment of the pathway). The intermediate descriptor has a direct impact of strength S2 on the impact target, again recorded in the cross-impact matrix (second segment of the pathway). Both segments together constitute the indirect impact pathway from the impact source to the impact target. The impact source, intermediate descriptor variant, and impact target are recorded using the format

`Short name descriptor _ Short name variant`

In the example, the pathway analysis yields four indirect pathways running from C1 to B3. Two of them make their way via descriptor A (Government), and two of them are running via E (Social cohesion). For instance, the first row of the list in the ‘Path analysis’ window expresses that a shrinking economy (C1) may indirectly stimulate foreign conflicts (B3) by promoting the chances of a government with pronounced patriotic habitus, which in turn may easily lead to more foreign-policy conflicts.

Generally, indirect pathways consisting of two pathway segments of equal signs of the impact strength (+/+ or -/-) tend to establish a supportive indirect influence, whereas pathways consisting of two segments with divergent signs (+/- or -/+) imply a repressive indirect influence.

Pathway analysis is not restricted to descriptor pairs without direct impact relations. It can be applied also to matrix cells carrying a direct impact. In this case, the indirect influences superimpose the direct impact.

In principle, direct influences are very common in cross-impact matrices. Nevertheless, they do not automatically come into effect in every scenario. Other descriptors may intervene on the intermediate descriptor and force it into a different direction, thus interrupting the impact pathway. Therefore, indirect influences are potential impacts and it depends on the overall scenario configuration whether they can unfold their power. Second or higher-order indirect pathways with two or more intermediate descriptors are under even higher risks of losing their power by successful interventions on the intermediate descriptors issued by other descriptors. Owing to this, the pathway analysis function in *ScenarioWizard* is restricted to displaying first-order pathways—they have the best chances to unfold and actually shape the system behaviour. Nevertheless, *ScenarioWizard's* scenario generation algorithm takes into account all orders of indirect pathways. The purpose of the pathway analysis function is rather to foster a better understanding of the evaluation results.

Echoes

A left-button double-click on a diagonal cell of a diagonal judgement section leads to a special type of pathway analysis. Although those cells are not emphasised in the matrix editor in the case of regular matrices, they nevertheless can be selected and they respond by providing a pathway analysis (Fig. 6-39).

In this special case, the *'impact echoes'* of a descriptor variant are calculated. They describe the impact pathways coming from the selected descriptor variant to another descriptor variant and from there directly back to the origin. Echoes reveal whether a descriptor variant is able to stabilise itself by activating supportive developments in other descriptors or by suppressing counteracting developments (reciprocal promotion and suppression). Alternatively, they show whether a descriptor variant has an inclination of self-destabilisation by promoting counteracting developments or suppressing supportive developments in other descriptors. Impact echoes in CIB are the equivalent of feedback loops in cybernetics.

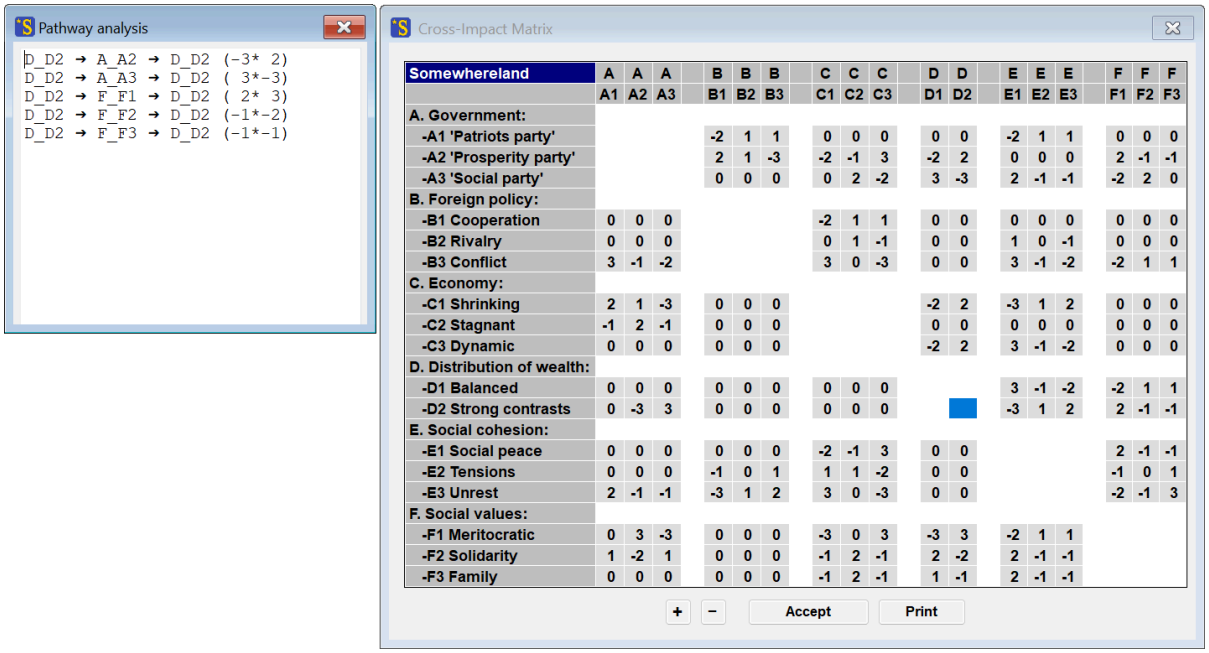


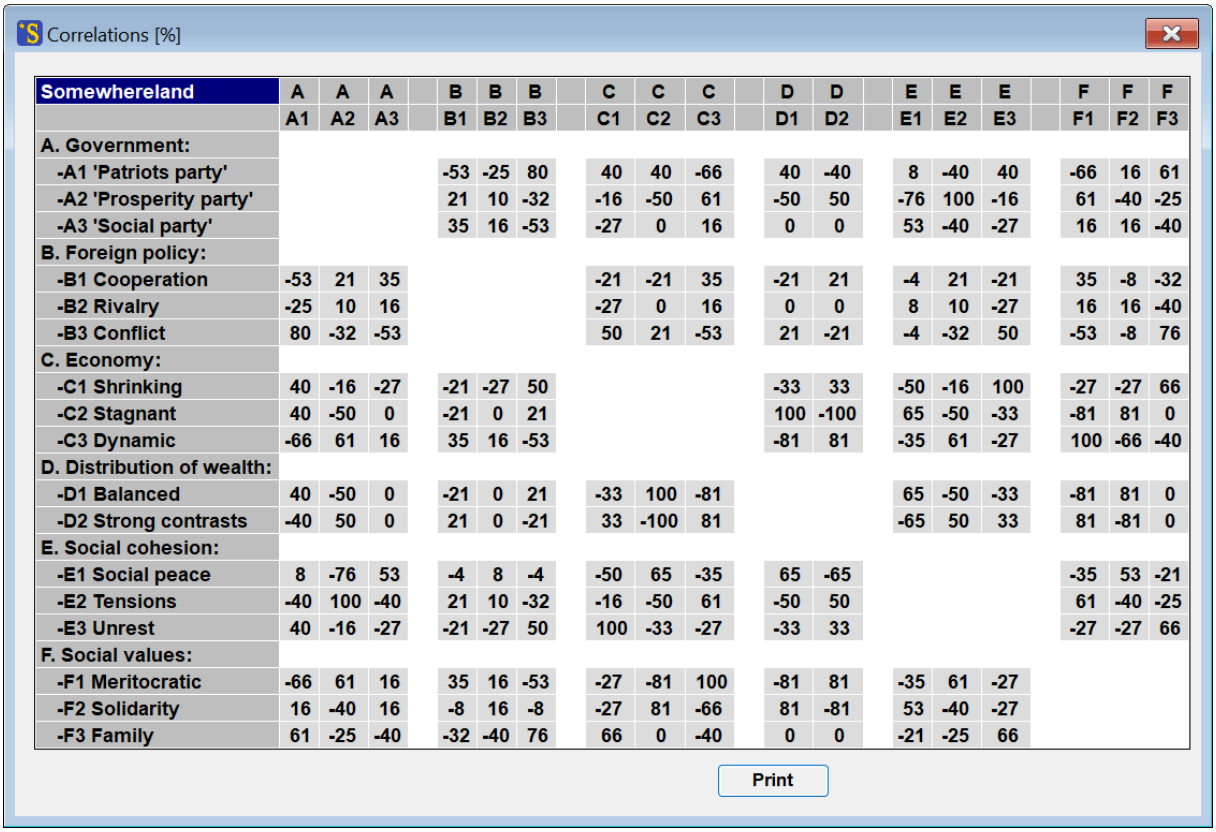
Fig. 6-39: Impact echoes of descriptor variant D2.

The example of an echo analysis shown in Fig. 6-39 reveals that D2 (strong contrasts in wealth distribution) receives an overall supportive echo from descriptor F (social values) because the echoes of all variants of F carry a +/+ or -/- signature. This means that strong wealth contrasts foster those social values with are supportive to this type of wealth distribution (meritocratic values) and counteract social values, which would challenge unequal wealth distribution (solidarity and family values). From descriptor A (government), D2 receives only an echo in scenarios showing A2 or A3 ('Prosperity party' of 'Social party'), and in those cases, the echo is destabilising (+/- or -/+ signature): with respect to elections, strong wealth contrasts promote a challenger ('Social party') and hamper a supporter ('Prosperity party').

6.13 Correlations

The menu item *Analyse - Correlations* calculates the correlation coefficients of the descriptor variants with respect to the current scenario set. The item is available once a set of consistent scenarios is calculated by the evaluation 'Consistent scenarios' (see Section 6.4) and the evaluation protocol displaying the scenarios is still open. The calculated correlation coefficients are expressed in rounded

percentage values and printed in a matrix form. The correlation coefficients of the Somewhereland scenarios (Fig. 6-20) are shown in Fig. 6-40.



Somewhereland	A	A	A	B	B	B	C	C	C	D	D	E	E	E	F	F	F
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	E1	E2	E3	F1	F2	F3
A. Government:																	
-A1 'Patriots party'				-53	-25	80	40	40	-66	40	-40	8	-40	40	-66	16	61
-A2 'Prosperity party'				21	10	-32	-16	-50	61	-50	50	-76	100	-16	61	-40	-25
-A3 'Social party'				35	16	-53	-27	0	16	0	0	53	-40	-27	16	16	-40
B. Foreign policy:																	
-B1 Cooperation	-53	21	35				-21	-21	35	-21	21	-4	21	-21	35	-8	-32
-B2 Rivalry	-25	10	16				-27	0	16	0	0	8	10	-27	16	16	-40
-B3 Conflict	80	-32	-53				50	21	-53	21	-21	-4	-32	50	-53	-8	76
C. Economy:																	
-C1 Shrinking	40	-16	-27	-21	-27	50				-33	33	-50	-16	100	-27	-27	66
-C2 Stagnant	40	-50	0	-21	0	21				100	-100	65	-50	-33	-81	81	0
-C3 Dynamic	-66	61	16	35	16	-53				-81	81	-35	61	-27	100	-66	-40
D. Distribution of wealth:																	
-D1 Balanced	40	-50	0	-21	0	21	-33	100	-81			65	-50	-33	-81	81	0
-D2 Strong contrasts	-40	50	0	21	0	-21	33	-100	81			-65	50	33	81	-81	0
E. Social cohesion:																	
-E1 Social peace	8	-76	53	-4	8	-4	-50	65	-35	65	-65				-35	53	-21
-E2 Tensions	-40	100	-40	21	10	-32	-16	-50	61	-50	50				61	-40	-25
-E3 Unrest	40	-16	-27	-21	-27	50	100	-33	-27	-33	33				-27	-27	66
F. Social values:																	
-F1 Meritocratic	-66	61	16	35	16	-53	-27	-81	100	-81	81	-35	61	-27			
-F2 Solidarity	16	-40	16	-8	16	-8	-27	81	-66	81	-81	53	-40	-27			
-F3 Family	61	-25	-40	-32	-40	76	66	0	-40	0	0	-21	-25	66			

Fig. 6-40: Correlation coefficients of Somewhereland scenarios.

The correlation table indicates that ‘F. Social values: meritocratic’ and ‘D. Distribution of wealth: balanced’ rarely occur jointly in a scenario (correlation coefficient of -81%). On the other hand, ‘E3 Unrest’ and ‘C1 Shrinking economy’ occur either together or not at all (correlation coefficient of +100%). Because correlation coefficients characterise the relation of a pair of descriptor variants in both directions, the correlation table is a symmetric matrix. The correlation table can be printed using the ‘Print’ button.

A bar chart of the array of correlation coefficients of a descriptor variant (‘correlation profile’) is generated by clicking on the descriptor variant in the first column using the right mouse button. The correlation profile makes it easy to see which descriptor variants are closely connected.

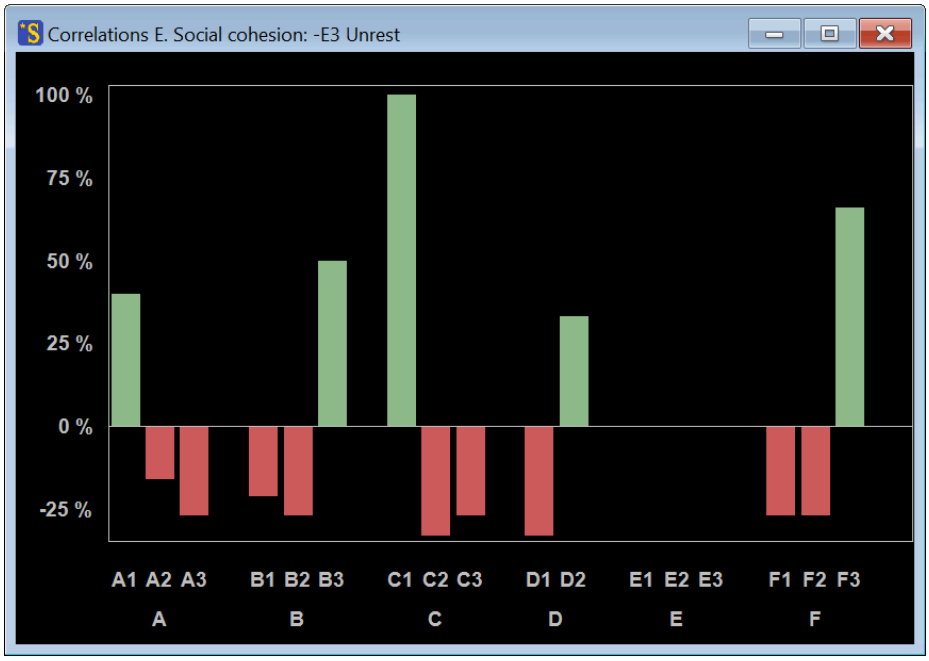


Fig. 6-41: Correlation profile of descriptor variant 'E3 Unrest'.

The menu item *Analyse - Correlations* is not available if the option 'Descriptor types' is activated (see Section 7.3). The correlation coefficients are calculated using Pearson's phi coefficient formula. Depending on the setting of the option 'Calculate weights' (see Section 7.1), weights are used (or not used) for this calculation (default setting: unweighted).

In the case where a descriptor variant does not occur in any scenario, the calculation of correlation coefficients is not meaningful. The respective row and column of the correlation table are filled with zeros, then.

Correlation coefficients are significant rather in cases of medium and large scenario sets. Correlation coefficients of small scenario sets containing only few scenarios may lead to artificial results.

6.14 Influence profile

This evaluation (menu item *Analyse - Influence profile*) is an auxiliary analysis procedure within the CIB analysis. It investigates the influence of an intervention on the scenario set. In the 'Somewhereland' example, for example, a global economic crisis could cause a decline in economic output in

Somewhereland, with no prospect of this being prevented by what happens at the national level described by the matrix.

The effect of an external influence in favour of a descriptor variant can be simulated with the function "force variant" described in Section 6.8 by forcing this variant and then determining the consistent scenarios that result under the effect of the forcing. The menu item *Analyse - Influence profile* offers two forms of influence profiles (qualitative and quantitative), which are described below.

Qualitative influence profile

For the qualitative influence profile, the effect of an external influence is assessed according to whether variants that are represented in the consistent scenarios without this influence no longer appear under the effect of the influence; or on the contrary, whether variants that are not represented in the consistent scenarios without this influence appear under the effect of the influence. This is explained below using a simple matrix for analysing the interrelationship of political and economic developments, and resource availability (Fig. 6-42).

Cross-Impact Matrix

Resource economy	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
A. Global economic growth:															
A1 stagnant				-2	1	1	2	0	-2	2	-1	-1	2	1	-3
A2 moderate				1	0	-1	-2	0	2	-1	2	-1	-1	2	-1
A3 dynamic				1	0	-1	-1	2	-1	-2	1	1	-3	1	2
B. International politics:															
B1 balance of interests	-1	0	1				0	0	0	-2	1	1	1	1	-2
B2 tensions	1	0	-1				-1	0	1	1	0	-1	-1	0	1
B3 conflicts	2	0	-2				-3	0	3	3	-1	-2	-2	-1	3
C. Increase of resource efficiency:															
C1 slow	0	0	0	0	0	0				-2	-1	3	-3	1	2
C2 moderate	-1	0	1	0	0	0				0	0	0	0	0	0
C3 fast	-2	0	2	0	0	0				3	-1	-2	2	1	-3
D. Exploration/production investments:															
D1 low	0	0	0	0	0	0	-1	0	1				-2	-1	3
D2 business as usual	0	0	0	-1	0	1	0	0	0				-1	2	-1
D3 massive	-1	0	1	-2	0	2	1	0	-1				2	1	-3
E. Price of resource:															
E1 low	-1	0	1	-2	1	1	3	0	-3	3	0	-3			
E2 moderate	0	0	0	0	0	0	-1	2	-1	-1	2	-1			
E3 high	2	0	-2	-2	1	1	-3	0	3	-3	0	3			

+ − Accept Print

Fig. 6-42: Cross-impact matrix for the ‘resource economy’ demonstration example.

The example refers to a fictitious resource essential to global economic development but in short supply, extracted by a group of underdeveloped countries and processed in industrialized countries.

Qualitative influence profile (mode: force variant)

To illustrate the concept of the qualitative influence profile, a single influence analysis will first be performed manually. The complete influence profile will then consist of a summary of a large number of analyses of this type carried out automatically. The matrix 'resource economy' leads without external influence to four consistent scenarios (Fig. 6-43).

<table>
<tr><th>Scenario No. 1</th><th>Scenario No. 2</th><th>Scenario No. 3</th><th>Scenario No. 4</th></tr>
<tr><td>A. Global economic growth:
A3 dynamic</td><td>A. Global economic growth:
A2 moderate</td><td>A. Global economic growth:
A3 dynamic</td><td>A. Global economic growth:
A1 stagnant</td></tr>
<tr><td>B. International politics:
B1 balance of interests</td><td colspan="2">B. International politics:
B2 tensions</td><td>B. International politics:
B3 conflicts</td></tr>
<tr><td colspan="3">C. Increase of resource efficiency:
C2 moderate</td><td>C. Increase of resource efficiency:
C3 fast</td></tr>
<tr><td colspan="3">D. Exploration/production investments:
D2 business as usual</td><td>D. Exploration/production investments:
D1 low</td></tr>
<tr><td colspan="3">E. Price of resource:
E2 moderate</td><td>E. Price of resource:
E3 high</td></tr>
</table>

Fig. 6-43: Scenario tableau of the resource economy matrix.

An external influence which inevitably imposes low resource prices can be represented by forcing variant E1 in the CIB analysis (cf. Section 6.8). This then results in the tableau shown in Fig. 6-44.

