Success Dynamics - a Concept for building System Dynamics Models as Decision Support within Strategic Management[1]

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Abstract

Successful corporate action requires a comprehensive recognition of the relevant cause-effect relationships. In combination with the mental models of decision-makers, and as a complement to static instruments for business management, system dynamics simulation models provide valuable support. However, due to the usually experienced big effort and the demand of specific modelling knowledge the use of such models is not yet widespread within management. In order to give medium-sized companies in particular access to such simulation models, a practice-oriented concept was developed, enabling the design and implementation of system dynamics models as to support decision-making within strategic management. Within the framework of an empirical case-study, simulation models were developed for and implemented in four production companies. Based on the notions of the decision makers involved in the model-building process, in each case a system dynamics model was created representing the perceived logic behind corporate success. These models did not address a single specific strategic question but rather the more general issue of what determines the long-term business success of the particular enterprise. In order to make the modelling process as simple, efficient, effective and relevant as possible, a practical procedure was derived out of the case studies. This procedure describes the entire modelling process encompassing the initial process of structuring the mental models, the development of quantitative simulation models, as well as the analysis of various scenarios. The concept is based on generic model components, assembled to form a fundamental model structure (backbone) in order to facilitate and to accelerate the modelling process. It is expected that such a generic procedure could thus lead to a spread of system dynamics models for the strategic management of medium-sized companies.

Keywords: System Dynamics, Simulation, Decision-support, Strategic management, small and medium-sized enterprise (SME)

[1] The paper refers to a substantial degree to the dissertation by L. Schmid (Schmid, 2012) and focuses on the main results and findings.

1 Introduction

Entrepreneurial thinking and action, in a nutshell, means identifying future business opportunities and putting them into practice taking into consideration the risks that are linked to those opportunities. However, recognizing opportunities is a creative process that can hardly be described by means of rigorous algorithms. In addition, the probabilities of success of a specific option are difficult to estimate.

As a consequence numerous decisions in business are taken intuitively (Muller, 2008). Deciding by intuition means that the decision is based on an implicit mental model. On the one hand mental models have numerous advantages and facilitate decision-making substantially (Gigerenzer, 2008). On the other hand they are frequently incomplete and flawed, difficult to communicate und often too simplified, in particular if time delays, non-linearities and feedbacks are neglected. Relying on such models becomes a problem in particular if model complexity is high, if business context is very dynamic, or if several people are involved in the decision making process (Weil, 2007). This applies in particular to corporate management decisions, due to rapidly changing business environment and due to the fact that the company itself has to be considered a complex adaptive system (Holland, 1992; GellMann, 1994; Gandolfi, 2001). Understanding intuitively the cause-effect relationships that are critical for corporate success is hardly possible and makes it difficult to anticipate possible consequences of a possible option.

This paper starts from the hypothesis that the probability for successful and effective corporate decisions is increased if the complex relationships are made explicit and transparent and if, based thereupon, the relation between action and effects is elucidated from a systemic perspective.

A number of methods to support corporate management in creating and maintaining the vital functions of a company are available (Malik, 2003). These are amongst others cause-effect diagrams (Ishikawa diagrams), instruments for strategic management planning (SWOT analysis, portfolio technique, gap analysis), Porter approach, shareholder-value approach, or the Balanced Scorecard approach (BSC). However, these classic, mostly static approaches are often inappropriate as they do not allow for a dynamic analysis and do not incorporate feedbacks. One reason for this is, that they were developed in a period where the dynamics of corporate environment was less pronounced and where complexity was easier to manage (Moormann, 2006). Even more serious is the fact that all these instruments rely almost entirely on the human brain, which, as has been demonstrated, is not appropriate to deal with complex, dynamic processes (Simon, 1957).

Against this background system dynamics simulation models provide a promising instrument to support corporate management. The (potential) contribution of system dynamics relies on the following aspects (Schwaninger, 2009):

- Fostering disciplined thinking
- Understanding dynamic system behaviours and the structures that generate them
- Exploring paths into the future and the concrete implications of decisions

- Assessing strategies as to their robustness and vulnerabilities, in ways precluded by other, more philosophical, and generally „soft“ approaches.

System dynamics in particular can be used to support a transparent debate about strategic choices referring to the information that is (implicitly and explicitly) available. This happens in a process in which models and simulations are an integral part of strategic management (Morecroft, 1988). System dynamics models provide an excellent platform to identify relevant decisions and to highlight the sources of information the decision makers rely on (Gary, 2008).

Although system dynamics is well established in research, it could not gain acceptance in the management of small and medium-sized enterprises (Winch, 2002; Bianchi, 2002; Sotaquira, 2004). These companies rather tend to use less robust and more qualitative approaches such as the Balanced Scorecard or scenario technique (Sotaquira, 2004). Main reasons for this behaviour are lack of knowledge about the existence of the system dynamics methodology and the resources required to develop system dynamics models (Winch, 2002).

However, the use of simulations relying on formal dynamic models is considered more and more important for private as well as for public corporations, as they have the potential to support decisions and to enable the creation of promising decision rules (Schwaninger, 2009). To foster broader acceptance of system dynamics in strategic management two requirements are to be fulfilled: generic models and model components have to be constructed (Sotaquira, 2004) and practical concepts, rules and methods to efficiently develop high quality models have to be developed (Schwaninger, 2010).

Main objective of this research project was to develop a practice-oriented concept enabling a modeller to depict with a system dynamics model efficiently and effectively the implicit ideas of corporate decision makers about the mechanisms ensuring the success of the company. Such a simulation model is expected to reveal structures and mechanisms in the company that are considered decisive for corporate success. In addition, the effect of potential changes of internal or external influence factors (scenarios) on corporate success should be analysed, highlighting their effect on corporate performance over time. Rather than addressing one specific question or problem the objective of this project was to elaborate a more abstract simulation model of a company that can be used to support decision making with regard to different strategic questions. Hence, the focus of these models was on the interrelationships that, according to the perception of the decision makers, are responsible for the sustainable success of the company. Following Dennis L. Meadows “sustainable” is understood here as longer-term existence of the company without sudden and uncontrollable collapse (Meadows, 1972).

While developing the concept the main focus was on practice orientation. Here the concept aims at going beyond existing approaches (Warren, 2007; Morecroft, 2007). In particular it claims that the concept can be applied to medium-sized companies. To achieve this goal the following aspects are considered essential:

- **Simplicity**: the concept has to be understood easily by strategic management

- **Efficiency**: the modelling process has to be as efficient as possible to be highly cost effective and not to bind more resources than necessary
- **Effectivity**: the concept has to support a correct and - with regard to the question addressed - meaningful modelling process
- **Relevance**: the simulation model has to be appropriate to provide relevant rudiments for strategic corporate decisions and to stimulate a learning process in the management of the company.

2 Theoretical background and contributions of the project

The concept to be developed here hinges on cognitions from different research areas, such as decision finding, success-factor studies, and system dynamics. In this chapter the relevant aspects to which the concept is referring to are described, and the specific contributions of the project are highlighted.

2.1 Decision finding

Decision finding in a company is rational only to a limited degree. Due to cognitive limitations (Miller, 1956) and organizational information filters (Morecroft, 2007) only selected information is taken into consideration in the decision making process. Heuristics, or mental models, that have evolved through experience and learning, determine to a wide extent which information sources are taken into consideration (Craik, 1943; Johnson-Laird, 1983). By mentally investigating different scenarios, intuitively the most promising option is selected (Ingvar, 1985).

The concept presented here aims at transferring the mental models of the decision makers related to the relevant cause-effect mechanisms into quantitative simulation models. Simplifications are made explicit and the plausibility and consistency of implicit assumptions can be tested.

