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Impact of Innovation on Sustainable Business Success

Diploma Thesis

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1. Preface

The project “Impact of Innovation on Sustainable Business Success” is a very complex and broad project. Therefore, a strong collaboration with different experts is necessary. Fortunately, the opportunity to collaborate with many experts and skilled students was afforded to me. This collaboration allowed the outcomes of this project to be deeper and more comprehensive.

First of all, I want to thank Dr. Georges Fadel (Clemson University, Clemson Research in Engineering, Design, and Optimization) and Dr. Markus Meier (ETH Zurich, Institute for Product Development). You made this diploma thesis and my stay at Clemson University possible. It has been a great experience and I am going to take a lot of new knowledge back home. Thank you for always having an open door to discuss problems and give your expert opinions.

Dr. Joshua Summers (Clemson University, Clemson Research in Engineering, Design, and Optimization), Dr. Caron St. John (Clemson University, Spiro Center for Entrepreneurial Leadership), and Dr. Carmen Kobe (ETH Zurich, Institute for Product Development) have also had an open door to discuss problems. They gave a lot of new input and ideas and showed me possible directions to pursue. Thank you for supporting me with your knowledge.

Kerem Arsal (Clemson University, graduate student in Business and Administration) and Matt Motyka (Clemson University, undergraduate student in Mechanical Engineering), you supported this work with a lot of commitment concerning the implementation of this thesis. The discussions with you have always been very helpful to me and I appreciate your work very much, thank you.

Martina Wilhelm (ETH Zurich, PhD student at the Institute for Operations Research) has been a great help in developing the mathematical model in this thesis. Thank you for supporting the development of the mathematical model with your knowledge as an expert in Operations Research.

2. Abstract

The research objective of this thesis is to develop a business model that illustrates the impact product innovation has upon the success of a company. This objective is reached by gathering information by means of industry feedback and literary research and using this information to further refine the fundamental “Impact of Innovation” model, established by Dr. Markus Meier, ETH Zurich.

The model represents the structure of a company’s product innovation by dividing it into three levels: *Innovation Enablers* (fundamental aspects of product innovation, success factors), *Innovation Outcomes* (intermediate goals of product innovation), and *Company Goals* (primary goals of a company). Each of these levels is comprised of a number of elements which are related to each other and influence the elements of the following level. It is of interest to establish which elements are the most influential in determining the overall success of a company.

In the first step, the fundamental “Impact of Innovation” model has been refined by integrating literary research and expertise of professionals. The levels, their elements and sub-elements have been characterized and defined in detail. They include all the fundamental aspects, the intermediate goals and the primary goals of product innovation.
In the second step, a mathematical model has been developed that illustrates the relationships between the three afore mentioned levels and their elements. This mathematical model is based on a linear approach. It expresses the qualitative impact produced by improvements in a company’s *Innovation Enablers* on its *Company Goals*.
In the third step, a survey and an extensive literature research have been performed to gather information about the determining influences between the elements within the three levels and the influences upwards to the elements of the following level.

Combining all the results of the three steps above and the Assessment of Innovation Capability developed at the Center for Product Development, ETH Zurich, leads to a broad model which allows one to visualize the qualitative impact of innovation on sustainable business success. Therefore, the content and outcome of this thesis enables a company to optimize its entire product innovation in a qualitative manner.

3. Introduction

3.1. Motivation

> *"Innovation is the successful exploitation of new ideas and is a vital ingredient for competitiveness, productivity and social gain within businesses and organizations."* [30]

Nowadays, the word "Innovation" is used in almost every company. But what do we know about innovation and how important is it to understand and apply innovation?

True innovation is the driving force, not only of individual companies, but also of entire economies [46]. More than 90 percent of the companies taking part in a survey by Arthur D. Little[1] report that the importance of innovation has increased significantly over the last ten years [46]. Furthermore, according to Leonard and Strauss [17], innovation became an integral part of a business organization's success.
In fact, innovation is so important to corporate entrepreneurship that it may be considered the essence of such activity [18]. Hence, the entire concept of innovation has become a subject of significant research interest. Optimizing a company's entire product innovation system and visualizing the qualitative impact of innovation on sustainable business success is therefore a important need of today's companies.

Many research topics in the innovation field deal with the critical factors of innovation success. Literature answers questions about what a company has to do to be a successful innovator (see [55], [42], [41]). But until now, no research has been detected that describes the detailed impact of innovation on sustainable business success. The explicit connection between successful innovation and a successful company is missing. Literature exists that shows a positive impact between successful innovators and successful companies (see [2]), but the detailed influence and connection of product innovation on sustainable business success has not been researched completely.

This thesis is a first step to describe the detailed, qualitative impact of product innovation on sustainable business success. Its focus of attention is only on product innovation, which is very important for manufacturing companies:

> *"…the long-term competitiveness of any manufacturing company depends ultimately on the success of its product development capabilities. New products development holds hope for improvement market positions and financial performance…"* [56]

[1] Result of a survey of Wall Street analysts [46]

3.2. Introduction to the Model

In order to illustrate this impact of innovation on sustainable business success in a qualitative manner, a model has been developed (Figure 3-1) which differentiates between three levels: *Innovation Enablers* (necessary conditions for product innovation), *Innovation Outcomes* (direct targets of the innovation process) and *Company Goals* (corporate targets). Within each level elements are related to each other and influence the elements of the subsequent level.

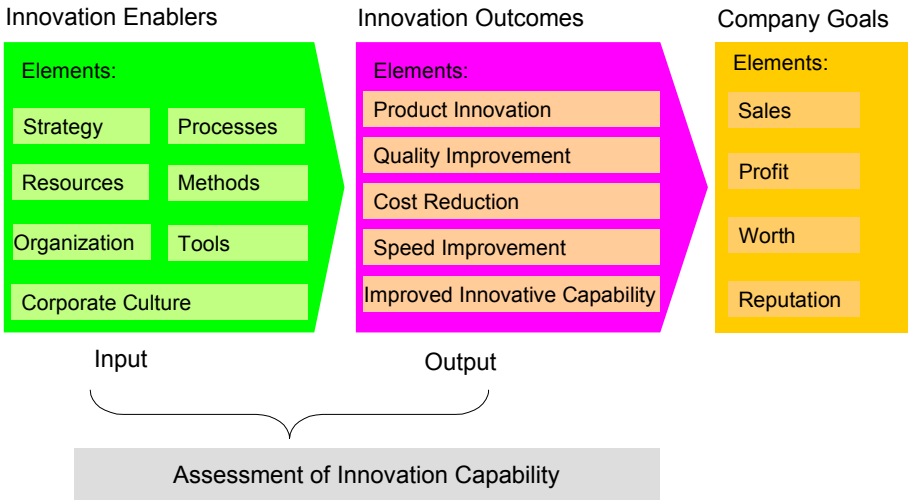


Figure 3-1: "Impact of Innovation" Model

The first step, from the bottom up, is the assessment of the *Innovation Enablers* (see section 11.6). A company is able to measure and control all of its *Innovation Enablers*-elements. This level is the place where a company can make direct changes and has direct influence. In Figure 3-2, the top of the model is the *Company Goals*-level which is not directly influenceable. This leads to the question of how a company can impact its *Company Goals*. How is the *Company Goals*-level effected by the *Innovation Enablers*-level?

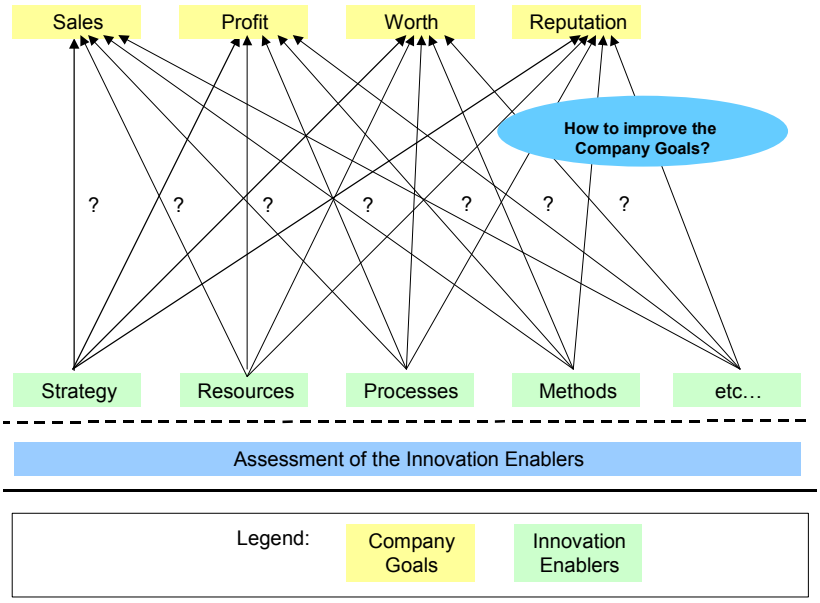


Figure 3-2: How to Improve *Company Goals*?

To analyze and verify the dependencies between *Innovation Enablers* and *Company Goals*, a new level has been implemented: the *Innovation Outcomes*-level (Figure 3-3). This level links the *Innovation Enablers*-level to the *Company Goals*-level. The questions now are, how do the *Innovation Outcomes*-elements influence the *Company Goals*-elements and how do the *Innovation Enablers*-elements effect the *Innovation Outcomes*-elements? With the *Innovation Outcomes*-level as a bridge in this model, it will be possible to point out the dependencies between *Innovation Enablers* and *Company Goals*.

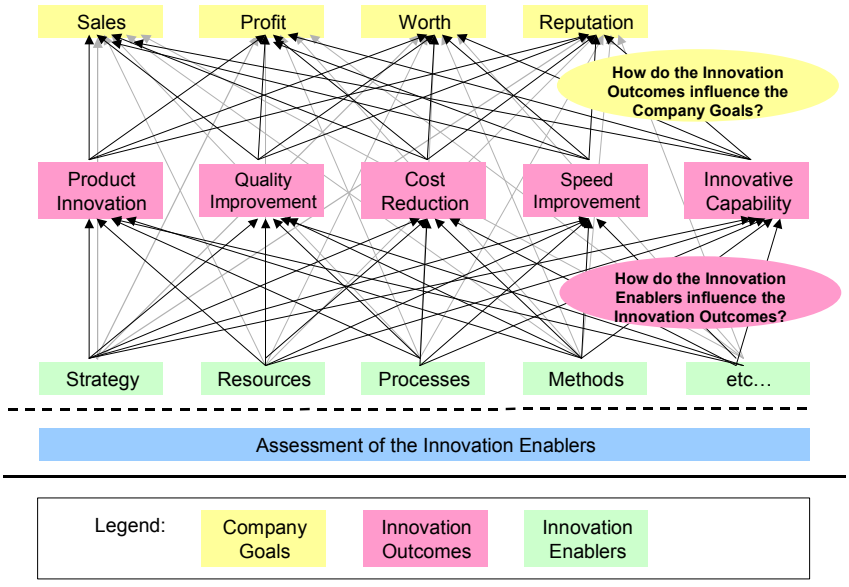


Figure 3-3: The *Innovation Outcomes*-Level as Connection

A significant part of this thesis is to improve and detail the content of this “Impact of Innovation“ model. Therefore, the detailed content is described in chapter 4.

3.3. Research Task

The dependencies between *Innovation Enablers*, *Innovation Outcomes*, and *Company Goals* are to be analyzed, verified, identified, and qualified.

The "Impact of Innovation" model has to be improved by making comparisons with already existing work in the literature, aligning it with the results established at ZPE[2] and through interviews and discussions. The three levels and their elements have to be improved, the individual elements defined and the dependencies described and weighted.

With the development of a mathematical model that illustrates the relationships between the three afore mentioned levels and their elements, the qualitative impact resulting from an improvement in a company's *Innovation Enablers* on its *Company Goals* should be visualized. Therefore, this thesis will qualitatively describe the impact of product innovation and its *Innovation Enablers* on long-term company success. The model will form the basis for the next step, a quantitative model.

Research Question:

How do the critical factors for innovation success
influence a company's performance?

Working Packages[3]:

- become familiar with the current state of the "Impact of Innovation" model
- additional literature study on the areas of innovation and company success; Balanced Scorecard; success factors for innovation
- interviews and discussions with faculty members of the Spiro Center (Dr. Caron St. John, Clemson University)
- become familiar with the model of innovation capability, developed by the ZPE (two theses)
- integrate the results of the studies into the "Impact of Innovation" model
- describe the individual levels and their elements
- describe and assess the dependencies and the impact of the elements within the level and between the levels
- verify the results with studies from the literature and interviews
- give suggestions for further improvement of the model

[2] Center for Product Development, ETH Zurich

[3] defined by the Center for Product Development, ETH Zurich

3.4. Outline

3.4.1. Definition of the Levels and their Elements

In an initial step, the “Impact of Innovation” model has to be refined. Dr. Markus Meier (ETH Zurich) developed the idea of this model. The essential idea is to bring a third level between *Innovation Enablers* and *Company Goals*, the *Innovation Outcomes*-level. With this *Innovation Outcomes*-level, it may finally be possible to show all the dependencies and influences – the impact of innovation on sustainable business success.

All the levels, elements, and their sub-elements are refined and verified comparing them with the relevant literature and by discussions with experts. The entire model is improved and elaborated in a detailed manner. Chapter 4 illustrates the explicit definitions of all the levels, elements and their sub-elements.

3.4.2. The Mathematical Model

In addition to the verbal refining of the “Impact of Innovation” model, a mathematical model has been developed, to show the qualitative impact of *Innovation Enablers* on *Company Goals* (see chapter 5). This mathematical model is based on a linear approach and is kept as general as possible, giving the opportunity to test the model with many different parameters. Currently, no real life data is available to adjust the model and its parameters to reflect reality. Therefore it is necessary to have the possibility of adjusting and testing the model with different parameters before data of parameter studies will be available.

3.4.3. The Program

After introducing the mathematical model, chapter 6 describes its implementation into a computer program. The selection of the software is explained and directions are given to run the program and evaluate the output. Chapter 6 can be viewed as a user manual for the application of the program and the mathematical model behind it. Operating the program enables the user to visualize the qualitative impact of innovation on sustainable business success.

3.4.4. Literature

There is not much literature discussing the desired dependencies between the defined elements. Unfortunately, but predictably since it is novel, no existing literature fits perfectly into the “Impact of Innovation” model. Thus, all the information gathered out of the literature had to be translated to fit into the “Impact of Innovation” model in order to extract at least some results about the element – dependencies (see section 7.2). Translating the literature study results into the structure of the actual model leads to falsifications of these results, and therefore a detailed discussion is needed at the end.

3.4.5. Survey

To support the literature study and its outcomes, a survey of faculty members and companies has been performed (see section 7.3). The output of the survey also gives a first qualitative estimation of how all the interdependencies within the levels, dependencies between the levels, and weights of the elements could be established. Finally, the results of the literature study and survey are compared and discussed in detail.

3.4.6. Conclusion and Outlook

Chapter 8 discusses the overall output and research of this thesis. All of the new insights and knowledge are combined to visualize the qualitative impact of innovation on sustainable business success. The conclusion discusses the new discoveries from this project, concerning the “Impact of Innovation” model. Chapter 9 proposes further research fields, topics and directions for future improvement of the “Impact of Innovation” model.

4. The Elements

4.1. Introduction

This chapter is about the core content of the “Impact of Innovation” model. It defines all elements and their sub-elements (Figure 3-1). The elements and sub-elements were derived from different literature resources and from several discussions with experts (see column “References” in the different sections below).

The first level is called *Innovation Enablers*. Its elements are essential for successful product innovation. The better a company fulfills its *Innovation Enablers*, the higher its chances for innovation success. The second level contains *Innovation Outcomes*. Its elements and sub-elements describe what companies expect from their product innovation. *Innovation Outcomes* is the output of a company’s product innovation. *Company Goals*, the third level, entails the targets companies have.

All these elements and their sub-elements are extracted out of leading literature that describes the innovation success factors and the most important innovation and company goals (see chapter 14). With the target to build a complete, orthogonal element-framework for the “Impact of Innovation” model, all elements of capital importance for each level, *Innovation Enablers*, *Innovation Outcomes*, and *Company Goals* have been taken into account. The sub-elements are also designed to build a complete, orthogonal sub-element-framework, including all sub-elements of capital importance for each element. Therefore, the elements and their sub-elements presented in this chapter are the most important factors related to the impact of innovation on sustainable business success. All innovation success factors brought up in the literature can be placed in a specific sub-element of this “Impact of Innovation” model.

Note that all the definitions in this chapter always relate to product innovation!

4.2. Innovation Enablers

Innovation Enablers constitutes the first level of the “Impact of Innovation” model. The level consists of different organizational characteristics that every company should be able to modify and influence directly. Figure 4-1 shows these different organizational characteristics.

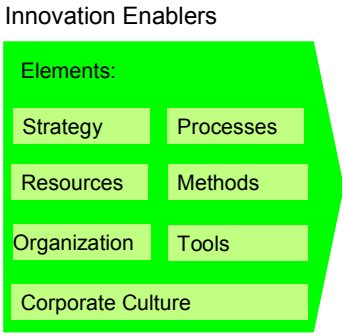


Figure 4-1: *Innovation Enablers*

Methods and *Tools* are independent from the element *Processes*. Certainly *Methods* and *Tools* can be seen as part of *Processes*, but they are also very important themselves and have strong weights not only in this model but also in the Assessment (see 11.6). Therefore, *Methods* and *Tools* are separate elements. This avoids *Processes* becoming a highly weighted element compared to the other elements, thus the model becomes more balanced.

All the elements have several sub-elements. The sub-elements are grouped into different categories (column “Category”). These categories are with regard to innovation in general, product, market, and technology. The structure helps to give an overview of all sub-elements in an element. *Strategy*, *Organization* and *Corporate Culture* are not divided into such categories because they only relate to innovation in general.

4.2.1. Strategy

(*Definition, Implementation and Continuous Improvement of Strategy*)
Description: A long-term plan of innovation set and agreed upon by the company's leadership and communicated to stakeholders and employees. Such strategy takes into account the company's corporate strategy, its core competencies and market situation.

Sub-Element	**Definition**	**Ref.**[4]	**Examples**
Product Innovation Strategy	Defines and communicates role and goals of innovation. It considers the fit to the market, the core competencies, and correlates the (product-) innovation strategy to the corporate strategy.	[42], [41], [13], [2]	
Strategy Fit	Correlates the (product-) innovation strategy to the innovation action.	[13]	

Table 4-1: Element Definition of *Strategy*

[4] References

4.2.2. Resources

Description: The engineering, production, and sales resources and capabilities that enable a company's innovation process. These include financial, personnel, knowledge, skills, equipment, and intellectual properties.

Category	Sub-Element	Definition	Ref.	Examples
Innovation	Innovation Resources	Financial resources and defined allocations that enable R&D and innovation projects.	[13], [41]	R&D budget; innovation project budget
	Project Fit	Fit between projects and resources.		
	Further Education	Improvement in technological knowledge and skills of the company's human resources, and effectiveness of the innovation process through well-trained employees.	[42], [41], [13]	training in: methods, tools, product innovation, creativity, knowledge and skills in technologies
Product	Personnel / Design Resources	Quantity and quality of facilitators in the entire design process.	[13], [41]	people; knowledge, intellect, skills; time allocation
Market	Sales / Services Resources	Quantity and quality of facilitators in the entire sales and customer service process.	[13], [41]	people; budget; software / hardware / equipment; knowledge
Technology	Technological Resources	Knowledge and skills available in the company related to technologies to design and produce a product.	[61], [11], [42], [41], [13], [16]	personnel / knowledge / skills; patents; facilities in labs and equipment; external resources
	Production Resources	Quantity and quality of facilitators in the entire production process.	[13], [41]	people; budget; software / hardware / equipment; knowledge; flexibility in production

Table 4-2: Element Definition of *Resources*

4.2.3. Processes

(*Definition, Implementation and Continuous Improvement of Processes*)
Description: The systematic approaches to move ideas into products and introduce them into the market, including processes for generating ideas, conceptualizing, embodiment, technology support, production, and launching the product.