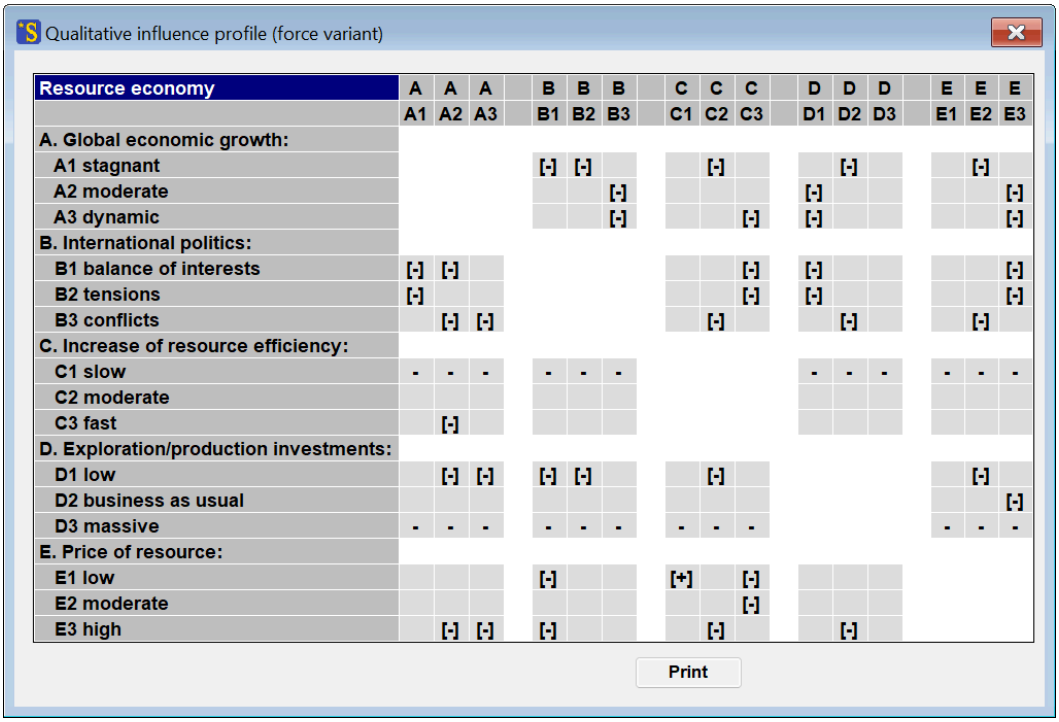
<table>
<tr><th>Scenario No. 1</th><th>Scenario No. 2</th><th>Scenario No. 3</th><th>Scenario No. 4</th></tr>
<tr><td colspan="2">A. Global economic growth:
A1 stagnant</td><td>A. Global economic growth:
A3 dynamic</td><td>A. Global economic growth:
A2 moderate</td></tr>
<tr><td>B. International politics:
B2 tensions</td><td>B. International politics:
B3 conflicts</td><td colspan="2">B. International politics:
B2 tensions</td></tr>
<tr><td colspan="2">C. Increase of resource efficiency:
C1 slow</td><td>C. Increase of resource efficiency:
C2 moderate</td><td>C. Increase of resource efficiency:
C1 slow</td></tr>
<tr><td colspan="3">D. Exploration/production investments:
D1 low</td><td>D. Exploration/production investments:
D2 business as usual</td></tr>
<tr><td colspan="4">E. Price of resource:
E1 low</td></tr>
</table>

Fig. 6-44: Scenario tableau of the resource economy matrix when variant E1 is forced.

The comparison of both tableaus shows that the variants 'B1 balance of interests' and 'C3 fast increase of resource efficiency' drop out of the set of consistent scenarios due to the forcing of low resource prices. On the other hand, the variant 'C1 slow increase of resource efficiency' is added. Thus, the analysis reveals that low resource prices - according to the logic of the interrelations coded

in this cross-impact matrix - exclude the possibility of a balance of interests between producer and consumer countries and the possibility of fast resource efficiency development and, on the other hand, produce the possibility of slow resource efficiency development.

In order to determine the qualitative influence profile, the described analysis is performed several times automatically by the *ScenarioWizard* software. All existing descriptor variants are forced one after the other and it is noted which variants enter or leave the scenario set compared to the reference case without forcing. The result for the 'resource economy' matrix is shown in Fig. 6-45. The matrix identifies the qualitative effects of forcing a variant (specified in the row) with the markings [+], [-] or ----.



Resource economy	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
A. Global economic growth:															
A1 stagnant				[-]	[-]			[-]			[-]			[-]	
A2 moderate						[-]				[-]					[-]
A3 dynamic						[-]			[-]	[-]					[-]
B. International politics:															
B1 balance of interests	[-]	[-]							[-]	[-]					[-]
B2 tensions	[-]								[-]	[-]					[-]
B3 conflicts		[-]	[-]					[-]			[-]			[-]	
C. Increase of resource efficiency:															
C1 slow	-	-	-	-	-	-				-	-	-	-	-	-
C2 moderate															
C3 fast		[-]													
D. Exploration/production investments:															
D1 low		[-]	[-]	[-]	[-]			[-]						[-]	
D2 business as usual															[-]
D3 massive	-	-	-	-	-	-	-	-	-				-	-	-
E. Price of resource:															
E1 low				[-]			[+]		[-]						
E2 moderate									[-]						
E3 high		[-]	[-]	[-]				[-]			[-]				

Fig. 6-45: Qualitative influence profile for the 'resource management' matrix (mode: force variant).

[+]

A [+] mark in the influence profile indicates that the variant specified in the relevant column is not represented in the original scenario set, but that it enters the scenario set when the variant specified in the relevant row is forced. The only case of a [+] mark in the example is located in row E1, column C1: The forcing of E1 (low resource price) causes consistent scenarios with variant C1 (slow increase of resource efficiency) to become possible, which is not the case without the forcing of E1.

[-]

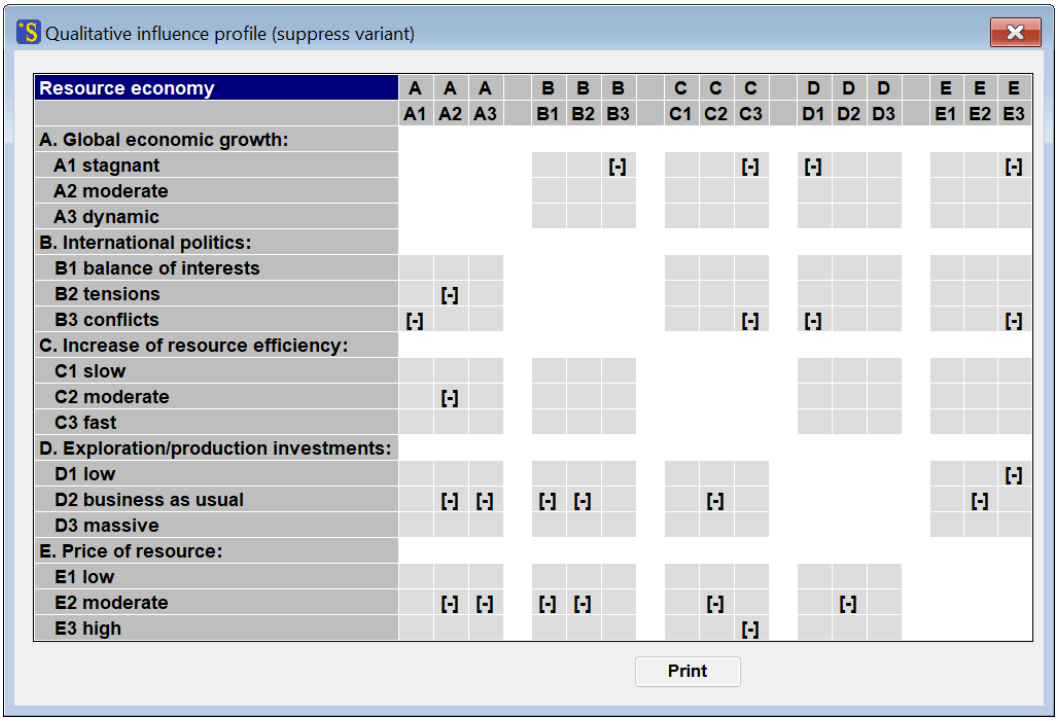
This marker indicates the opposite: the variant indicated in the column is represented in the original scenario set. However, by forcing the variant indicated in the row, it is eliminated from the scenario set. Thus, the [-] marks in cells D1/A2 and D1/A3 mean that the forcing of low investments leads to the exclusion of the variants ‘moderate economic growth’ and ‘dynamic economic growth’ from the scenario set, so that for descriptor ‘A. Global economic growth’ only the variant ‘stagnant’ remains possible.

The effect of forcing D3 (massive investments) is marked in the example by continuous crossbars in the line. This indicates that no consistent scenarios are possible if D3 is forced and that the set of consistent scenarios is therefore empty.

In addition, the case can also occur that a line does not contain any markers (in the example for variant C2). In this case, the forcing of the variants in question does not cause any changes in the presence of the other variants in the scenario set: all variants originally present continue to be in the scenario set after forcing (but possibly more frequently or less frequently than in the original set), and on the other hand, no additional variants appear in the set.

Qualitative influence profile (mode: suppress variant)

In addition to the option of examining the effects of forcing a variant on the variant presences in the scenario portfolio, there is the alternative option of examining the effects of suppressing a variant. In this mode, all variants are suppressed one after the other and the resulting scenario portfolio is compared with the original set. As in the “Force variant” mode, the influence profile then indicates which variants are displaced from the scenario portfolio by the intervention and which originally vacant variants enter the scenario portfolio as a result of the intervention (Fig. 6-46).



Resource economy	A	A	A		B	B	B		C	C	C		D	D	D		E	E	E
	A1	A2	A3		B1	B2	B3		C1	C2	C3		D1	D2	D3		E1	E2	E3
A. Global economic growth:																			
A1 stagnant							[-]				[-]		[-]						[-]
A2 moderate																			
A3 dynamic																			
B. International politics:																			
B1 balance of interests																			
B2 tensions		[-]																	
B3 conflicts	[-]										[-]		[-]						[-]
C. Increase of resource efficiency:																			
C1 slow																			
C2 moderate		[-]																	
C3 fast																			
D. Exploration/production investments:																			
D1 low																			[-]
D2 business as usual		[-]	[-]		[-]	[-]				[-]								[-]	
D3 massive																			
E. Price of resource:																			
E1 low																			
E2 moderate		[-]	[-]		[-]	[-]				[-]				[-]					
E3 high											[-]								

Fig. 6-46: Qualitative influence profile for the ‘resource management‘ matrix (mode: suppress variant).

This form of influence analysis is referred to as ‘qualitative’ because it does not perform counts or report numerical values as results. Instead, it aims exclusively at the yes-no information whether certain variants are present in the scenario set or not, and whether this information changes under the impression of a variant forcing.

Quantitative influence profile

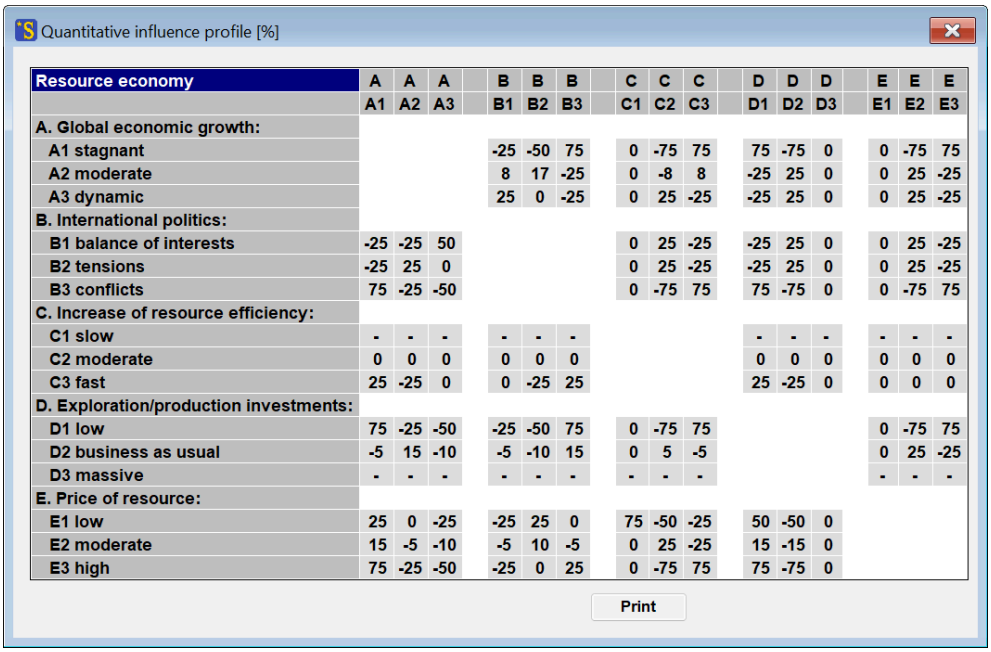
The quantitative influence profile aims at statements about the change in the relative frequency of the descriptor variants as a result of the forcing of a variant. Since the CIB is designed as a method of qualitative system and scenario analysis, quantitative evaluations are only of limited conformity with the spirit of the method and require particularly careful interpretation. Therefore, the *qualitative* influence profile described above should be understood as the standard tool for analyzing the effect of external influences within the CIB method, and the *quantitative* influence profile as supplementary technical information.

A non-automated quantitative analysis of the forcing of a certain descriptor variant without using the function “Analysis - Influence profile - Quantitative” would proceed as follows:

1. The frequencies of all descriptor variants are calculated as shown in Fig. 6-15 and Fig. 6-16.
2. The descriptor variant under investigation is forced as described in Section 6.8.
3. The descriptor variant frequencies are recalculated under the influence of the forcing.
4. The differences between the recalculated and the basic frequencies are calculated.

The increase or decrease in frequencies for the different variants is then interpreted as the characteristic effect of the forced descriptor variant.

The “Analyse - Influence profile - Quantitative” function performs this analysis automatically for all possible forcings. It performs the analysis described above (forcing of a variant and determination of the resulting changes in variant frequency) successively for all descriptor variants and records the results in the form of frequency changes in a matrix. The result of the evaluation "Influence Profile - Quantitative" for the "Resource Management" example is shown in Fig. 6-47.



Resource economy	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
A. Global economic growth:															
A1 stagnant				-25	-50	75	0	-75	75	75	-75	0	0	-75	75
A2 moderate				8	17	-25	0	-8	8	-25	25	0	0	25	-25
A3 dynamic				25	0	-25	0	25	-25	-25	25	0	0	25	-25
B. International politics:															
B1 balance of interests	-25	-25	50				0	25	-25	-25	25	0	0	25	-25
B2 tensions	-25	25	0				0	25	-25	-25	25	0	0	25	-25
B3 conflicts	75	-25	-50				0	-75	75	75	-75	0	0	-75	75
C. Increase of resource efficiency:															
C1 slow	-	-	-	-	-	-				-	-	-	-	-	-
C2 moderate	0	0	0	0	0	0				0	0	0	0	0	0
C3 fast	25	-25	0	0	-25	25				25	-25	0	0	0	0
D. Exploration/production investments:															
D1 low	75	-25	-50	-25	-50	75	0	-75	75				0	-75	75
D2 business as usual	-5	15	-10	-5	-10	15	0	5	-5				0	25	-25
D3 massive	-	-	-	-	-	-	-	-	-				-	-	-
E. Price of resource:															
E1 low	25	0	-25	-25	25	0	75	-50	-25	50	-50	0			
E2 moderate	15	-5	-10	-5	10	-5	0	25	-25	15	-15	0			
E3 high	75	-25	-50	-25	0	25	0	-75	75	75	-75	0			

Fig. 6-47: Quantitative influence profile for the ‘resource management‘ matrix.

The value "50" is displayed in the crossing of the row "E1 Price of resource: low" and the column "D1 Exploration/production investments: low" in Fig. 6-47. This indicates that a fixation of the system to low resource prices caused by external influences leads to the variant "D1 Exploration/production investments: low" occurring 50 percentage points more frequently than in the reference case without forcing: Without forcing, the frequency of D1 is 25% (1 scenario out of 4, see Fig. 6-43). When E1 is forced, the frequency of D1 increases to 75% (3 scenarios out of 4, see Fig. 6-44).

In cases where the fixing of a descriptor variant does not result in consistent scenarios, dashes are entered in the corresponding row (in the example, variants C1 and D3). If there are no consistent scenarios for the reference case (without forcing a variant), the evaluation is aborted with a message.

In contrast to the correlation table (Section 6.13), the matrix of the evaluation "quantitative influence profile" is usually not symmetrical. The reason for this is that, for example, the values in row "E1" have a completely different meaning than the values in column "E1". While the row "E1" shows which effects it would have on the frequency of other descriptor variants if variant E1 were forced by external influence, the column "E1" shows at which descriptors and variants an external influence would be effective to promote or reduce the frequency of variant E1 in the scenario set.

Similar to the correlation table, a graphical representation of the row values assigned to a descriptor variant in the influence profile matrix can be generated: Clicking on the variant "D1 Exploration/production investments: low" in the left title column and then pressing the right mouse button opens the influence profile shown in Fig. 6-48.

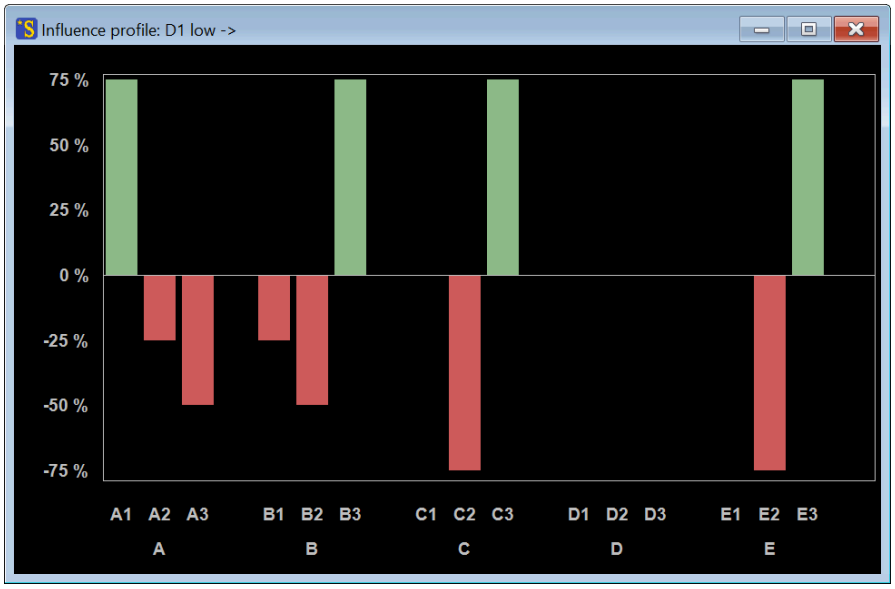


Fig. 6-48: Bar chart of the influence profile of descriptor variant ‘D1 - Low investments’.

The "inverse influence profile" represented in the columns can also be displayed graphically. To do this, click on the selected variant (in the example: D1) at the title bar and press the right mouse button. The inverse influence profile (the column values) then appears for this variant (cf. Fig. 6-49).

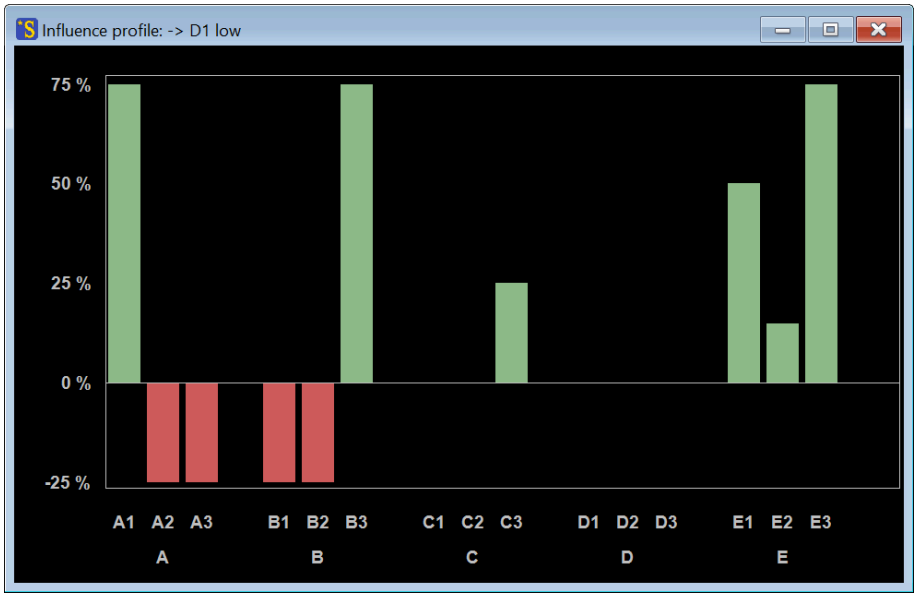


Fig. 6-49: Bar chart of the inverse influence profile of descriptor variant ‘D1 - Low investments’.

The frequency statistics on which the influence values are based are calculated either unweighted (default setting) or weighted according to the "Calculate weights" option in the Options - Evaluation form (see Section 7.1).

The *Analyse* - *Influence profil*e menu item is only available after a project file has been loaded or structure data and cross-impact data have been entered.

Interpreting influence profiles

It should be noted that variant frequencies cannot be interpreted as probabilities without further justification; rather, they primarily express a diversity of possibilities (cf. Section 6.4, Section "Frequencies"). Accordingly, a high value in the quantitative influence profile does not express that a certain variant is made more probable by an intervention, but that under the conditions of the intervention there are more ways than without this intervention to construct plausible scenarios using this variant.

6.15 Index calculations

The menu item *Edit - Assess variants* makes it possible to assign evaluations to the descriptor variants in the form of an integer. These can, for example, express the desirability of the developments from the point of view of a certain group of stakeholders or also take up criteria such as the present (dis)similarity or the risk potential of a development. In the case of a desirability assessment, you could follow the cross-impact rating scale and rate on a scale of -3 (particularly undesirable) to +3 (particularly desirable). However, there is no obligation to use the same rating scale for the variant assessment as for the cross-impact assessments.

Fig. 6-50 shows an example of the evaluation of the future dissimilarity of the Somewhereland variants, assuming for this example that scenario [A3 B1 C3 D2 E1 F1] (scenario no. 1 in Fig. 6-19) corresponds to the present. A score of 0 corresponds to complete similarity to the present and a score of 2 corresponds to strong dissimilarity to the present.