Yet, the cause-effect relationships that lead to success or failure of a company are based on processes, mechanisms and behavioural patterns that are the result of conscious and unconscious decisions. In this context the decisions are hardly perceived as a choice between alternatives. Individual decisions rather dissipate in an "ocean" of day-to-day decisions. Accordingly the abstraction level of a model involving these cause-effect mechanisms has to be higher than the abstraction level of single decisions. It does not refer to cognitive mechanisms of individuals taking a specific decision. Modelling the success logic of a company has to represent the success of a company as a result of daily decisions as a whole.

2.2 Success-factor studies

Success-factor studies aim at identifying a comprehensive collection of generic factors that correlate with the success of the company (for example ROI) (Nicolai, 2002). In contrast to this approach the concept presented here focuses on causal rather than on correlational relations. A purely statistical approach such as the success-factor studies disguises the difference between correlation and causality. The findings of the empirical success-factor studies (e.g. Porter, 1980; Peters, 1982; Buzzel, 1987; Simon, 1996; Joyce, 2004; Bailom, 2007), however, provide substantial hints to potentially relevant factors for the success of the company. In particular, empirically validated correlations should be incorporated in the causal model.

A combination between empirically identified success factors and causal relations has been aimed at by Roland Waibel and Michael Käppeli in their model of a corporate success logic (“Unternehmerische Erfolgslogik”) (Waibel, 2006). The model provides a synthesis between different empirical findings and integrates the key factors into a qualitative causal structure. This instrument mainly developed for didactical purposes is well appropriate to convey an integrative perception of business management. As a practical instrument in strategic management, however, it has become evident that even a well-founded understanding of the qualitative success logic in combination with a qualitative cockpit is not adequate (Waibel, 2006). The system “company” is by far more comprehensive and interrelated with the consequence that a purely qualitative understanding of the cause-effect relationships is not adequate to estimate the effect of potential actions on corporate success. Quantitative simulation models, on the contrary, have the potential for such a dynamic analysis. As such, knowing the qualitative relationships is necessary, but not sufficient.

2.3 System dynamics

System dynamics is considered an appropriate approach to support strategic decision making in complex dynamic questions (Forrester, 1961). The quantitative formal nature of the simulation models brings about the main advantage in comparison with mental models. Although aspiring at the development of quantitative models the concept presented here gives specific weight to qualitative models. The representation of the relevant cause-effect relationships is decisive for the formation of shared mental models and as such provides a first step towards an understanding of the system.

Representing the success logic of the company asks for the cause-effect relationships that are considered vital for the success of the company. It is assumed that understanding these relationships is essential for different strategic decisions. Hence, the models have to be able to address different problems. Still, the system dynamics principle according to which a model has to represent a problem, rather than a system (Stermann, 2000), is followed. However, not a single problem is addressed, but rather a class of problems. As such, it is expected that the cost/benefit ratio can be improved, which is a challenge to numerous system-dynamics applications.

Identifying generic structures serves two purposes: on the one hand it helps to orient problem formulation and on the other hand it increases efficiency and effectivity in the modelling process. Generic structures claim to transfer experiences and understanding of one dynamic problem to another (Lane, 1996). From this point of view this research project aimed at identifying structural components as elements of a generic backbone. Being part of the concept presented here, these generic structural elements are expected to contribute to an efficient development of integral company-specific models.

3 Methodology

As has been pointed out the main research interest was on elaborating a practice-oriented concept that enables the representation of the corporate success logic. As such it is intended to provide knowledge that is appropriate to solve practically relevant problems. To provide this practice orientation and to take into consideration the characteristics of the social systems under study the research refers to the *Soft Systems Methodology* (Checkland, 1985; Checkland, 2000), connected with system dynamics.

The concept has been developed following the procedure established in qualitative social research, including description, analysis, explanation and the elaboration of design rules (Mayring, 2002). The description addresses the study object, in particular the corporate decision logic. This has been undertaken in cooperation with the involved decision makers of the specific companies following the method of *model-based theory building* (Schwaninger, 2008).

Analysis, explanation and elaboration of design rules, respectively, have been undertaken by comparing the individual study objects and the corresponding elaboration processes. These steps have been undertaken following the methodology of the *case study research* (Yin, 2003; Eisenhardt, 2007). The resulting findings were integrated, finally, into the envisaged concept.

The research project has been structured into a series of different steps. These include conceptual considerations, the development of four individual simulation models of the corporate success logic (case studies), as well as analysis and comparison of these models and their corresponding elaboration processes. The conceptual considerations aimed on the one hand at a general framework which refers to the BSC and serves as a general orientation for the modelling process. On the other hand existing theories and concepts related to decision finding, success-factor studies, and system dynamics modelling have been investigated and evaluated with regard to their usefulness for modelling corporate success logic (figure 1).

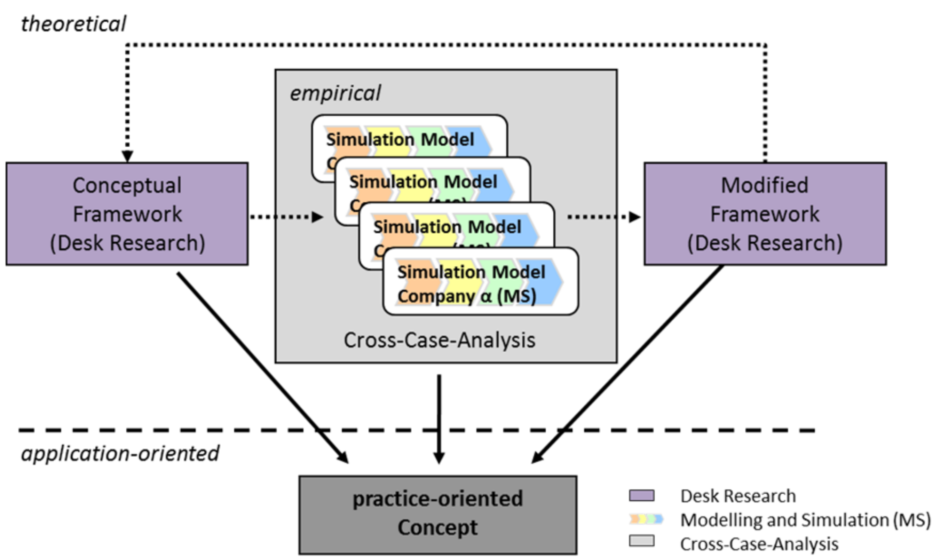

Figure 1: Research methodology

The development of these four individual simulation models provided the empirical basis of the concept. The entire process including problem definition, dynamic hypotheses formulation, development of qualitative and quantitative models, model validation as well as scenario simulation has been undertaken together with the decision makers. This procedure followed the *group model building* approach (Vennix, 1996) to a wide extent.

The concept, consisting of generic model components and guidelines for the modelling process, finally, was created through analysis and comparison of the four models and their elaboration process.

4 Case studies and empirical findings

The empirical basis of this research project includes the elaboration and the use of four individual simulation models of the corporate success logic. Each model was elaborated in cooperation with the decision makers of these companies within a series of 12 workshops. All companies were medium-sized, value-oriented (not shareholder value-oriented) industrial enterprises located in Switzerland.

In a first phase the focus was on problem formulation and qualitative modelling. It was aimed at elaborating a qualitative representation of a shared mental model with regard to the cause-effect mechanisms that were perceived as decisive for corporate success. Word models were created, and a shared dynamic hypothesis was formulated in terms of qualitative causal loop diagrams. This resulted in networks demonstrating the influence of single effects on the financial performance indicators of the company (see figure A1 in the appendix for an example of a CLD).