Category	Sub-Element	Definition	Ref.	Examples
Innovation	Innovation Pipeline	Process to collect innovation ideas through technology push and market pull.	[13], [26], [42], [41], [2]	idea suggestion-, improvement-, and assessment-programs; improvement teams; voice of the customer
	Product Innovation Process	Systematic and flexible approaches between initiation process and product launch.	[26], [13], [2], [41]	idea management; prestudy process; business-planning-process; conceptual process; design process; embodiment process; documentation process; implementation process; testing of prototypes
	Innovation Filters	Milestones in process to assess, balance, and prioritize projects in order to maximize the value of the project-portfolio.	[42], [41], [13], [2], [26]	balance of short-/ long-term-, as well as evolutionary- / revolutionary projects; bullet-proof gates; detecting disruptive innovations; resources allocation

Product	Product Management[5]	Bridges strategy, market, and technology to innovation through a strong collaboration with the design team. It creates an early and stable product definition, and acts flexibly when faced with unforeseen outcomes.	[42], [41], [13], [34]	product specifications; product requirements and constraints; cost and timetable
Market	Market Launch Planning Process	Definition and resource allocation to a concept aimed at introducing an innovation into a defined market / customers, and couples this concept to the innovation process.	[42], [41], [26], [13]	early planning
Technology	Production Planning Process	Defines and resources concept and stages of product manufacturing and its coupling to the innovation process.	[26], [13]	
	Technology Management	Processes for monitoring, capturing, and assessing of mainstream and disruptive technologies, and to transform those to innovation.	[13], [16],	processes to perform competence platforms, knowledge transfer from extern (universities, students, experts, associations) to innovation; define a patent- and license-strategy, and technology road-maps; monitoring regulations, standards, patents, literature

Table 4-3: Element Definition of *Processes*

[5] The reader may have a different understanding of "product management" than it is defined in this model. Since this model is focused on product innovation, the definition of "product management" is less broad than it might be in business literature.

4.2.4. Methods

(*Knowledge, Application and Continuous Improvement of Methods*)
Description: The specific working procedures that improve the effectiveness and efficiency of a company's approach to innovation and communication.

Category	Sub-Element	Definition	Ref.	Examples
Innovation	Project Management and Controlling	Administrates and controls the entire innovation project. Assesses, documents, and evaluates the outcomes, and improves and adapts processes where necessary.	[13], [42], [41], [2]	coupled with process model; definition of milestones with strict go / no go decision points; lessons learned concepts
	Innovation / Design Methods	Support the entire innovation- and design process in efficiency and effectiveness.	[2], [13], [61]	quality function deployment (QFD); lead user concept, conjoint analysis; target costing; simultaneous engineering; collaborative design; benchmarking; value engineering; failure mode and effect analysis (FMEA); product modularity
	Internal Communication Methods	Support team-internal communication.	[13], [59]	project meetings; review meetings; presentations
	External Communication Methods	Support different tasks in team-external communication.	[13], [59]	information push to stakeholder (newsletter, press-conference); stakeholder pulls communication (internet); defined communication channels
Product	Product-Analysis	Gathers worldwide information about own and competitive products, concerning past, current situation, and future trends.	[14]	customer needs; market share; satisfaction analysis; cost analysis; service data analysis

Market	Market Analysis	Gathers worldwide information about market / customers, competitors, and market attractiveness, concerning past, current situation, and future trends.	[2], [42], [41], [13]	customer needs and satisfaction analysis; cost analysis for own and competitor products; competition analysis; service data analysis
Technology	Technology-Analysis	Gathers worldwide information about known and new technologies, concerning past, current situation, and future trends.	[14]	technology scanning-, monitoring; cooperation with universities; expert interviews

Table 4-4: Element Definition of *Methods*

4.2.5. Tools

(*State and Continuous Improvement of Tools*)
Description: The software, hardware and equipment to facilitate the design and engineering of the products, the management of product information, and the communication.

Category	Sub-Element	Definition	Ref.	Examples
Innovation	Design Tools	Software and hardware to support the entire design process in efficiency and effectiveness.	[13], [16]	Computer Aided Design (CAD); visual prototyping: Virtual Reality (VR); physical prototyping: Rapid Prototyping (RP); Computer Aided Manufacturing (CAM)
	Data Integration Tools	Software and hardware to support the entire data acquisition and management process and enable the consequent reuse of information in adjacent business processes.	[13], [16]	Product-Data-Management (PDM); Product Lifecycle Management (PLM)
	Engineering Analysis Tools	Software and hardware to support the entire product analysis and verification.	[13], [2], [16]	Computer Aided Engineering (CAE); simulation tools; FEA, CFD; standardized dimensioning procedures
	Communication Tools	Software and hardware to support information exchange.	[13], [16], [59]	shared servers, shared desktops, knowledge-transfer tools, knowledge information center; video conferencing, phone-networks; email system, net chat; application sharing; electronic project rooms; computer supported cooperative work (CSCW)

Table 4-5: Element Definition of *Tools*

4.2.6. Organization

(*Definition, Implementation and Continuous Improvement of Organization*)
Description: The management of the relationships of those involved in the innovation process, including the innovation teams within the company and suppliers, customers, and others.

Sub-Element	Definition	Ref.	Examples
Innovation Team	Team working with a common goal using shared ideas, expertise, empowered with responsibilities and resources. The team is linked to the company's organization, supported through management, where the team's structure and composition leads to a successful output.	[42], [41], [13], [18]	concept to select innovative people and form successful teams; excellent gifted teamleader; team-organization fit to project-type; team which understands the goal; self responsible acting teams; short ways to decisions; reintegration of the team after the project
Cross-functional Interaction	Connects people locally and globally from different sites and functions in the enterprise, suppliers, customers, and competitors, for an effective and successful collaboration.	[42], [41], [11], [2], [13], [18]	strong interaction with marketing, production, research lab, service, customer; engineering contact with customer
Network Competence and Multidisciplinary	Connects involved disciplines and information flow within enterprise, and externally with universities and partners.	[61], [13], [46]	knowledge, how to deal with joint venture or alliance partners (including the legal side)

Table 4-6: Element Definition of *Organization*

4.2.7. Corporate Culture

(*State and Continuous Improvement of Corporate Culture*)
Description: The shared values, way of working and behaving, especially the general customs, beliefs, and behavior of the entire company, including the company's approach to communication, leadership, and motivational factors.

Sub-Element	Definition	Ref.	Examples
Innovation Culture	Way of innovating, which supports continuous learning and improvement of core- and social-competencies, and high customer-value-orientation.	[11], [42], [41], [2], [13]	vision of the future; complete company is assigned to be innovative; realistic self-assessment; corporate pride and passion; suppliers seen as innovation partners; openness for change; high ethic standards
Communication	Way of communication and interaction within company and towards outside the company.	[13], [59]	discussions culture; directness; honesty; speaking the same design-language; understand / know different habits; take time for communication
Leadership	Structure, behavior and charisma of leading people in a company and how management supports or constrains innovation culture in the company.	[55], [42], [41], [13], [46]	management attention for innovation; setting broad goals; ability not to overload the amount of project; positive failure treatment; supporting of decision making and taking risk; provide the direction and stimuli to spur creativity; reward for innovative inputs; promotion of innovation success; celebrate success
Motivation of Employees	Concepts to cultivate committed employees in order to be creative, innovative and self learning.	[13], [42], [41]	incentive system; rewards; time for creativity; culture of self responsibility; possibility and support for further education; groom project team leaders

Table 4-7: Element Definition of *Corporate Culture*

4.3. Innovation Outcomes

Innovation Outcomes (Figure 4-2) builds the middle level in the "Impact of Innovation" model. It acts as a bridge between *Innovation Enablers* and *Company Goals*. The *Innovation Outcomes*-level enables the detection of the detailed dependencies between *Innovation Enablers* and *Company Goals*.

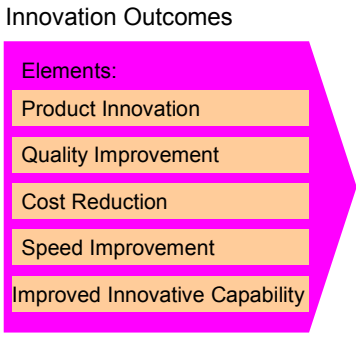


Figure 4-2: *Innovation Outcomes*

Innovation Outcomes is the output or the goal of a company's product innovation. *Innovation Outcomes* describes what a company expects out of the product innovation, such as quality improvement, cost reduction, speed improvement, an improved innovative capability and an overall, real, visible product innovation.

4.3.1. Product Innovation

Description: The product innovation redefines or creates new market needs, provides higher customer value, builds new or improves existing core competencies within the innovation team, and provides potential for further product development.

Sub-Element	Definition	Ref.	Examples
High Market Value	Innovation satisfies customer needs with a high customer advantage and value in defined market segment. The innovation has a good price / performance ratio.	[2], [13], [16], [34]	product is user friendly in all phases of life-cycle; unexpected, recognized product functions and features; high market response of the product; high image value
High Company Value	The innovation fits the company's culture and strategy, uses synergies with other product segments, seizes interesting market segments with added potential, and leads to a high product market share.	[13], [61], [42], [41] [31], [34]	high market potential; high differentiations; high entry barriers; innovation improves customer trust; builds and improves core competencies; potential to build up new market segments; low substitution; good supplier market; improvement or potential for assortment extension and further options

Table 4-8: Element Definition of *Product Innovation*

4.3.2. Quality Improvement

Description: Quality of product innovation is improved if the characteristics of one product have the ability to fulfill the needs that customers expect, and is supported by a high innovation process quality.

Sub-Element	Definition	Ref.	Examples
High Product Quality	Meets or exceeds customers' quality expectations.	[2], [13], [16], [34], [32]	low warranty problems; high product reliability; low risks
High Process Quality	High quality in all processes from innovation to production.	[2], [13]	high quality in the design process and in the production process; low modification rate after production start and after market launch

Table 4-9: Element Definition of *Quality Improvement*

4.3.3. Cost Reduction

Description: *Cost Reduction* allows reduction in the costs of producing a product or reduction in costs associated with other processes or activities of the company.

Sub-Element	Definition	Ref.	Examples
Low Product Costs	Costs for material, manufacture, purchase, assembly, storage, and installation of the product and potential for future cost reduction.	[2], [13], [34], [32], [19]	low costs for material; manufacture and assembly oriented design; low supplier (price-) dependencies; low investments in facilities, equipment, tools; economy of scale; improving the scale factor
Low Innovation Costs	Minimum related R&D expenses and related development costs.	[2], [13], [61], [34], [32]	efficient product innovation process

Table 4-10: Element Definition of *Cost Reduction*

4.3.4. Speed Improvement

Description: *Speed Improvement* allows the company to respond to customer needs more quickly, through faster production processes, responsive scheduling, faster innovation and design, etc..

Sub-Element	Definition	Ref.	Examples
Short Innovation Process	Minimum time of product innovation and production.	[2], [13], [42], [41] [61], [16], [34], [32], [59]	short overall development time; short production time: strong interaction between development and production
Short Market Launch Process	Minimum time to launch product to market.	[2], [13], [42], [41] [61], [16], [34], [32], [59]	short market introduction time: strong interaction between development an marketing

Table 4-11: Element Definition of *Speed Improvement*

4.3.5. Improved Innovative Capability

Description: Improvements in the capability of the organization to innovate over time and the added values. The improved innovative capability is the enhanced worth of a company through the entire product innovation process.

Sub-Element	Definition	Ref.	Examples
Measurable Assets	Improvements in a company's measurable assets through product innovation.	[13]	patents, innovation patents; facilities, equipment, software, tools, processes
Non-measurable Assets	Improvement in a company's non-measurable assets through product innovation.	[13]	improved efficiency of projects; improved culture, reputation in innovation, network, strategy

Table 4-12: Element Definition of *Improved Innovative Capability*

4.4. The Company Goals

Company Goals (Figure 4-3) are the main targets of a company. Every company defines its own goals. This model includes just the main goals of almost every company and groups them into four basic elements which may have different weights for specific companies. Eventually, every company's goal is to make money and to assure its existence. This is the leading idea that the *Company Goals*-level of this model is based on.

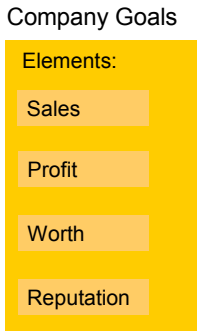


Figure 4-3: *Company Goals*

A company's goals are not influenced solely by product innovation. There are a lot of other factors like marketing, logistics, top-management etc. influencing a company's goals. This model's focus is only on the impact of product innovation on company goals and does not deal with other influences.

4.4.1. Sales

Description: The sales-target of a company is increase in direct and indirect product related sales and increase in market share.

Sub-Element	Definition	Ref.	Examples
Increase of Direct Product Related Sales	Income (at invoice values) received for products over a given period of time.	[13], [2], [41]; [15]	balanced product portfolio; sales of products with different ages
Increase of Indirect Sales	Income (at invoice values) received for services over a given period of time.	[13], [2], [41]; [15]	services; training; spare parts; license manufacturing
Increase of Market Share	Ratio of sales of a company's products to the total sales of the defined market.	[13], [2], [41], [34]; [15]	customer loyalty and acquisition; market leadership; ensure growth (advance into new fields)

Table 4-13: Element Definition of *Sales*

4.4.2. Profit

Description: The profit-target of a company is increase in profit, shareholder profit, return on investment and covering of a company's growth.

Sub-Element	Definition	Ref.	Examples
Increase Profit	Amount of monetary gain for a company.	[13], [41], [34]; [15]	finance and ensure the company's future; increase of selling price; reduction of product costs; reduction of overhead costs
Return on Investment	Return ratio that compares net benefits of a project, verses its total costs. ROI is a measure of operating performance and efficiency in utilizing assets by a company.	[46], [41], [59]; [15]	

Table 4-14: Element Definition of *Profit*

4.4.3. Worth

Description: The worth-target of a company is a company's monetary value and its value based on subjective estimation.

Sub-Element	Definition	Ref.	Examples
Capitalized Worth of the Company	Monetary value of a company.	[13], [2], [46]; [15]	shareholder value / profit; return on assets; return on equity
Emotional Worth	Value of a company based on subjective estimation.	[13], [2]; [15]	input into environment relieve; input into humanity; advance skills

Table 4-15: Element Definition of *Worth*

4.4.4. Reputation

Description: The reputation-target of a company is the general esteem that public and employees have for the company.

Sub-Element	Definition	Ref.	Examples
Outwards Oriented Reputation	General estimation that public has for the company.	[13]; [15]	reputation to customers, society, stakeholders, finance world, universities, potential employees
Inwards Oriented Reputation	The general estimation that employees have for their company.	[13]; [15]	reputation to employees, board; pleased employees

Table 4-16: Element Definition of *Reputation*

4.5. Summary

Through extensive literature studies and discussions with experts in the business and innovation field, it was possible to define all most important elements in the “Impact of Innovation” model (Figure 3-1). Also the sub-elements of these elements are defined now. All the input of literature taken into account (see chapter 14) fits into this “Impact of Innovation” model. Every factor out of the literature concerning product innovation can be placed into an element of the model. Therefore, it is likely that the model includes all of the most important elements and sub-elements for product innovation. But even if the effort has been great to establish the best possible independent elements, the overall problem is extremely intertwined and the goal of orthogonality could only be approximately but not exactly reached.

5. The Mathematical Model

5.1. Introduction

In chapter 3.2 “Introduction to the Model”, the basic idea of the “Impact of Innovation” model was introduced. This chapter presents a mathematical model to visualize the qualitative impact of innovation on sustainable business success. Initially, the main objectives of the mathematical model are formalized. Further, a concept is developed to solve the mathematical problem. Finally, the mathematical approach and concept are evaluated and a conclusion is given.

5.2. Objectives of the Mathematical Model

The mathematical model should show the relative impact on *Company Goals* depends upon the modification of the *Innovation Enablers*. The user asks the following question: “In which *Innovation Enablers*-element should I invest, in order to optimize my *Company Goals*?.”

In Table 5-1 the main objectives for the mathematical model are listed. The objectives distinguish “musts”- and “wishes”-goals. These goals are gathered out of discussions with experts and out of the research task.

	Objectives
Must	show the qualitative impact of *Innovation Enablers* on *Company Goals*
	include the inter-level dependencies
	include the intra-level dependencies
Wishes	weigh the importance of the elements
	simple user-interface (user-friendly)
	control the ratio between the importance of the inter-level and the intra-level dependencies

Table 5-1: Objectives of the Mathematical Model

Figure 5-1 demonstrates the influence flow in the entire “Impact of Innovation” model. From bottom to top, the influence flow starts with the Assessment of Innovation Capability (see section 11.6). This Assessment aids companies in their awareness of their strengths and weaknesses in product innovation. Taking its strengths and weaknesses into account, the company then plans improvements in its product innovation. For example, the Assessment may signal a weakness in *Strategy* and *Methods*. It is highly important that the company has insight on whether improvements in *Strategy* and / or *Methods* have no, slight or strong impact on its *Company Goals* and whether it is worth investing money in such courses of action.

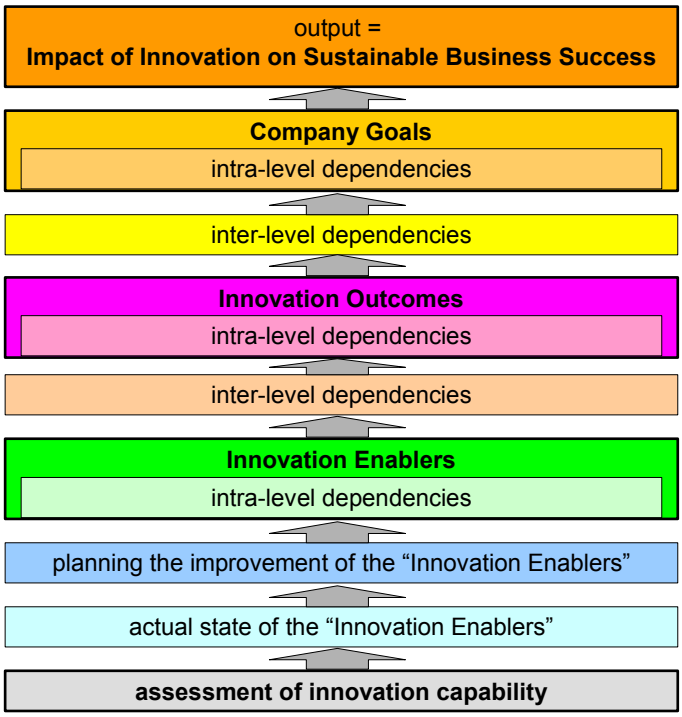


Figure 5-1: From the Assessment to the Output

To measure the impact of an improvement in *Innovation Enablers* on *Company Goals*, a mathematical model is needed.

The required input into the model is:

- planned improvement of *Innovation Enablers*
- intra-level dependencies within *Innovation Enablers* (interdependencies between all *Innovation Enablers*-elements)
- inter-level dependencies between *Innovation Enablers* and *Innovation Outcomes* (influence of every *Innovation Enablers*-element on every *Innovation Outcomes*-element)
- intra-level dependencies within *Innovation Outcomes* (interdependencies between all *Innovation Outcomes*-elements)
- inter-level dependencies between *Innovation Outcomes* and *Company Goals* (influence of every *Innovation Outcomes*-element on every *Company Goals*-element)
- intra-level dependencies within *Company Goals* (interdependencies between all *Company Goals*-elements)

The “wishes”-input into the models is:

- weight of each *Innovation Enablers*-element
- weight of each *Innovation Outcomes*-element
- weight of each *Company Goals*-element
- relative ratio of the importance of inter-level dependencies compared to intra-level dependencies

At the end of the influence flow, the model adjusts the qualitative impact of innovation on sustainable business success dependent on the modification in the *Innovation Enablers*-level of a company. Thus, a company can now answer the question: "In which *Innovation Enablers*-element should I invest, in order to optimize my *Company Goals*?."

5.3. Modeling the Dependencies

Even if the actual state of research does not permit the specification of exact dependencies of all elements included in the "Impact of Innovation" model, it is possible to describe these dependencies in a qualitative way. The mathematical model is independent of the values of the dependencies.

To develop this mathematical model, no initial experience and data exists. The *Innovation Enablers*-elements influence the *Innovation Outcomes*-elements, the *Innovation Outcomes*-elements influence the *Company Goals*-elements and within every level, the elements influence each other as well. All these influences are described by flows (see section 3.2). Flows are comprehensive and make these influences easy to visualize for people. Imaginable dependencies are very important, because for the modeling of these influences, their numbers have to be known. These numbers can only be gathered out of information from people very close to the innovation field. To be able to gather this required information, people need to understand the model, it has to be easy to visualize for them. For example: If the model flow was supposed to be like a damped system, how would people be able to come up with numbers for the dependencies between the elements? The non-linear behavior of the damped system can only be characterized through extensive testing, where a linear approach would be a good approximation for a first qualitative model without extensive testing.