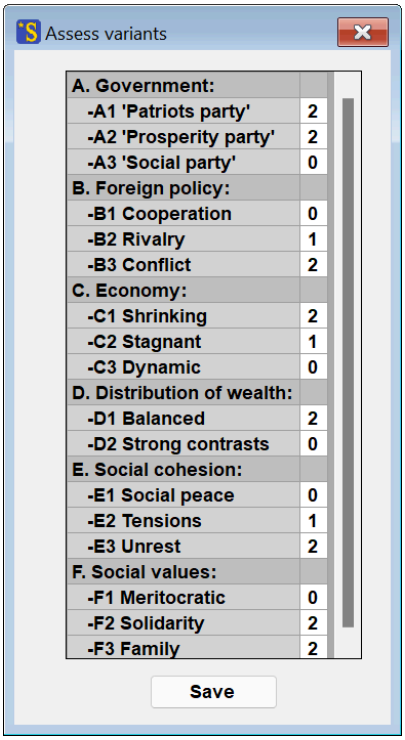


Fig. 6-50: An example of a variant assessment.

By pressing the “Save” button, the evaluations are saved in the working memory and are available for further calculations during the current session. They are saved permanently when the project file is saved and made available again in the working memory when a project file is reloaded.

Furthermore, the descriptor variants are automatically assigned colours according to the ratings when the “Save” button is pressed. If both positive and negative ratings are assigned, colours are

assigned according to a red-green scale. If, on the other hand, only positive ratings are assigned, as in the example, the software assumes that intensities are to be expressed and uses a blue-grey monochrome scale for the colour coding. However, the colour coding made by the system can be changed at any time using the structure editor (Section 5.5).

The aim of the index calculation is to assign an index value to each consistent scenario on the basis of the evaluation data, which expresses the overall performance of the scenario with regard to the assessment criterion. For this purpose, the ratings of all descriptor variants represented in the scenario are added together. These index values are automatically determined during the scenario calculation and can then be used in various representations and operations.

Index values in the evaluation protocol

If index values are available, they are automatically output in the evaluation protocol after the consistent scenarios have been calculated (Fig. 6-51).

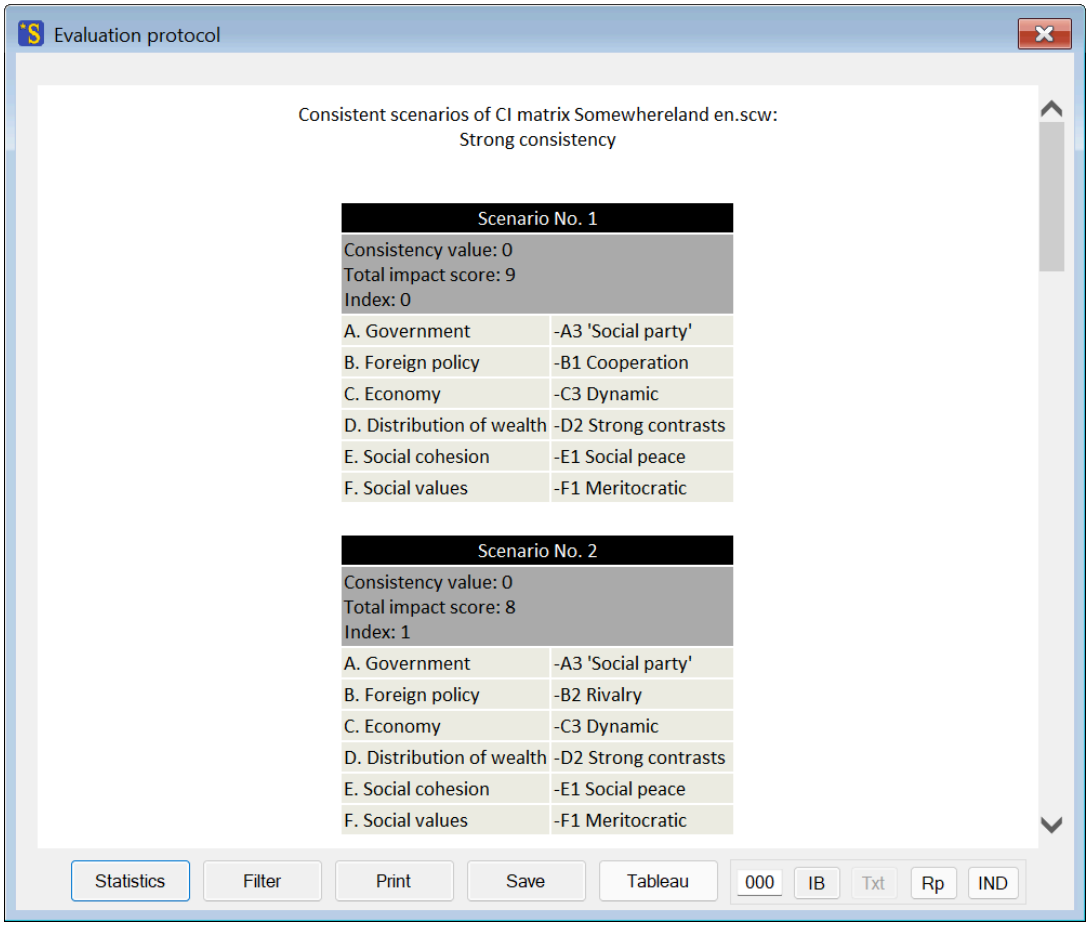


Fig. 6-51: Display of the index values of the consistent scenarios in the evaluation protocol.

Index values in the "Statistics" evaluation

If index values are available, the *Analyse - Statistics* menu item produces the frequency distribution of the index values in the set of all possible variant combinations to the series of evaluations (Fig. 6-52). The frequency distribution supports the interpretation of the index values of the consistent scenarios as "normal", "particularly high", "particularly low" etc. and appears in the output window of the evaluation following the "Total impact score" statistics.

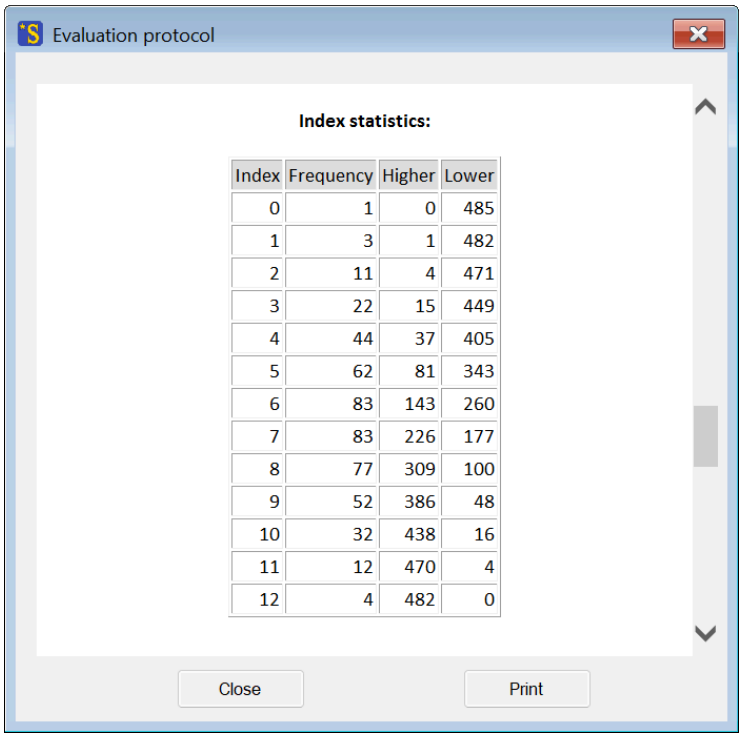


Fig. 6-52: Frequency statistics of the index values in the "Statistics" evaluation.

In the present case, for example, it can be seen that the median for the index values (in the case of the ratings shown in Fig. 6-50) is between 6 and 7 and that index values significantly below 6 - 7 are therefore to be interpreted as relatively low and index values significantly higher than 6 - 7 as relatively high.

Index values in the scenario tableau

If index values are available, these are also displayed in the "Scenario tableau" (see Section 6.5). The colour assignments made by the software as part of the variant evaluation are also used in the tab-

leau. In this example, a monochrome colour scale is used, as the variant evaluation only contains positive values.

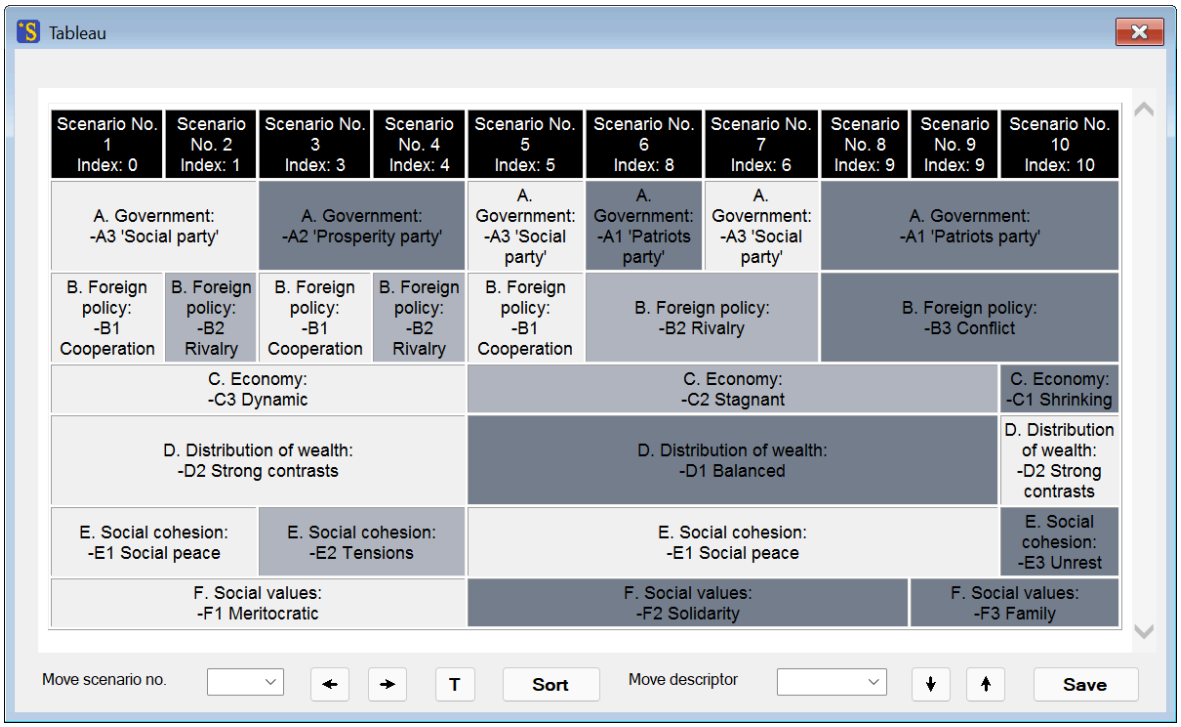


Fig. 6-53: Display of index information in the scenario tableau.

The colour coding for the descriptor variants makes it easy to understand which developments contribute to the index value for each scenario. The scenarios are not sorted by index value immediately after the scenario calculation (the rough sorting in this example is random). However, the sorting function in the “Output options” form (Section 7.2) can be used to sort the scenario list according to index values in order to achieve a strict order in the tableau according to increasing index values.

7 Options

Several options for the execution of CIB evaluations and for the display of data are available. Appropriate settings can be specified using the menu item *Options*. In previous chapters, only default settings were used.

7.1 Evaluation options

The menu item *Options* - *Evaluation Options* or the button  on the toolbar opens the options window shown in Fig. 7-1.

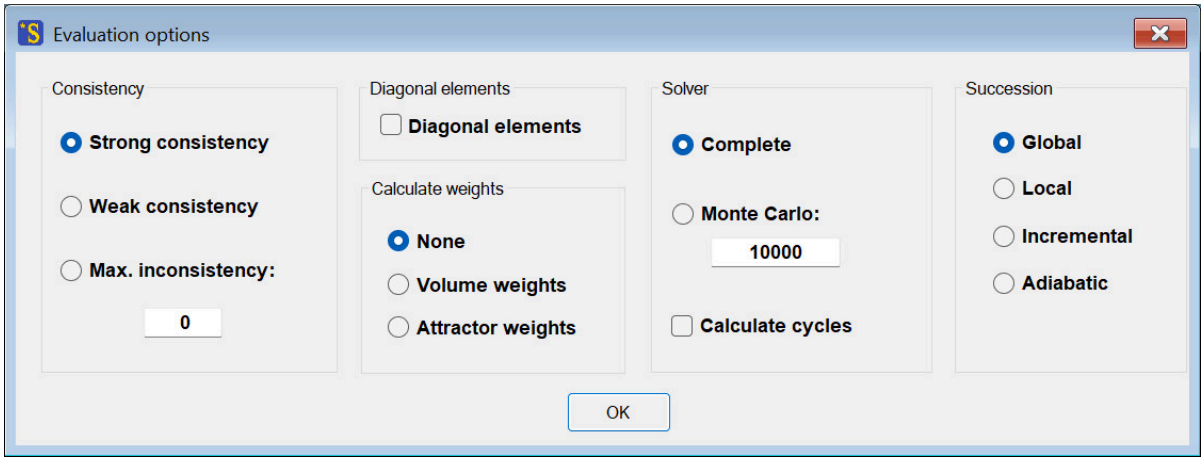


Fig. 7-1: The 'Evaluation options' window.

Consistency

The 'Consistency' option determines the consistency mode, which controls the consistency assessment of the scenarios over the course of the evaluation procedure.

- 'Strong consistency' (default setting): A scenario is accepted only if every state owns the maximum impact score of the descriptor impact balance. According to this, in the CIB succession procedure (see Section 6.2), a state will be adjusted if it does not possess the maximum impact score of the descriptor impact balance.
- 'Weak consistency': A scenario is accepted if every state owns a positive or zero impact score. According to this, in the CIB succession procedure, a state will be adjusted if it possesses a negative impact score. Weak consistency only makes sense in the case of standardised cross-impact matrices. This option usually results in a larger, less stringently selected scenario set.
- 'Max. inconsistency': A scenario as accepted if no state has a larger gap between its impact score and the maximum impact score than the specified value permits. According to this, a variant will be adjusted in the CIB succession procedure if the gap between its impact score and the maximum impact score exceeds the specified value. This option is intended for analysing the influence of data uncertainties. If zero is assigned as the maximum inconsistency, this option yields the same results as the option 'Strong consistency'. The specified value for the maximum inconsistency will only enter into the calculation if the option button 'Max. inconsistency' is selected. If the option 'Max. inconsistency' and a maximum inconsistency value > 0 are chosen, the scenario information provided by the evaluation protocol 'Consistent scenarios' includes the number of inconsistent descriptors.

Diagonal elements

The checkbox 'Diagonal elements' controls whether diagonal judgement sections of the cross-impact matrix are permitted (extended cross-impact matrix) or not (regular cross-impact matrix). The exclusion of diagonal judgement sections is the default setting. While loading a new project file, *ScenarioWizard* will check whether the data contain non-zero diagonal elements, and the program will set this option according to the data. If the user changes this option while cross-impact data are present in the workspace, the diagonal judgement sections will be cleared and filled with zeros respectively.

Calculate weights

The option group 'Calculate weights' controls if scenario weights are calculated by the evaluation 'Consistent scenarios' (see Section 6.4) and which type of weight is calculated.

- Default setting is 'None'. No weights are calculated and no weights are reported in the evaluation protocol. On the other hand, this setting allows the maximum computation speed.
- The option 'Volume weights' activates the calculation of weights during the evaluation of consistent scenarios. The volume weight of a consistent scenario (shown as percentages) indicates the share of the total configuration space, which is best represented by this scenario in terms of scenario similarity. The calculation of volume weights takes the following course: i) weight 1 is assigned to all possible configurations (all possible combinations of descriptor variants); ii) each configuration passes on its weight to the most similar consistent scenario. If

two or more consistent scenarios are equal to the configuration, the weight to be passed is divided into equal parts. Similarity is measured by the number of matching descriptors. The option 'Volume weight' requires two evaluation runs (indicated by two runs of the progress bar). The first run calculates the set of consistent scenarios, whereas the second run calculates the volume weights. Depending on the number of scenarios, the second run may require considerably less or considerably more calculation time than the first run[6].

– The option 'Attractor weight' also activates the calculation of scenario weights. In this case, the weight of a consistent scenario (shown in absolute figures) indicates the probability that a randomly chosen initial scenario will be transformed into this scenario by the CIB succession procedure. The results depend on the choice of the succession type by the option group 'Succession' (see below).

If the option 'Volume weights' or the option 'Attractor weights' is activated, the resulting scenario weights are printed into the protocol of the evaluation 'Consistent scenarios' together with the other scenario key figures. Some evaluations use weight information if available, e.g. the calculation of descriptor variant frequencies (using option 'weighted frequencies'; see Section 6.4), the calculation of correlations (Section 6.13), or the calculation of influence profiles (Section 6.14).

Excursus: Why scenario weights?

Scenario weights should not be confused with scenario probabilities. Scenario weighting is a tool for protecting statistical calculations (e.g. the calculation of descriptor variant frequencies) against statistical distortion. Statistical distortion can occur if some members of a scenario set describe clearly distinct types of system behaviour while other scenarios of the same set represent simply some highly related variants of the same one scenario pattern. Consider for example the scenario set of six descriptors, each owning three variants:

$$S_1 = [\, a_1 \;\; b_3 \;\; c_2 \;\; d_1 \;\; e_3 \;\; f_2 \,]$$
$$S_2 = [\, a_2 \;\; b_2 \;\; c_1 \;\; d_3 \;\; e_1 \;\; f_3 \,]$$
$$S_3 = [\, a_2 \;\; b_2 \;\; c_1 \;\; d_3 \;\; e_1 \;\; f_1 \,]$$

S_1 is relatively different to S_2 and S_3, whereas S_2 and S_3 are very similar and differ only by one descriptor (f). In a formal sense, the scenario set consists of three scenarios, and the frequency of, e.g. a_2, is 66.7% in this set. Arguing from a more content-oriented point of view, things are different because the scenario set shows in fact only two genuine scenario types (one of them can occur in two slightly different ways). Thinking in scenario types, the correct answer for the frequency of a_2 is 50%.

[6] For matrices up to a maximum of 3 million possible combinations of variants and under complete evaluation, the volume weights are determined exactly. For larger matrices, a Monte-Carlo calculation of the volume weights with 1 million randomly drawn variant combinations is carried out to limit the computing time.

Weighted statistical calculations are better suited to address such considerations than unweighted calculations. In the example shown above, the volume weights of scenario S_1 is 309 and both the scenario weights of S_2 and S_3 are 210. Therefore, the weighted frequency of a_2 is 57.6%, which reflects the character of S_2 and S_3 as variants of a single scenario type better than the unweighted result, although the formal aspect is not completely omitted.

Solver

The 'Solver' option controls the selection of the method, which *ScenarioWizard* uses for finding the solutions of a cross-impact matrix (the consistent scenarios and cyclic attractors).

- 'Complete' (default setting): A complete exploration of all possible scenarios will be performed. All solutions of a matrix will be reliably determined. For large matrices, this method may cause a long computation time, however. For very large matrices, the computation time of a complete exploration may even be unacceptable.
- The 'Monte Carlo' option can be used for an approximate evaluation of large matrices. In this case, there will be no complete exploration of all possible scenarios. Instead, a number of randomly chosen scenarios will be used as a starting point for constructing a solution by the succession method. All solutions found by this procedure will be reported in the evaluation protocol and the occurrence frequency will be interpreted as the weight of a solution. The number of random scenarios can be set by the user in the textbox of this option.

The 'Monte Carlo' option offers an approximate evaluation of very large matrices. However, only the main solutions (i.e. solutions with high combinatorial weight) will be identified in a reliable way. Solutions with low weights may be missed. The higher the number of random runs (default setting: 10,000), the more probable solutions with low weights will be found.

If the 'Monte Carlo' option is selected, the evaluations 'Consistent scenarios', 'Ensemble evaluation', and 'Statistics' described in Chapter 6 will be executed using this method. As aforementioned, the output variable 'weight' of the evaluations 'Consistent scenarios' and 'Statistics' no longer indicates the volume weight or the attractor weight. It indicates the frequency of solutions in which they occur in all random runs.

A repetition of the Monte Carlo evaluation will usually not lead exactly to the same solution set and solution weights: weights may differ and solutions with low weights may be found only in some runs. This is a consequence of the random nature of the method. Weight scattering will decrease if the number of runs is increased.

Although the Monte Carlo evaluation is an approximation method, all consistent scenarios and cyclic attractors found by this method are exact solutions with regard to their structure. The approximate nature of the method concerns exclusively the calculation of the weights and the fact that the solution set may be incomplete.

If the 'Monte Carlo' option is selected, a hint is printed in the head of the evaluation protocol and the number of random runs is indicated.

If the number of runs chosen is smaller than 1 in the options textbox, then this parameter is set as 1 by the program. An entry with more than 9 digits will be ignored by the program. Do not use periods or other non-numeric characters for the entry of this textbox.

The entry of the 'Monte Carlo' option textbox does not affect any evaluation if the 'Monte Carlo' option is not selected.