The second phase dedicated to quantification introduced the decision makers to system dynamics. Starting from the financial indicators the core value chain was jointly developed as a quantitative model. This resulted in a mainly static model. By including "soft" factors and factors not directly linked to the financial domain, the models became more dynamic. Finally additional feedbacks were included arising from a more systemic point of view (see figure A2 in the appendix for an example of a SFD).

A particular challenge was to choose an appropriate abstraction level. Here, the general framework offered by the BSC provided valuable guidance. Aiming at minimising model complexity the statements of the involved decision-makers were represented as abstract and as simple as possible. As a consequence the developed models could be kept rather small and include on average approximately 100 variables and 150 causal relationships, respectively. As a consequence of the procedure adopted here the models show a relatively small number of disjoint feedback mechanisms. The explanation for this is seen on the one hand in the fact that feedback thinking is not a familiar way for decision makers to describe and to analyse corporate problems. On the other hand it has been observed that in the period under consideration no dynamical patterns could be identified which would be indicative for the existence of dominating feedback mechanisms. The dynamics of the final models is thus rather dominated by exogenous factors and structural delays than by feedback mechanisms. The general dynamics of the investigated variables is well captured by the simulation model, as can be seen in figure

A3 in the appendix, with a comparison between model results and historical data.

In the course of the entire modelling process the developed models were continually tested and validated. Model validation, including a number of different tests, was carried out in the final project phase, taking into consideration the entire model with the complete set of feedback mechanisms. The validity criterion was primarily based on the judgements of the decision makers as to whether their mental models were represented consistently and correctly in the model and as to whether they felt sufficiently confident with the model to analyse possible scenarios.

To support model validation and to analyse different scenarios an appropriate software was developed. Main purpose of this was to provide a cockpit that corresponded better to the expectations of the decision makers with regard to an instrument for decision making support (figure 2). By means of this software different scenarios were simulated and analysed in order to answer specific strategic questions. Main focus of the project, however, was on model development, not on software development.

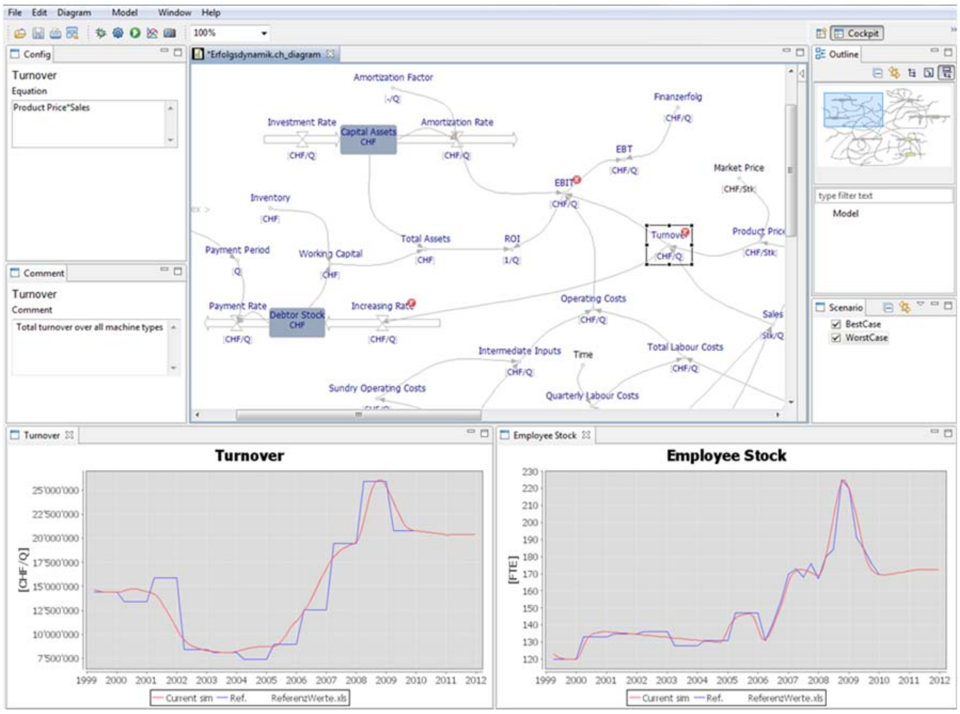

Figure 2: Model cockpit

Relevant results of the model analysis are the structural components that are considered generic (see appendix). First experience gained in the four modelling processes shows the potential of these components with regard to an increase in efficiency and effectivity in the model-building process. By comparing the four models ten components could be identified, which combine to a generic structure (backbone) (figure 3). The full backbone with the stock-and-flow structure and the underlying model equations is presented in the appendix (figure A4 and A5).

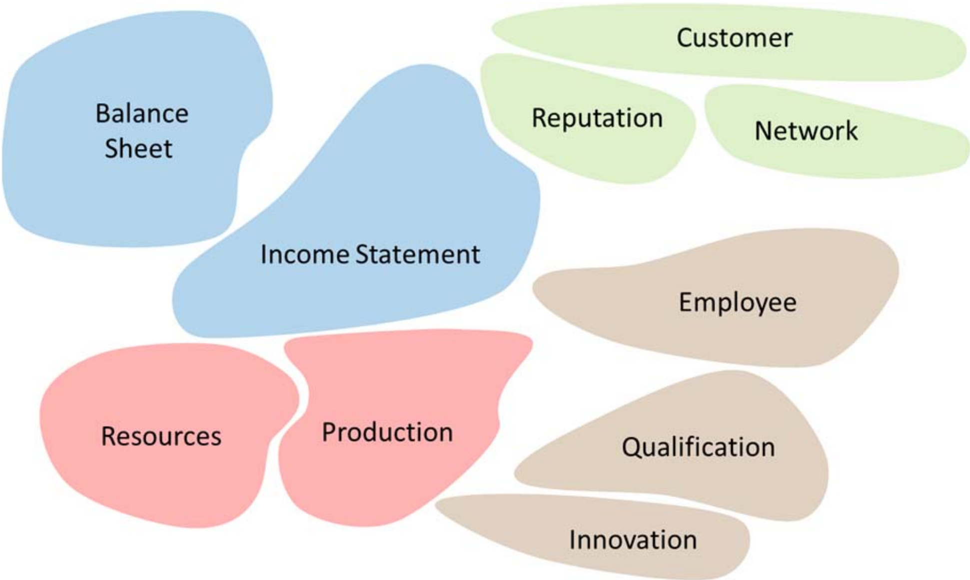

Figure 3: Backbone including ten generic components

5 Step-by-step procedure (concept)

The concept presented here describes a framework and a step-by-step procedure to develop as efficiently and as effectively as possible a system dynamics model to represent the corporate success logic. The concept provides a conclusive summary of the findings and experiences gained during the research project, offering a number of conditions, rules and recommendations for the practical implementation. The process is structured into three phases, distinguishing structuration, modelling, and simulation (figure 4).