Based on these facts above, the research-team made an assumption for the further development of the mathematical model:

Assumption 1:
The behavior of intra-level and inter-level dependencies is linear.

In the first step, the conceptual design of the intra-level dependencies is explained. Afterwards, the modeling of the inter-level dependencies is visualized. Finally, the mathematical calculation and the merging of the intra-level dependencies with the inter-level dependencies are described.

5.3.1. Intra-Level Dependencies

The intra-level dependencies show how the different elements within one level influence each other. Research on how strong these intra-level influences in each level are compared to the inter-level dependencies has not yet been conducted. But as the survey (see section 7.3) proves, intra-level dependencies exist and therefore, these dependencies have to be included in the mathematical model.

Example of the intra-level dependencies (Figure 5-2): The user wants to know how all elements influence each other, when he wishes to plug in a certain value as input for the *Innovation Enablers Resources* (A), *Strategy* (B), and *Processes* (C). This idea leads to a loop-solution.

Value of the impact *Resources* (A) has on *Strategy* (B): ab
Value of the impact *Resources* (A) has on *Processes* (C): ac
Value of the impact *Processes* (C) has on *Strategy* (B): cb
Value of the impact *Strategy* (B) has on *Processes* (C): bc

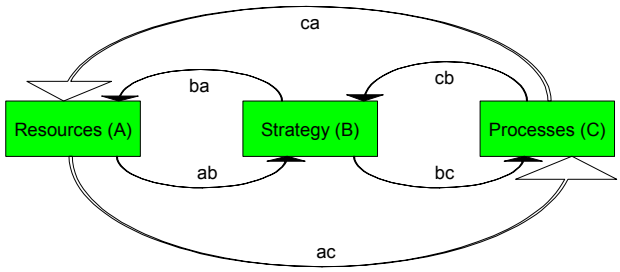


Figure 5-2: Loop-Solution Overview

Making this loop-solution easier to understand, the following example explains the concept with only two elements, *Resources* and *Strategy*:

The user invests 10,000$ in *Resources* (Figure 5-3). This investment triggers a value-enhancement of *Strategy*. But the value-enhancement of *Strategy* causes a new value-enhancement of *Resources*, and this new value-enhancement of *Resources* again causes a new value-enhancement of *Strategy* and so on.

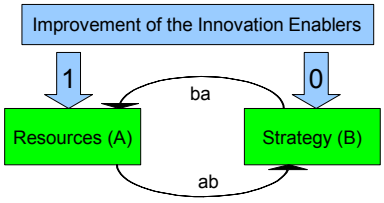


Figure 5-3: Loop-Solution Input

This concept causes a loop. The calculation of this loop is explained in Figure 5-4.

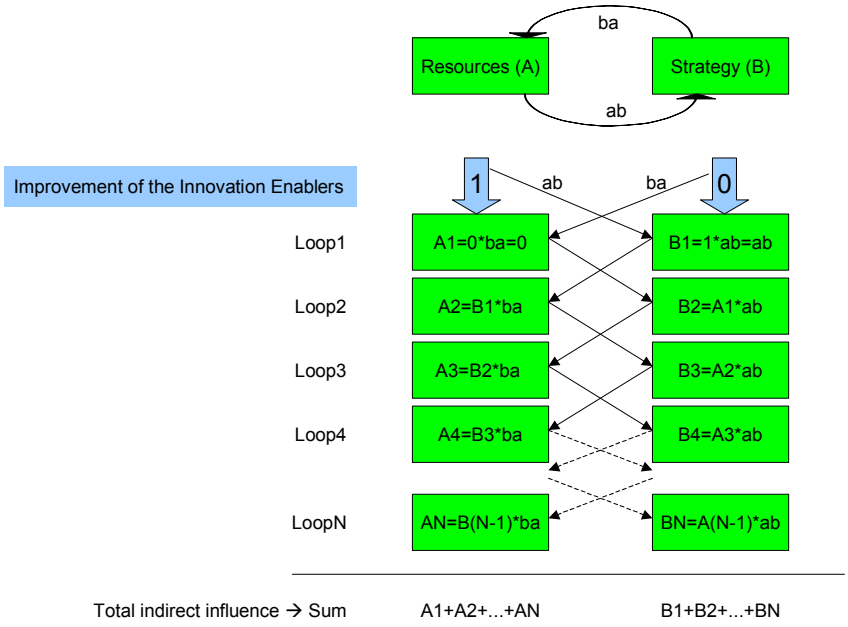


Figure 5-4: Loop-Solution Calculation

First loop:
A1 = ba * input B
B1 = ab * input A

Second loop:
A2 = ba * B1
B2 = ab * A1

Loop N:
AN = ba * A(N-1)
BN = ab * A(N-1)

AN and BN are the intra-level interaction of the loop N.

What values for ab and ba make sense?

- Decreasing values (values ≥ 0 and < 1): The more the iterations are, the less impact the improvement of the *Innovation Enablers* has on an element. If a company invests in its *Resources* directly, the indirect improvement of *Strategy* will be less than the direct improvement of *Resources*. In other words, the direct value-enhancement of *Resources* impacts a value-enhancement in *Strategy*, but not as high as the direct value-enhancement in *Resources* itself.
- Increasing values (values ≥ 1): The more the iterations are, the higher impact the improvement of the *Innovation Enablers* has on an element. If a company invests in its *Resources* directly, the indirect improvement of *Strategy* will be higher than the direct improvement of *Resources*. In other words, the direct value-enhancement of *Resources* creates a higher value-enhancement in *Strategy* than in *Resources*.

For further analysis the research-team assumes decreasing values. Calculating with values ≥ 0 and < 1 is very important in this model because if the values were ≥ 1, the new value-enhancement would increase with every loop and from experience this is unrealistic for the actual problem. If $0 \leq ab < 1$ and $0 \leq ba < 1$ then the new value-enhancement decreases with every loop. Hence, the intra-level influence decreases and converges to zero.

At the current state of research it is not known if loops are realistic or if the intra-level influence is too small compared to the inter-level influence. Further research in this field is necessary to answer this question (see chapter 9).

5.3.2. Inter-Level Dependencies

The next step, after measuring the final values of the *Innovation Enablers*-elements (intra-level dependencies), is the calculation of the inter-level influences (Figure 5-5). The values out of level 1 will be multiplied with the according influence values of the inter-level dependencies (*Assumption 1*).

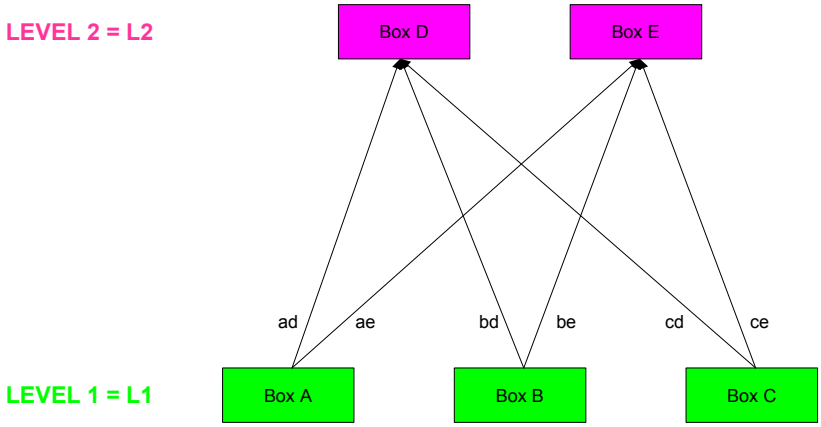


Figure 5-5: Inter-Level Dependencies

Hence, the input into level 2 is as follows:
Input D = Output A * ad + Output B * bd + Output C * cd
Input E = Output A * ae + Output B + be + Output C * ce

The principles of the calculation with intra- and inter-level dependencies should be clarified by now. These principles can be used between every level (inter-level dependencies) and within every level (intra-level dependencies), regardless of the level that is measured.

5.4. The Calculation

5.4.1. Input of the Calculation

The following parameters into the calculation are required[6] (Figure 5-6):

$in1 = \begin{bmatrix} ia \\ ib \\ ic \end{bmatrix}$ planned improvement of *Innovation Enablers*

$L1 = \begin{bmatrix} 0 & ab & ac \\ ba & 0 & bc \\ ca & cb & 0 \end{bmatrix}$ intra-level dependencies within *Innovation Enablers*

$C1 = \begin{bmatrix} ad & ae \\ bd & be \\ cd & ce \end{bmatrix}$ inter-level dependencies between *Innovation Enablers* and *Innovation Outcomes*

$L2 = \begin{bmatrix} 0 & de \\ ed & 0 \end{bmatrix}$ intra-level dependencies within *Innovation Outcomes*

$C2 = \begin{bmatrix} df & dg & dh \\ ef & eg & eh \end{bmatrix}$ inter-level dependencies between *Innovation Outcomes* and *Company Goals*

$L3 = \begin{bmatrix} 0 & fg & fh \\ gf & 0 & gh \\ hf & hg & 0 \end{bmatrix}$ intra-level dependencies within *Company Goals*

$d = \begin{bmatrix} d1 \\ d2 \\ d3 \end{bmatrix}$ ratio between importance of inter-level influence and intra-level influence

N_end number of loops in the intra-level

[6] The actual "Impact of Innovation" model consists of more elements than contained in the following matrices. These matrices are based on a model with three *Innovation Enablers*-elements, two *Innovation Outcomes*-elements, and three *Company Goals*-elements, to make the calculation more clear and comprehensible. Of course, these matrices can always be expanded to their real dimensions very easily!

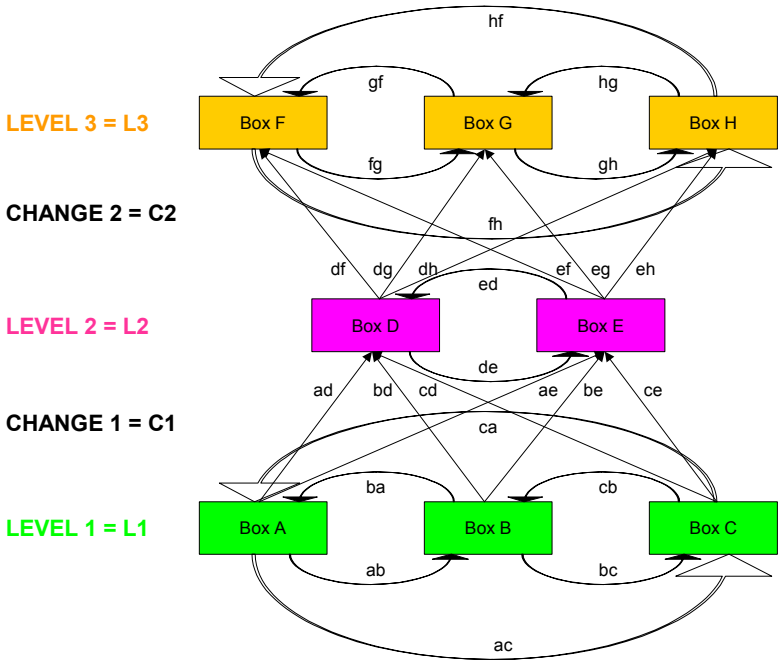


Figure 5-6: Loop-Solution

5.4.2. Calculation

(1) Inter-level influences in the first level (*Innovation Enablers*):

$in1 = 1 * in1$

(2) Intra-level influence in the first level (within *Innovation Enablers*):

(2.1) First step in the loop:

$L1^T * in1$

This step creates a value-enhancement in the *Innovation Enablers*-elements and this value-enhancement influences all other *Innovation Enablers*-elements again.

(2.2) Second step in the loop:

$L1^T * L1 * in1 + L1^T * in1$ (with $L1^T * in1$ out of (2.1))

This step causes a new value-enhancement in the *Innovation Enablers*-elements and this new value-enhancement influences all other *Innovation Enablers*-elements again in a pattern of a loop.

…

(2.N_end) This is the end of the loop. The loop is calculated as:

$$\sum_{i=1}^{N\_end} (L1^T)^i * in1$$

This loop results in very high values compared to the input (inter-level influences in (1)). Thus, the ratio between intra-level influence and inter-level influence becomes unrealistic. To solve this problem, a normalization has been implemented (see section

5.4.3). With this normalization, the user is able to choose the ratio between the inter-level influence and intra-level influence and make the simulation as realistic as possible[7]. To observe what happens without normalization, the user has the chance to switch it off.

(3) Calculation of the total value in every element:

$$1 * in1 + \sum_{i=1}^{N\_end} (L1^T)^i * in1 = (1 + \sum_{i=1}^{N\_end} (L1^T)^i) * in1$$

This is the sum of the values out of step (1) to (2.N_end).

(4) The change to level 2 (*Innovation Outcomes*) is:

$$(C1^T) * (1 + \sum_{i=1}^{N\_end} (L1^T)^i) * in1 =: in2$$

(5) The value $in2$ is the new input into step (1) where the same calculations can be implemented.

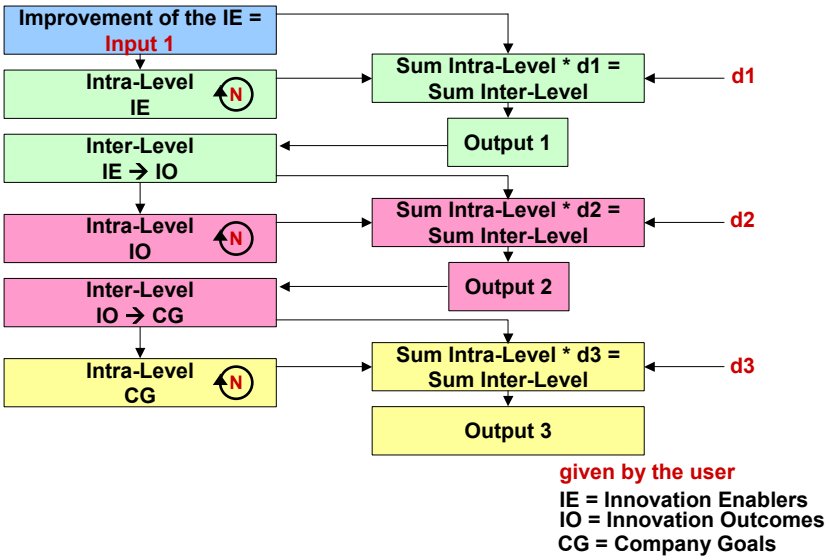


Figure 5-7: Calculation Structure

(6) Figure 5-7: The final calculation for all the levels (steps (1) to (5) for all the three levels) results in the following formula:

$out = A * in1$ with

$$A = (1 + \sum_{i=1}^{N\_end} (L3^T)^i) * (C2^T) * (1 + \sum_{i=1}^{N\_end} (L2^T)^i) * (C1^T) * (1 + \sum_{i=1}^{N\_end} (L1^T)^i)$$

out is the qualitative improvement of *Company Goals* with $in1$ as the qualitative improvement of *Innovation Enablers*.

[7] At the moment, it is not known what „realistic“ is. Further investigation will be necessary.

5.4.3. Normalization

To choose the ratio between the importance of inter-level- and intra-level influences and to add the loop-influence into relation to the direct influences, normalization is required.
The idea is to set the weight of the intra-level influences equal to the weight of the inter-level influences (see also Figure 5-7). Therefore, the goal is:

weight of inter-level influences = weight of intra-level influences

The following procedure is applied to normalize the influences:

(1) $s1 = size(L1)$ $s1$ indicates the size of matrix $L1$

(2) $e1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ identity matrix with the same size as $L1$

(3) $SL1$ matrix after N_end loops, describing the intra-level influences

(4) $sum(sum(e1)) = s1(1)$ sums all elements in $e1$ = weight of the inter-level influences

(5) $sum(sum(SL1))$ sums all elements in $SL1$ = weight of the intra-level influences

(6) $sum(sum(SL1)) = s1(1)$ weight of the intra-level influences = weight of the inter-level influences

(7) $n1 = 1 = \frac{sum(sum(SL1))}{s1(1)}$ normalization

(8) $N1 = n1 * ones(s1)$ $N1$ is a matrix equivalent to the size of $L1$, and all elements of this matrix are equal to the normalization factor

(9) $SL1 = SL1./N1$ every element of the matrix $SL1$ is divided by the normalization factor → the intra-level influences are normalized or in other words: The weight of the intra-level influence is equal the weight of the inter-level influence.

(During all the steps (1) to (9), the input vector $in1$ is factored out.)

The entire MATLAB code is written in section 11.4.

5.4.4. Weights of the Elements

The mathematical model allows for a weighting of the different elements. The rationality of this weighting should be researched in real life to check what values are realistic for a company. Certainly it can be necessary to weigh different elements and thus adjust the model to a specific company. The weighting of the elements is implemented as described in the two following paragraphs.

Input into the Calculation:

weight of elements in level 1: $w1 = \begin{bmatrix} wa \\ wb \\ wc \end{bmatrix}$

weight of elements in level 2: $w2 = \begin{bmatrix} wd \\ we \end{bmatrix}$

weight of elements in level 3: $w3 = \begin{bmatrix} wf \\ wg \\ wh \end{bmatrix}$

amount of elements in level 1: $s1$

amount of elements in level 2: $s2$

amount of elements in level 3: $s3$

Calculation:

(1) A new variable $sw1$ is defined as the sum of all weights in level 1 divided by the number of elements in level 1:
$sw1 = sum(w1)/s1$

(2) Every weight in level 1 is divided by $sw1$:
$w1\_new = w1/sw1$

(3) The same calculations are carried out with $w2$ and $w3$.

This way, the weight of the levels stays always the same, no matter what the different weights of the elements are. It is a redistribution of the weights within the level without any change of the weight of the level itself.

Another approach would be to weight the different levels, not only the elements. The reason why the calculation above is used instead of a weighting of the different levels is the following:
If there were three elements in level 1 and level 1 would have a weight of “1” like level 2 and level 3, each element in level 1 would have a weight of 1/3. With only two elements in level 1, each element in level 1 would have a weight of 1/2. This way, the

elements would get more important if there were only two instead of three elements in level 1. This does not agree with the main idea behind the “Impact of Innovation” model because each weight of the elements is supposed to stay constant regardless the amount of elements in the level. Every element should influence the other elements in the same way, whatever the number of elements in a level is.

5.5. Time Lag

The goal is to adjust this mathematical model to real life as realistically as possible. However, real life is not static like the model described in this chapter, therefore the aspect of time should also be included in a detailed model. When discussing whether to include the time lag and other possible features, the reader has to keep in mind, that this model is brand new and no real life data is available.

To include the time lag into this static mathematical model, there is a possible approach: The user detects the different dependencies and interdependencies dependent on the time and lets the program run for every aspect of time.

Example:
The user runs the program three times, once with short-term dependencies, once with middle-term dependencies, and once with long-term dependencies. That way it is possible to visualize the qualitative impact of innovation with respect to short-term, middle-term, and long-term.

Until this existing mathematical model has been tested in real life and improved with the data from real life studies, there are too many uncertainties that prevent the improvement of the model and adding special features like the time aspect. First of all, this mathematical model has to be approved by companies. Only then can research include other features and the time lag (see chapter 9).

5.6. Including the Assessment into the Mathematical Model

Developing the mathematical model, the research group also took into account the linkage of the mathematical model with the Assessment (see section 11.6). This section discusses the integration of the Assessment not only into the input of the mathematical model but also into the output.

Section 11.5 includes the Assessment into the MATLAB code of the mathematical model as follows:

(1) Improved Assessment:
The user chooses the improvement of the *Innovation Enablers* which is equal to the input into the mathematical model. Because of the intra-level influences, the Assessment grade increases in every element of the *Innovation Enablers*. Unfortunately, the new grades increase above the maximum grade of the Assessment. This is unrealistic and leads again to the conclusion, that the output of the mathematical model is qualitative, not quantitative!

(2) in_max_as = input for the maximum grade in the Assessment:
Where and how much should a company invest (after the calculation of the intra-level influences of the *Innovation Enablers*) to reach the maximum grade in the Assessment? Calculating in_max_as results in negative values and this does not make any economical sense. The negative values are again caused by the qualitative calculation of the mathematical model.