The 'Calculate cycles' option controls if the evaluation 'Consistent scenarios' (see Section 6.4) will check also for cyclic solutions of the cross-impact matrix (default setting: deactivated). In the case of a cyclic solution, the succession procedure repeats a certain series of scenarios (the cycle). Cyclic solutions should be interpreted with care; depending on the nature of the descriptors, they are not in every case meaningful. However, for some systems, they correctly indicate a tendency towards vacillation.

If the 'Calculate cycles' option is activated, the evaluation protocol 'Consistent scenarios' reports not only the scenario solutions, but also the identified cyclic solutions. The header of each solution shows the list number of the solution, its attractor weight, and the period of the cycle (number of involved scenarios: 1 for consistent scenarios, > 1 for cycles).

Succession

The 'Succession' option determines the rules, which control the succession algorithm of the matrix evaluation procedures. One of the following rules can be chosen:

- 'Global' (default setting): In each succession step, adjust all inconsistent descriptors to the state of the highest impact score. This rule should be used as a generic rule if none of the following alternatives applies.
- 'Local': Adjust only the descriptor(s) with the highest inconsistency and change it to the state of the highest impact score. This rule expresses the idea that the reaction of the system elements is accelerated by high system forces and that the system element sensing the greatest forces reacts first.
- 'Incremental': Adjust all inconsistent descriptors towards the state of the highest impact score, but only by jumping to a neighbouring state. This rule is appropriate if abrupt state transitions are not plausible in the system under consideration. It should be used only if all descriptors of the matrix are ordinal descriptors.
- 'Adiabatic': Adjust only the first inconsistent descriptor to the state of the highest impact score. This rule is suitable if the descriptor reaction times feature distinct time scales, and the descriptors are sorted according to the time scale, starting with the fastest descriptor.

All rules are valid CIB succession modes, i.e. they all yield the same set of consistent scenarios when a matrix is evaluated by them. However, they produce different succession pathways (transients), and therefore, they may result in different attractor weights and in different cyclic attractors.

The chosen succession rule affects all evaluations launched in the windows *Analyse - Consistent scenarios* (Section 6.4) and *Analyse - Impact balances* (Section 6.2). On the other hand, the setting of the

evaluation option ‘Consistency’ is properly taken into consideration for all of the offered succession rules.

7.2 Output options

The menu item *Options - Output Options* (or the button  on the toolbar) opens the window shown in Fig. 7-2.

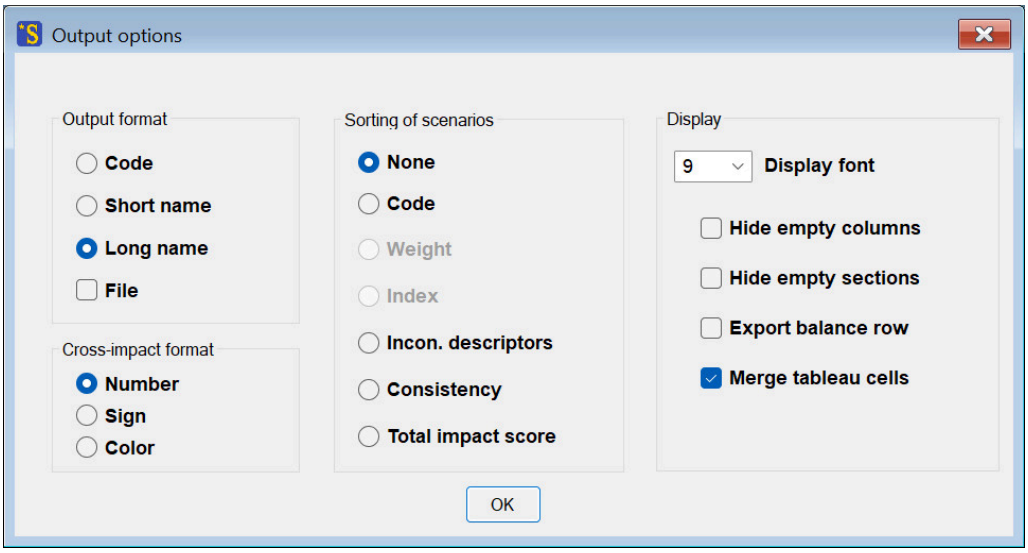


Fig. 7-2: The ‘Output options’ window.

Output format

The ‘Output format’ option controls the format of the consistent scenario printouts belonging to the evaluation protocols.

- ‘Code’: The consistent scenarios are printed in the form of a code rather than a text. For instance, the code ‘2 1 3 2’ of a scenario with four descriptors expresses that the first descriptor takes state no. 2, the second descriptor state no. 1, the third descriptor state no. 3, and the fourth descriptor state no. 2. The coded format helps list a large number of consistent scenarios in a clear and compact way. On the other hand, reading this format takes some practice. All scenario data (code, weight, consistency value, total impact score and, in the case of the option ‘Max. inconsistency’, the number of inconsistent descriptors) are printed in a line.
- ‘Code and header’ uses the coded form as well. In addition, at the top of the list of scenarios, a header is printed. The header indicates the columns of the scenario list by the first character of the descriptor's name. This should improve the comprehensibility of the

coded scenario list, provided that the names of the descriptors are chosen in a suitable way (e.g. starting with A, B, C, etc.).

- 'Short name': Each scenario is printed as a list of its descriptors and their selected states. The descriptors are printed with long names, and the states are printed with short names.
- 'Long name' (default setting): Each scenario is printed as a list of its descriptors and their selected states. Both descriptors and states are printed with long names. This option yields the largest output text. On the other hand, the output text is easy to understand without explanations. This option is therefore particularly appropriate for presentations and workshops.

Cyclic attractors are printed with the descriptors (long name) and the sequence of states (short names) for one cycle period if either 'Short name' or 'Long name' is selected. If the 'Code' option is chosen, the scenarios of a cycle are printed in rows, using the code described above.

The output format of ensemble evaluation protocols (see Section 6.9) is not affected by the 'Output format' option. The ensemble evaluation protocol always appears in coded format.

Activate the checkbox 'File' to print the protocol of the evaluation 'Consistent scenarios' into a file. The file name and location will be enquired once an evaluation is started. The protocol will not be displayed on the screen in this case.

Sorting of scenarios

The 'Sorting of consistent scenarios' option controls the sorting of the evaluation output list *Analyse - Consistent scenarios*.

- 'None' (default setting): Scenarios are printed in unsorted form. In this case, the sequence of scenarios listed reflects the sequence in which *ScenarioWizard*'s computation algorithm identifies the solutions.
- 'Code': Scenarios are sorted in ascending numerical order according to their codes (the codes are read as numbers with *n* digits, where *n* is the number of descriptors).
- 'Weight' (available only if the option 'Calculate weights' is selected; see Section 7.1): Scenarios are sorted in descending numerical order according to their combinatorial weights.
- 'Index' (only available if evaluations of the descriptor variants are provided, see Section 6.15): The scenarios are sorted according to increasing index values.
- 'Consistency': Scenarios are sorted in descending numerical order according to their consistency values.
- 'Incon. descriptors': Scenarios are sorted in ascending numerical order according to the number of inconsistent descriptors. This sorting is only meaningful if the evaluation option 'Max. inconsistency' and a maximum inconsistency > 0, or the evaluation option "Weak consistency" is chosen (see Section 7.1). Otherwise, the number of inconsistent descriptors would be zero for each listed scenario.

- 'Total impact score': Scenarios are sorted in descending numerical order according to their total impact scores.

The output of the ensemble evaluations is always printed unsorted. The same is true if the option 'Calculate cycles' (Section 7.1) is activated.

Live change of output options

The window 'Output options' can be opened while the evaluation protocol is still open. Settings can be changed and the content of the evaluation protocol is accordingly updated once the 'Output option' window is closed by the button 'OK'. In this way, a new choice of output formatting can be applied without possibly time-consuming recalculations.

Display font

The user can change the font used to print the names of descriptors and states in the program windows. The font is also used for the printout of all evaluation protocols on the screen. The combo box 'Display font' controls this font. The default font setting is 9 pt. A small font helps display large matrices without scrolling. A large font is useful for projector presentations.

Hiding empty descriptor columns

Cross-impact matrices may contain descriptors free of influence ('autonomous descriptors'). This sort of descriptor has non-zero cross-impacts in its descriptor row, whereas there are only zero entries in its descriptor column. If the option 'Hide empty descriptor columns' is activated, the window 'Edit cross-impact matrix' will display the matrix without the columns of the independent descriptors, sparing the space otherwise occupied by columns containing no information. The rows of the independent descriptors are displayed, however. The 'Print' button of the window 'Edit cross-impact matrix' produces the corresponding printouts without the columns of the independent descriptors. The option 'Hide empty descriptor columns' is effective also if the option 'Descriptor types' is used (see Section 7.3). Matrices without independent descriptors are displayed as usual. Activating the option 'Hide empty descriptor columns' will cause no effect in this case.

Hide empty sections

In most cases, not all descriptors of a matrix exert influences onto all other descriptors. Some judgement sections of a matrix are completely filled with zeros instead. In the interest of greater clarity, the option 'Hide empty sections' can be used to suppress the empty sections. The option is effective in the matrix editor (the suppressed sections stay editable, however, and are highlighted to indicate this), matrix print function, impact-balance window, and html export functions.

Merge tableau cells

In the default state, matching neighbouring cells in the scenario tableau are merged to make similarities between scenarios easier to see (Section 6.5). However, this function can be deselected in the

Output Options window by removing the checkmark in the “Merge tableau cells” check box. When *ScenarioWizard* is restarted, however, the default state is restored.

Cross-impact format option: “Sign”

As a default setting, *ScenarioWizard* uses integer numbers to depict cross-impact judgements (usually within a scale of -3 to +3). Occasionally, experts feel uncomfortable to express their qualitative influence judgements in numbers. To avoid mental obstacles when interviewing experts and eliciting their judgements, the format option ‘Sign’ can be chosen in this case. Under this option, cross-impacts are depicted in a format free of numbers, using only ‘+’ and ‘-’ symbols.

The cross-impact matrix of the exercise Somewhereland (Fig. 5-7) appears as shown in Fig. 7-3. The sign of each impact (promoting or hindering) is represented by (+) or (-), and the strength is classified by assigning more than one (maximum of three) sign to a cell. Promoting impacts are printed in green and hindering impacts in red. Zeros (no impact) are omitted. Data can be assigned into the cells simply by entering + or - signs using the keyboard or by marking the cell by a mouse click and using the +/- buttons of the matrix editor.

The judgement scale is strictly restricted to the range [--- to +++] (corresponding to -3 to +3) in this case. The matrix editor will refuse to accept inputs outside of this range. If a project file containing judgements outside of this range is loaded, the cross-impact format option will be automatically changed to ‘Numbers’.

The print function of the matrix editor answers to the format option and prints a matrix corresponding to the depiction in the editor.

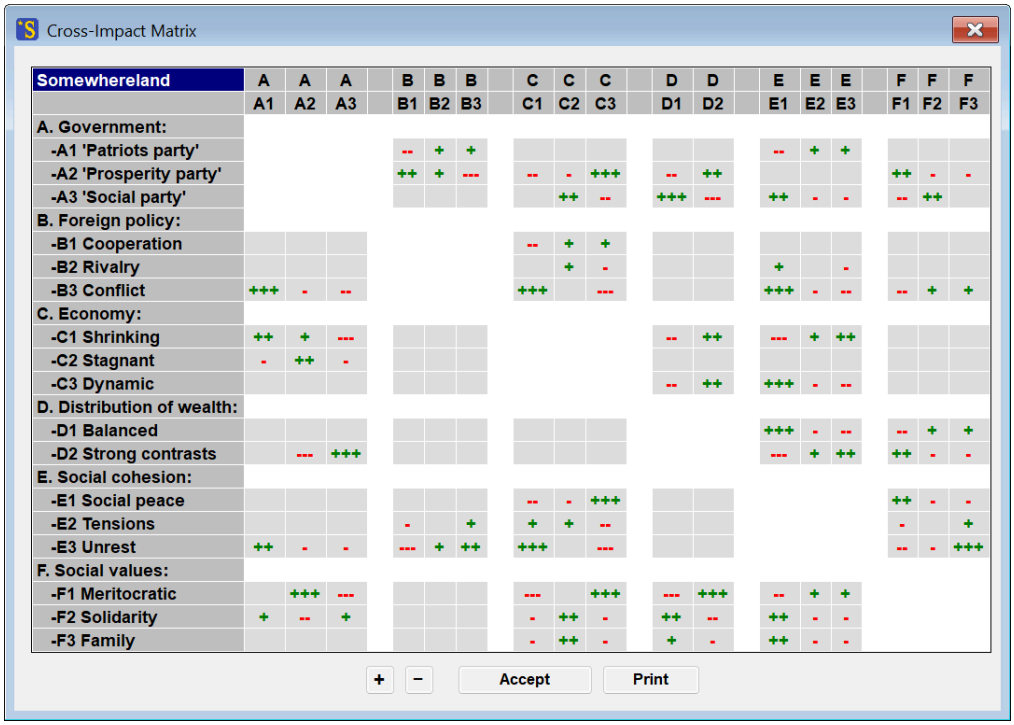


Fig. 7-3: Displaying a cross-impact matrix using the format option ‘Sign’.

The chosen cross-impact format is also used in the window ‘Impact balances’ (Fig. 7-4). To emphasise the qualitative aspect of the analysis, the impact balances are also not shown as numbers. Only the fundamental information is expressed: the symbol [+] in an impact balance indicates that the respective impact sum is the highest one within the impact balance, qualifying the respective descriptor variant for the criterion of strong consistency (see Section 7.1). The symbol [0] stands for an impact sum smaller than the maximum, but positive so that its descriptor variant fulfils the criterion of weak consistency. A descriptor variant characterised by [-] in the balance row has a negative impact sum and fulfils none of both consistency types.

Storing the impact balance window using the button ‘Export’ creates an html table, using the chosen format option.

The format option ‘Sign’ is exclusively a display option. It does not affect any calculation, neither the evaluation ‘Consistent scenarios’ nor the operations of the window ‘Impact balance’.

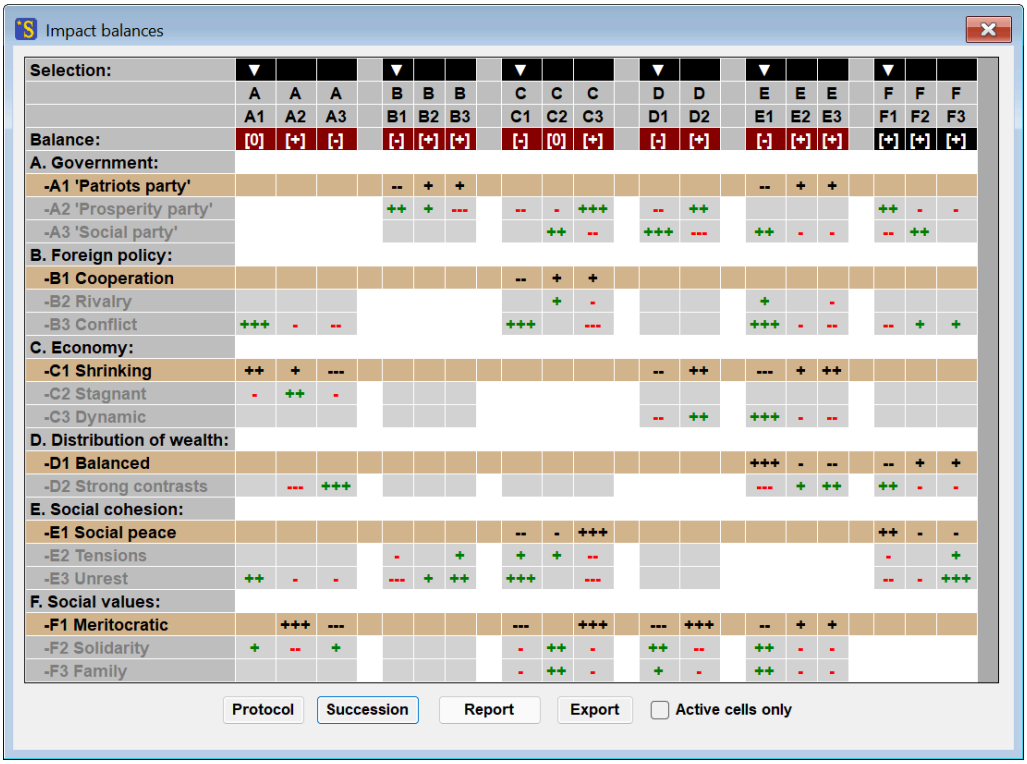


Fig. 7-4: Impact balance window for the cross-impact format ‘Sign’.

Cross-impact format option: “Color”

Alternatively, the cross-impact data can also be displayed color-coded on a red-green scale by selecting the "Color" format option. Red values stand for hindering, green for promoting influences. The color coding is effective in the matrix editor (Fig. 7-5) and in the html export of the cross-impact matrix (Fig. 7-6). The approach to color-coded cross-impact matrices is originated by Weitz et al. (2018).[7]

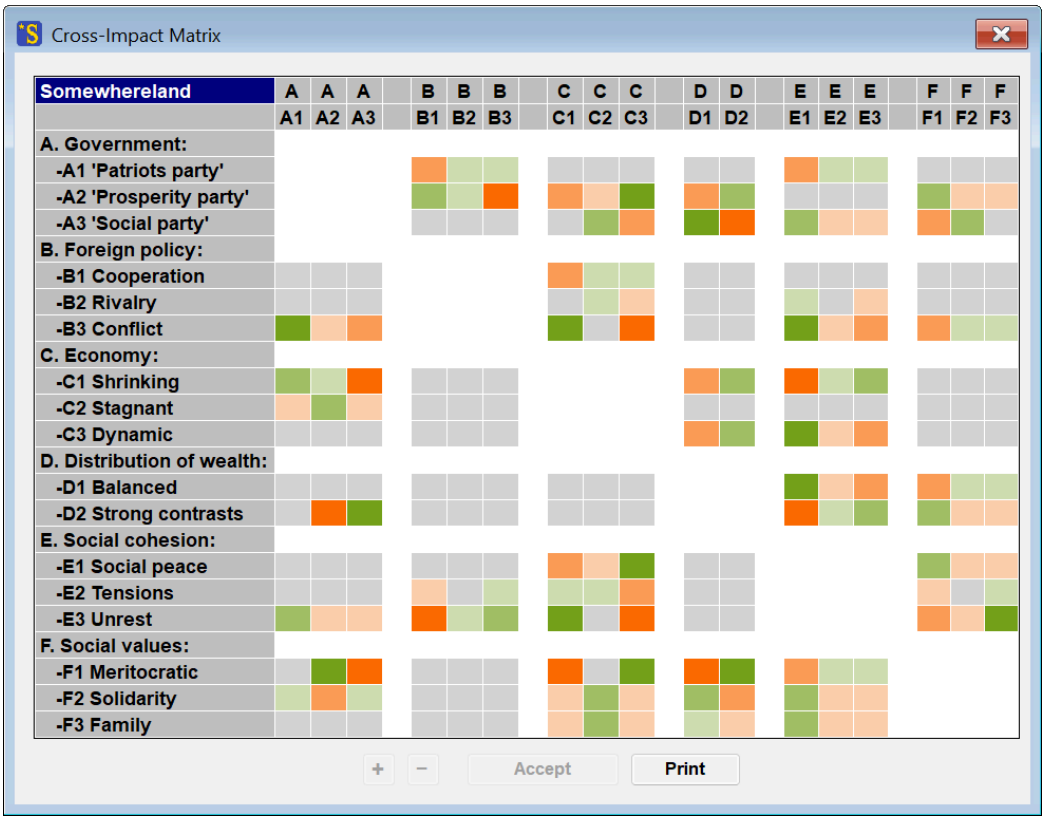


Fig. 7-5: Displaying color-coded cross-impact data in the matrix editor.

The “Color” format is intended exclusively for displaying the cross-impact data. As long as this option is activated, the cross-impact matrix cannot be edited in the matrix editor and the + and - buttons in the matrix editor are deactivated. The print function of the matrix editor does not generate a colour representation. Instead, it generates the number-based standard representation of the matrix. To print the color-coded matrix on a colour printer, a color-coded html file can be created using the

[7] Weitz N., Carlsen H., Nilsson M., Skånberg K. (2018): Towards systemic and contextual priority setting for implementing the 2030 Agenda. Sustain Sci 13, 531–548.

export function (Section 5.16) and printed directly with the browser's print function, or the html file can be transferred to a spreadsheet program such as MS Excel and printed there.