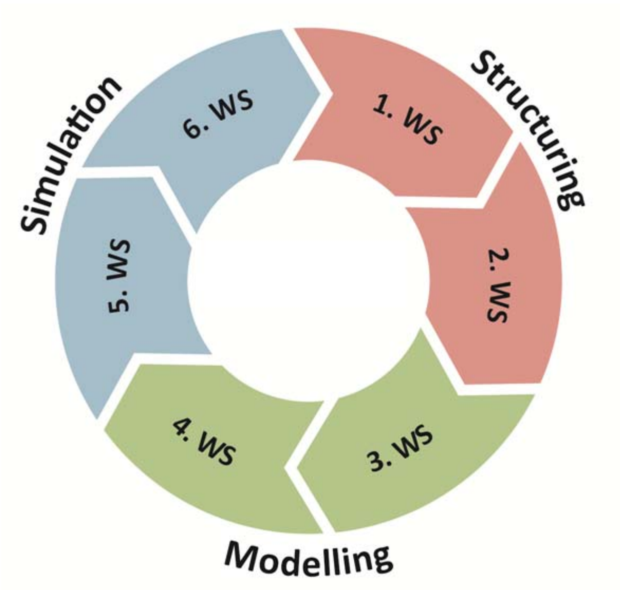

Figure 4: Concept

5.1 Conditions for a successful application of the concept

One of the most important conditions for a successful application of the concept is the curiosity of the involved decision maker. They should be interested in new insights related to the corporate success logic and should be convinced that not all relevant cause-effect relationships are already known and integrated into management decisions. This implies the acknowledgment that at least some of these relationships are not known or only vaguely, which requires some sort of self-criticism to question one's own viewpoints and actions. This type of insights is considered a particular potential of the concept presented here.

Medium-sized companies offer good preconditions for the application of the concept. This is due to the fact that the management of these companies relies to a considerable degree on the decision rules of only a limited number of people (occasionally exclusively on those of the company owner), based on which the relevance of specific scenarios is evaluated and strategic decisions are taken (Thiel, 2007). These leading people identify themselves strongly with the company and its success. As a consequence they are genuinely interested in and curious about the fundamental mechanisms of their business, to ensure a long-term sustainable success of "their" company.

Another condition relates to the allocation of time resources. Even with a very efficient modelling process it is indispensable for the management team to engage deeply in the topic. It is the dialogue amongst the decision makers and with the modelling experts which reveals valuable insights. The involved decision makers should be able and willing to invest approximately 30 hours for the project (six workshops of three hours with preparation and follow-up).

As a consequence, the group of involved decision makers should include high-ranked representatives from top-management (e.g. company CEO), finance, marketing, production, and if possible, from human resources.

5.2 Model development and policy analysis

The entire process includes six workshops. Here the process is shown step-by-step, starting from problem formulation, including qualitative model structuration and quantitative modelling using a generic backbone, leading to model validation and scenario analysis. For each step, content, method, and workshop results are described, together with preparatory and follow-up tasks.

Workshop 1: Problem definition and target specification

Content:
- Introduction and presentation of the company
- Problem specification
- Identification of success criteria for the modelling project
- Problem analysis and identification of key drivers for corporate success

Method:
- Group discussion
- SWOT- or PARTS-analysis

Results:
- Confidence and common language amongst the involved people
- Clarification of the objectives of the simulation model
- Problem definition and structuration
- Identification of first success-relevant mechanisms

Between the first and the second workshop the modelling experts formulate a briefing document summarising problem focus, project objectives and success criteria for the entire modelling project. This document provides a binding guideline for the project. In addition, a first rudimentary causal loop diagram (CLD) is developed, using information gathered during the first workshop about problem focus and driving forces for corporate success. This visualisation is developed using the framework of the Balanced Scorecard Method, in order to take into consideration different perspectives. This CLD is then discussed and further developed in the second workshop.

Workshop 2: Qualitative success logic

Content:
- Presentation of a first, rudimentary CLD developed by the modelling experts
- Joint further development of the CLDs by integrating soft factors and feedbacks

Method:
- Joint model development (“group modelling”)
- “Real-time” modelling using appropriate software tools

Result:
- Qualitative , visual representation of the corporate success logic
- Shared understanding of the cause-effect relationships responsible for corporate success

Although the two workshops of the structuration phase are dedicated to provide the fundament for the following quantitative modelling, the value of the qualitative representation should not be underestimated. Making explicit and structuring the corporate success logic may already influence considerably future strategic decisions.

Building on the results of the first two workshops and in particular on the qualitative model developed there, it is the modelling phase (workshops three and four) which is the core of the project resulting in a quantitative simulation model. Using generic model components and a fundamental structure (backbone) the modelling process is reduced to only two workshops. It turned out that the order in which model development is carried out plays a major role. Based on the experience of the case studies the most promising (because most efficient) order of the backbone components is the following:

1. Balance Sheet and Income Statement

2. Production, Employee and Customer

3. Resources, Qualification, Innovation, Reputation, Network

In order to stay within the given timeframe the backbone has to be adjusted to the specific company in advance of workshop three. This is achieved by introducing company specific indicators and adjusting a number of weighting values. To specify the backbone the modelling team refers on the one hand to the qualitative success logic and on the other hand to historical data, in particular to quarterly performance indicators from finance, production and human resources. It turned out that for model calibration and validation approximately 20 quarterly values are necessary. If fewer data are available they have to be completed with estimations describing the dynamic behaviour of selected key variables.

At this stage the backbone should not be enlarged substantially in order to present a simple, comprehensible basic model to the decision makers for them to start with model quantification. On the contrary, it is desirable that discrepancies between the model and the perceived reality of the company occur in order to encourage the involved decision makers to come up with their own suggestions for improvement. The decision makers should contribute to individualising the model and not be confronted with a complete model. This allows for creating the necessary confidence into the simulation model.

Workshop 3: Backbone

Content:
- Step-by-step development of the quantitative model referring to structure and individual components of the backbone
- Completion of the backbone by corporate-specific mechanisms (soft factors, feedbacks)

Method:
- Step-by-step introduction of the backbone (presentation)
- “real-time” model extensions within appropriate modelling environment

Results:
- Adjusted backbone representing quantitatively the key mechanisms of the corporate success logic
- Congruence between dynamic behaviour of the model with reference values
- Information collected to further specify the backbone

Between workshops three and four the simulation model is extended and the discussed extensions are implemented. To validate the model the available historical data as well as estimations provided by the experts are used and first validation tests are applied (with reference to model structure and model behaviour). Discrepancies between model behaviour and reference data provide the starting point for workshop four, which is dedicated to model simulation, model extension and validation.

Workshop 4: Validation

Content:
- Discussion of discrepancies between the quantitative model and observed dynamic, leading to further model development and/or modification of the mental models of the decision makers
- Application of model validation tests

Method:
- Joint simulation and model refinement
- Scenario-management: representation, documentation and analysis of individual simulations to demonstrate the effect of changes in the underlying assumptions

Result:
- Comprehensive, quantified success logic representing adequately the dynamic behaviour of corporate performance indicators

After workshop four the modelling experts apply systematically a number of validation tests and occasionally adapt the model slightly. To implement these adjustments bilateral meetings with selected experts from the company are necessary.

The third phase in the concept presented here is dedicated to model simulation. Utilising an easy-to-use cockpit different scenarios are analysed and the expected effects of potential options or of extreme conditions are evaluated. The insights gained here contribute essentially to the envisaged support for the decision makers related to strategic decisions.

As a preparation for workshop five an easy-to-use cockpit has to be developed. This is achieved either by extending the software used for creating the simulation model (e.g. using VENAPP in addition to VENSIM) or by transferring the model to a software environment which is more appropriate to design easy-to-operate graphical user interfaces[2].

In addition to developing this cockpit, the modelling team has to prepare a number of scenarios, which may show generic[3] characteristics, in order to stimulate scenario generation and scenario analysis in the following workshop.

Workshop five is dedicated to scenario generation and scenario analysis. Scenario simulation involves i) scenario definition, ii) parameter specification, iii) formulation of expectations about model behaviour, and iv) analysis of simulation results.