(3) out_max = maximal possible output in *Company Goals*, if a company reaches the maximum grade in the Assessment:
To get the maximum grade, the company has to improve its *Innovation Enablers* with in_max_as (2). This means out_max = A * in_max_as with

$$A = (1 + \sum_{i=1}^{N\_end} (L3^T)^i) * (C2^T) * (1 + \sum_{i=1}^{N\_end} (L2^T)^i) * (C1^T) * (1 + \sum_{i=1}^{N\_end} (L1^T)^i)$$

(section 5.4)

If all the parameters in the mathematical model were quantitative, the in_max_as would have positive values and therefore the out_max would be realistic. Out_max shows (only with quantitative parameters), how close a company would reach the maximum possible improvement of its *Company Goals* (with respect to product innovation!) with the planned improvement of its *Innovation Enablers*.

5.7. Qualitative Values of the Dependencies

A qualitative number gives the output, dependent upon the numbers the user chooses for the dependencies. What numbers make sense to model the qualitative dependencies?

To describe the qualitative dependencies between different elements, the research-team suggests using a well known and highly established scale in the innovation business. The scale used in Quality Function Deployment [36] is used to describe a qualitative correlation between different attributes. Quality Function Deployment uses the following scale:

9 = strong correlation
3 = moderate correlation
1 = slight correlation

This scale is well established within the innovation field and therefore the research-team suggests to implement the same qualitative scale for the “Impact of Innovation” model. Since the values of the dependencies in the mathematical model have to be ≥ 0 and < 1 (see section 5.3.1), the scale of the Quality Function Deployment has to be modified to:

0.9 = strong impact
0.3 = moderate impact
0.1 = slight impact

From now on, this suggested scale is used to model the qualitative influences between the different elements in the “Impact of Innovation” model.

5.8. Conclusion of the Mathematical Model

The input into the mathematical model is the qualitative planned improvement of the *Innovation Enablers*. The user wants to know, how this planned improvement influences *Company Goals*.

Example:
A company does the Assessment of Innovation Capability (see section 11.6) and finds out it has weaknesses in *Methods* and *Organization*. So the company is interested in knowing whether it can achieve more impact on its *Company Goals* by investing money in *Methods* or *Organization*. The company plans an improvement of either *Methods* or *Organization* with the same amount of effort (for example an improvement of “1”). Now the company can run the program, once with an improvement of “1” in *Methods*, once with an improvement of “1” in *Organization*. The output shows, qualita-

tively, how strong the impact of the planned improvement in the *Innovation Enablers* on *Company Goals* is and which element of *Company Goals* would strongly be influenced by the planned improvement. Therefore, the company is able to optimize its impact on *Company Goals* with a planned amount of effort.

The output of the mathematical model shows the qualitative impact of the planned improvement in the *Innovation Enablers* on *Company Goals*. Comparing different input / output scenarios enables a company to optimize its investment of effort into product innovation.

The mathematical model presented in this chapter offers a lot of different possibilities for an adjustment to reality. However, it must be kept in mind that this mathematical model is based on a linear approach and its parameters have not been researched enough yet. Therefore the model may not represent the exact, but certainly approximate impact of innovation on sustainable business success.

5.9. Summary

The mathematical model, its conceptualization and its calculation, have been described in detail and all its objectives (see section 5.2) have been achieved. It shows the relative impact an improvement of an *Innovation Enablers*-element has on *Company Goals*. There are a lot of possibilities to improve the model and to add other features. For example, a suggestion on how to include the Assessment of Innovation Capability in the mathematical model is already introduced. For now, no real life data is available for this specific model and therefore it is not logical at the current state of the research to develop other features such as including time lag, before real life data is available. The parameters in this mathematical model first have to be adapted to reality. The number of loops, the ratio between inter-level and intra-level influences, and the weights of the elements cannot be exactly defined at the current state of the research. After all the parameters and exact influences in this model are known (through extensive real life-studies), it will be possible to receive a quantitative output and to link the Assessment of Innovation Capability to the mathematical model “Impact of Innovation”.

6. The Program

6.1. Introduction

This chapter describes the program related to the mathematical model (see chapter 5). First of all, the selection of the software is explained: “How has the choice of the program been made?”. Afterwards, the running of the program and its handling is illustrated.

6.2. Selection of Software

While selecting the software, different aspects were taken into account. The desired program characteristics are the following:

- Easy tool for doing numerical computations with matrices and vectors (the mathematical model shows, that a calculation with matrices and vectors has to be possible)
- Easy to develop and improve the program (for future improvement)
- Well known software at universities (and future users)
- Friendly user-interface

For the numerical computations with matrices and vectors, MATLAB has been selected. MATLAB is well known at Clemson University and ETH Zurich and is easy to handle. MATLAB is a commercial “Matrix Laboratory” package, which operates as an interactive programming environment. Its program and script files always have filenames ending with “.m” and the programming language is quite straightforward since almost every data object is assumed to be an array [33].

Simulink is an interactive tool for modeling, simulating, and analyzing dynamic, multidomain systems. Simulink integrates seamlessly with MATLAB [50]. Therefore it is likely that Simulink could build the software for further researches and developments, such as the inclusion of time lag, in expansions of this study. Both MATLAB and Simulink are programs of MathWorks (www.MathWorks.com).

MATLAB is not very well known among managers without engineering backgrounds. It also does not provide a well-structured and friendly user-interface. Therefore, another software for the user-interface is selected. MATLAB is linked to a more user-interface-friendly software which in this study is Microsoft Excel. Excel is well known within both academia and industry and offers linkage possibilities to MATLAB. Thus, Excel has been chosen to build the user-interface for the mathematical model.

6.3. Running the Program

6.3.1. Getting Started

The user does not have to worry about the details of MATLAB, but she needs a running MATLAB version on the computer to run the program.

Instructions:

Open the Excel-file “Mathematical Model” and activate the macros. It will open a similar window like in Figure 6-1. Once the user opens the Excel-file, MATLAB automatically starts running in the background.

	A	B	C	D	E	F	G	H	I
1	**Interdependencies within the Innovation Enablers** (0=no, 0.1=slight, 0.3=moderate, 0.9=strong influence)								
2		Strategy	Resources	Processes	Methods	Tools	Organization	Corporate Culture	**Active-Sum**
3	Strategy	0.00	0.30	0.30	0.30	0.30	0.30	0.30	**1.80**
4	Resources	0.30	0.00	0.30	0.30	0.30	0.10	0.10	**1.40**
5	Processes	0.10	0.10	0.00	0.30	0.30	0.10	0.00	**0.90**
6	Methods	0.10	0.00	0.00	0.00	0.90	0.30	0.00	**1.30**
7	Tools	0.00	0.00	0.10	0.10	0.00	0.10	0.00	**0.30**
8	Organization	0.10	0.10	0.10	0.10	0.00	0.00	0.10	**0.50**
9	Corporate Culture	0.90	0.10	0.10	0.10	0.10	0.30	0.00	**1.60**
10	**Passive-Sum**	**1.50**	**0.60**	**0.90**	**1.20**	**1.90**	**1.20**	**0.50**	

Matrix L1 | Matrix L2 | Matrix L3 | Matrix C1 | Matrix C2 | Weight_W | Influence Ratio | Input | Sum

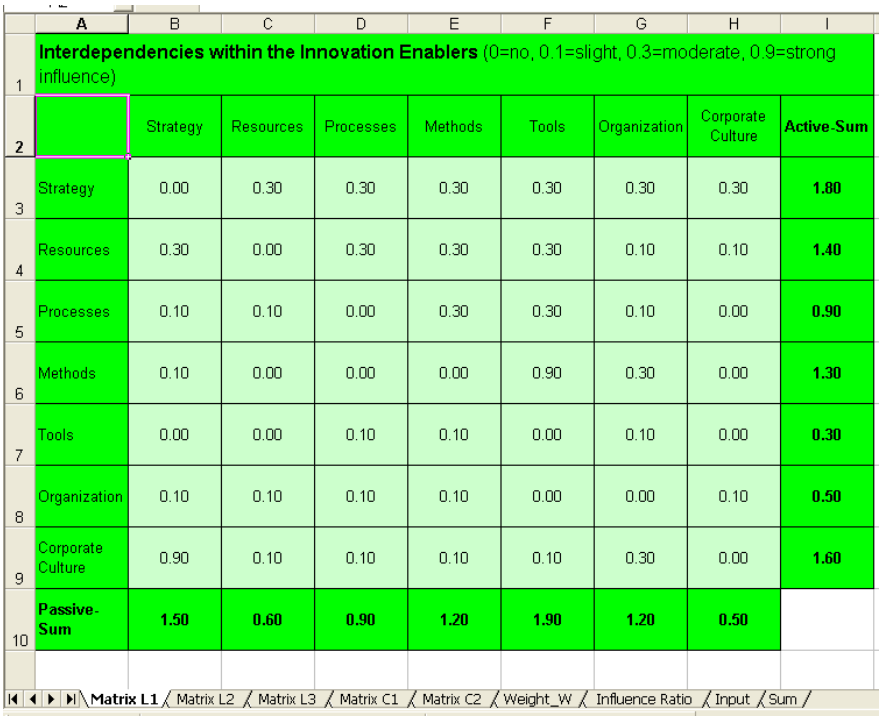
Figure 6-1: Getting Started

On the bottom of the spreadsheet are a lot of different tables. In Figure 6-1 the table *Matrix L1* is activated. If you want to activate another table, clicking on the desired table is sufficient.

6.3.2. Different Tables

Matrix L1, Marix L2, and Matrix L3:

In *Matrix L1*, *Matrix L2*, and *Matrix L3* the user can plug in all the interdependencies within *Innovation Enablers*, *Innovation Outcomes*, and *Company Goals* (Figure 6-2).



	A	B	C	D	E	F	G	H	I
1	**Interdependencies within the Innovation Enablers** (0=no, 0.1=slight, 0.3=moderate, 0.9=strong influence)								
2		Strategy	Resources	Processes	Methods	Tools	Organization	Corporate Culture	**Active-Sum**
3	Strategy	0.00	0.30	0.30	0.30	0.30	0.30	0.30	**1.80**
4	Resources	0.30	0.00	0.30	0.30	0.30	0.10	0.10	**1.40**
5	Processes	0.10	0.10	0.00	0.30	0.30	0.10	0.00	**0.90**
6	Methods	0.10	0.00	0.00	0.00	0.90	0.30	0.00	**1.30**
7	Tools	0.00	0.00	0.10	0.10	0.00	0.10	0.00	**0.30**
8	Organization	0.10	0.10	0.10	0.10	0.00	0.00	0.10	**0.50**
9	Corporate Culture	0.90	0.10	0.10	0.10	0.10	0.30	0.00	**1.60**
10	**Passive-Sum**	**1.50**	**0.60**	**0.90**	**1.20**	**1.90**	**1.20**	**0.50**	

Matrix L1 | Matrix L2 | Matrix L3 | Matrix C1 | Matrix C2 | Weight_W | Influence Ratio | Input | Sum

Figure 6-2: Fill in the *Matrix L1*

The column represents “From” and the row represents “To” (see also Table 6-1) in the influence relationship.

The user has to fill in the interdependencies as follows (Table 6-1):

		“To”		
		Strategy	Resources	Processes
“From”	Strategy	0	Influence of *Strategy* on *Resources*	Influence of *Strategy* on *Processes*
	Resources	Influence of *Resources* on *Strategy*	0	Influence of *Resources* on *Processes*
	Processes	Influence of *Processes* on *Strategy*	Influence of *Processes* on *Resources*	0
	…	…	…	…

Table 6-1: *Matrix L1*

Please note that on the diagonal from top left to the bottom right, the values have to be zero, because the elements cannot influence themselves.

Matrix C1 and Matrix C2:

The tables *Matrix C1* and *Matrix C2* (Figure 6-3) are to fill with the dependencies between *Innovation Enablers* and *Innovation Outcomes* (*Matrix C1*) and between *Innovation Outcomes* and *Company Goals* (*Matrix C2*). The column represents "From" and the row represents "To" (see also Table 6-1) regarding the influence relationship.

	A	B	C	D	E	F	G	H
1	**Dependencies between Innovation Enablers and Innovation Outcomes** (0=no, 0.1=slight, 0.3=moderate, 0.9=strong influence)							
2		Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability	**Active-Sum**	
3	Strategy	0.90	0.30	0.30	0.30	0.90	**2.70**	
4	Resources	0.30	0.30	0.30	0.30	0.30	**1.50**	
5	Processes	0.30	0.30	0.30	0.90	0.30	**2.10**	
6	Methods	0.30	0.30	0.30	0.30	0.30	**1.50**	
7	Tools	0.30	0.30	0.30	0.30	0.30	**1.50**	
8	Organization	0.30	0.30	0.30	0.30	0.30	**1.50**	
9	Corporate Culture	0.30	0.30	0.30	0.30	0.30	**1.50**	
10	**Passive-Sum**	**2.70**	**2.10**	**2.10**	**2.70**	**2.70**		

Matrix L1 / Matrix L2 / Matrix L3 / **Matrix C1** / Matrix C2 / Weight_W / Influence Ratio / Input / Sum /

Figure 6-3: Fill in the *Matrix C1*

Weight_W:

In table *Weight_W* (Figure 6-4) the user can define the weight of the different elements. Using weights enable the elements to possess more or less importance for a company (see section 5.4.4).

For example: Each company may weight its company goals differently. Therefore, it is necessary to adjust the weights to the company's specific *Company Goals*.

	A	B	C	D	E	F	G	H
1	**Weights of Innovation Enablers**			**Weights of Innovation Outcomes**			**Weights of Company Goals**	
2		Weight			Weight			Weight
3	Strategy	1.00		Prouct Innovation	1.00		Sales	1.00
4	Resources	1.00		Quality Improvement	1.00		Profit	1.00
5	Processes	1.00		Cost Reduction	1.00		Worth	1.00
6	Methods	1.00		Speed Improvement	1.00		Reputation	1.00
7	Tools	1.00		Improved Innovative Capability	1.00			
8	Organization	1.00						
9	Corporate Culture	1.00						
10								

Matrix L1 | Matrix L2 | Matrix L3 | Matrix C1 | Matrix C2 | **Weight_W** | Influence Ratio | Input | Sum

Figure 6-4: Fill in the *Weight_W*

Influence Ratio:

Table *Influence Ratio* gives the possibility to select the influence ratio between the importance of inter-level and intra-level influence (see section 5.4). Selecting "1" means that the inter-level and the intra-level influence have the same weight. Choosing a ratio of "2", for example, weights the inter-level influence twice as strong as the intra-level influence. With this feature the user can adjust the ratio to the real life behavior of the company in question.

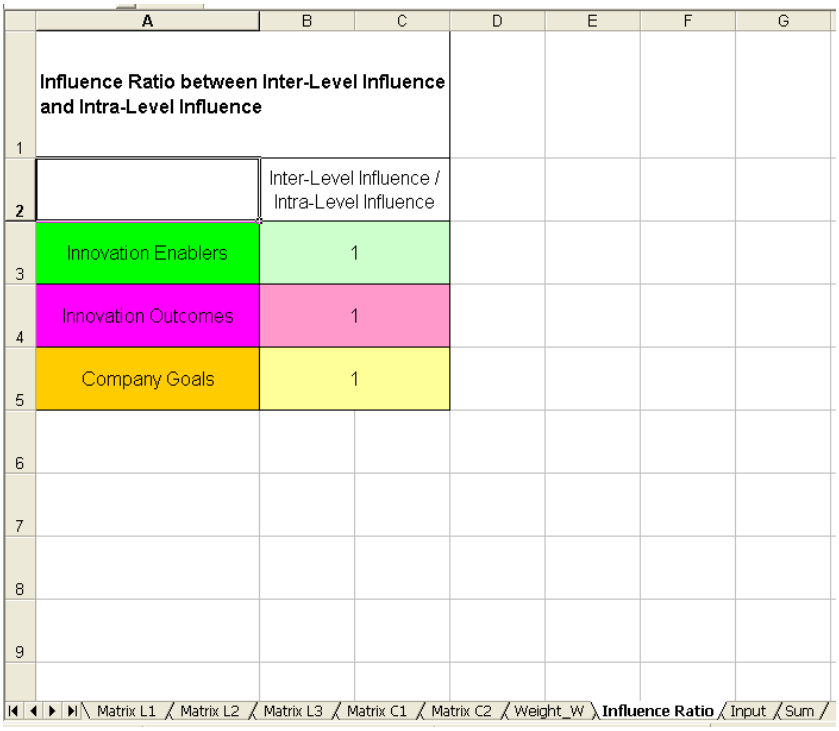


Figure 6-5: Fill in the *Influence Ratio*

Input / Output:

In column B of the table *Input* (Figure 6-6) the user enters in the planned improvement of *Innovation Enablers*.

Afterwards, the user chooses whether she wants to normalize the intra-level influences or not (see section 5.4). Normalization (field D2 in table *Input* = YES) enables the user to choose the ratio between the inter-level influences and the intra-level influences and to weight the different elements. If "normalize" = "NO" (field D2 in table *Input*), the program runs without any weighting of the elements and without taking the

influence ratio into account. Therefore it is possible to run the program without any special parameters, just calculating the intra- and inter-level dependencies[8].

The number of loops has to be set by the user (table *Input* field E2). Zero loops means that the intra-level influences will not be taken into account of this calculation.

After choosing all parameters, the user has to press the button "MATLAB Calculation" (table *Input*, fields H1-J1). Pressing this button starts the calculation process of the impact of the planned improvement in the *Innovation Enablers* on *Company Goals* in MATLAB. The result of this calculation is then displayed in column H of the table *Input*. Column I shows the relative output of the impact. This relative impact expresses the amount of impact each company goal absorbs from the planned improvement: ($output\_sales + output\_profit + output\_worth + output\_reputation = 100\%$).

	A	B	C	D	E	F	G	H	I
1		Planned Improvement of the Innovation Enablers		Normalize	# of Loops			Matlab Calculation	Output
2	Strategy	1		YES	100			Output	Output relative [%]
3	Resources	0					Sales	7.52	25.27
4	Processes	0					Profit	6.56	22.05
5	Methods	0					Worth	7.37	24.80
6	Tools	0					Reputation	8.29	27.88
7	Organization	0							
8	Corporate Culture	0							
9									
10									

Matrix L1 | Matrix L2 | Matrix L3 | Matrix C1 | Matrix C2 | Weight_W | Influence Ratio | Input | Sum

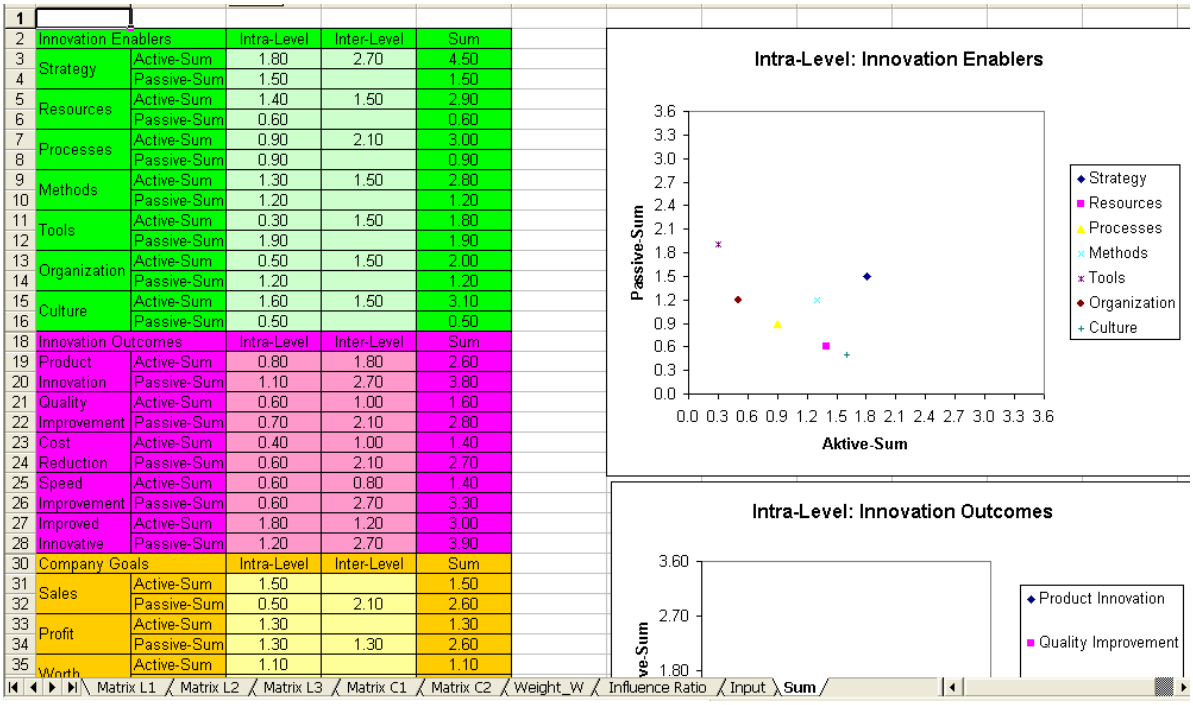
Figure 6-6: Fill in the *Input* and Calculate the *Output*

[8] This normalization feature has been used for developing the mathematical model and its program. It might not be a need for further applications, but in case this feature can be used for the next step of improving the mathematical model, it has been left in the program until now.