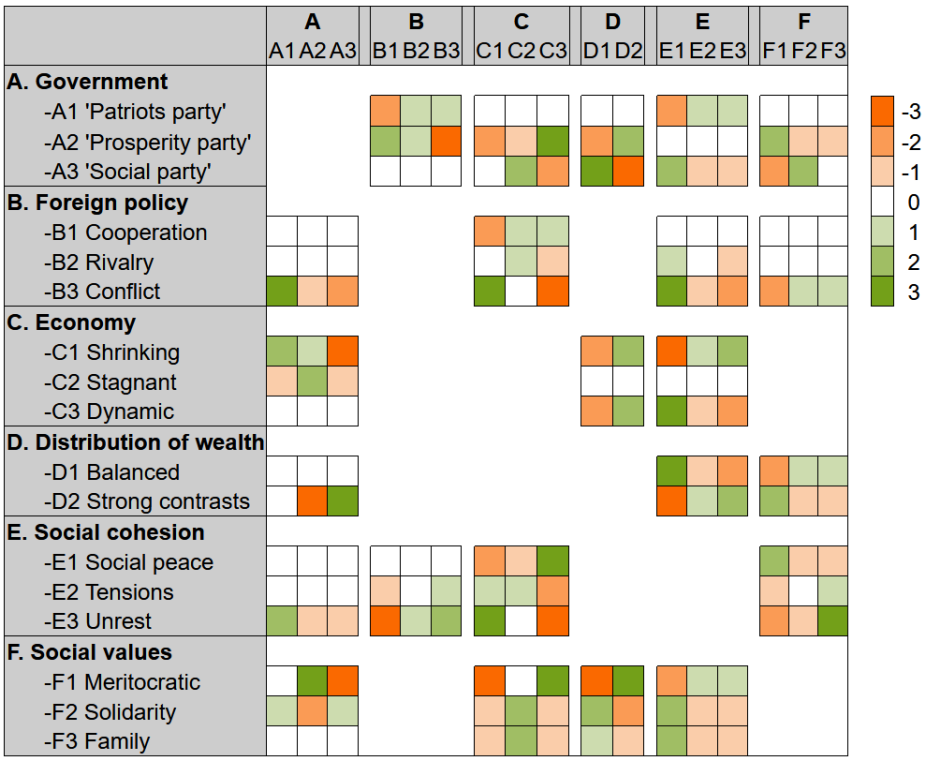


Fig. 7-6: Displaying color-coded cross-impact data via the html export function.

7.3 Descriptor types

For some analytic problems, the impacts between the descriptors differ in their strength and orientation, while they all share a common internal structure of their judgement Sections. In this case, it is possible to characterise the impact by a single number instead of a submatrix. This considerably reduces the amount of necessary data and simplifies the processes of data procurement and data quality management.

The window *Options - Descriptor type* offers some useful descriptor types (Fig. 7-7). If a descriptor type is chosen, *ScenarioWizard* will use a predefined impact pattern for all calculations and a compact representation of the matrix is used when the cross-impact matrix is edited or printed.

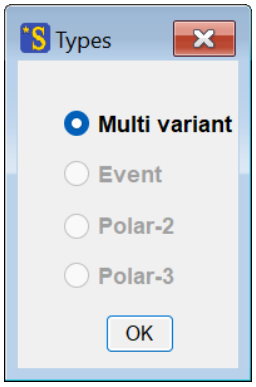


Fig. 7-7: The options window 'Descriptor type'.

The options of this window are as follows:

- The 'Multi variant' option is the default option. It represents the general case of CIB analysis without predefined impact patterns. It offers a free choice of the number of descriptor variants and the internal structure of each interrelationship.
- The 'Event' option uses a descriptor type with two variants representing a passive ('0') and an active state ('1') of the descriptor. Only the active state is assumed to cause impacts on other descriptors. For example, the judgement 'impact strength of descriptor A on descriptor B is +2' will be identified with the impact pattern

		B	
		0	1
A	0	0	0
	1	-2	+2

in this option.

- The 'Polar-2' option also uses descriptors with two variants. However, it is assumed that the variants express an opposite and cause opposite impacts (e.g. 'rising'/'falling' or 'good'/'bad'). In this case, the judgement 'impact strength of descriptor A on descriptor B is +1' will be identified with the impact pattern

-

		B	
		-	+
A	-	+1	-1
	+	-1	+1

- The ‘Polar-3’ option is similar to ‘Polar-2’ option. However, it is assumed that an additional, neutral variant exists. As a neutral variant, it causes no impacts. The judgement ‘impact strength of descriptor A on descriptor B is -3’ is expressed by the impact pattern

		B		
		-	0	+
A	-	-3	0	+3
	0	0	0	0
	+	+3	0	-3

The procedure for the use of types is different, depending on whether a new project shall be built up by using descriptor types or whether an existing project shall be transformed to descriptor types.

Building up a new project using descriptor types

Step 1: Restart *ScenarioWizard* and select a descriptor type in the window *Options - Descriptor type*.

Step 2: Open the structure editor (see Section 5.3) and enter the descriptors of the project. The structure editor operates in a different way if one of the options ‘Event’, ‘Polar-2’, or ‘Polar-3’ is selected. The state column of the editor form is invisible because only the descriptor list and descriptor names must be entered. The variants and their names (‘0’/‘+1’, ‘-1’/‘+1’, or ‘-1’/‘0’/‘+1’) are automatically assigned to each newly defined descriptor according to the chosen descriptor type.

Step 3: Enter the cross-impact date using the matrix editor (see Section 5.8). The use of an impact pattern makes it possible to portray an impact relation by a single number and to represent a cross-impact matrix in a compact way without displaying the descriptor variants. If the options ‘Event’, ‘Polar-2’, or ‘Polar-3’ are chosen, the matrix editor uses the compact representation of the matrix. The printout of a matrix will also be done in the compact format. Once the matrix editor is closed, the full cross-impact matrix is automatically generated in the program’s workspace.

Step 4: Save the project data as usual and proceed to the evaluation of the data.

The usage of descriptor types does not affect the evaluation procedures and the display of their results. In these respects, there is no difference to the default option ‘Multi variant’.

Transforming an existing project to descriptor types

Existing projects can be transformed to descriptor types if their structure is compatible with at least one of the descriptor types, i.e. all descriptors have either two variants or three variants.

Step 1: Load the file of the project to be transformed (see Section 5.2).

Step 2: Select the requested descriptor type in the window *Options - Descriptor type*. Options incompatible with the analysis structure are automatically disabled. For example, the option ‘Polar-3’ is disabled if the analysis structure contains a descriptor with more than three variants, or with less than three variants. The option ‘Multi variant’ (i.e. no use of descriptor types) is available in every

case. Once the option window is closed by clicking the 'OK' button and a warning message is confirmed, the old variant names of the analysis structure are replaced by predefined names of the selected descriptor type. The existing cross-impact data are overwritten by the selected descriptor type pattern, calibrating the pattern with the original cross-impact value in the bottom right cell of each judgement section (cell '1/1' or '+/+').

Step 3: Edit the cross-impact data using the matrix editor (see Section 5.8) if necessary.

Step 4: Save the project file as usual and proceed to the evaluation of the data.

The use of descriptor types does not affect the evaluation procedures and the display of their results.

7.4 System reset

The menu item *File - Reset* offers three functions to clear *ScenarioWizard*'s workspace either partly or completely.

Clear comments

The menu item *File - Reset - Clear comments* deletes all comments on the project, descriptors, and cross-impacts from the workspace. All data saved in project files remain unchanged, however. Only the workspace of the current *ScenarioWizard* session is affected. If any comments were modified since the last storing operation, a warning will appear before starting the clearing procedure.

Clear cross-impact data

Selecting the menu item *File - Reset - Clear cross-impact data* removes the content of the cross-impact matrix from the workspace. The analysis structure (descriptors and their variants) and all comments remain unchanged.

Reset *ScenarioWizard*

The menu item *File - Reset - Reset ScenarioWizard* resets the program to its initial state after starting. All project data in the workspace (analysis structure, cross-impact data, comments, and evaluation results) are removed and all settings are changed back to their default values.

Each type of data reset is confined to *ScenarioWizard*'s workspace, however. All data already saved in project files remain unchanged. If any project data were modified since the last storing operation, a warning will appear before starting the clearing procedure.

7.5 Language selection

ScenarioWizard supports three language versions: English, German, and Spanish. If you start *ScenarioWizard* for the first time, a window will ask you to select the language of the program. Your choice will be stored and the selected language will be used in all succeeding sessions until you make another choice.

Use the menu item *Options* - *Language* to change the initial language setting. The welcome window will then open in the selected language, and all labels, text outputs, messages, and the help function will appear in the selected language (exception: the Spanish language version uses the English help text. A Spanish version of the help function is not available). Opened windows will not be affected, but their language will change if closed and reopened.

The last valid language will be stored when *ScenarioWizard* is closed, and it will be used again for the next program session.

The language selection within *ScenarioWizard* does not affect the names stored in the project files. An analysis structure written in English will remain unchanged even if the program language mode is changed to German (and vice versa). The specification of descriptor names and variant names and the formulation of comments (including the choice of language used) are left up to the user. Furthermore, *ScenarioWizard* does not control the language of several Windows dialogs (Load file, Save file, Printer setup). The language mode of these dialogs is determined by the language settings of the installed Windows operating system.

8 The Presenter

The menu item *Presenter* starts *ScenarioWizard*'s 'Presenter Mode'. The purpose of this mode is to present data and evaluation results of a CIB analysis to an auditorium in a prestructured way. However, some functions of the Presenter Mode can be useful also for personal reflections about the analysis and its results.

After starting the Presenter, the window shown in Fig. 8-1 appears. Initially, the Presenter window is started in a full-screen mode to maximise the space available for the presentation. The window can be scaled independently from the size of *ScenarioWizard*'s main program window but some contents may be hidden.

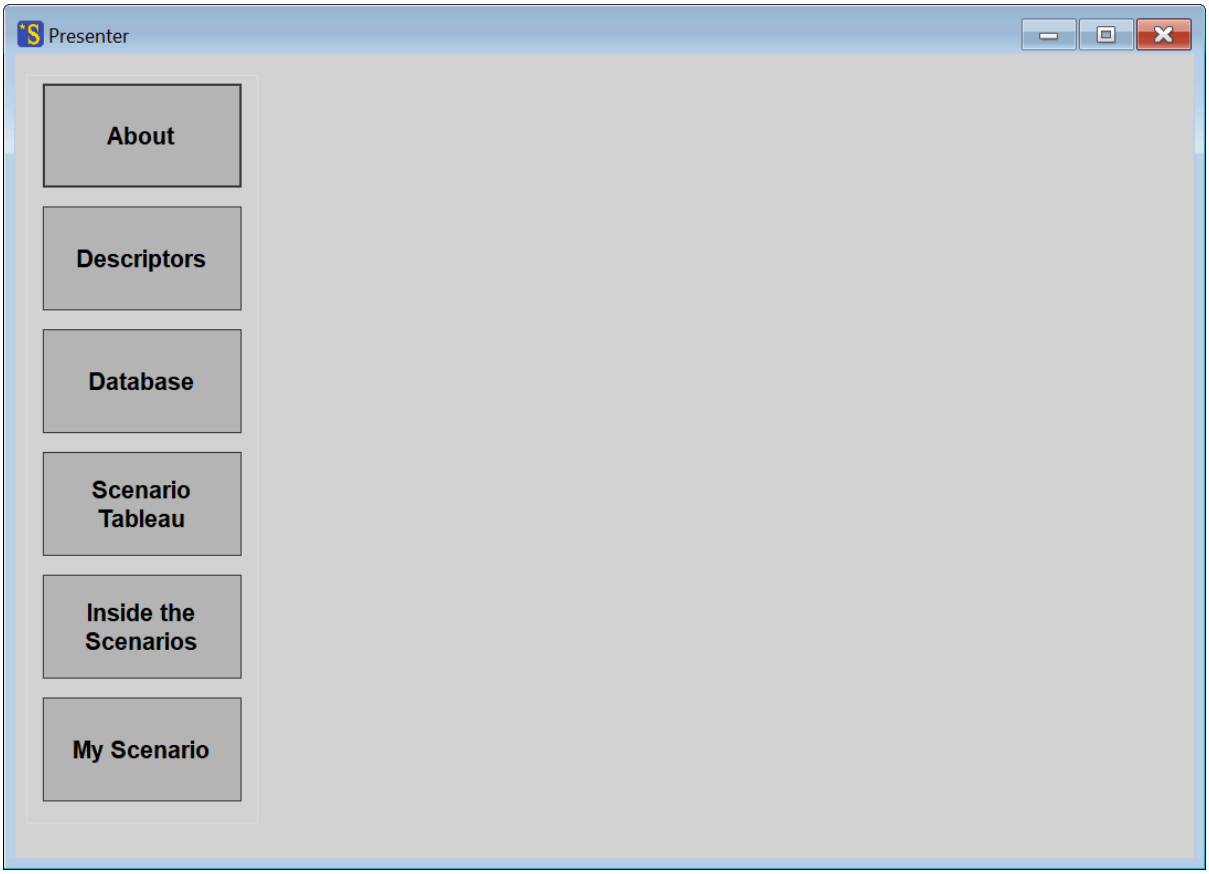


Fig. 8-1: Screenshot after starting the Presenter window.

The command bar on the left side of the window contains a column of buttons for starting six ‘chapters’. The chapters are aligned following a standard course of a CIB presentation. Nonetheless, the presentation chapters can be started in an arbitrary sequence.

The Presenter Mode is available only if a project file was loaded or built up before. As long as the project matrix is not evaluated and no scenarios are available in an activated evaluation protocol, the presenter chapters ‘Scenario Tableau’ and ‘Inside the Scenarios’ are deactivated. Both presenter chapters are available only after calculating scenarios using the menu item *Consistent scenarios* (see Section 6.4) or loading a scenario list using the menu item *File - Load solution set* (see Section 6.4, paragraph ‘Saving’).

Both chapters are deactivated also in the case of solution sets consisting of more than 50 scenarios because it appears unmanageable to discuss larger scenario sets during a presentation. For large scenario sets, it is advisable to prepare a selection of scenarios in advance and to store the selection in a separate solution set (SL file), which is used during the presentation.

All Presenter functions are deliberately programmed in a way that avoids any control actions besides simple mouse clicks. The intention is to ease the usage of the Presenter on touch-screen computers.

The presenter chapters are described step by step in the following paragraphs. Because the Presenter Mode is intended basically for presentation purposes, all display elements used in the Presenter are locked for input.

8.1 ‘About’ Chapter

The purpose of the Presenter's opening chapter ‘About’ is to offer basic information about the project to the auditorium. After pressing the button ‘About’, the project description text (as entered in the structure editor (Section 5.4) or in the matrix editor (Section 5.10)) is displayed. Information about the topic, goal of the analysis, working steps of the project, and contributors might be included in this text. In the simplest case, the project description consists of plain unformatted text as shown in Fig. 8-2.

The font size of the text can be changed using the output option ‘Display font’ (Section 7.2).

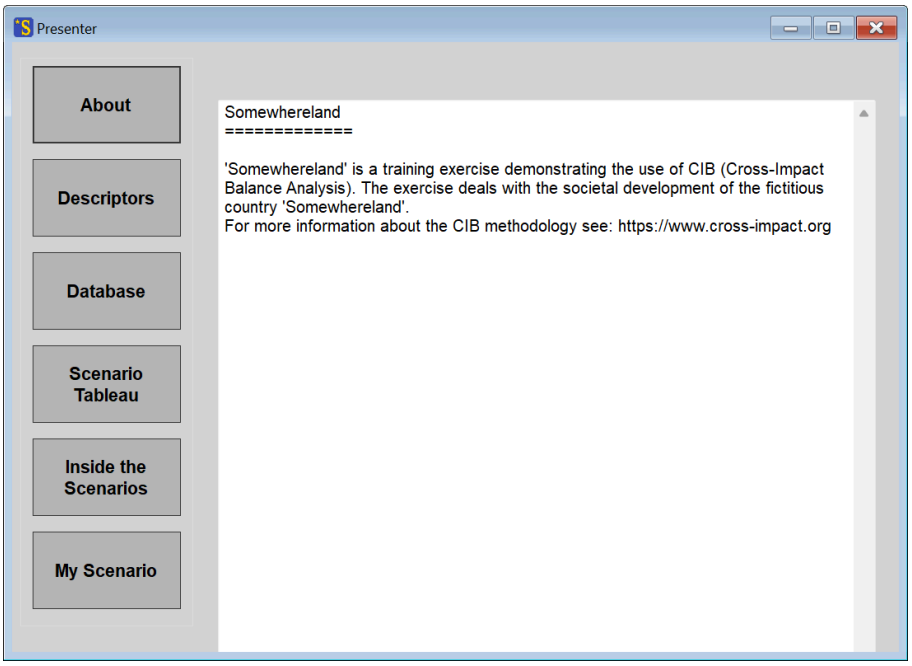


Fig. 8-2: Presenter chapter ‘About’: plain text project description.

A more appealing layout of the project description can be achieved using html-formatted text. Project description text starting with the tag <html> and ending with the tag </html> will be displayed using an internal browser and all usual html tags can be applied for formatting the project description text. If the computer is connected to the Internet, links can also be used. An example of an html-formatted ‘About’ chapter is shown in Fig. 8-3.

If no project description text is defined, the button ‘About’ is deactivated and displayed in dark grey.

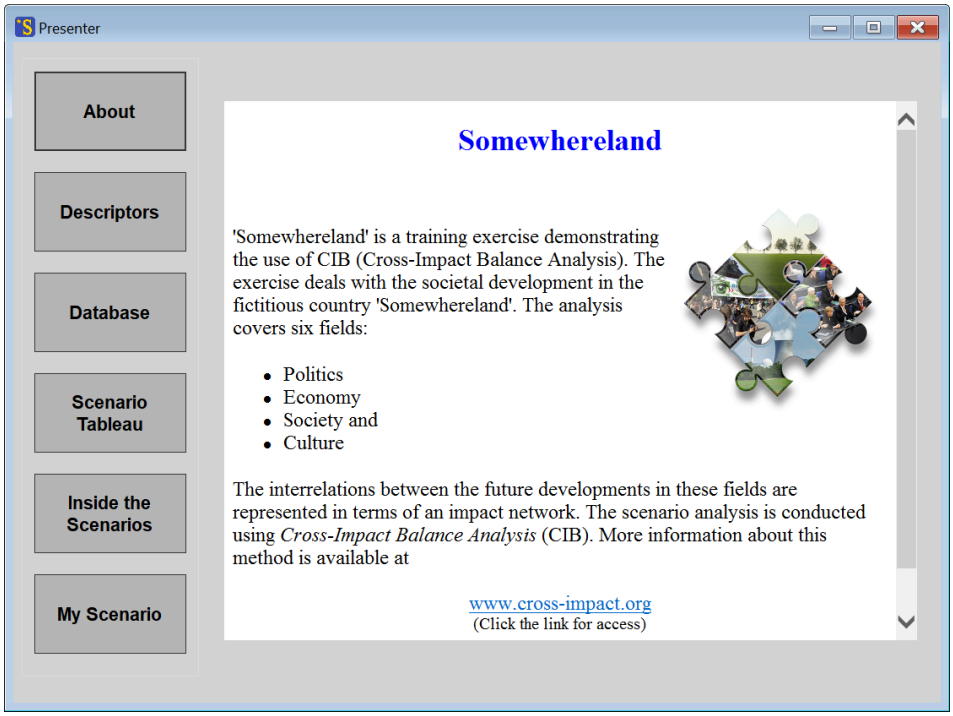


Fig. 8-3: Presenter chapter 'About': html-formatted project description.

8.2 'Descriptors' Chapter

This Presenter chapter deals with the descriptors of the scenario analysis and the alternative futures (variants) assigned to the descriptors. After pressing the button 'Descriptors', the list of descriptors is displayed (Fig. 8-4). Again, the font size of the text can be changed using the output option 'Display font' (Section 7.2).

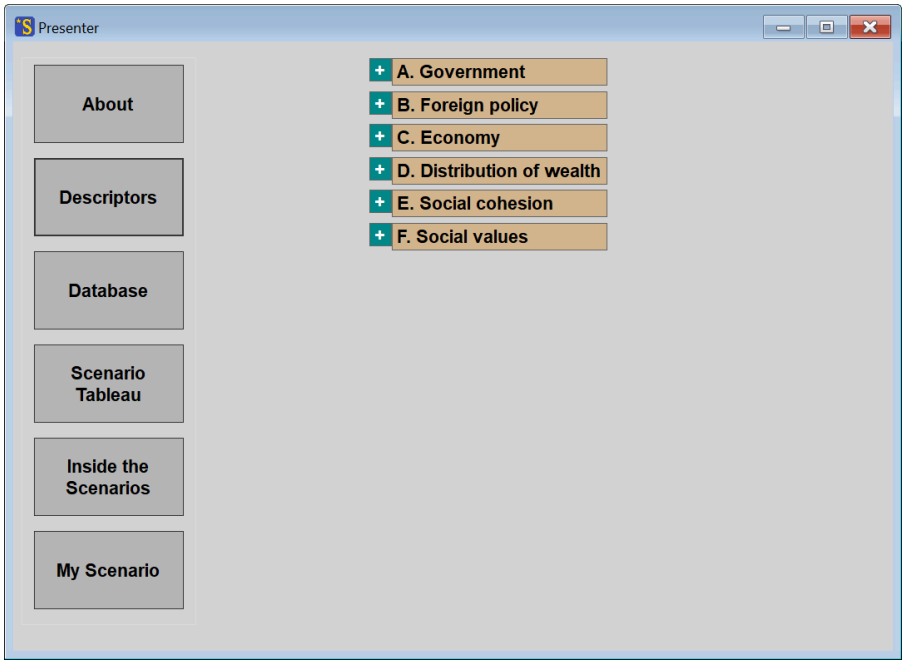


Fig. 8-4: The Presenter window after starting the 'Descriptors' chapter.