Workshop 5: Cockpit

Content:

- Introduction in and familiarisation with cockpit
- Presentation of simple, generic scenarios to introduce the decision makers into scenario simulation, model parameterization and policy analysis
- Identification of a variety of widely differing scenarios

Method:

- Presentation of the simulation model
- Scenario simulation (scenario definition, parameter specification, formulation of expectations about model behaviour, analysis of simulation results)
- Identification of scenarios by means of creativity techniques (brainstorming, mind-mapping, etc.)

Results:

- Decision makers are able to individually simulate scenarios using the cockpit
- A collection of interesting, insightful scenarios is developed

[2] In this project the cockpit has been developed with JAVA using the ECLIPSE-framework.

[3] „Generic“ is understood here in the sense that these scenarios are not primarily corporate specific but show more general characteristics (e.g. boom phase, weak economy, increase in material and resource costs, etc.)

Between the fifth and the sixth (final) workshop the decision makers are invited to use and to experiment with the simulation model intensively and to evaluate individually and/or in smaller groups a number of scenarios. The lessons learned during this process should be recorded and communicated with other involved decision makers and with the modelling team.

These insights will be taken into consideration by the modelling team in the continuous improvement and further development of the simulation model and in the scenario generation. Furthermore the modelling experts collect information and opinions related to potential scenarios that were expressed during the fifth workshop to prepare a selection of appropriate scenarios for the sixth workshop. This workshop is entirely dedicated to policy analysis and to the formulation and evaluation of strategic recommendations.

Workshop 6: Policy analysis

Content:
- Scenario analysis by using jointly the simulation model together with the decision makers
- Discussion of potential consequences of selected decisions and of measures envisaged to implement these decisions
- Project feedback and comparison with briefing document

Method:
- Joint simulation and policy analysis using the simulation cockpit

Results:
- Collection of potentially interesting scenarios with evaluation and interpretation of the corresponding simulation results
- Appraisal of the overall success of the simulation modelling project

After completing the entire project the insights gained during model development and scenario simulation should be recorded in a short final document. This ensures that the value added during the project is made explicit and that the process and the result can be understood at a later point in time. In addition the final report documents the validation procedure as well as model limitations. This will make it possible in future to compare observed data with model results.

5.3 Model implementation and follow-up

Due to the integral representation of the corporate success logic the simulation model can be applied to various issues and the model can be used repeatedly, ideally it is even used periodically. Here some aspects concerning the continuous and sustainable use of the simulation model are discussed.

Contrary to many classical approaches the concept does not analyse a static situation, but focuses on the dynamics of the company. In particular the dynamic behaviour of corporate success influenced by strategic actions and external influences is considered. This approach and the dynamic planning process building thereupon ask for a continuous monitoring of the projected model results. In addition the management receives information if their expectations and reality are congruent or if there are discrepancies related to external factors and as a consequence in model behaviour. Periodic comparison between reality and the simulation results can either assert model validity or reveal inconsistencies which have to be addressed. As a consequence model validity and confidence in the model will increase gradually.

The issue addressed by the simulation model in principle encompasses the success-relevant cause-effect relationships at large. As a consequence the model is not oriented per se towards a specific strategic question. In the course of the modelling phase described here, however, model development and as a consequence scenario simulation, will pursue a particular direction. Nevertheless, due to the generic structure of the model, it can be applied to various issues without fundamental changes and as a consequence without disproportionate efforts. As such the initial effort necessary for model development can be portioned in supporting various concrete strategic problems.

In order to reflect the time behaviour of the corporate performance indicators in comparison with the simulation projections and to apply the simulation model to various management issues it is important to integrate model application and scenario simulation into the annual schedule of strategic management.

6. Discussion

This project started from the undisputed fact that, on the one hand, taking long-term successful strategic decisions is challenging due to the high complexity both within the company as well as in its environment, and on the other hand, that these decisions are of great relevance to sustainable corporate success. Relying on intuition alone is dangerous, because intuition is conservative, difficult to communicate and often too simplifying. Decision support based on static management instruments is inadequate, moreover, because all relevant factors are time-dependent and as a consequence time aspects play a predominant role in strategic decisions.

This paper started from the hypothesis that the probability of successful and effective decisions is increased if the complex relationships are made explicit and transparent and if, based thereupon, the relation between action and effects is elucidated from a systemic perspective.

The objective of this research project was to develop a practice-oriented concept which allows for a system-dynamic modelling of the cause-effect mechanisms that are perceived as relevant for corporate success in order to provide decision support for strategic management in medium-sized enterprises. This concept relies on the body of the relevant scientific literature and on the empirical experiences gained during model development and scenario simulation with four medium-sized industrial companies.

Here the concept is discussed with reference to the four criteria for practice-orientation outlined in chapter one, which are i) simplicity, ii) efficiency, iii) effectivity, and iv) relevance.

6.1 Simplicity of the concept

One of the primary conditions for the use of the concept in strategic management is to provide an easy access for the decision makers. For this reason the concept starts from the way of thinking the decision makers are familiar with, introducing step-by-step systems thinking and system-dynamics modelling. Rather than starting primarily from feedback thinking the concept proceeds from classical financial indicators, such as balance sheet and income statement. The model is constructed with reference to the core value chain, gradually leading to an integral view of the success-relevant cause-effect relationships. Only in this last modelling phase the focus is on additional feedback mechanisms which might have been overlooked in the previous phases.

One of the main advantages of this procedure is thus to provide an easy access to quantitative modelling for the involved decision makers. As a consequence, however, the role of feedback thinking becomes less predominant. This has two aspects: first, systemic feedbacks are integrated only in the final phase, and second, some feedback mechanisms are not taken into account as endogenous model components but rather as exogenous influence factors to be determined by the decision makers during model simulation. Simplicity of the concept is relevant on the one hand for the decision makers in order to make the concept accessible and useful for them. On the other hand, it is of primary relevance for consultants aiming at developing a system dynamics model for strategic decision support. Here the concept presents a clear description of the process with reference to each phase in addition to the backbone with the generic components.

6.2 Efficiency of the concept

Efficiency of model development is the second prerequisite for a widespread adoption of the concept presented here. The main contribution of this project to an increase in efficiency in quantitative modelling is the development of generic model components. With this backbone as a generic, parameterizable fundamental structure the entry into the modelling process is facilitated and accelerated substantially. The backbone is a sort of “blueprint” [4] that is adjusted to a specific case during the modelling process by means of structural modifications. While in the four case studies a total of twelve workshops were necessary, the final concept now encompasses only six workshops. This reduction could be achieved mainly, but not exclusively, as a result of this backbone.

6.3 Effectivity of the concept

To model corporate success logic by means of a system dynamics model an appropriate level of abstraction has to be chosen. In this research project an integral, although manageable perspective on the success-relevant cause-effect relationships has been

[4] „Blueprint“ in the sense of a detailed structuration plan as a guideline to modelling a corporate success logic.

adopted allowing for the analysis of concrete strategic options. As a consequence the models were developed in a way as to represent historical reference values with appropriate accuracy and to enable insightful predictions about the effects of different scenarios.

With the backbone the concept offers an important guideline with regard to the choice of the appropriate abstraction level. In addition the individual components of the backbone provide concrete indications how certain core mechanisms (e.g. build-up of qualification of human resources, production planning capacities, etc.) can be constructed in a meaningful and valid way.

Moreover, by aiming at a representation of the mental models of the decision makers, the concept asks for an active involvement of the decision makers themselves. Empirical evidence shows that the insights gained during the modelling process often lead to the creation of shared mental models in management teams. This in itself is considered a valuable intermediate result, enhancing the quality of management decisions, and as such, strengthening the effectivity of this concept.