Sum:

The table *Sum* is related to all the matrix-tables (Figure 6-7). In each matrix-table, there is a row for the Passive-Sum and a column for the Active-Sum. These Active- and Passive-Sums are related to the definition of the Center for Product Development, ETH Zurich [8]. The sums express the entire impact of an element on all other elements. The Active-Sum shows, how strong the element influences all other elements and the Passive-Sum describes, how strong the element is influenced by all other elements.

Results of the Active- and Passive-Sum evaluation are displayed in diagrams (Figure 6-7).



Innovation Enablers		Intra-Level	Inter-Level	Sum
Strategy	Active-Sum	1.80	2.70	4.50
	Passive-Sum	1.50		1.50
Resources	Active-Sum	1.40	1.50	2.90
	Passive-Sum	0.60		0.60
Processes	Active-Sum	0.90	2.10	3.00
	Passive-Sum	0.90		0.90
Methods	Active-Sum	1.30	1.50	2.80
	Passive-Sum	1.20		1.20
Tools	Active-Sum	0.30	1.50	1.80
	Passive-Sum	1.90		1.90
Organization	Active-Sum	0.50	1.50	2.00
	Passive-Sum	1.20		1.20
Culture	Active-Sum	1.60	1.50	3.10
	Passive-Sum	0.50		0.50

Innovation Outcomes		Intra-Level	Inter-Level	Sum
Product Innovation	Active-Sum	0.80	1.80	2.60
	Passive-Sum	1.10	2.70	3.80
Quality Improvement	Active-Sum	0.60	1.00	1.60
	Passive-Sum	0.70	2.10	2.80
Cost Reduction	Active-Sum	0.40	1.00	1.40
	Passive-Sum	0.60	2.10	2.70
Speed Improvement	Active-Sum	0.60	0.80	1.40
	Passive-Sum	0.60	2.70	3.30
Improved Innovative	Active-Sum	1.80	1.20	3.00
	Passive-Sum	1.20	2.70	3.90

Company Goals		Intra-Level	Inter-Level	Sum
Sales	Active-Sum	1.50		1.50
	Passive-Sum	0.50	2.10	2.60
Profit	Active-Sum	1.30		1.30
	Passive-Sum	1.30	1.30	2.60
Worth	Active-Sum	1.10		1.10

Figure 6-7: ***Sum***

6.4. Summary

The user is now able to run the program itself, without any knowledge in MATLAB and with just some knowledge in Excel. The handling of the program is very easy and clear. To get an idea, what elements are strong influencer or get influenced very strong, the last table *Sum* shows diagrams related to the Active- and Passive-Sum [8]. The easy handling of the program enables the user to compare different parameter situations and to receive information for a discussion concerning the qualitative impact of innovation on sustainable business success.

7. The Dependencies

7.1. Introduction

To describe the impact of innovation on sustainable business success not only the definition of the elements (chapter 4) and a mathematical model (chapter 5) but also an idea about the values of intra- and inter-level dependencies is required. Two different approaches are possible to gather information about these dependencies: Collect real life data, for example by a survey or gather data out of already existing studies and literature.

This thesis does both, gathering data by a survey and out of the literature. Since the survey used in this thesis is exactly adjusted to the actual problem, the output might be more significant than the data out of already existing studies.

7.2. Literature Results

Unfortunately there is not much literature describing the detailed impact of some *Innovation Enablers*-elements on parts of *Company Goals*-elements. This section describes the results of the extensive literature study. The authors of these studies do not use the same model as the “Impact of Innovation” model. Therefore, the results of these studies had to be translated into the new invented “Impact of Innovation” model. Actually, this translation is not very difficult, because all the elements the authors use in their studies are also used in the “Impact of Innovation” model. On the other hand, all authors used different point of views as base for their studies, therefore the results of the translation have to be considered very, very carefully.

7.2.1. Impact of Innovation Enablers on Innovation Outcomes

Stars of Innovation [2]:

The data of the Agamus Consult Study "Stars der Innovation" [2] has been put into the "Impact of Innovation" model (see section 11.3). Agamus Consult does not exactly deal with the same elements and sub-elements. Therefore, the Agamus Consult elements had to be translated into the elements of the "Impact of Innovation" model.

Some examples of this translation:

Agamus Consult Study	**Model "Impact of Innovation"**
Low development costs	Cost Reduction
Internal sales inquiry	Processes
High customer value	Product Innovation
Ideal price/performance ratio	Product Innovation
Low modification rates	Quality Improvement
Short design and development time	Speed Improvement
…	…

Table 7-1: Translation of the Agamus Consult Elements

The evaluation of the Agamus Consult Study results are illustrated in Table 7-2.

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement
Strategy	0.9	0.0	0.9	0.1
Processes	0.3	0.1	0.3	0.3
Methods	0.1	0.3	0.1	0.3
Organization	0.3	0.3	0.1	0.1
Corp. Culture	0.1	0.1	0.3	0.1

Table 7-2: Impact of *Innovation Enablers* on *Innovation Outcomes* [2]

The impact of *Strategy* on *Product Innovation* and *Cost Reduction* seems to be very strong. However, the reader has to be careful considering these results, since only one data point was collected about a *Strategy*'s impact on *Innovation Outcomes* in the Agamus Consult Study. Thus, the impact of *Strategy* on *Innovation Outcomes* has not been researched broadly enough in this study.

The Impact of a Company's Business Strategy [61]:

Of particular relevance to a company's innovation success is its ability to develop and use technology-oriented inter-organizational relationships to link the company's (technological) competencies with those of its partners in the innovation network. The article shows that both *Network Competence* and *Technological Competence* have a significant positive impact on *Innovation Success*. The impacts of both types of competencies are about equal. The article also proves that *Strategy* has a strong impact on *Network Competence* and *Technological Competence*, but there is no direct relation to *Innovation Success*.

Technological Competencies is related to *Technological Resources* in the "Impact of Innovation" model, a sub-element of *Resources*. *Network Competencies* is a sub-element of *Organization*. The *Business Strategy* is related to *Strategy* in the "Impact of Innovation" model (see Figure 7-1).

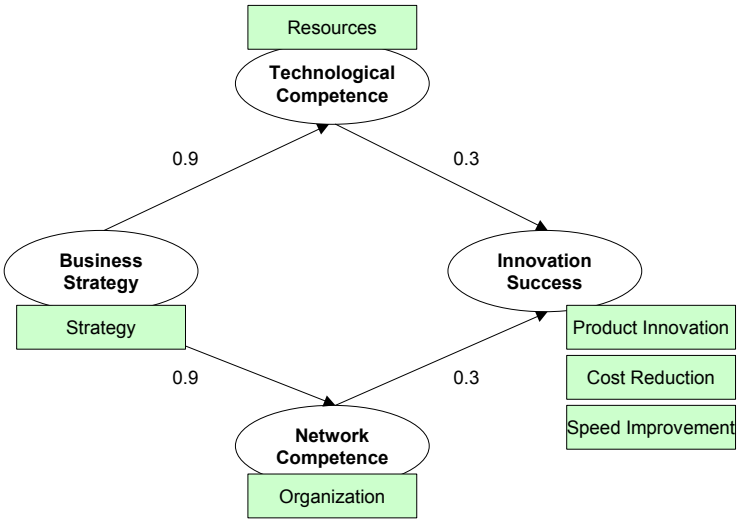


Figure 7-1: Results of the Structural Model [61]

The results of this article, integrated into the "Impact of Innovation" model are presented in Table 7-3.

	Product Innovation	Cost Reduction	Speed Improvement
Strategy	0.0	0.0	0.0
Resources	0.3	0.3	0.3
Organization	0.3	0.3	0.3

Table 7-3: Impact of *Innovation Enablers* on *Innovation Outcomes* [61]

Discussion

The literature studied above is all the literature found with information about the detailed influence of *Innovation Enablers* on *Innovation Outcomes*. Comparing the results, no correlation between the two studies is visible, except the influence of *Organization* on *Product Innovation* where the two studies show the same results (Table 7-4). The main reason for these deviations might be that they used different models. Using different approaches leads to a different point of view on the impact-problem and therefore the results differ. An other reason for these deviations might be that they do not have the same element-definition. Unfortunately, there is no information in these studies about their definition of the elements. These definitions are also part of the point of view on the impact-problem.

	Product Innovation		Quality Improvement		Cost Reduction		Speed Improvement	
	[2]	[61]	[2]	[61]	[2]	[61]	[2]	[61]
Strategy	**0.9**	**0**	0		**0.9**	**0**	**0.1**	**0**
Resources		0.3				0.3		0.3
Processes	0.3		0.1		0.3		0.3	
Methods	0.1		0.3		0.1		0.3	
Organization	**0.3**	**0.3**	0.3		**0.1**	**0.3**	**0.1**	**0.3**
Corp. Culture	0.1		0.1		0.3		0.1	

Table 7-4: Comparison of the Results in [2] and [61]

7.2.2. Impact of Innovation Outcomes on Company Goals

The Influence of Organizational Process Factors and Capabilities on Development Performance [34]:

For *Sales*, they found that *Product Quality* and *Unit Costs* are significant positive predictors, while *Time-to-Market* has no significant effect. They also found that *Product Quality* has not just a significant, but a strong positive effect on *Sales*. Thus, *Time-to Market* may help ensure at least some realization of *Profit*. Being early or first to market may please the customer, but does not determine purchase behavior because quality and cost are the dominant purchase decision criteria. One possible explanation for this result may be that *Sales* is largely determined by *Product Quality* and *Cost*. This is an interesting counterintuitive relationship that merits further research attention.

	Sales	Profit
Quality Improvement (Product Quality)	0.9	
Cost Reduction (Unit Costs)	0.3	
Speed Improvement (Time-to-Market)	0.0	0.1

Table 7-5: Impact of *Innovation Outcomes* on *Company Goals* [34]

7.2.3. Impact of Innovation Enablers on Company Goals

Benchmarking New Product Performance: Results of the Best Practice Study [40]:

This study is about benchmarking new product performance. It is investigating the impact and ratings of major success factors. The paper distinguishes between three cornerstones of performance: high quality new product process, clear and well-communicated new product strategy for the business, and resource commitment.

High Quality New Product Process:

This process includes the steps and activities in a new product project from idea to launch. In this study, a quality process is by far the number one driver of performance. The high quality new product process:

- increases success rates by 37.5%;
- improves the business's ability to meet its sales objectives from new products by 88%; and
- improves the meeting of profit objectives by 72%;

versus businesses with a weak or poor quality new product process. Additionally, a high quality new product process is strongly linked to the business's new product profitability.

The ingredients of a high quality new product process are:

- up-front homework – both market and technical assessment – before projects move into the development phase
- sharp, early product definition, before development work begins
- strong market orientation, and representing the voice of the customer throughout
- well defined go/kill decision points in the process, where projects really do get killed
- focus on quality of execution, where activities in new product projects are carried out in a quality fashion
- complete or thorough process, where every needed activity is carried out – no hasty corner-cutting
- flexible process – where stages and decision points can be skipped or combined, as dictated by the nature and associated with the risk of the project

Clear and Well-Communicated New Product Strategy for the Business:

Having a new product strategy – a clear and visible one – is the number two driver of a business's new product performance in this study. Businesses that have clear and visible new product strategies fare much better than those found lacking here:

- 32% higher new product success rates;
- meet sales objectives (42% better); and
- meet profit objectives (39% better)

The four main ingredients of a positive new product strategy are:

- existing goals or objectives for the business's total new product efforts; e.g. what sales, profits, etc. new products will contribute to the business goal
- the role of new products in achieving the business's goals is clearly communicated to all
- clearly defined arenas – specified areas of strategic focus or strategic thrust, such as specific products, markets or technologies – to give direction to the business' total new product effort
- the new product effort has a long term thrust and focus, including some longer term projects

Resource Commitment:

Some companies in this study had drastically cut product development efforts – R&D and marketing money and staff – in an attempt to produce short term profits. The longer term effects are very negative, however. Resource commitment is virtually tied for second place as a driver of superior performance. Business with strong resources commitment:

- have a 40% higher new product success rate; and
- meeting sales and profit objectives is 46% better

than those with weak resource commitment.

There are three main ingredients in strong resource commitment as follows:

- senior management has devoted the necessary resources to achieve the business unit's new product objectives
- R&D budgets are adequate to achieve the stated objectives
- The necessary people are in place, and their time is freed up for new products

Figure 7-2 shows the impact of the *Innovation Enablers* on the *Company Goals*. This study is certainly the best literature study found, describing the impact of innovation on sustainable business success. It includes three of the seven *Innovation Enablers* and shows the qualitative impact these three *Innovation Enablers* have on the company goal *Strategy*.

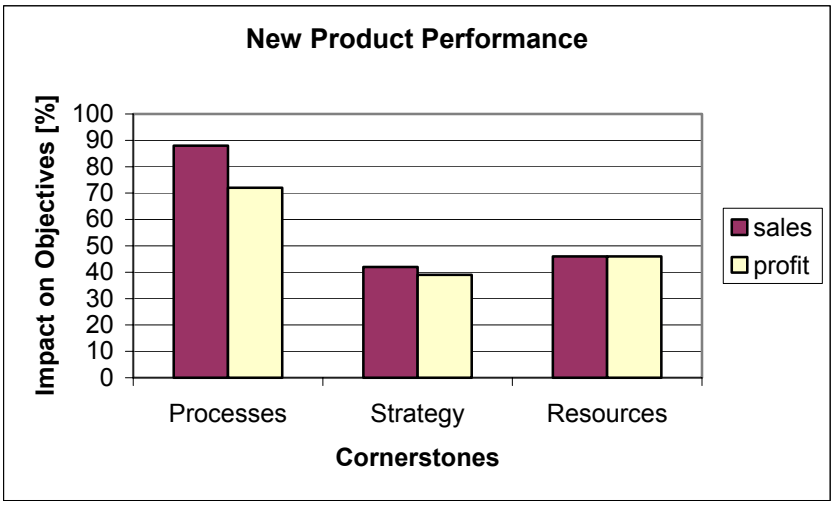


Figure 7-2: New Product Performance

The results of this study presented in Figure 7-2 are translated into the "Impact of Innovation" model (see Table 7-6). The qualitative impact is shown in Figure 7-2 whereas

$0 <$ slight impact $\leq 20\%$ (equal to 0.1[9])

$20\% <$ moderate impact $\leq 60\%$ (equal to 0.3)

$60\% <$ strong impact (equal to 0.9).

	Sales	Profit
Strategy	0.3	0.3
Resources	0.3	0.3
Processes	0.9	0.9

Table 7-6: Impact of *Innovation Enablers* on *Company Goals*

[9] See section 5.7

7.2.4. Impact within the Innovation Outcomes

The Influence of Organizational Process Factors and Capabilities on Development Performance [34]:

They found that *Product Quality* and *Time-to-Market* are significantly positively associated with *Customer Satisfaction*, while *Unit Cost* has no significant effect. Overall, they found that *Product Quality* has a strong positive effect on *Customer Satisfaction*. *Unit Costs* does not have a significant effect and *Time-to-Market* has a significant positive effect on *Customer Satisfaction* (see Table 7-7).

	Product Innovation (Customer Satisfaction)
Quality Improvement (Product Quality)	0.9
Cost Reduction (Unit Costs)	0.0
Speed Improvement (Time-to-Market)	0.3

Table 7-7: Impact within the *Innovation Outcomes* [34]

7.3. Survey Results

This section illustrates the results of a survey launched to evaluate the qualitative influences between the different elements in the "Impact of Innovation" model. The actual survey is shown in section 11.1 and detailed survey results can be found in section 11.2.

Eleven interviews regarding the survey have been conducted with highly representative participants. The requested characteristics of the participants were the following:

- experienced and successful people in product innovation
- current or former, experienced representatives of highly innovative organizations

such as presidents, product managers, head of technology development, chief of IT etc.. No constraints concerning the industry field and country have been made, with the objective of receiving a broad overview of the desired dependencies[10].

7.3.1. Statistics

To evaluate the survey results, the mean and standard deviation have been calculated and illustrated in diagrams. An important attribute of the standard deviation as a measure of spread is that if mean and standard deviation of a normal distribution are known, it is possible to compute the percentile rank associated with any given score. In a normal distribution, 68.27% of the scores are within one standard deviation of the mean. The most common formula for computing standard deviation in a sample is [54]:

$$\sigma = \sqrt{\frac{\sum (X - Ø)^2}{N - 1}}$$

$Ø =$ Mean of the sample

$X =$ Score

$N =$ Number of scores

The range between $Ø + \sigma$ and $Ø - \sigma$ and the mean are visualized in diagrams of the survey results. $Ø - \sigma$ is shown by the bottom level of the bar, $Ø + \sigma$ by the upper level of the bar, and the mean by the middle of the bar (fully blue). The probability that the score is in the range between $Ø + \sigma$ and $Ø - \sigma$ is 68.27% [53]. As the reader may recognize while studying the survey results, in many cases the standard deviation is high compared to the possible range between 0 and 1. Aside from reasons concerning different industries, countries and companies, it might have a statistical reason as well. The scale used for survey evaluation leads inevitably to a higher standard deviation than a scale from 0 to 0.3, with steps of 0.1 for example.

[10] Due to confidential constraints, no names of companies and people participating in the survey can be mentioned.

In the evaluation of the survey, the scale introduced in section 5.7 is used. The range of this scale is illustrated as follows:

0.9 = strong impact ($0.6 < Ø$)

0.3 = moderate impact ($0.2 < Ø \leq 0.6$)

0.1 = slight impact ($0 < Ø \leq 0.2$)

This scale is well established for visualizing qualitative dependencies [22].

No negative impact is assumed, since the entire model is designed and defined as an "innovation *enabling*" model and exclusively positive values have been found in the literature research (see section 7.2).

Assumption 2:
No negative influence between two elements exists.

Participants, however, had the possibility to choose between different positive and negative values in the survey, just in case someone assumes negative influences. As results show, few participants rated some influences as being negative. These cases are commented upon in footnotes and these values have not been taken into account for evaluation (*Assumption 2*).

7.3.2. Importance of Company Goals

In order to get an idea about a company's goals and their relative importance, the survey asks participants to list their goals and provide a score between 1 (unimportant) and 5 (very important). The resulting evaluation proves that the participants are highly pleased with the suggested company goals and nobody came up with different or additional goals which are not already included in the "Impact of Innovation" model. Figure 7-3 illustrates the survey result.

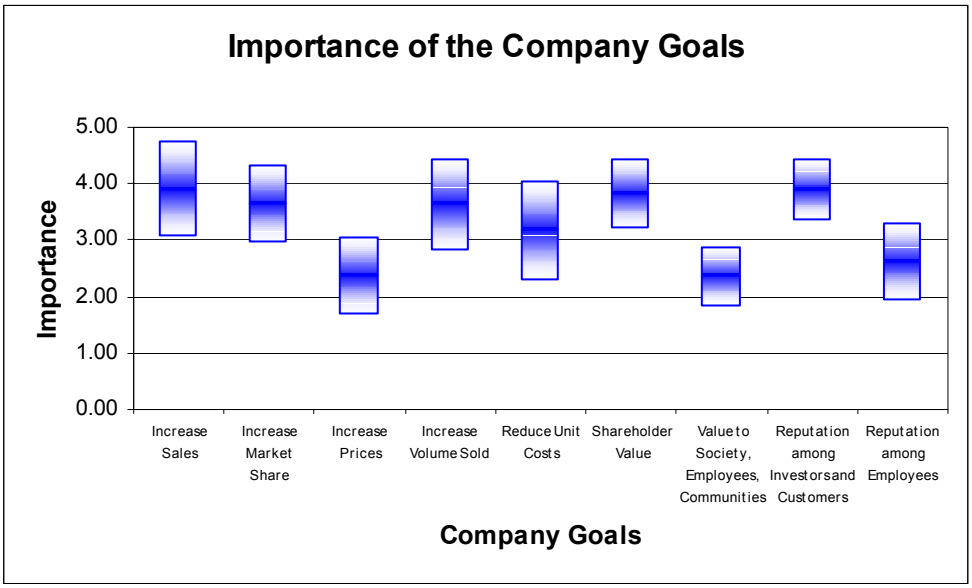


Figure 7-3: Importance of *Company Goals*-Elements

	Sales		Profit			Worth		Reputation	
	Increase Sales	Increase Market Share	Increase Price	Increase Volume Sold	Reduce Unit Costs	Share-holder Value	Value to Society, Employees, Communities	Reputa-tion among Investors and Customers	Reputa-tion among Employees
Ø	3.9	3.6	2.4	3.6	3.2	3.8	2.4	3.9	2.6
σ	0.8	0.7	0.7	0.8	0.9	0.6	0.5	0.5	0.7
Total Ø		3.8			3.1		3.1		3.3

Table 7-8: Importance of *Company Goals*-Elements

As the results in Figure 7-3 and Table 7-8 show, the company goals *Increase Sales*, *Reputation among Investors and Customers*, and *Shareholder Value* are very important for companies. Also important are *Increase Market Share*, *Increase Volume Sold*, and *Reduce Unit Costs*. *Increase Price*, *Value to Society, Employees, Communities*, and *Reputation among Employees* are still important, but less than the others. Using the "Impact of Innovation" model, this evaluation of the importance of different company goals supports the investment decisions of companies.