Clicking on the '+' label on the left side of a descriptor expands the descriptor box and displays the descriptor variants (Fig. 8-5).

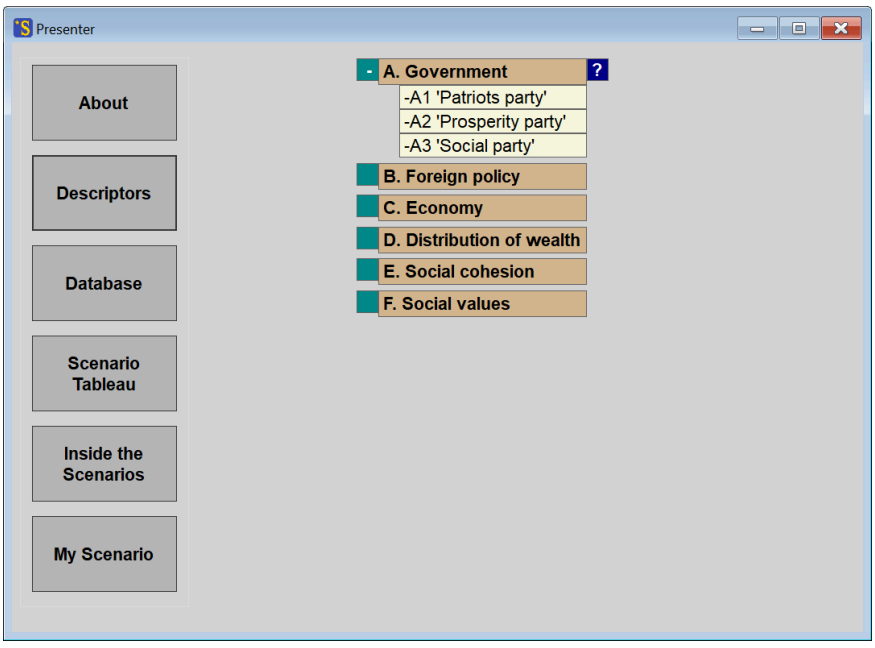


Fig. 8-5: Presenter chapter 'Descriptors': expanded descriptor box.

Clicking again on the same label (now marked by '-') will fold in the list of variants. As long as the list of variants is displayed for a descriptor, the expansion labels of all other descriptors are deactivated.

Whilst a descriptor box is expanded as shown in Fig. 8-5 the blue '?' label on the right side of the descriptor box can be used for displaying the respective descriptor comment (see Section 5.4 and Section 5.10). This is shown in Fig. 8-6. Clicking again on the same label (now marked by 'X') will close the text window.

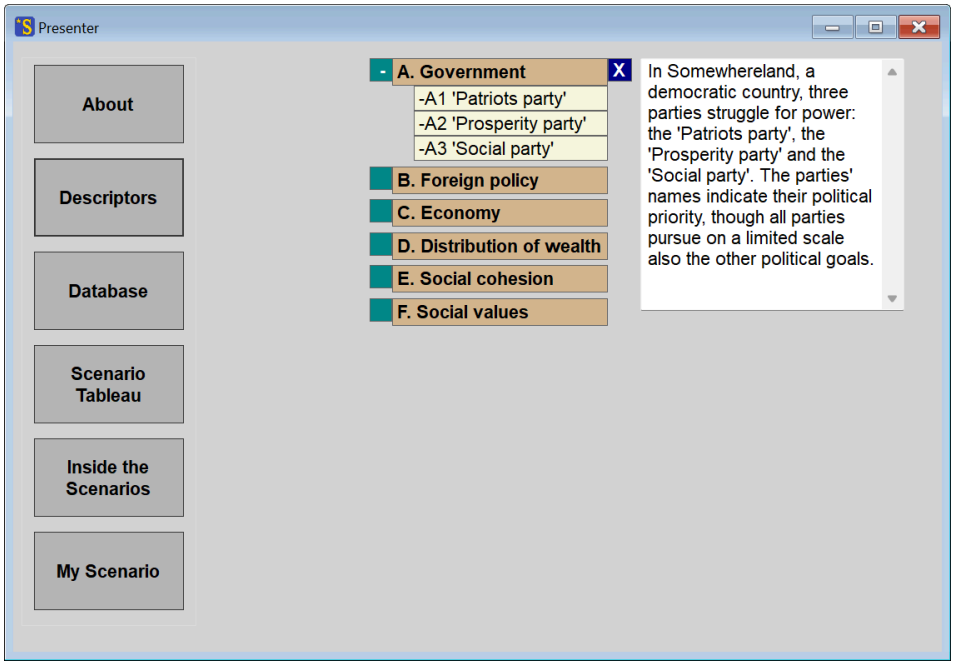


Fig. 8-6: Presenter chapter 'Descriptors': variant list and comment window.

Due to length limitations, very long variant names may be displayed incompletely. In this case, the complete name of a variant can be depicted by clicking on the name label using the left mouse button. While the mouse button is pressed down, the name label will be expanded to show the complete name. Once the mouse button is released, the name label shrinks to its normal size.

8.3 ‘Database’ Chapter

The purpose of the Presenter chapter ‘Database’ is to display the database of the analysis, i.e. the cross-impact data and their textual explanations. After starting the chapter, the Presenter displays a diagram showing for which impact relations the database contains information. The colour of a node indicates if the database provides cross-impact data, or text, or both types of information about this node (connectivity chart).

Again, the font size of the text can be changed using the output option ‘Display font’ (Section 7.2).

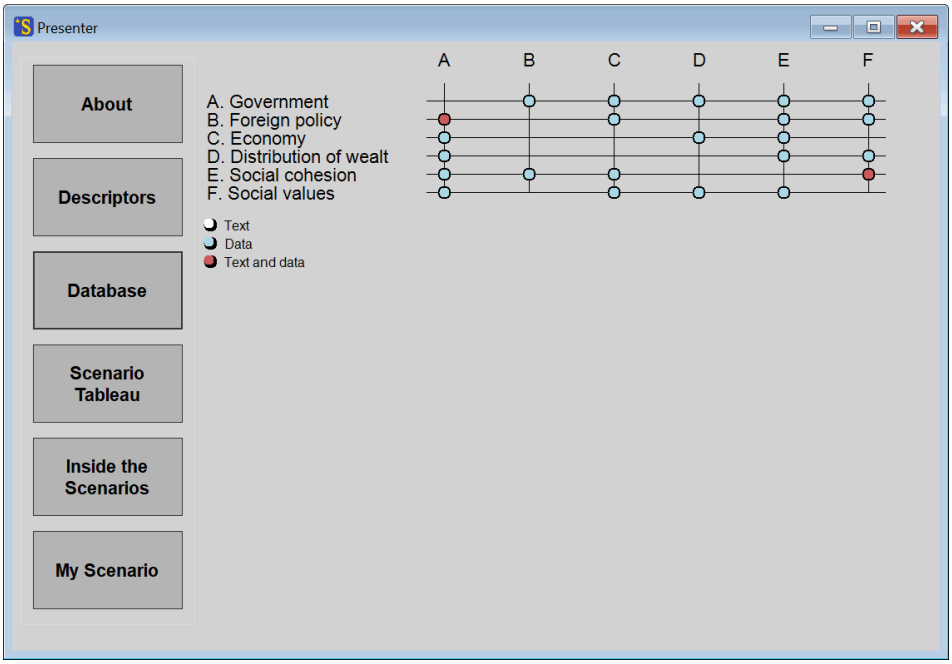


Fig. 8-7: Presenter chapter ‘Database’: connectivity chart.

Long descriptor names will be truncated, if necessary, to ensure sufficient space for the connectivity chart. When preparing a presentation about a CIB analysis with very long descriptor names, it is advisable to build a presentation version of the project file and to use appropriate abbreviations of the descriptor names in the presentation version.

The connectivity chart serves as an access point leading to further database content. Clicking on a descriptor name opens a text box showing the respective descriptor explanation text (Fig. 8-8).

Clicking on a node of the connectivity chart produces the cross-impact data of the respective impact relation and the associated explanations (if available), as shown in Fig. 8-9. The text window can be

scrolled for complete access to a long explanation text. The selected node is marked by yellow colour.

Large matrices and the choice of a large font size can result in a connectivity chart that is too large to be displayed entirely on the Presenter window. The Presenter will automatically reduce the font size in those cases.

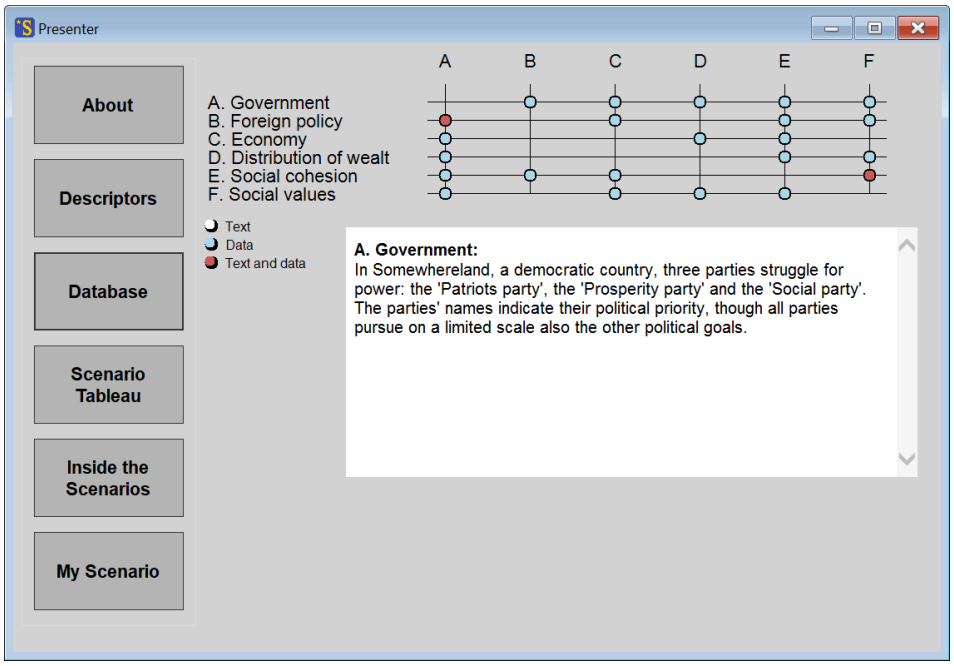


Fig. 8-8: Presenter chapter ‘Database’: displaying a descriptor essay.

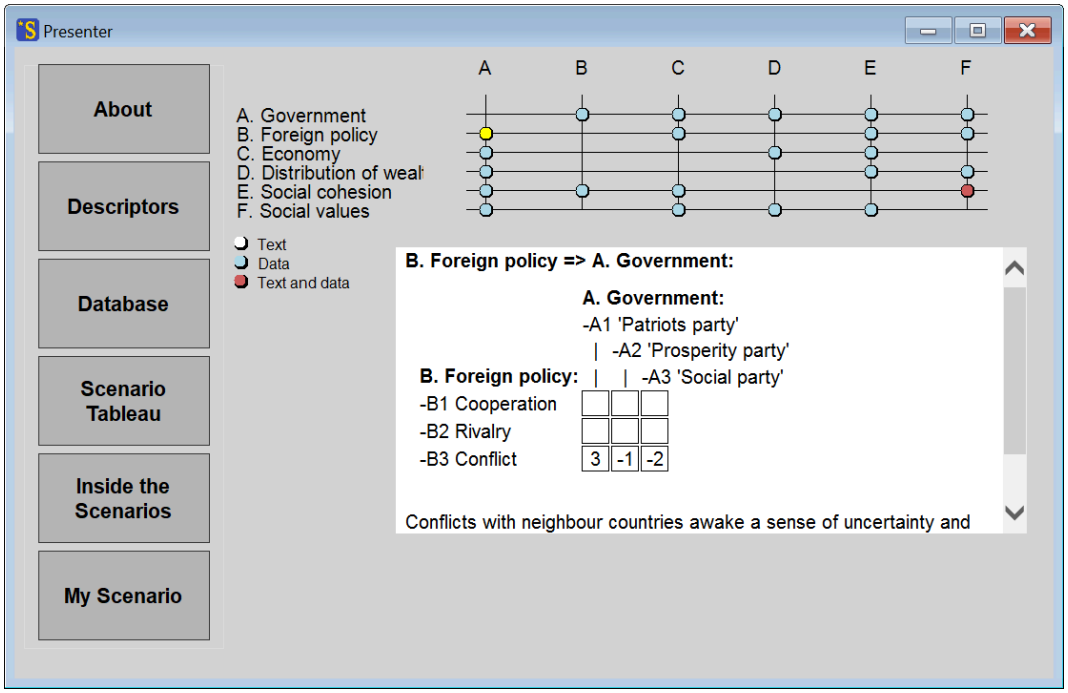


Fig. 8-9: Presenter chapter 'Database': displaying cross-impact data.

8.4 'Scenario Tableau' Chapter

The Presenter chapter 'Scenario Tableau' aims at displaying all scenarios in an integrated way. The chapter is available only after scenarios are calculated using the menu item *Consistent scenarios* (see Section 6.4) or loaded using the menu item *File - Load solution set* (see Section 6.4, paragraph 'Saving'). Otherwise, the 'Scenario Tableau' button is depicted in dark grey and deactivated.

After pressing the 'Scenario Tableau' button, all current scenarios are shown in a representation equivalent to the representation described in Section 6.5. Different from the scenario tableau function presented in Section 6.5, the user cannot edit or modify the tableau during a Presenter session.

The font size used in the tableau can be changed using the output option 'Display font' (Section 7.2).

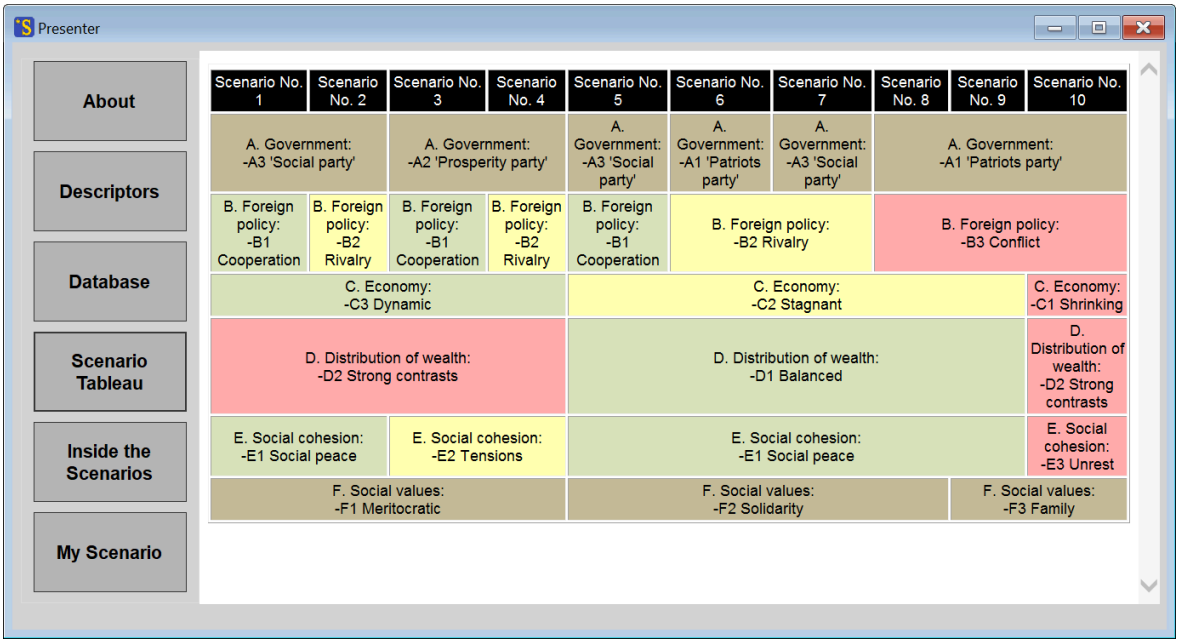


Fig. 8-10: Presenter chapter 'Scenario Tableau': depiction of a scenario set.

8.5 'Inside the Scenarios' Chapter

This chapter is also available only after scenarios are calculated using the menu item *Consistent scenarios* (see Section 6.4) or loaded using the menu item *File - Load solution set* (see Section 6.4, paragraph 'Saving'). Otherwise, the 'Inside the Scenarios' button is depicted in dark grey and deactivated. The purpose of the chapter is to take a closer look at a single scenario and unveil its internal logic structure.

Selecting a scenario to be scrutinised

Pressing the 'Inside the Scenarios' button produces an array of buttons, one for each scenario listed in the evaluation protocol. The buttons are labelled with the scenario number (assigned in the evaluation protocol) or if available, the scenario title (see Section 6.5, paragraph 'Scenario titles'). Using

the scenario titles of the Somewhereland exercise shown in Fig. 2-4, the Presenter displays the screenshot shown in Fig. 8-11.

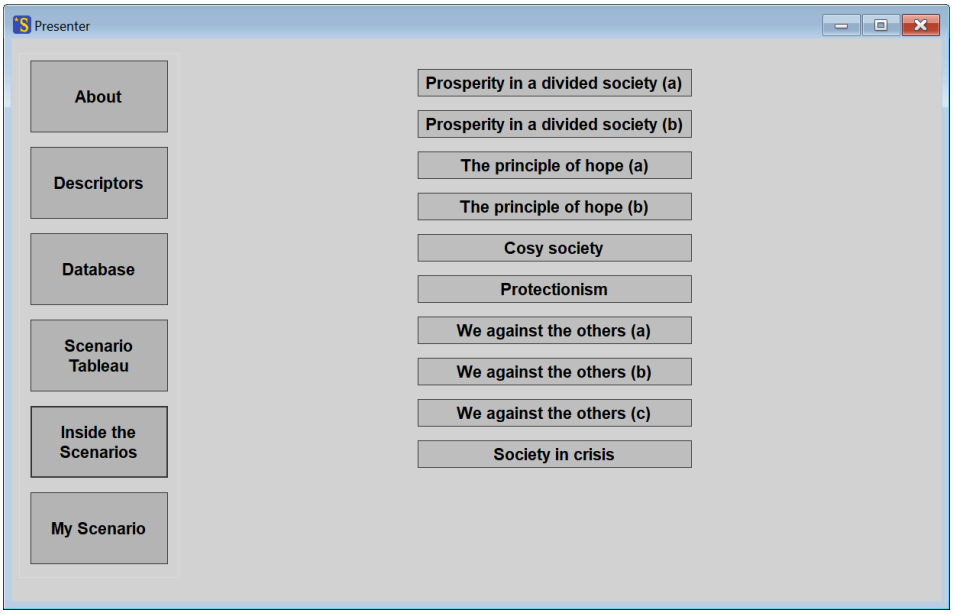


Fig. 8-11: Presenter chapter 'Inside the Scenarios': selecting a scenario.

In the case of subsequent scenarios with identical titles, the Presenter attaches an identification suffix (a), (b), etc. to the scenario title. The use of identical titles for a group of scenarios makes sense to express their similarity and their affiliation to a scenario family.

Mapping the scenario

Pressing one of the scenario buttons draws the respective scenario using an array of descriptor boxes showing the descriptor name in the upper part and the allocated future variant in the lower part (Fig. 8-12**).**

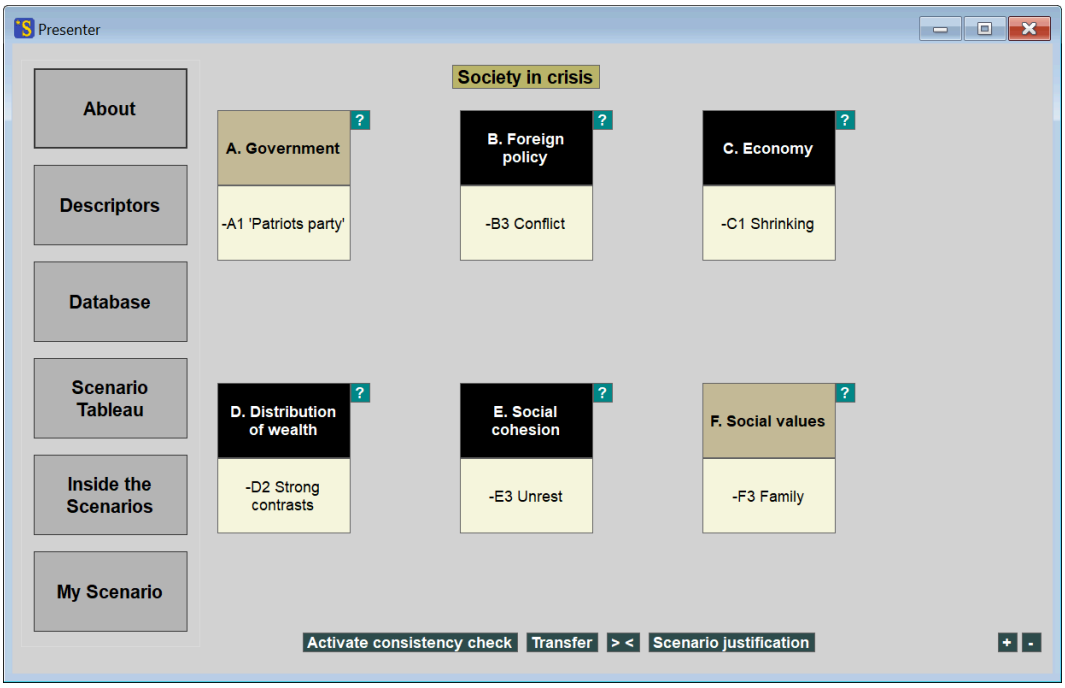


Fig. 8-12: Presenter chapter ‘Inside the Scenarios’: depiction of the ‘Society in crisis’ scenario.