6.4 Relevance of the concept

The application of the concept is only justified if a relevant foundation for strategic decisions can be provided and if a learning process in the management team can be stimulated. The latter objective could undoubtedly be achieved in the case studies. This is documented by a number of statements made during the structuration of the mental models and surprising insights while analysing the simulation results. This is mainly due to the participatory modelling approach and the interactive use of the simulation models as it is proposed in this concept.

Moreover, it could be demonstrated in exemplary situations that with the so-developed simulation model concrete strategic options could be analysed. It has to be stated, though, that during the case studies the simulation models could be applied to specific questions only to a limited extent. As a consequence the relevance of the simulation model for decision support in concrete strategic issues will have to be assessed at a later point in time.

7. Further development

The development of the four individual simulation models has demonstrated the feasibility of such an endeavour and provided valuable insights and guidelines for a practice-oriented procedure. The simulation models, however, could not be applied sufficiently to specific strategic issues in the companies. Further development therefore has to focus on the application of the simulation models and on the generation of value added for the companies. Most important aspects in this regard are the transfer to different concrete management problems, the integration in the annual schedule and the ordinary management processes, as well as using the potential of involving additional staff members into strategic processes.

The conceptual orientation of this project asks for additional research activities. The concept presented here has to be considered a well-grounded hypothesis about a practice-oriented development and implementation of system dynamics models in strategic management. Further research has to validate this hypothesis using a number of applications and to sharpen and further develop this hypothesis. In particular the generic model components and their integration into a fundamental model structure have to be further validated by means of additional applications.

Further research should address the following questions related to practical application of the concept:

- How can the progress in understanding taking place in the course of modelling be measured and documented?
- What are appropriate methods to motivate decision makers for developing novel options that previously have been overlooked?
- How can the variety of potential options be measured and documented in the course of the decision making process?
- What is the contribution of the simulation model in the decision process when it comes to reducing the number of potential options, and how can the modelling process be optimized with regard to this objective?
- How can simulation results be compared and evaluated – taking into consideration that a number of conflicting goals exist?

Of particular interest is the question how these simulation models can be used as a "catalyst" to enlarge the variety of potential options. The concept asks for a high level of abstraction, which in itself should lead to new perspectives, and as such to new ideas. In this context new approaches of interactive cooperation (e.g. "social media" [5]) should be applied and tested with regard to their suitability for including a wider variety of perspectives. The combination of participatory modelling with location- and time-independent interaction and exchange modes seems a promising avenue to follow.

8. References

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[5] "Social Media" is understood here as web-based applications building on the ideas and the technology of Web2.0 and allowing for creation and exchange of information (Kaplan, 2010).