7.3.3. Impact of Innovation Enablers on Innovation Outcomes

Inter-Level Influence of Strategy:

Figure 7-4, Table 7-9: Based upon the survey results, *Strategy* has a strong impact on *Product Innovation* and *Improved Innovative Capability*. *Strategy* also significantly affects *Quality Improvement*, *Cost Reduction*, and *Speed Improvement* but in a more moderate manner. The overall high deviation might be the result of the different company characteristics.

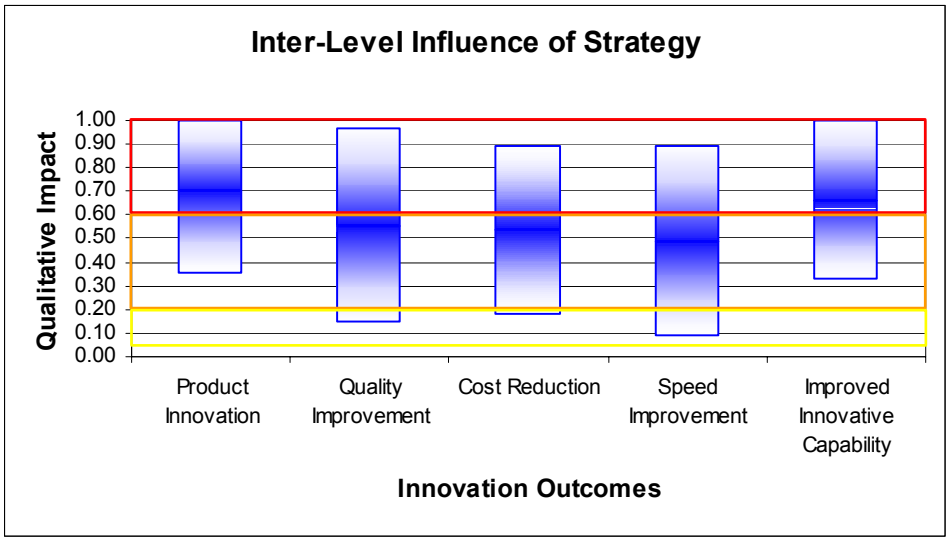


Figure 7-4: Inter-Level Influence of *Strategy*

	Impact of Strategy on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.70	0.55	0.54	0.49	0.66
Scale[11]	0.90	0.30	0.30	0.30	0.90
σ	0.35	0.41	0.36	0.40	0.33

Table 7-9: Inter-Level Influence of *Strategy*

The effect of *Strategy* on *Product Innovation* determined by the survey results is supported by the Agamus Consult Study [2]. There appears to be little correlation between the rest of the survey findings and the existing literature (see section 7.2.1). The main reason for these deviations might be that the literature studies used different models with different approaches. Also the definition of the element *Strategy* might not be the same as used in the "Impact of Innovation" model.

[11] Qualitative scale, introduced in 5.7

Inter-Level Influence of Resources:

Figure 7-5, Table 7-10: The overall impact of *Resources* on *Innovation Outcomes* appears to be moderate. *Product Innovation* was found to be most affected by *Resources*. *Cost Reduction* and *Improved Innovative Capability* are more independent of *Resources*.

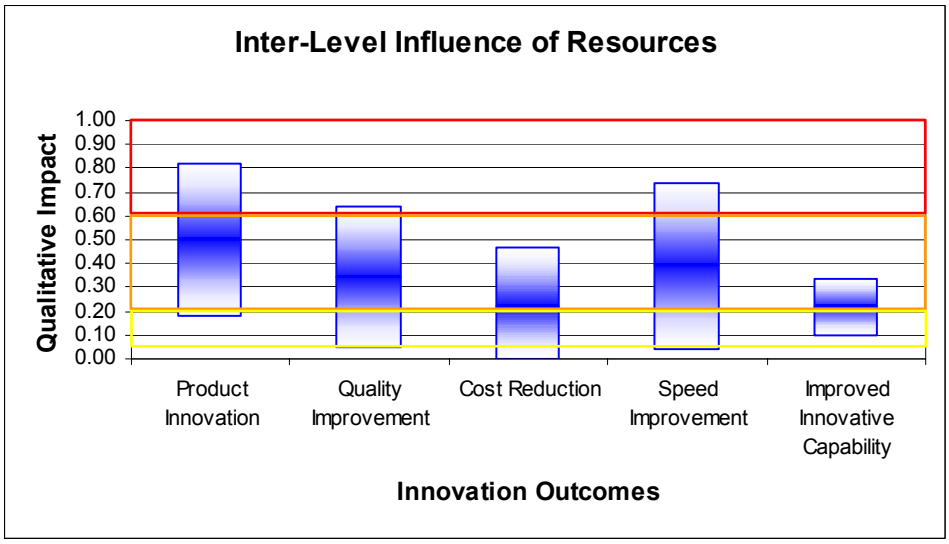


Figure 7-5: Inter-Level Influence of *Resources*

	Impact of Resources on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.50	0.35	0.22	0.39	0.22
Scale	0.30	0.30	0.30	0.30	0.30
σ	0.32	0.29	0.25	0.35	0.12

Table 7-10: Inter-Level Influence of *Resources*

The Impact of a Company's Business Strategy [61] study supports the outcomes of the survey. Both indicate that *Product Innovation*, *Cost Reduction*, and *Speed Improvement* are moderately affected by *Resources* (see section 7.2.1).

Inter-Level Influence of Processes:

Figure 7-6, Table 7-11: *Speed Improvement* is strongly linked to *Processes*. The other elements are moderately affected by *Processes*, with *Cost Reduction* showing the least correlation.

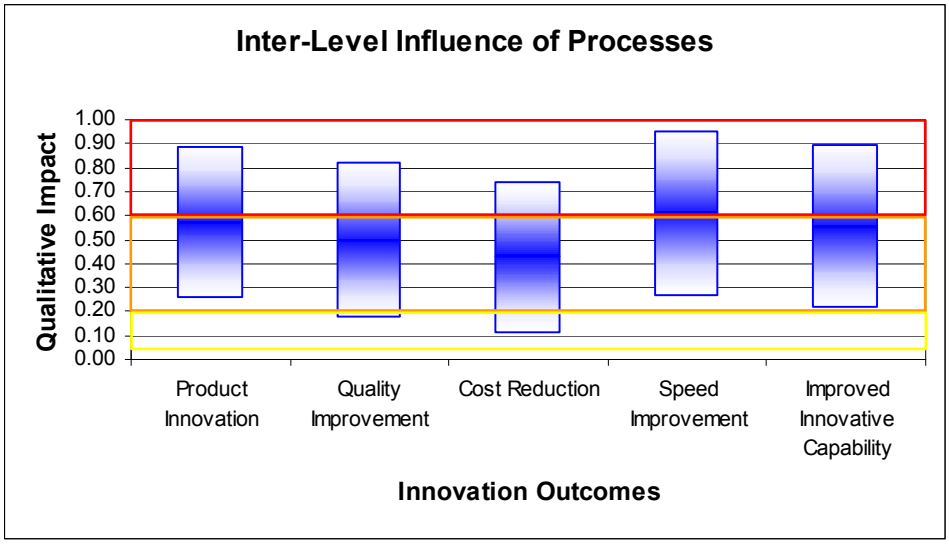


Figure 7-6: Inter-Level Influence of *Processes*

	Impact of Processes on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.57	0.50	0.43	0.61	0.55
Scale	0.30	0.30	0.30	0.90	0.30
σ	0.31	0.32	0.31	0.34	0.34

Table 7-11: Inter-Level Influence of *Processes*

The Agamus Consult Study [2] supports the survey findings that the element *Processes* moderately affects *Product Innovation* and *Speed Improvement*. The study suggests that the element *Processes* has less impact on *Quality Improvement* and *Cost Reduction* than the survey indicated (see section 7.2.1). Deviations of these two elements in the survey results show that a less impact is possible.

Inter-Level Influence of Methods:

Figure 7-7, Table 7-12: The element *Methods* appears to have a moderate impact on all of the elements in *Innovation Outcomes*. *Product Innovation* displays a slightly higher average and deviation than the other elements.

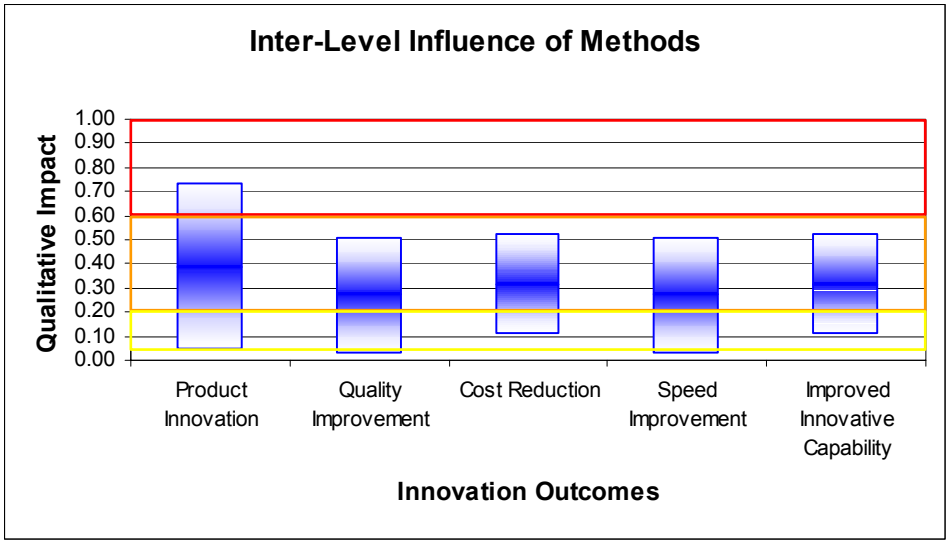


Figure 7-7: Inter-Level Influence of *Methods*

	Impact of Methods on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.39	0.27	0.32	0.27	0.32
Scale	0.30	0.30	0.30	0.30	0.30
σ	0.34	0.24	0.21	0.24	0.21

Table 7-12: Inter-Level Influence of *Methods*

The Agamus Consult Study [2] supports the survey findings that the element *Methods* moderately affects *Quality Improvement* and *Speed Improvement*. The study suggests that the element *Methods* has a weaker impact on *Product Innovation* and *Cost Reduction* than the survey indicated (see section 7.2.1). These deviations might derive from different definitions of the elements.

Inter-Level Influence of Tools:

Figure 7-8, Table 7-13: The element *Tools* moderately affects all of the *Innovation Outcomes*-elements. The survey shows that *Cost Reduction* was the most influenced by *Tools* and *Product Innovation* the least influenced.

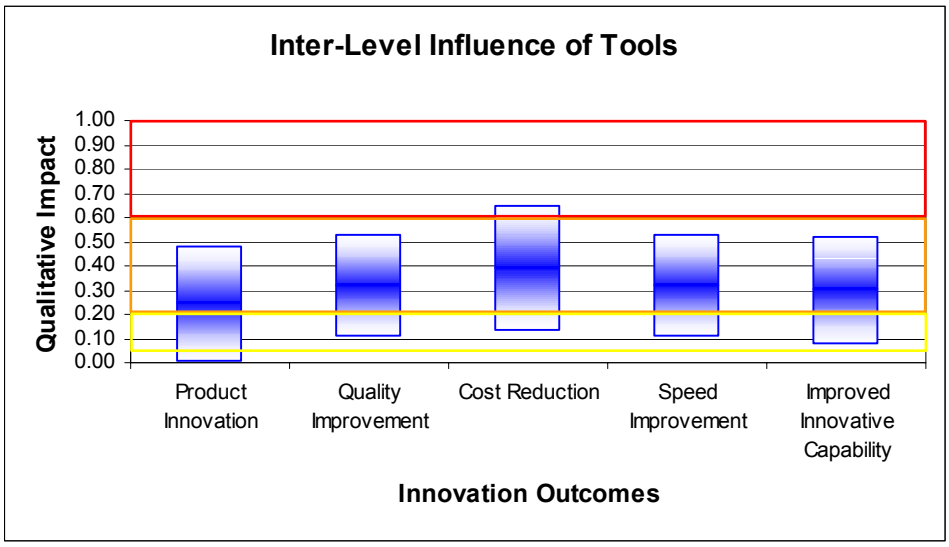


Figure 7-8: Inter-Level Influence of *Tools*

	Impact of Tools on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.25	0.32	0.39	0.32	0.30
Scale	0.30	0.30	0.30	0.30	0.30
σ	0.24	0.21	0.26	0.21	0.22

Table 7-13: Inter-Level Influence of *Tools*

No literature has been found concerning the impact of *Tools* on *Innovation Outcomes*.

Inter-Level Influence of Organization:

Figure 7-9, Table 7-14: *Organization* appears to have a moderate impact on all of the elements in *Innovation Outcomes*. *Product Innovation* displays a slightly higher average and deviation than the other elements.

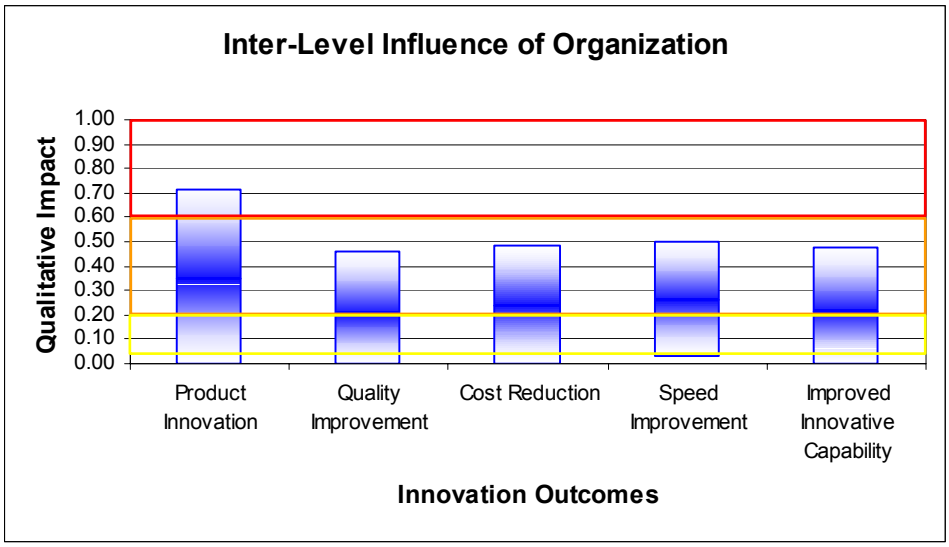


Figure 7-9: Inter-Level Influence of *Organization*

	Impact of Organization on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.35	0.21	0.24	0.26	0.22
Scale	0.30	0.30	0.30	0.30	0.30
σ	0.37	0.25	0.25	0.23	0.26

Table 7-14: Inter-Level Influence of *Organization*

The Agamus Consult Study [2] supports the survey findings that *Organization* moderately affects *Product Innovation* and *Quality Improvement*. The study suggests that *Organization* has a weaker impact on *Cost Reduction* and *Speed Improvement* than the survey indicated. The Impact of a Company's Business Success [61] study completely supports the survey findings (see section 7.2.1).

Inter-Level Influence of Corporate Culture:

Figure 7-10, Table 7-15: *Corporate Culture* appears to have a moderate impact on all of the elements in *Innovation Outcomes*. The impact of *Corporate Culture* on *Quality Improvement* is the strongest.

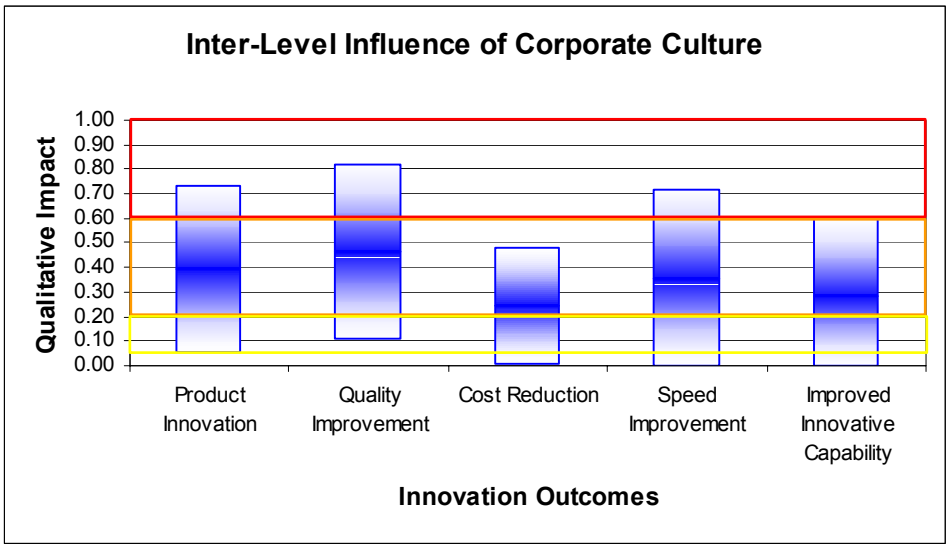


Figure 7-10: Inter-Level Influence of *Corporate Culture*

	Impact of Corporate Culture on:				
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.39	0.46	0.25	0.35	0.28
Scale	0.30	0.30	0.30	0.30	0.30
σ	0.34	0.36	0.24	0.36	0.32

Table 7-15: Inter-Level Influence of *Corporate Culture*

The Agamus Consult Study [2] suggests an overall weaker correlation between *Corporate Culture* and the *Innovation Outcomes*-elements. The standard deviations of these elements indicate that a weaker impact of *Corporate Culture* on *Innovation Outcomes* has to be taken into account. The study and the survey agree that *Corporate Culture* has a moderate impact on *Cost Reduction* (see section 7.2.1).

7.3.4. Impact of Innovation Outcomes on Company Goals

Inter-Level Influence of Product Innovation:

Figure 7-11, Table 7-16: The element *Sales* is strongly linked to *Product Innovation*. The other elements are moderately affected by *Product Innovation*, with *Worth* showing the least correlation.

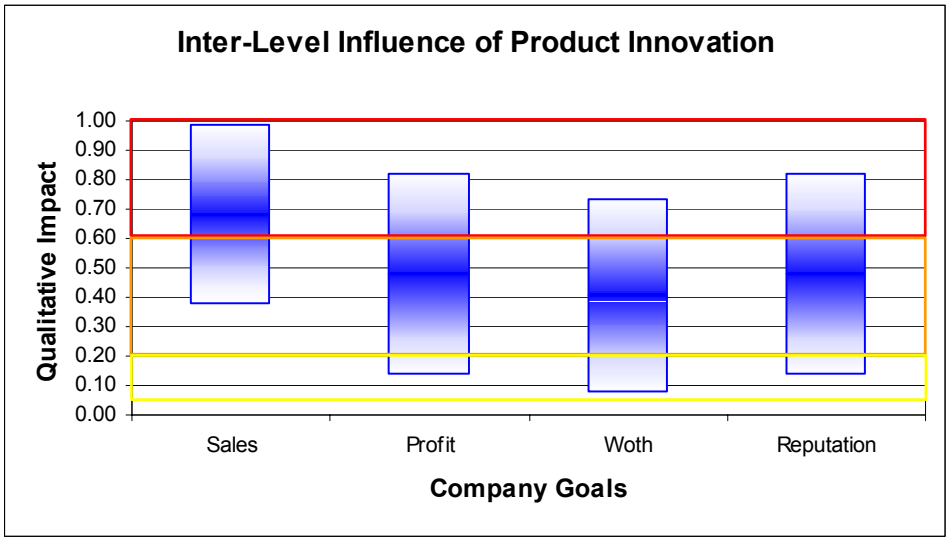


Figure 7-11: Inter-Level Influence of *Product Innovation*

	Impact of Product Innovation on:			
	Sales	Profit	Worth	Reputation
Ø	0.68	0.48	0.41	0.48
Scale	0.90	0.30	0.30	0.30
σ	0.30	0.34	0.33	0.34

Table 7-16: Intra-Level Influence of *Product Innovation*

No literature has been found concerning the impact of *Product Innovation* on *Company Goals*.