Checking the scenario consistency

A consistency check of the scenario can be activated by clicking on the dark green button at the bottom of the window. The lower part of each consistent descriptor will be depicted in light green colour. In the case of an inconsistent descriptor, the lower part of the respective descriptor box is coloured in red. Different intensity shades indicate how strong the consistency or inconsistency of a descriptor turns out to be. When deciding which descriptors are coloured in green or in red, the evaluation option "maximum inconsistency" (Section 7.1) is also considered, i.e. with an allowed inconsistency of 2, a descriptor with inconsistency 1 would be coloured green. Consistency 0 (or an inconsistency corresponding to the maximum allowed inconsistency) is represented by beige colour.

Not surprisingly, the consistency check of the ‘Society in crisis’ scenario shown in Fig. 8-12 leads to green marks with varying intensity for all descriptors. Finally, this scenario is the result of the ‘Consistent scenarios’ evaluation, and the result of the consistency check is simply a confirmation of the validity of the calculation. The actual purpose of the consistency check is to study the effect of scenario modifications on the descriptor's consistency. This can be demonstrated by changing the assumed variant for a descriptor by clicking on the descriptor name. The Presenter changes the variant to the next item of the descriptor's list of variants and updates all consistency assessments. In the case where the last variant is active before clicking, the Presenter jumps back to the first item of the variant list. For instance, clicking on the box ‘B3. Conflict’ (lower part of descriptor box ‘B. Foreign policy’) produces (where "B. Foreign policy" is more inconsistent than "C. Economic performance" and therefore coloured in a deeper shade of red. See Fig. 8-13**)**. The scenario title label is now empty, since the modified scenario no longer corresponds to the original scenario "Society in crisis". If fur-

ther modifications of descriptor variants finally result in a member of the scenario selection (Fig. 8-11) again, the corresponding scenario title is displayed.

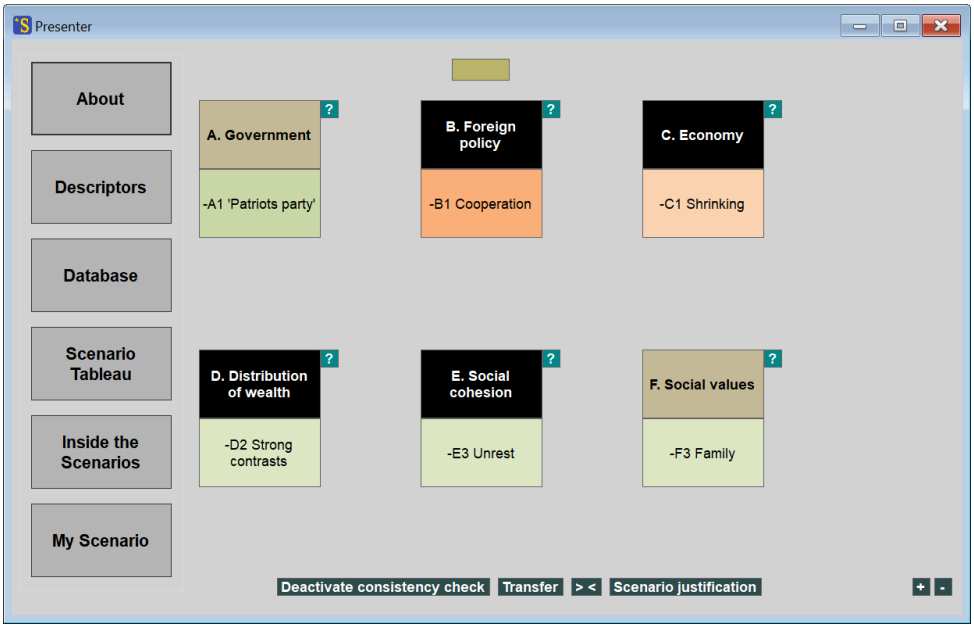


Fig. 8-13: Presenter chapter 'Inside the Scenarios': activated consistency check.

The assigned future variant of descriptor 'B. Foreign policy' changes from 'B3. Conflict' to 'B1. Cooperation'. The consistency check immediately identifies that the descriptor 'B. Foreign policy' itself and the descriptor 'C. Economy' become inconsistent as a result of this change.

After activating the consistency check, the button 'Activate consistency check' is renamed to 'Deactivate consistency check'. Pressing the button again will deactivate the function and restore the original caption of the button.

Saving a modified scenario

In the course of a presentation, discussions may lead to the desire to modify a scenario and to store the modified scenario. The dark green button 'Transfer' at the bottom of the window offers the opportunity to copy the modified scenario to the evaluation protocol and to supplement the protocol's scenario list. So far, the modified scenario is stored only until the evaluation protocol is closed, however. For permanent storage of the modified scenario, the expanded scenario list should be stored using the 'Save' button of the evaluation protocol before closing the protocol window.

The Presenter assigns the titles 'MyScenario 1', 'MyScenario 2', etc. to the supplemented scenarios. The user can change the scenario titles using the 'Tableau' function of the evaluation protocol (see Section 6.5).

Function 'Transfer' is not available while window 'Filter' or 'Selection manager' is active.

Scaling the size of the descriptor boxes

When generating the Presenter window, the software decides on the size of the descriptor boxes in consideration of the maximum length of descriptor names, number of descriptors, font size chosen by the user, and size of the Presenter window. Scenarios with a large number of descriptors will cover more or less the entire available space. Scenarios with a small number of descriptors may use only a small part of the window, because Presenter limits the boxes to a size necessary to contain the longest caption, including the option of word divisions.

However, the user can change the box size using the [+] and [-] buttons on the bottom of the Presenter window. Hint: The [+] and [-] buttons do not modify the font size. The font size can be selected via the 'Output options' (see Section 7.2).

Impact diagrams (incoming impacts)

A natural question from an auditorium when faced with Fig. 8-12 is to ask for an explanation of the consistency assessments. As a support for explaining the consistency assessments, the Presenter offers impact diagrams. Clicking on the dark green control boxes on the right side of a descriptor box (marked with '?') produces the impact diagram of the respective descriptor ('focus descriptor'). The focus descriptor changes the colour of its lower part to dark khaki. Descriptors without direct impact on the future variant assumed for the focus descriptor are hidden. Impacting descriptors show their influence on the focus descriptor by issuing green (promoting) or red (hindering) arrows (Fig. 8-14).

The thickness of an arrow indicates the impact strength. The latter is also indicated by a number near the arrowhead. The impact sum of the focus descriptor (sum of all impacts pointing at the focus descriptor) is shown in a dark blue box beneath the focus descriptor box.

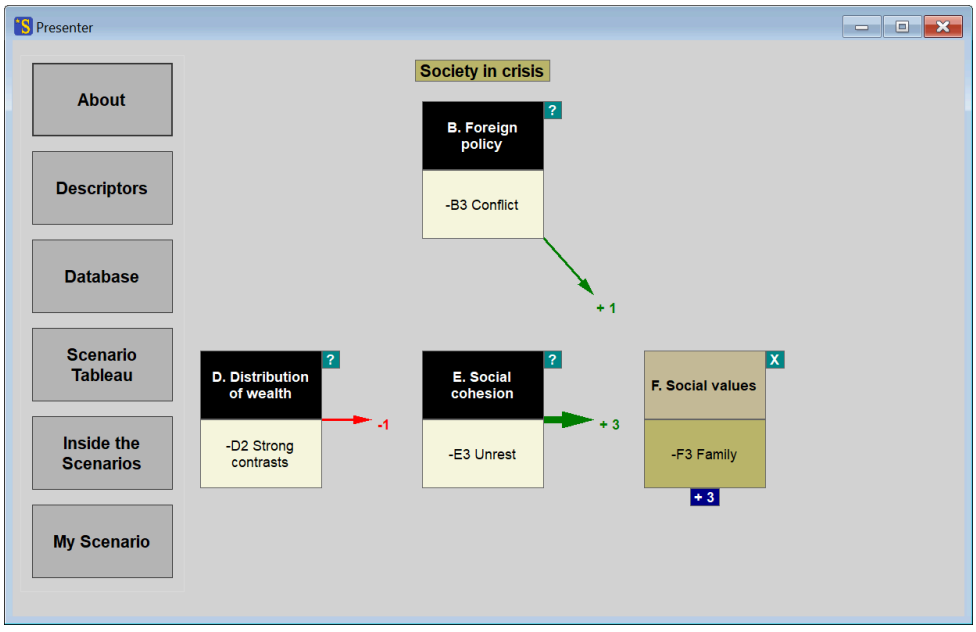


Fig. 8-14: Presenter chapter 'Inside the Scenarios': impact diagram explaining consistency assessments.

The effect of changing the focus descriptor's future variant can be demonstrated by clicking on the lower part of the focus descriptor box. The next item of the focus descriptor's variant list is selected and the impact diagram is updated. Consistency means that a change in variant will never improve the impact sum of the focus descriptor. In the case of inconsistent descriptors, there will be at least one variant that achieves a higher impact sum and therefore, would have been a more appropriate choice of the focus descriptor's assumed future.

For a deeper understanding of the impact relations depicted by the impact diagram, the impact comments can be retrieved, if available. This can be done by clicking on the green control boxes marked by '?' and located on the right side of the box of each impacting descriptor. In Fig. 8-15, this is shown for the descriptor 'E. Social cohesion'.

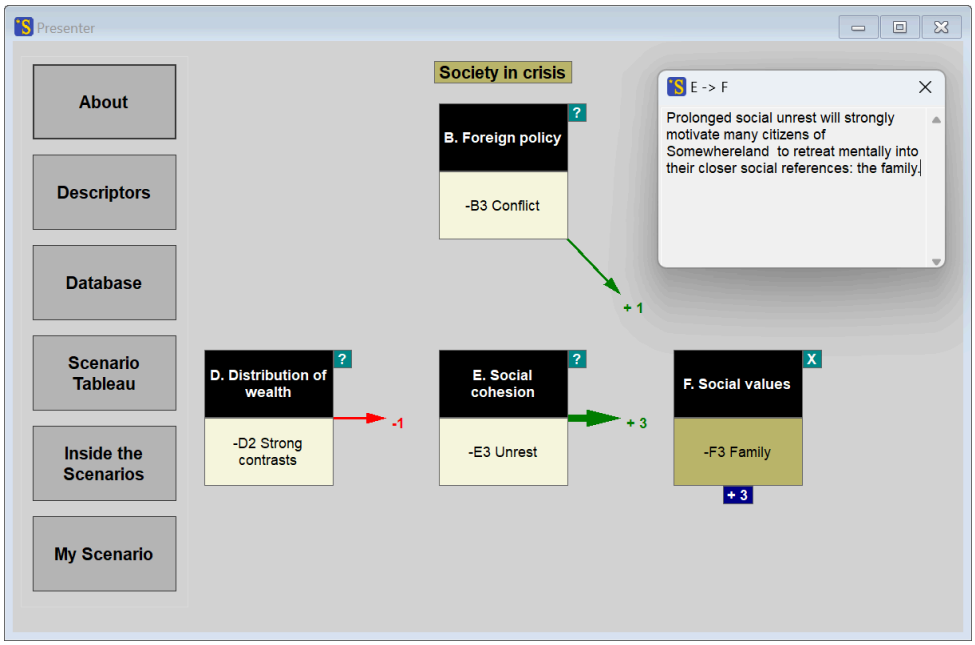


Fig. 8-15: Presenter chapter 'Inside the Scenarios': displaying explanatory text about impact relations.

The text box can be resized or moved by 'click and drag' using the mouse. It can be closed by clicking on the red closing button on the upper right side of the text box. Clicking on the control button of the focus descriptor (marked by 'X') will close the impact diagram and the Presenter returns to the general scenario map shown in Fig. 8-12 and Fig. 8-13.

Impact diagrams (outgoing impacts)

A different type of impact diagram can be requested by clicking on the dark green '> <' button on the bottom of Fig. 8-12. The button is renamed to '< >', indicating that, from now on, impact diagrams will display the outgoing impacts of a focus descriptor, instead of the incoming impacts (see Fig. 8-16). Clicking again on the same button restores the original mode.

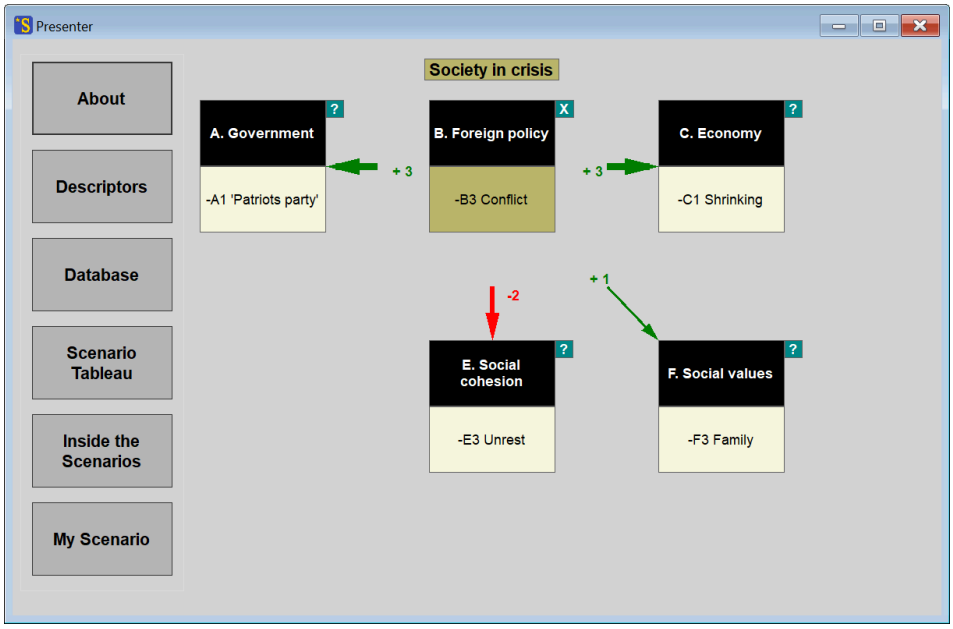


Fig. 8-16: Presenter chapter 'Inside the Scenarios': impact diagram displaying outgoing impacts of the focus descriptor.

Scenario justification

As an alternative to the analysis presented above, which focuses on a single descriptor at a time, the presenter also offers a compact overview of the reasons behind all developments of a scenario. To do so, click on the "X" control box next to the focus descriptor "B. Foreign Policy" to close the diagram shown in Fig. 8-16 and the Presenter returns to the diagram Fig. 8-12**.**

Clicking on the green "Scenario justification" control box at the bottom creates a table that shows for each descriptor, shown in light brown on the left in Fig. 8-17, which of the other descriptor are promoting because of their active variants (green-coloured descriptors) and which are hindering (red-coloured descriptors). The colour shade indicates the strength of the influence, with dark shades representing strong influences. The influencing descriptors are ordered in each row so that each row on the left begins with the strongest promoting influences and ends with the strongest hindering influences.

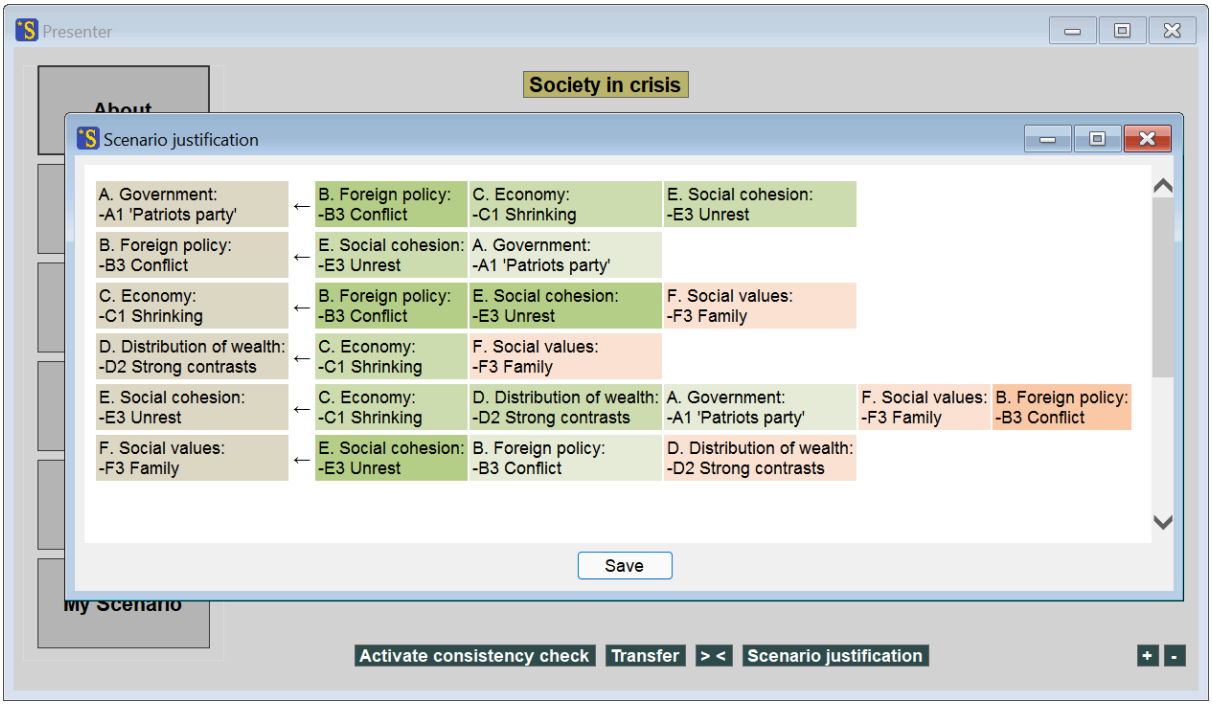


Fig. 8-17: List representation of the promoting and hindering influences in the “Society in crisis” scenario.

The table enables an argumentative interpretation of the scenario examined. It shows, for example, that the reason for the shrinking economy assumed in the scenario is the presence of a confrontational foreign policy and social unrest, and that the effect of the family-oriented value system, which is in itself favourable for economic development, is too weak to compensate for these negative economic influences.

When you click on one of the red or green cross-impact boxes, the display jumps to the textual explanations for this impact (see Section 5.10), provided that such explanations have been entered. Clicking on a cross-impact box without a stored explanation has no effect.

The table can be saved as an html file by clicking on the "Save" button. By changing the font size setting in the "Output options" window (Section 7.2), the font display in the justification table can also be enlarged or reduced. However, a change in the font size setting will only take effect the next time the table window is opened.

8.6 ‘My Scenario’ Chapter

The purpose of the Presenter chapter ‘My Scenario’ is to design a scenario following the ideas of the auditorium.

The functions of the chapter are identical to the functions of the Presenter chapter ‘Inside the Scenarios’ (Section 8.5). However, this chapter starts with a neutral basic state of the scenario: each descriptor is set as the first item of its variant list. Now the user can select the desired variant for each descriptor by clicking on the lower part of each descriptor box. After pressing the ‘Activate consistency check’ button, all inconsistencies of the chosen scenario are marked by red colour. A click on the control box ‘?’ of an inconsistent descriptor shows the reasons behind the inconsistency by displaying the impact diagram of the descriptor.

Once the auditorium is satisfied with the scenario, it can be transferred to the evaluation protocol by pressing the ‘Transfer’ button regardless of its consistency status (if the evaluation protocol is not active, it will be automatically opened once the ‘Transfer’ button is used). For permanent storage of the scenario, the content of the evaluation protocol should be stored using the ‘Save’ button of the evaluation protocol before closing the protocol window.

The Presenter chapter ‘My Scenario’ is particularly suitable to demonstrate the difficulties of an unsystematic scenario construction. Especially in the case of large matrices, it is instructive to observe how fixing the inconsistency of one descriptor can generate new inconsistencies for other descriptors.