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Appendix

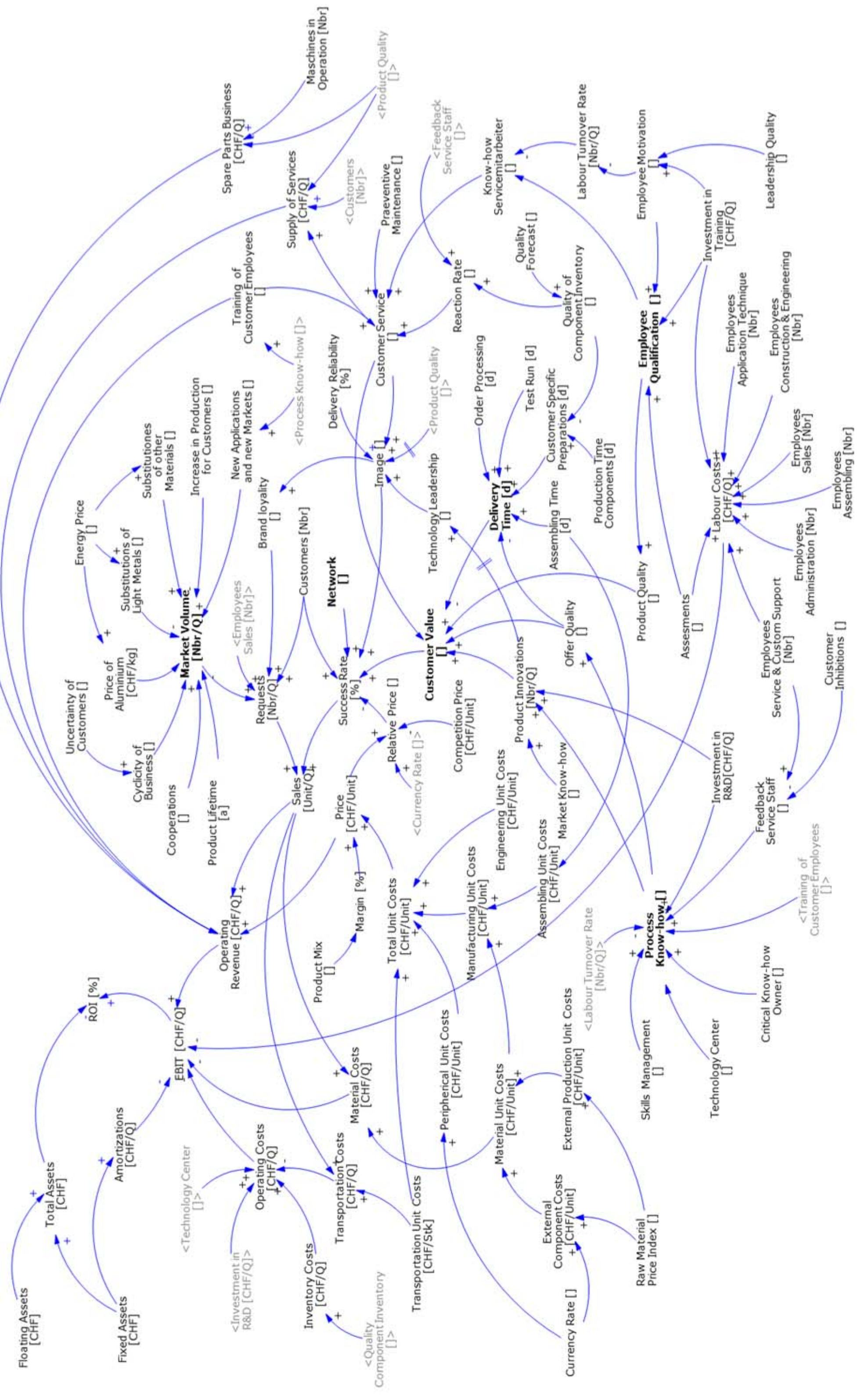

Figure A1: Exemplary qualitative success logic

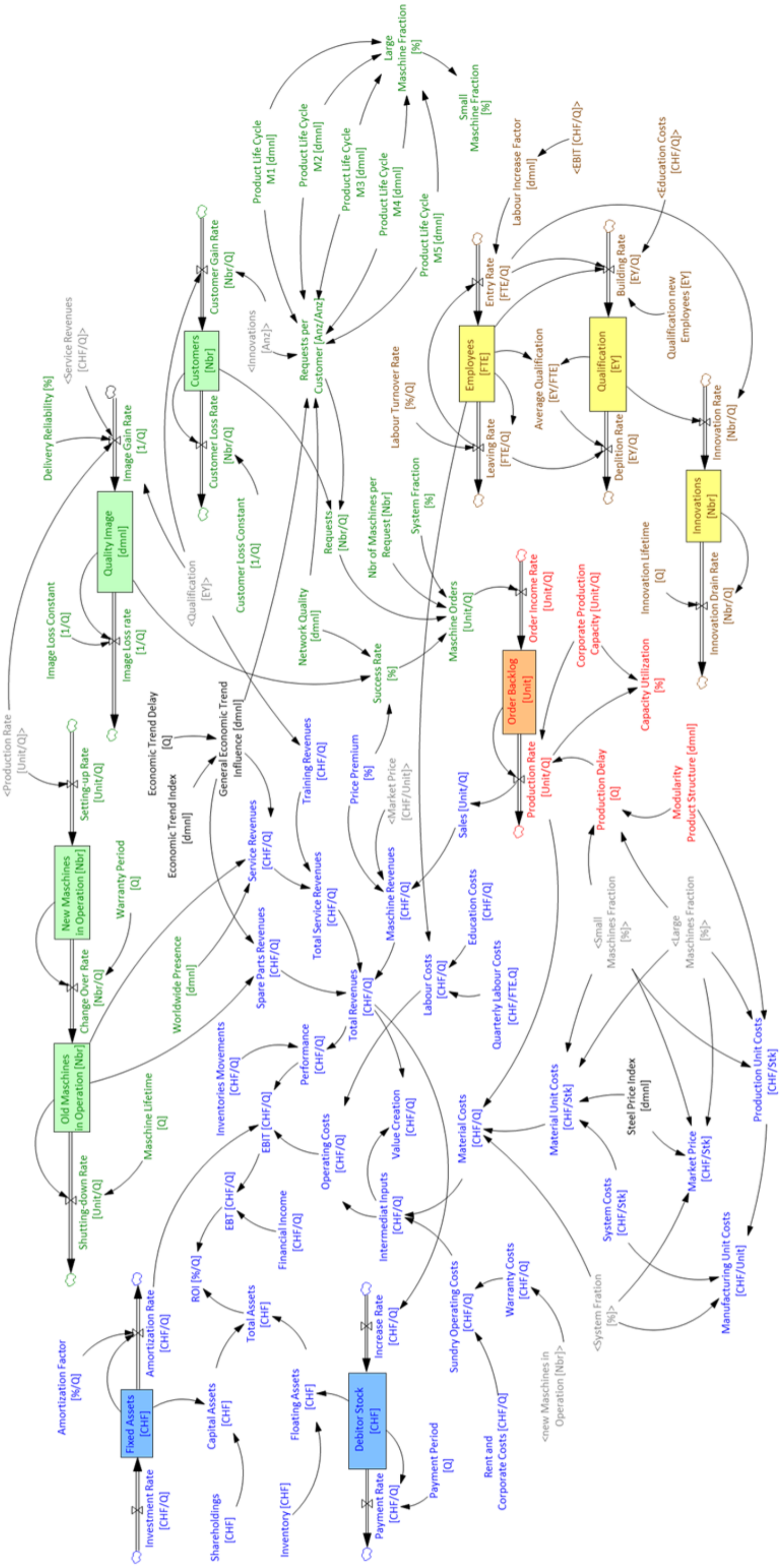

Figure A2 : Exemplary quantitative success logic

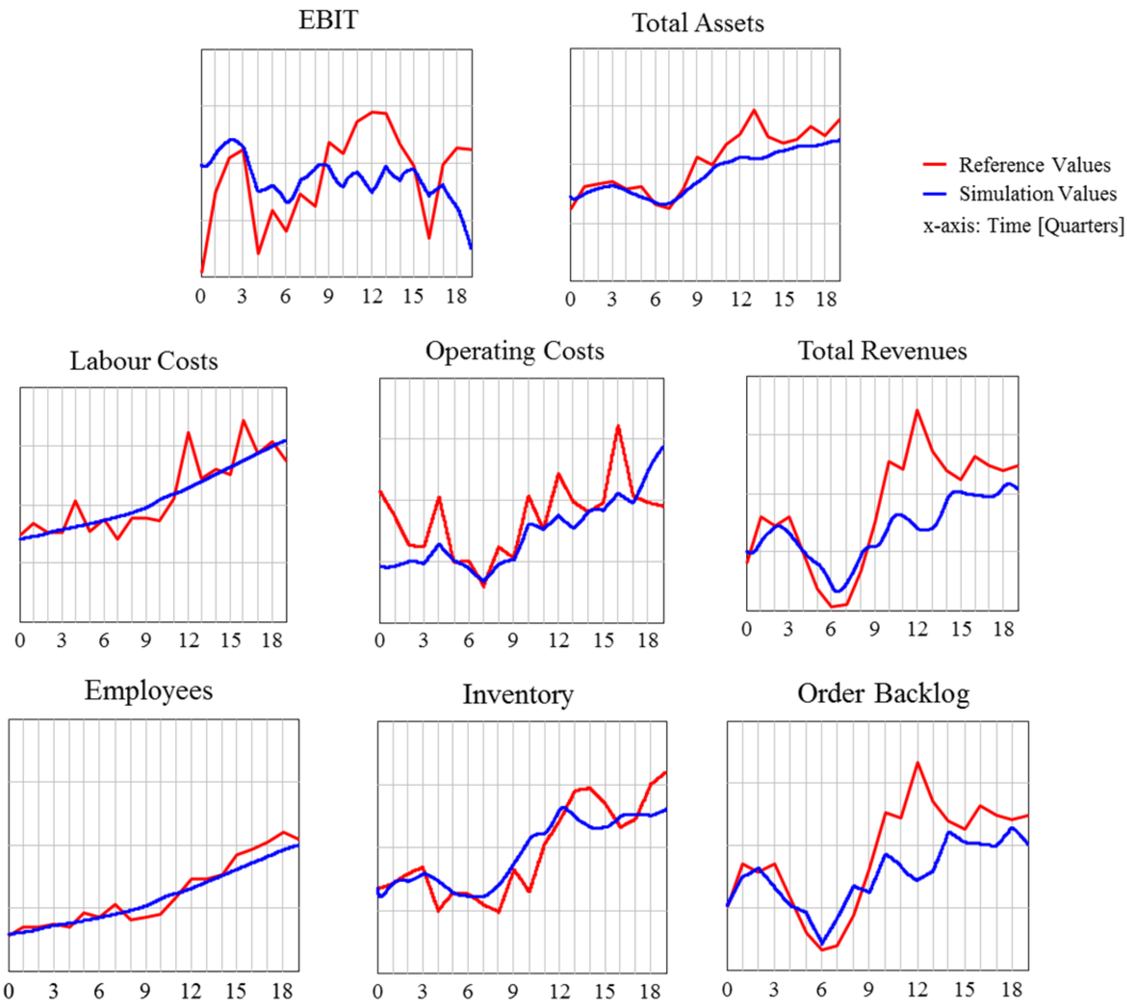

Figure A3 : Exemplary dynamic behaviour

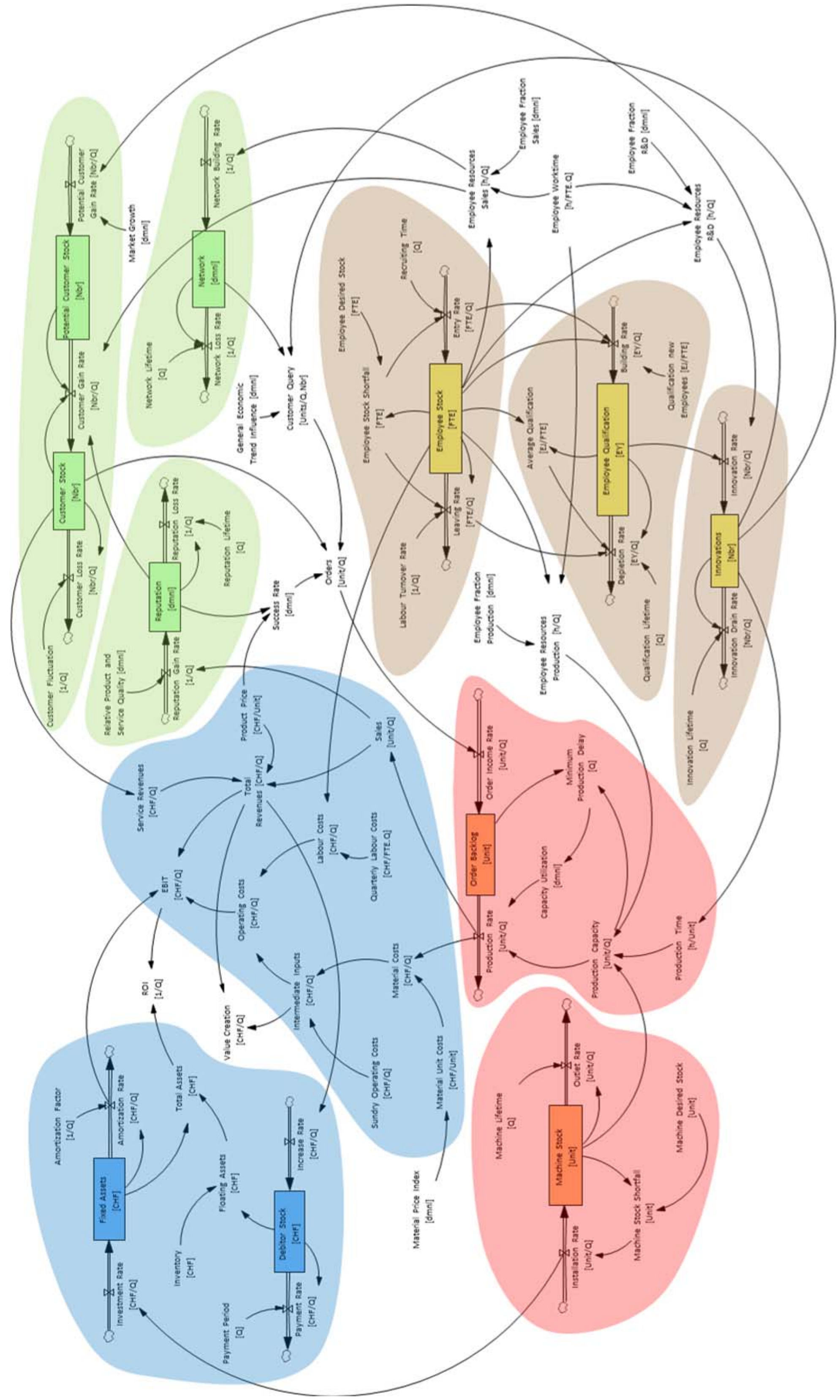

Figure A4: Stock and flow representation of the backbone

A5: Equations of the Backbone

$Fixed\ Assets = \int(Investment\ Rate - Amortization\ Rate)$ [6]
Amortization Rate = Fixed Assets · Amortization Factor
Investment Rate = $\mathcal{F}$(Installation Rate)[7]
Total Assets = Fixed Assets + Floating Assets
Floating Assets = Inventory + Debitor Stock
$Debitor\ Stock = \int(Increase\ Rate - Payment\ Rate)$
Increase Rate = Total Revenues
Payment Rate = Debitor Stock / Payment Period
ROI = EBIT / Total Assets
Value Creation = Total Revenues / Intermediate Inputs
EBIT = Total Revenues – Operating Costs
Total Revenues = (Sales · Product Price) + Service Revenues
Sales = Production Rate
Service Revenues = $\mathcal{F}$(Customer Stock)
Operating Costs = Intermediate Inputs + Labour Costs
Labour Costs = Quarterly Labour Costs · Employee Stock
Intermediate Inputs = Material Costs + Sundry Operating Costs
Material Costs = Material Unit Costs · Production Rate
Material Unit Costs = $\mathcal{F}$(Material Price Index)

$Order\ Backlog = \int(Order\ Income\ Rate - Production\ Rate)$
Order Income Rate = Orders
Production Rate = Production Capacity · Capacity Utilization
Capacity Utilization = $\mathcal{F}$(Minimum Production Delay)
Minimum Production Delay = Order Backlog / Production Capacity
Production Capacity = $\mathcal{F}$(Production Time, Machine Stock, Employee Resources Production)
Production Time = $\mathcal{F}$(Innovations)

$Machine\ Resources = \int(Installation\ Rate - Outlet\ Rate)$
Outlet Rate = Machine Resources / Machine Lifetime
Installation Rate = $\mathcal{F}$(Machine Stock Shortfall)
Machine Stock Shortfall = Machine Desired Stock – Machine Stock

$Employee\ Stock = \int(Entry\ Rate - Leaving\ Rate)$
Entry Rate = Employee Stock Shortfall / Recruiting Time
Employee Stock Shortfall = Employee Desired Stock – Employee Stock