Inter-Level Influence of Quality Improvement:

Figure 7-12, Table 7-17: *Quality Improvement* appears to have a moderate impact on *Sales*, *Profit*, and *Reputation*. On *Worth* it displays a slight impact with a very low deviation.

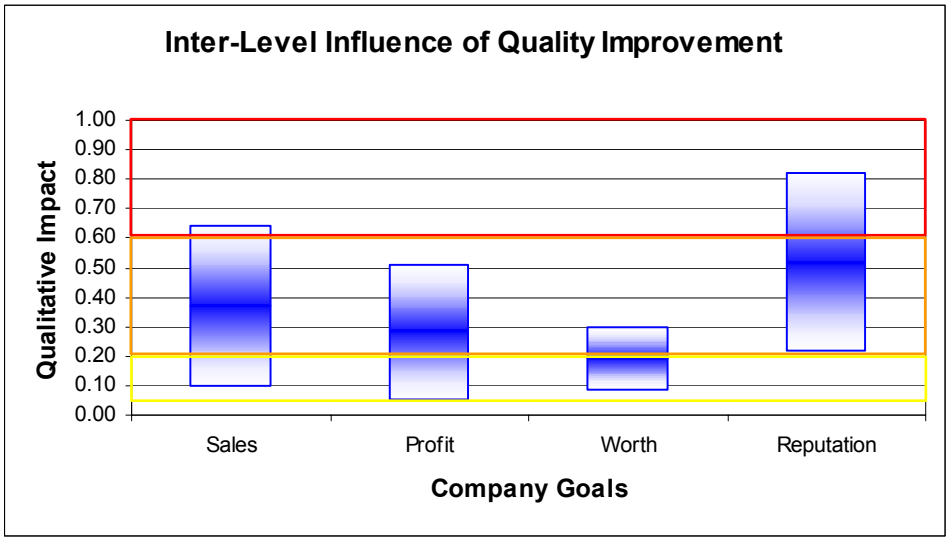


Figure 7-12: Inter-Level Influence of *Quality Improvement*

	Impact of Quality Improvement on:			
	Sales	Profit	Worth	Reputation
Ø	0.37	0.28	0.19	0.52
Scale	0.30	0.30	0.10	0.30
σ	0.27	0.23	0.10	0.30

Table 7-17: Inter-Level Influence of *Quality Improvement*

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study suggests a higher impact of *Quality Improvement* on *Sales* than the survey indicated (see section 7.2.2). These deviations might derive from a different interpretation and from different definitions of the elements.

Inter-Level Influence of Cost Reduction:

Figure 7-13, Table 7-18: *Reputation* is only slightly linked to *Cost Reduction*. The other elements are moderately affected by *Cost Reduction*, with *Profit* showing the highest correlation.

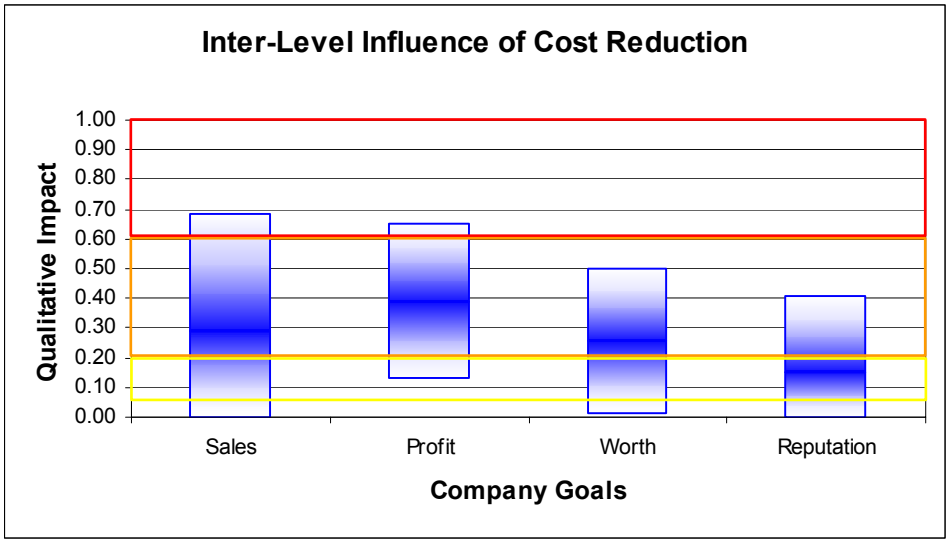


Figure 7-13: Inter-Level Influence of *Cost Reduction*

	Impact of Cost Reduction on:			
	Sales	Profit	Worth	Reputation
Ø	0.29	0.39	0.25	0.15
Scale	0.30	0.30	0.30	0.10
σ	0.39	0.26	0.24	0.25

Table 7-18: Inter-Level Influence of *Cost Reduction*

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study and the survey agree that *Cost Reduction* has a moderate impact on *Sales* (see section 7.2.2).

Inter-Level Influence of Speed Improvement:

Figure 7-14, Table 7-19: *Speed Improvement* appears to have a moderate impact on *Sales* and *Reputation*. *Profit* and *Worth* are only slightly linked to *Speed Improvement* and display a very low deviation.

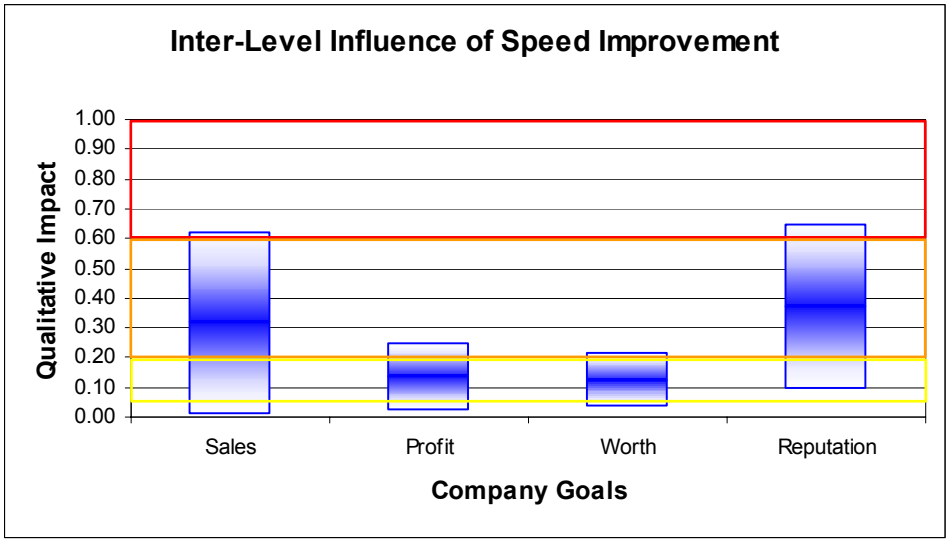


Figure 7-14: Inter-Level Influence of *Speed Improvement*

	Impact of Speed Improvement on:			
	Sales	Profit	Worth	Reputation
Ø	0.32	0.14	0.13	0.37
Scale	0.30	0.10	0.10	0.30
σ	0.30	0.11	0.09	0.27

Table 7-19: Inter-Level Influence of *Speed Improvement*

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study suggests no correlation between *Speed Improvement* and *Sales*. The study and the survey agree that *Speed Improvement* has a slight impact on *Profit* (see section 7.2.2).

Inter-Level Influence of Improved Innovative Capability:

Figure 7-15, Table 7-20: *Improved Innovative Capability* moderately affects all of the *Company Goals*-elements. The survey shows that *Reputation* is most influenced by *Improved Innovative Capability* and *Worth* the least influenced.

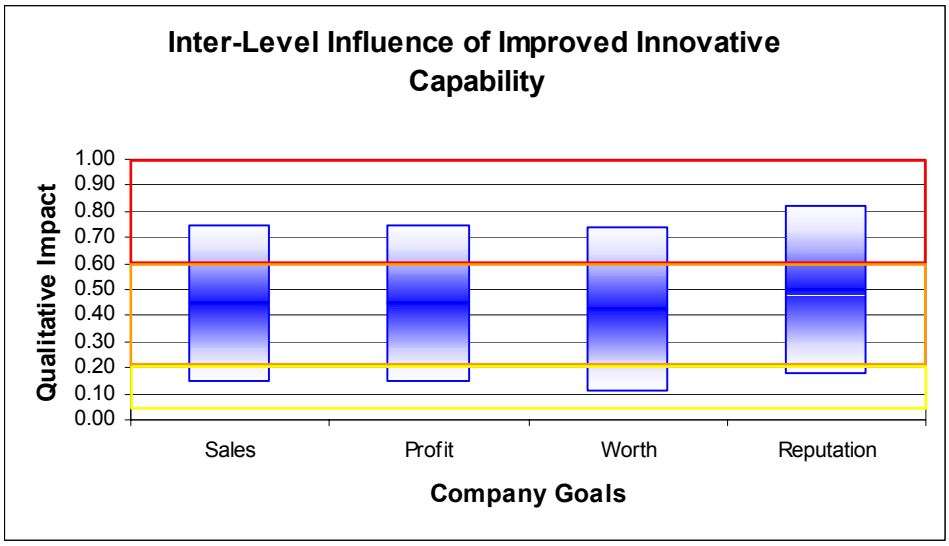


Figure 7-15: Inter-Level Influence of *Improved Innovative Capability*

	Impact of Improved Innovative Capability on:			
	Sales	Profit	Worth	Reputation
Ø	0.45	0.45	0.43	0.50
Scale	0.30	0.30	0.30	0.30
σ	0.30	0.30	0.31	0.32

Table 7-20: Inter-Level Influence of *Improved Innovative Capability*

No literature has been detected concerning the impact of *Improved Innovative Capability* on *Company Goals*.

7.3.5. Impact within Innovation Enablers

Intra-Level Influence of Strategy:

Figure 7-16, Table 7-21: *Strategy* moderately affects all of the *Innovation Enablers*-elements. The survey shows that the element *Processes* is the most influenced by *Strategy* and *Corporate Culture* the least influenced. The overall high deviations might derive from the different companies, because the importance and impact of a company's *Innovation Enablers* are strongly related to its industry field and size [2].

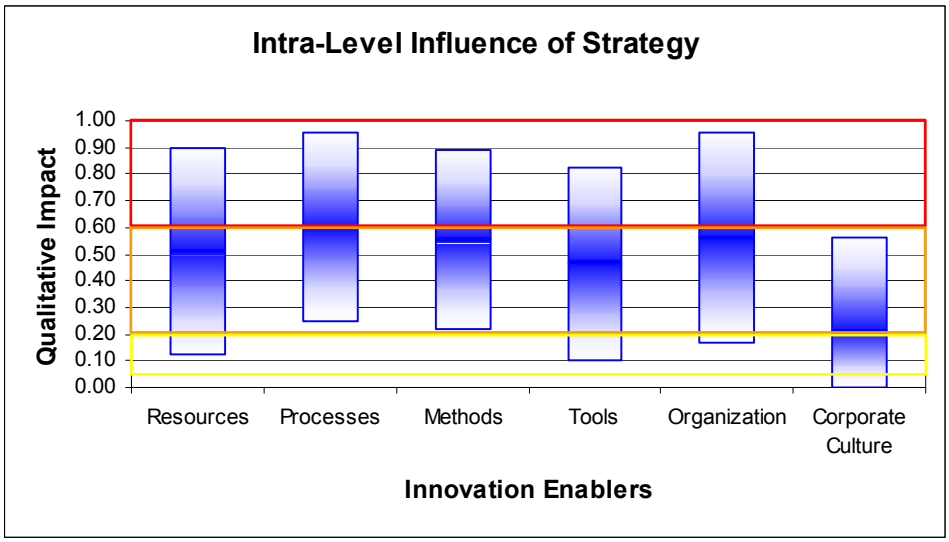


Figure 7-16: Intra-Level Influence of *Strategy*

	Impact of Strategy on:					
	Resources	Processes	Methods	Tools	Organization	Culture
Ø	0.51	0.60	0.55	0.46	0.56	0.21
Scale	0.30	0.30	0.30	0.30	0.30	0.30
σ	0.39	0.35	0.34	0.36	0.40	0.35

Table 7-21: Intra-Level Influence of *Strategy*

No literature has been found concerning the impact within the *Innovation Enablers*.

Intra-Level Influence of Resources:

Figure 7-17, Table 7-22: The element *Resources* moderately affects *Strategy*, *Processes*, *Methods*, and *Tools*. It has the highest influence on *Methods*. *Organization* and *Corporate Culture* are only slightly linked to *Resources*. The overall high deviations might also derive from the different companies, like discussed in the paragraph above.

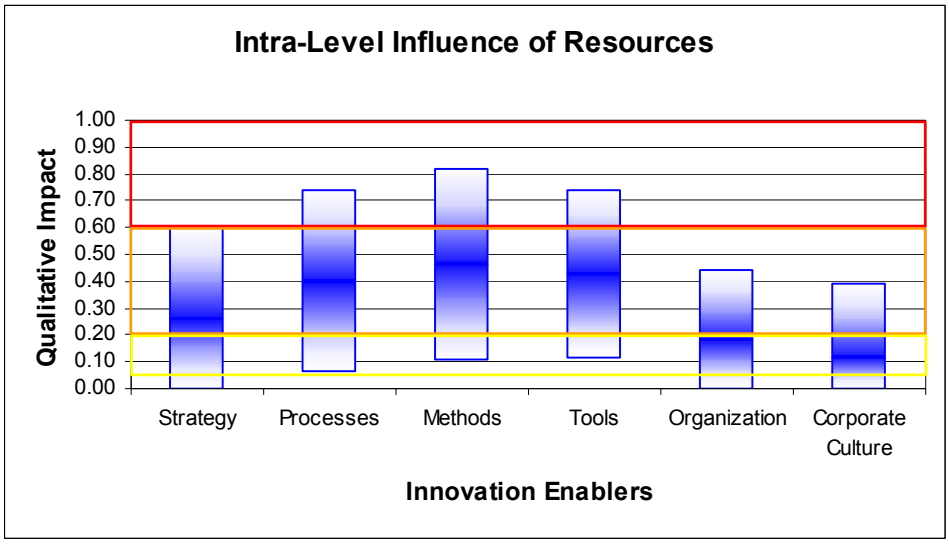


Figure 7-17: Intra-Level Influence of *Resources*

	Impact of Resources on:					
	Strategy	Processes	Methods	Tools	Organization	Culture
Ø	0.26	0.40	0.46	0.43	0.18	0.12
Scale	0.30	0.30	0.30	0.30	0.10	0.10
σ	0.34	0.34	0.36	0.31	0.26	0.28

Table 7-22: Intra-Level Influence of *Resources*

Intra-Level Influence of Processes:

Figure 7-18, Table 7-23: *Methods* and *Tools* are moderately affected by *Processes*. *Strategy*, *Resources*, and *Organization* are only slightly influenced by *Processes* and *Corporate Culture* is just negligibly linked to *Processes*. The high standard deviations of *Methods* and *Tools* might be evidence that especially these two elements are strongly related to a company's characteristics.

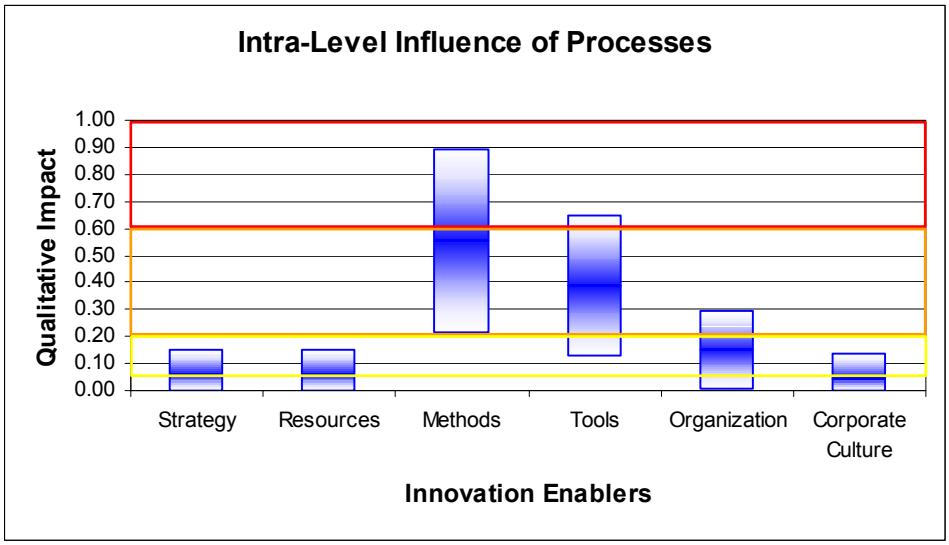


Figure 7-18: Intra-Level Influence of *Processes*

	Impact of Processes on:					
	Strategy	Resources	Methods	Tools	Organization	Culture
Ø	0.05	0.05	0.55	0.39	0.15	0.05
Scale	0.10	0.10	0.30	0.30	0.10	0.00
σ	0.09	0.09	0.34	0.26	0.14	0.09

Table 7-23: Intra-Level Influence of *Processes*

Intra-Level Influence of Methods:

Figure 7-19, Table 7-24: The element *Methods* appears to have a strong impact on *Tools* and a moderate impact on *Organization*. The survey shows that *Strategy* is just slightly influenced by *Methods* and *Resources*, *Processes*, and *Corporate Culture* are negligibly influenced. Whereas *Tools* and *Organization* have a high standard deviation, the impact of *Methods* on all other *Innovation Enablers* is very clear. *Tools* and *Organization* might be more related to a company's characteristics than the other *Innovation Enablers*.

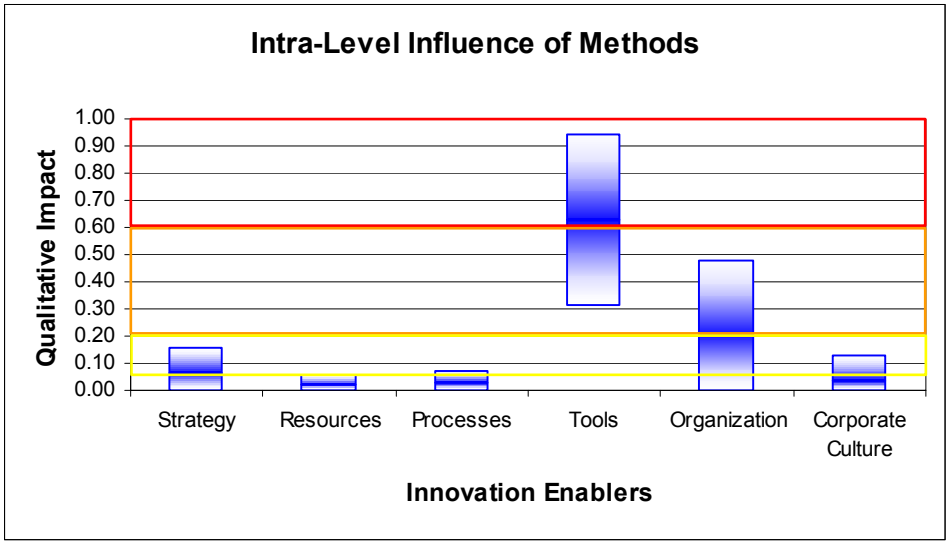


Figure 7-19: Intra-Level Influence of *Methods*

	Impact of Methods on:					
	Strategy	Resources	Processes	Tools	Organization	Culture
Ø	0.06	0.02	0.03	0.63	0.21	0.04
Scale	0.10	0.00	0.00	0.90	0.30	0.00
σ	0.09	0.04	0.05	0.31	0.27	0.09

Table 7-24: Intra-Level Influence of *Methods*

Intra-Level Influence of Tools:

Figure 7-20, Table 7-25: *Organization*, *Methods*, and *Processes* are slightly linked to *Tools* with *Organization* exhibiting a higher deviation (might be more related to a company's characteristics, than the other *Innovation Enablers*). The other elements are negligibly affected by *Tools*.