9 Technical information

9.1 Limitations

The limitations for the size of *ScenarioWizard 5.1* data structures are as follows:

- Not more than 199 descriptors;
- Not more than 9 variants for each descriptor;
- Not more than 99 ensemble members;
- The sorting function is enabled for scenario lists up to a maximum of 10,000 scenarios.
- A maximum of 1 million consistent scenarios can be registered per evaluation. The calculated scenario list is only displayed in the evaluation protocol if it contains a maximum of 1,000 scenarios in coded or short name representation or a maximum of 200 scenarios in long name representation. If these values are exceeded, the scenarios are not displayed directly, but they are available in the software's working memory for evaluations;
- In the course of the evaluations “Consistent scenarios” including weight calculation (cf. Section 7.1) or activated option “Calculate cycles”, solutions will be found by the evaluation procedure if the length of their transient plus the cycle period does not exceed 300 iteration steps. A transgression of this limit is indicated by “cycles” of period 299 in the evaluation protocol. In this case, the list of solutions may be incomplete and the weights are not valid. In practice such cases are extremely rare. Typical values for the length of cycle periods and transients are about 10 or less. In case of an evaluation “Consistent scenarios” without weight calculation (default setting) there is no such limitation. All solutions will be identified by the search algorithm also in the (rare) case of excessive transient length.
- The Presenter mode is limited to import max. 50 scenarios from the evaluation protocol. The total number of scenarios in the Presenter mode, including all "MyScenarios" generated during a presentation, is limited to max. 100 scenarios.

The limit values are by far sufficient to carry out a cross-impact analysis of typical size. In the case of large descriptor and variant numbers, the computation time is more likely to put a limit on the size of the matrix.

9.2 Evaluation speed

The evaluation speed of the *ScenarioWizard* on a standard PC is sufficient to solve small and medium-sized cross-impact matrices (up to around 17 descriptors and around 40-50 variants) instantaneously or within a few seconds. The following notes apply to large matrices:

The evaluation speed of *ScenarioWizard* has been substantially increased in Version 5 by implementing the Warp Solver, which makes it possible to solve much larger cross-impact matrices than before. While matrices with a typical mixture of descriptors with 2, 3 and occasionally 4 variants up to a descriptor count of around 23 were solved within an hour on an average PC, it is now possible to completely solve matrices with around 40 descriptors (and a configuration space larger by a factor of around 10 million) in the same period of time if typical practice conditions are met (see below). Matrices with particularly favourable properties (see below) can also be solved with considerably more than 40 descriptors in practicable time periods.

The principle of the Warp Solver is to identify parts of the configuration space in which the occurrence of consistent scenarios can be reliably excluded and then to skip these parts when searching for solutions. On the one hand, this principle enables a significant acceleration in the evaluation of large matrices. On the other hand, however, it also means that the evaluation time of a matrix is difficult to estimate in advance, as it depends considerably on the data of the matrix. It should be noted in particular:

- The evaluation speed of the Warp Solver generally increases with the size of the matrix. This means that a matrix with a configuration space 10 times larger than that of a comparison matrix requires significantly less than 10 times the time for evaluation.
- The evaluation speed depends considerably on the data of the matrix, in particular on the connectivity of the descriptors, i.e. the average number of influencing descriptors per descriptor. Matrices with low connectivity are evaluated faster than densely connected matrices.
- The evaluation progress, as displayed in the software's progress bar, is often unsteady: phases of rapid progress alternate with phases of apparent standstill. This is due to the fact that the Warp Solver can sometimes skip larger sections of the configuration space, but occasionally also has to clarify parts of the configuration space on a small scale.

If the calculation times for very large matrices are impractically high despite the acceleration effect of the Warp Solver, an approximate evaluation with the Monte Carlo option should be considered (cf. Section 7.1).

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12 Glossary

Analysis structure

The set of descriptors and their alternative variants is called the 'analysis structure' because they define the extents and limits of a CIB analysis in a fundamental manner.

Attractor weights

Attractor weight (combinatorial weight) is a number for characterising scenarios. The attractor weight indicates how often a scenario is found by a *scenario succession* if all possible descriptor variant combinations are used as a start scenario of the scenario succession (see glossary entry 'Succession').

This means that the ratio of a scenario's attractor weight and the total number of possible descriptor variant combinations indicates the probability of finding this scenario by applying succession on a random start scenario.

Autonomous descriptors

(Primary) autonomous descriptors are not objects to any impacts within a cross-impact matrix. I.e. the column of an autonomous descriptor is completely filled with zeros.

Secondary autonomous descriptors are influenced only by primary autonomous descriptors.

Bias

A descriptor is biased if the maximum impact score of a randomly chosen scenario is assigned more frequently to some descriptor variants than to others.

Coded representation of a scenario

An example of a coded scenario representation is '2 1 3 2'. The code indicates that the scenario consists of four descriptors. The first descriptor takes variant no. 2, the second variant no. 1, the third variant no. 3, and the fourth variant no. 2.

Descriptor

A system element, which is required to describe the state or the development of a system or the influences that determine the system behaviour.

Echo

(Impact) Echoes are a special type of indirect impact path-

ways coming from an impact source to an intermediate descriptor and directly back to the impact source. That is, if descriptor variant A1 impacts descriptor variant B3, and B3 in turn affects A1, then A1 receives an 'impact echo' from B3. If the impact strengths of both parts of this impact pathway show the same sign, the echo stabilises the impact source A1; otherwise, it unfolds a destabilising effect. Echoes can be identified using the pathway analysis function of *ScenarioWizard* (see Section 6.12).

Ensemble

A system may be represented by more than one cross-impact matrix. This can be the case if different experts are asked to design a qualitative model of the system under consideration, and each of them codes his/her model as a separate cross-impact matrix. The elicitation of different expert opinions is a suitable procedure to obtain a broader view of a system and to obtain information about the uncertainties of judgements. A set of cross-impact matrices, each of them concerning the same system, is called a 'matrix ensemble'. Discrepancies between the members of the ensemble express judgement difficulties or indicate a dissent of expert opinions. *ScenarioWizard* provides several procedures to handle matrix ensembles.

Ensemble mode and normal mode

There are two operation modes of *ScenarioWizard*. In the normal mode, only menu items intended to process single cross-impact matrices, are enabled. In the ensemble mode, only menu items intended to process a set of cross-impact matrices (the ensemble) are enabled. *ScenarioWizard* automatically switches between both operation modes.

Ensemble weight

Ensemble weights are calculated in the course of an ensemble scenario evaluation (see Section 6.9). In this evaluation, scenarios are calculated for a set of several cross-impact matrices (ensemble members), sharing a common analysis structure, yet differing in their cross-impact data. The ensemble weight of a scenario indicates how many ensemble members include this scenario in their solution list, i.e. how many ensemble members accept this scenario as a consistent scenario.

Impact score

The impact score represents a scenario's aggregated impact

on a certain descriptor variant. The impact score is calculated by highlighting the rows of all descriptor variants in the cross-impact matrix selected by the scenario and adding all highlighted impacts within a variant's column. The impact scores of all variants of a descriptor set up the descriptor's impact balance.

Inconsistency of a descriptor The inconsistency value of a descriptor is equal to the gap between the impact score of the selected variant of the descriptor and the maximum impact score of the descriptor impact balance.

Inconsistency of a scenario The maximum descriptor inconsistency of the scenario. The scenario inconsistency is a local measure of the plausibility of the scenario (see 'Total impact score').

Judgement group One row of a judgement section.

Judgement section A data block (submatrix) of the cross-impact matrix. It describes the impact of a descriptor on another descriptor.

Monte Carlo method A method of conducting an approximate evaluation of large matrices. In this case, there will be no complete exploration of all possible scenarios. Instead, a number of randomly chosen scenarios will be used as a starting point for constructing a consistent scenario by the succession method. However, only the main solutions (i.e. consistent scenarios with high combinatorial weight) will be identified in a reliable way. Consistent scenarios with low weights may be missed.

News value The 'News value' of a scenario X with respect to a scenario group G is defined as the minimum of all distances between X and the scenarios of G (the distance between two scenarios is defined as the amount of descriptors showing different variants for the two scenarios). That is, the news value of a scenario with respect to a scenario group is the scenario's distance to its closest relative among the group's scenarios. This means that a scenario achieves a high news value if it resembles none of the group's scenarios. On the other hand, a scenario that is very similar to one or more of the group's scenarios is assessed to have a low news value.

Passive descriptor

(Primary) passive descriptors do not exert any influence on other descriptors. The row of a (primary) passive descriptor is therefore completely filled with zeros.

Secondary passive descriptors exert influences only on primary passive descriptors.

Pathway analysis

Descriptors in CIB are usually connected (also) by indirect pathways. That is, descriptor A may influence descriptor B even in those cases when there is no (direct) cross-impact from A to B because A impacts descriptor C, and C impacts B.

Pathway analysis is a tool for identifying indirect pathways between a given pair of descriptors by promoting a better understanding of the internal logic structure of consistent scenarios. *ScenarioWizard* provides a function for identifying first-order indirect pathways (pathways running from an impact source to an impact target via one intermediate descriptor; see Section 6.12).

'Echoes' (see above) are special types of impact pathways.

Standardisation

A judgement group of a cross-impact matrix is standardized, if its cross-impacts sum to zero. The standardisation is not demanded by the mathematics of CIB, but it supports the comprehensibility of the data. This convention expresses that promoting influences towards one state restricts respective opposites.

States

Former name of the possible variants of descriptor behaviour (see glossary entry 'Variant').

Succession

A CIB procedure for finding the solutions of a cross-impact matrix (consistent scenario or scenario cycle) using an iteration procedure. The succession starts with an initial scenario, computes the impact balances by summing up the cross-impacts of all rows of the scenario, and switches all descriptor variants to the variants of the maximum impact score within every descriptor impact balance ('Global succession mode'). This procedure is repeated until it yields a consistent scenario (or a scenario cycle).

When calculating attractor weights (see glossary entry 'Attractor weights' and Section 7.1), *ScenarioWizard* executes a scenario succession for every possible initial scenario. The

succession is repeated until a result is found (consistent scenario or scenario cycle), and the result of every succession is counted and indicated in the evaluation protocol. Depending on the size of the cross-impact matrix, a matrix evaluation requires several thousand or several million succession steps.

ScenarioWizard provides four alternative succession modes ('Global', 'Local', 'Incremental', and 'Adiabatic'). The modes are described in Section 7.1.

Total impact score

The sum of the impact scores of all selected variants of a scenario. The total impact score is a global measure of the plausibility of a scenario (see 'Inconsistency').

Variants (descriptor variants)

The range of possible system behaviour is characterised in CIB by assigning a set of 'variants' to each descriptor. For example, in the exercise 'Somewhereland', the descriptor 'Social cohesion' contains the three variants 'Social peace', 'Tensions', and 'Unrest'.

In former versions of *ScenarioWizard*, the descriptor variants were named 'states'. The more neutral name 'variant' is preferred in *ScenarioWizard4* because descriptors can be used not only to describe stationary system states ('Tensions') but also temporal developments (e.g. 'Increasing tensions').

Volume weights

The 'Volume weight' of a scenario indicates the share of the configuration space (possible combinations of descriptor variants), which is related to this scenario closer than to any other scenario of the solution list. The closeness of relation is measured by the number of matching descriptor variants. The volume weights are calculated during the evaluation 'Consistent scenarios' if the option 'Calculate weights - Volume weights' is activated in the evaluation options window (see Section 7.1).

Scenarios with high volume weights are frequently scenarios with a characteristic scenario theme that is distinct from all other scenarios. Scenarios with low volume weights are closely related to other scenarios and can be interpreted as variants of a scenario theme, which they share with one or more other scenarios (see Section 7.1).

Weights

ScenarioWizard uses three types of weights to characterise

scenarios:

- Attractor weights
- Volume weights
- Ensemble weights

Each type of weight corresponds to a specific interpretation. See respective glossary entries.

Appendix

Appendix 1: The scw file format

ScenarioWizard project files (scw-files) are text files. As an alternative to editing the project data using the analysis editor or the cim editor they can be edited using a text editor. In such instances *ScenarioWizard* syntax rules governing scw files have to be observed exactly. In version 5, scw files consist of six data sections:

- Section I: General information (File signature and project name)
- Section II: Analysis structure (long names and short names of descriptors and variants)
- Section III: Color codes of descriptor variants
- Section IV: Cross-impact data
- Section V: Comments on descriptors and cross-impacts
- Section VI: Variant assessment data

The initial section consists of two rows:

```
$ ScenarioWizard 4.0
Somewhereland
```

The first line serves as a signature. It enables the program to recognize a *ScenarioWizard4* project file (or higher). If *ScenarioWizard* cannot read this signature, the loading procedure is aborted. The second line stores the project name and is usually identical to the file name.

Now follows the long names and the short names of the descriptors and their variants (data section II). The data of the exercise “Somewhereland”:

Long names	
Descriptors:	Variants:
A. Government	A1 "Patriots party" A2 "Prosperity party" A3 "Social party"
B. Foreign policy	B1 Cooperation B2 Rivalry B3 Conflict
C. Economy	C1 Shrinking C2 Stagnant C3 Dynamic
D. Distribution of wealth	D1 Balanced D2 Strong contrasts
E. Social cohesion	E1 Social peace E2 Tensions E3 Unrest
F. Social values	F1 Meritocratic F2 Solidarity F3 Family

Short names	
Descriptors:	Variants:
A.	A1 A2 A3
B.	B1 B2 B3
C.	C1 C2 C3
D.	D1 D2
E.	E1 E2 E3
F.	F1 F2 F3

are stored as follows:

```
&A. Government
 -A1 "Patriots party"
 -A2 "Prosperity party"
 -A3 "Social party"
&B. Foreign policy
 -B1 Cooperation
 -B2 Rivalry
 -B3 Conflict
&C. Economy
 -C1 Shrinking
 -C2 Stagnant
 -C3 Dynamic
&D. Distribution of wealth
 -D1 Balanced
 -D2 Strong contrasts
&E. Social cohesion
 -E1 Social peace
 -E2 Tensions
 -E3 Unrest
&F. Social values
 -F1 Meritocratic
 -F2 Solidarity
 -F3 Family
#
&A
 A1
 A2
 A3
&B
 B1
 B2
 B3
&C
 C1
 C2
 C3
&D
 D1
 D2
&E
 E1
 E2
 E3
&F
 F1
 F2
 F3
#
#
```

First, a paragraph with the long names follows. The character “&“ is put at the beginning of each descriptor name. The following lines up to the next descriptor name contain the variant names with an empty character and hyphen at the beginning of each line. The section ends with the character “#“.

The next paragraph contains the short names using the same pattern. But the lines with the variant names begin only with an empty character and not a hyphen, as was the case for the long names. The paragraph ends with two successive lines with the character “#”. This is also the end of the data section II.

The subsequent data section contains the color code data. The colors are stored using hexadecimal RGB code. The list starts with the color codes of the first descriptor’s variants, then the second descriptor’s variants, and so on. Again, the section ends with two successive lines with the character “#”.

C4BD97
C4BD97
C4BD97
D7E4BD
FFFFAF
FFAAAA
FFAAAA
FFFFAF
D7E4BD
D7E4BD
FFAAAA
D7E4BD
FFFFAF
FFAAAA
C4BD97
C4BD97
C4BD97
#
#

These color codes correspond to the colors shown in Fig. 5-4. The “Somewhereland” project file included in the installation package is not color-coded, however. All color data in section III show the value “FFFFFF” (white).

Now follows section IV storing the cross-impact data. The structure of the section is displayed in the following table. Every line contains the data of one row. For regular cross-impact matrices, the diagonal sectors are filled with zeros. All data are separated by commas. The section ends with one line with the character “#”.

```
 0 , 0 , 0 ,-2 , 1 , 1 , 0 , 0 , 0 , 0 , 0 ,-2 , 1 , 1 , 0 , 0 , 0
 0 , 0 , 0 , 2 , 1 ,-3 ,-2 ,-1 , 3 ,-2 , 2 , 0 , 0 , 0 , 2 ,-1 ,-1
 0 , 0 , 0 , 0 , 0 , 0 , 0 , 2 ,-2 , 3 ,-3 , 2 ,-1 ,-1 ,-2 , 2 , 0
 0 , 0 , 0 , 0 , 0 , 0 ,-2 , 1 , 1 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0
 0 , 0 , 0 , 0 , 0 , 0 , 0 , 1 ,-1 , 0 , 0 , 1 , 0 ,-1 , 0 , 0 , 0
 3 ,-1 ,-2 , 0 , 0 , 0 , 3 , 0 ,-3 , 0 , 0 , 3 ,-1 ,-2 ,-2 , 1 , 1
 2 , 1 ,-3 , 0 , 0 , 0 , 0 , 0 , 0 ,-2 , 2 ,-3 , 1 , 2 , 0 , 0 , 0
-1 , 2 ,-1 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0
 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 ,-2 , 2 , 3 ,-1 ,-2 , 0 , 0 , 0
 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 3 ,-1 ,-2 ,-2 , 1 , 1
 0 ,-3 , 3 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 ,-3 , 1 , 2 , 2 ,-1 ,-1
 0 , 0 , 0 , 0 , 0 , 0 ,-2 ,-1 , 3 , 0 , 0 , 0 , 0 , 0 , 2 ,-1 ,-1
 0 , 0 , 0 ,-1 , 0 , 1 , 1 , 1 ,-2 , 0 , 0 , 0 , 0 , 0 ,-1 , 0 , 1
 2 ,-1 ,-1 ,-3 , 1 , 2 , 3 , 0 ,-3 , 0 , 0 , 0 , 0 , 0 ,-2 ,-1 , 3
 0 , 3 ,-3 , 0 , 0 , 0 ,-3 , 0 , 3 ,-3 , 3 ,-2 , 1 , 1 , 0 , 0 , 0
 1 ,-2 , 1 , 0 , 0 , 0 ,-1 , 2 ,-1 , 2 ,-2 , 2 ,-1 ,-1 , 0 , 0 , 0
 0 , 0 , 0 , 0 , 0 , 0 ,-1 , 2 ,-1 , 1 ,-1 , 2 ,-1 ,-1 , 0 , 0 , 0
#
```

The last data section contains the comments. First the general project description is displayed under the title “# 0-0”. Then the descriptor comments follow, each under the title “# Short name of descriptor”. The comments are printed in quotation marks. If a descriptor was not commented, the corresponding paragraph is reduced to “”

```
# 0-0
"’Somewhereland’ is a CIB training exercise analysing the political and social development of a fictitious country."
# A
"In Somewhereland, a democratic country, three parties struggle for power: the 'Patriots party', the 'Prosperity party' and the 'Social party'. The parties' names indicate their general political priority, though all parties pursue on a limited scale also the other political issues."
# B
…
```

After the descriptor comments the comments on the cross-impacts follow. The cross-impact comments are organized in rows. E.g. the first comment in this paragraph describes the impact of the first descriptor on itself. Next comes the impact of the first descriptor on the second descriptor, and so on. The diagonal judgement sections are included also in case of regular cross-impact matrices where no diagonal impacts are assumed. They consist of an empty string (“”) in this case. Each paragraph describing a judgement section is initiated by a line

Short name of the impact source -> Short name of the impact target

The section ends with two successive lines with the character “#”.

The last section of the scw file consists of the evaluation data for the descriptor variants. If no evaluations have been made, all values are set to zero. The section and thus the scw file is concluded with two lines, each containing a “#” character. In the case of the example in Fig. 6-50, this final section takes the following form:

```
 2
 2
 0
 0
 1
 2
 2
 1
 0
 2
 0
 0
 1
 2
 0
 2
 2
#
#
```

Appendix 2: Formating csv import-files

The menu item *File - Load ... import* imports a csv-formated cross-impact matrix. The import function reads the cross-impact data of the csv file whereas the names of the descriptors and variants of the current analysis structure remain unchanged. To be ready for import a csv file must show a specific structure. The requested structure corresponds to the usual structure of a cross-impact matrix (cf. Fig. 5-14) and is shown in the following table for the simple example of two descriptors, each with three variants:

```
1st heading line, contains descriptor's short names (skipped)
2nd heading line, contains value's short names (skipped)
Block descriptor 1, descriptor's long name (skipped)
Block descriptor 1, 1st data row: value's long name;data;data;data;;data;data;data
Block descriptor 1, 2nd data row: value's long name;data;data;data;;data;data;data
Block descriptor 1, 3rd data row: value's long name;data;data;data;;data;data;data
Block descriptor 2, descriptor's long name (skipped)
Block descriptor 2, 1st data row: value's long name;data;data;data;;data;data;data
Block descriptor 2, 2nd data row: value's long name;data;data;data;;data;data;data
Block descriptor 2, 3rd data row: value's long name;data;data;data;;data;data;data
```

The import function uses only the data rows, skipping all other rows. Each data row consists of the variant's name. Then the impacts of the variant follow separated by semicolons. The empty columns separating the descriptors (cf. Fig. 5-14) are represented in the csv-file by two successive semicolons.

Appendix 3: New functions in Version 5.1

The following functionalities are new in Version 5.1 compared to Version 5.0:

- The “Impact Network Diagram” function enables a graphical representation of the impact relationships within a scenario (Section 6.6).
- The “Show analysis structure” function generates a clear list of the descriptors and variants (Section 5.7)
- When creating a random matrix, the degree of connectivity can now be set via a query (Section 5.15).
- The maximum transient length for the successive determination of consistent scenarios in Monte Carlo mode has been increased from 100 to 300 in order to take into account the solvability of larger matrices as a result of the implementation of the warp solver in Version 5.0. This has also increased the maximum detectable cycle length.
- Various bugs have been fixed.