Leaving Rate = Employee Stock · Labour Turnover Rate + $\mathcal{F}$(Employee Stock Shortfall)
*Employee Resources Production = Employee Fraction Production * Employee Stock * Employee Worktime;*

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[6] $\int(\ldots)$ denotes an integration over time
[7] $\mathcal{F}(\ldots)$ denotes a company specific function

*Employee Resources Sales = Employee Fraction Sales * Employee Stock * Employee Worktime;*

*Employee Resources R&D = Employee Fraction R&D * Employee Stock * Employee Worktime;*

Employee Qualification = $\int(\mathit{Building\ Rate} - \mathit{Depletion\ Rate})$

*Building Rate = Employee Stock / 4 + Entry Rate * Qualification new Employees*

*Depletion Rate = Employee Qualification / Qualification Lifetime + Leaving Rate * Average Qualification*

Average Qualification = Employee Qualification / Employee Stock

Innovations = $\int(\mathit{Innovation\ Rate} - \mathit{Innovation\ Drain\ Rate})$

Innovation Rate = $\mathcal{F}$*(Employee Qualification, Employee Resources R&D)*

Innovation Drain Rate = Innovations / Innovation Lifetime

Reputation = $\int(\mathit{Reputaion\ Gain\ Rate} - \mathit{Reputation\ Loss\ Rate})$

Reputation Gain Rate = $\mathcal{F}$*(Relative Product and Service Quality, Sales)*

Reputation Loss Rate = Reputation / Reputation Lifetime

Network = $\int(\mathit{Network\ Building\ Rate} - \mathit{Network\ Loss\ Rate})$

Network Building Rate = $\mathcal{F}$*(Employee Resources Sales)*

Network Loss Rate = Network / Network Lifetime

Customer Stock = $\int(\mathit{Customer\ Gain\ Rate} - \mathit{Customer\ Loss\ Rate})$

Customer Gain Rate = $\mathcal{F}$*(Potential Customer Stock, Reputation, Customer Stock)*

*Customer Loss Rate = Customer Stock * Customer Fluctuation*

Potential Customer Stock = $\int(\mathit{Potential\ Customer\ Gain\ Rate} - \mathit{Potential\ Customer\ Loss\ Rate})$

Potential Customer Gain Rate = $\mathcal{F}$*(Market Growth, Innovations)*

*Orders = Customer Query * Customer Stock * Success Rate*

Success Rate = $\mathcal{F}$*(Reputation, Product Price)*

Customer Query = $\mathcal{F}$*(Network, Innovations, General Economic Trend Influence)*