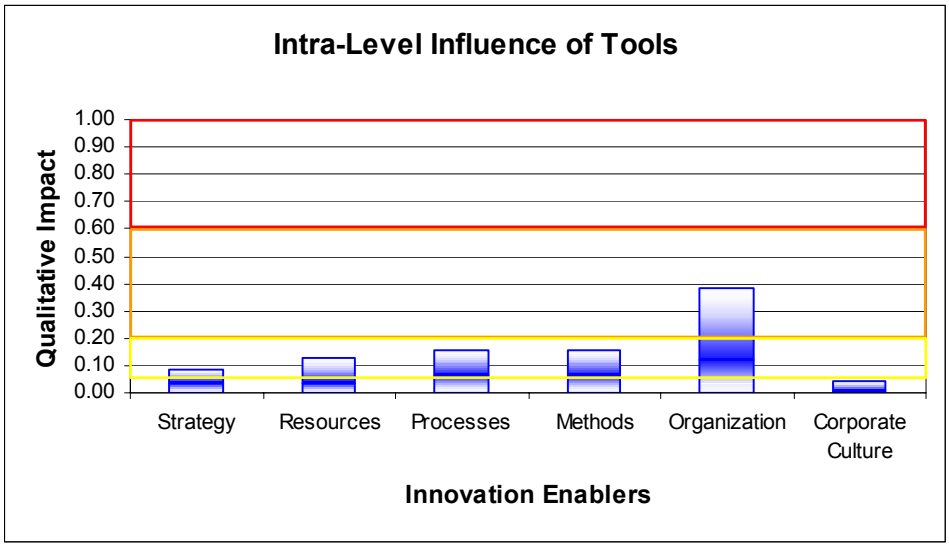


Figure 7-20: Intra-Level Influence of *Tools*

	Impact of Tools on:					
	Strategy	Resources	Processes	Methods	Organization	Culture
Ø	0.04	0.04	0.06	0.06	0.12	0.01
Scale	0.00	0.00	0.10	0.10	0.10	0.00
σ	0.05	0.09	0.09	0.09	0.26	0.03

Table 7-25: Intra-Level Influence of *Tools*

Intra-Level Influence of Organization:

Figure 7-21, Table 7-26: All elements are slightly affected by *Organization*, with *Corporate Culture* showing the highest correlation and deviation and *Tools* showing a negligible correlation. A possible reason for the high standard deviation of *Corporate Culture* might be that its element definition was not specific enough.

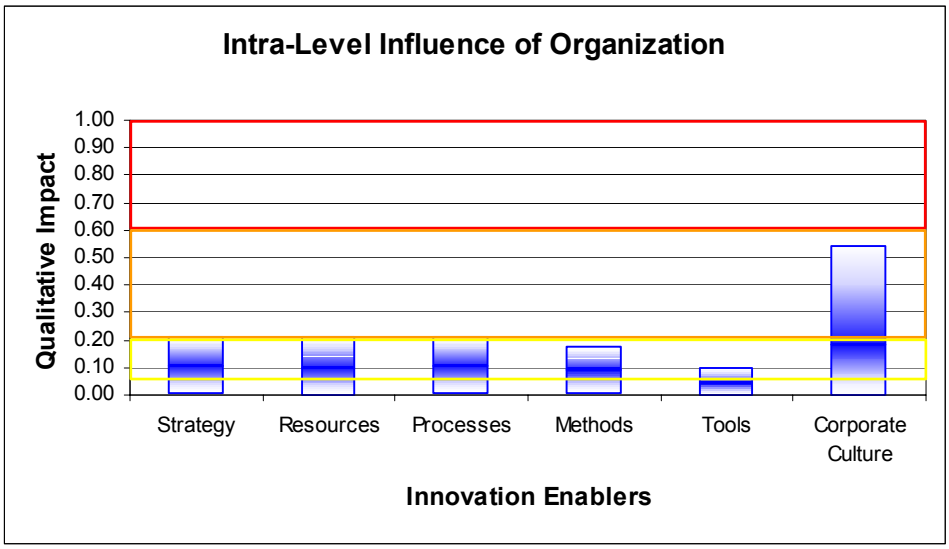


Figure 7-21: Intra-Level Influence of *Organization*

	Impact of Organization on:					
	Strategy	Resources	Processes	Methods	Tools	Culture
Ø	0.11	0.10	0.11	0.09	0.05	0.18
Scale	0.10	0.10	0.10	0.10	0.00	0.10
σ	0.10	0.11	0.10	0.08	0.05	0.36

Table 7-26: Intra-Level Influence of *Organization*

Intra-Level Influence of Corporate Culture:

Figure 7-22, Table 7-27: *Corporate Culture* appears to have a strong impact on *Strategy* and a moderate impact on *Organization*. All other elements are slightly affected by *Corporate Culture*.

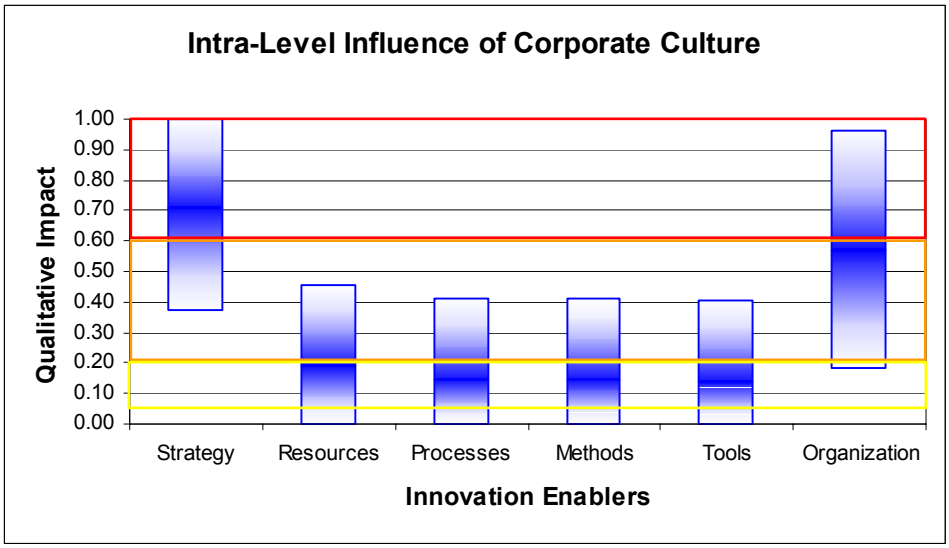


Figure 7-22: Intra-Level Influence of *Corporate Culture*

	Impact of Corporate Culture on:					
	Strategy	Resources	Processes	Methods	Tools	Organization
Ø	0.71	0.19	0.15	0.15	0.14	0.57
Scale	0.90	0.10	0.10	0.10	0.10	0.30
σ	0.34	0.27	0.27	0.27	0.27	0.39

Table 7-27: Intra-Level Influence of *Corporate Culture*

7.3.6. Impact within Innovation Outcomes

Intra-Level Influence of Product Innovation:

Figure 7-23, Table 7-28: *Quality Improvement* and *Improved Innovative Capability* are moderately linked to *Product Innovation*. The survey shows that *Cost Reduction* and *Speed Improvement* are slightly influenced by *Product Innovation*. Whereas the probability that *Product Innovation* has a slight impact on *Cost Reduction* is very high, the impact of *Product Innovation* on *Improved Innovative Capability* could also be slight or moderate. One possible reason is that no constraints were made in the survey regarding the time-period. Considering a long-term impact of *Product Innovation* on *Improved Innovative Capability* probably leads to a stronger influence than considering a short-term impact.

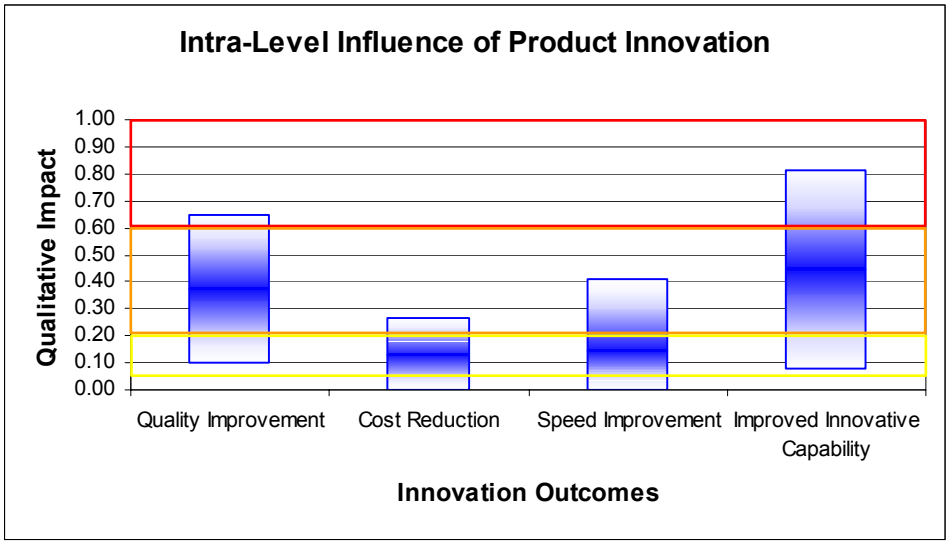


Figure 7-23: Intra-Level Influence of *Product Innovation*

	Impact of Product Innovation on:			
	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.37	0.13	0.15	0.45
Scale	0.30	0.10	0.10	0.30
σ	0.27	0.14	0.27	0.37

Table 7-28: Intra-Level Influence of *Product Innovation*

No literature has been detected to support the survey results of the impact of *Product Innovation* within the *Innovation Outcomes*.

Intra-Level Influence of Quality Improvement:

Figure 7-24, Table 7-29: *Quality Improvement* appears to have a moderate impact on *Improved Innovative Capability*. It also slightly affects all of the other *Innovation Outcomes* with *Speed Improvement* being the least influenced. The high deviation of *Improved Innovative Capability* might derive from the same reason as discussed in the paragraph above (aspect of time).

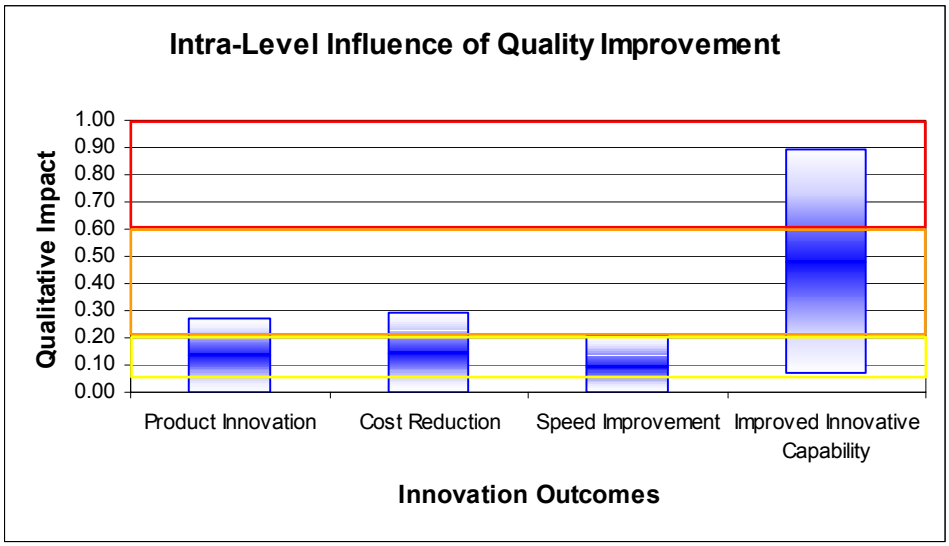


Figure 7-24: Intra-Level Influence of *Quality Improvement*

	Impact of Quality Improvement on:			
	Product Innovation	Cost Reduction	Speed Improvement	Improved Innovative Capability
Ø	0.14	0.14	0.09	0.48
Scale	0.10	0.10	0.10	0.30
σ	0.14	0.15	0.11	0.41

Table 7-29: Intra-Level Influence of *Quality Improvement*[12]

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study suggests a higher impact of *Quality Improvement* on *Product Innovation* than the survey results (see section 7.2.4).

[12] Two participants assume a slight negative impact of *Quality Improvement* on *Cost Reduction*

Intra-Level Influence of Cost Reduction:

Figure 7-25, Table 7-30: *Cost Reduction* moderately affects *Improved Innovative Capability* and it influences *Speed Improvement* slightly. *Product Innovation* and *Quality Improvement* are the least influenced elements, their values are negligible. The high deviation of *Improved Innovative Capability* might derive from the same reason as discussed in the paragraphs above (aspect of time).

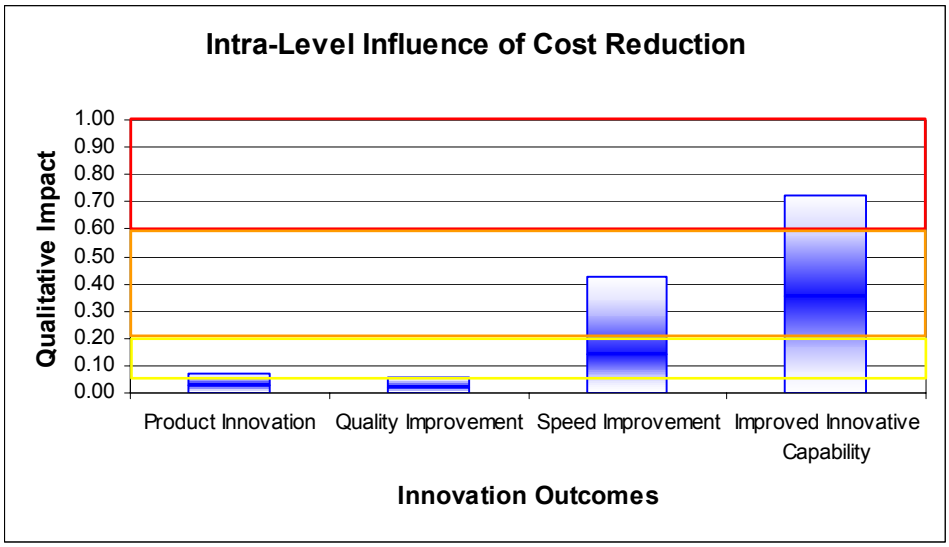


Figure 7-25: Intra-Level Influence of *Cost Reduction*

	Impact of Cost Reduction on:			
	Product Innovation	Quality Improvement	Speed Improvement	Improved Innovative Capability
Ø	0.03	0.02	0.14	0.35
Scale	0.00	0.00	0.10	0.30
σ	0.05	0.04	0.28	0.37

Table 7-30: Intra-Level Influence of *Cost Reduction*[13]

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study and the survey agree that *Cost Reduction* has no impact on *Product Innovation* (see section 7.2.4).

[13] One participant assumes a slight negative impact of *Cost Reduction* on *Speed Improvement*

Intra-Level Influence of Speed Improvement:

Figure 7-26, Table 7-31: The survey shows that *Speed Improvement* influences *Improved Innovative Capability* the most. *Speed Improvement* slightly affects all other *Innovation Outcomes* elements, with *Quality Improvement* as the least influenced.

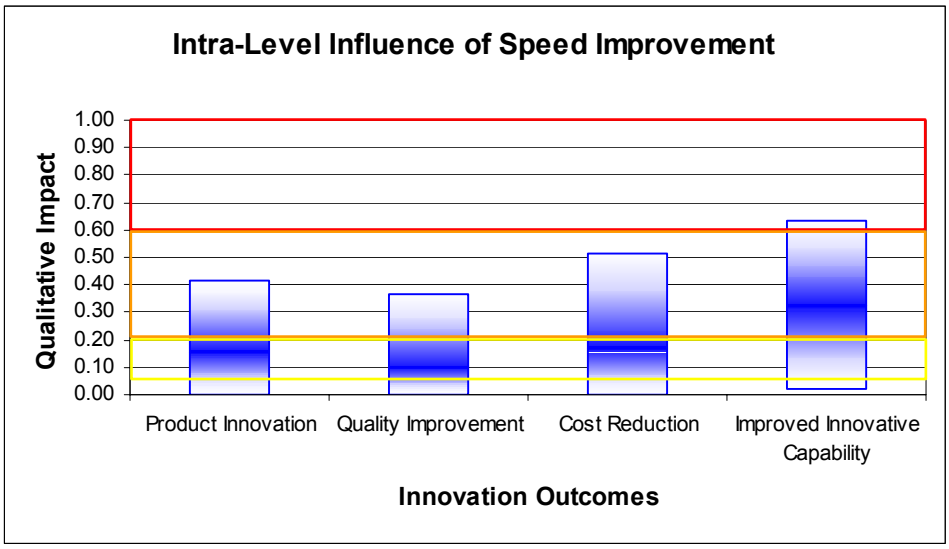


Figure 7-26: Intra-Level Influence of *Speed Improvement*

	Impact of Speed Improvement on:			
	Product Innovation	Quality Improvement	Cost Reduction	Improved Innovative Capability
Ø	0.15	0.10	0.17	0.33
Scale	0.10	0.10	0.10	0.30
σ	0.26	0.27	0.34	0.30

Table 7-31: Intra-Level Influence of *Speed Improvement*[14]

The Influence of Organizational Process Factors and Capabilities on Development Performance [34] study suggests a slightly higher correlation between *Speed Improvement* and *Product Innovation* (see section 7.2.4).

[14] Three participants assume a slight negative impact of *Speed Improvement* on *Cost Reduction*, one participant assumes even a moderate negative impact.

Intra-Level Influence of Improved Innovative Capability:

Figure 7-27, Table 7-32: *Product Innovation* is strongly linked to *Improved Innovative Capability*. The other elements are moderately affected by *Improved Innovative Capability*, with *Cost Reduction* showing the lowest correlation. One possible reason for the overall high standard deviation might be that no constraints were made in the survey regarding the time-period. Considering a long-term impact of *Improved Innovative Capability* on *Innovation Outcomes* probably leads to a stronger correlation than considering a short-term impact.

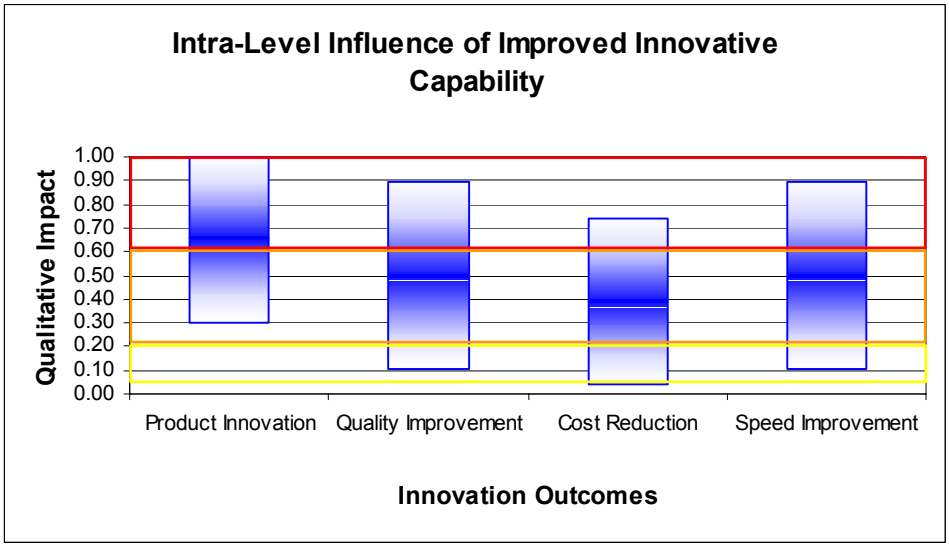


Figure 7-27: Intra-Level Influence of *Improved Innovative Capability*

	Impact of Improved Innovative Capability on:			
	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement
Ø	0.65	0.50	0.39	0.50
Scale	0.90	0.30	0.30	0.30
σ	0.35	0.40	0.35	0.40

Table 7-32: Intra-Level Influence of *Improved Innovative Capability*

No literature has been detected to support the survey results of the impact of *Improved Innovative Capability* within the *Innovation Outcomes*.

7.3.7. Impact within Company Goals

Intra-Level Influence of Sales:

Figure 7-28, Table 7-33: The element *Sales* appears to have a strong impact on *Profit*. The other elements are moderately affected by *Sales*, with *Reputation* showing the lowest correlation.

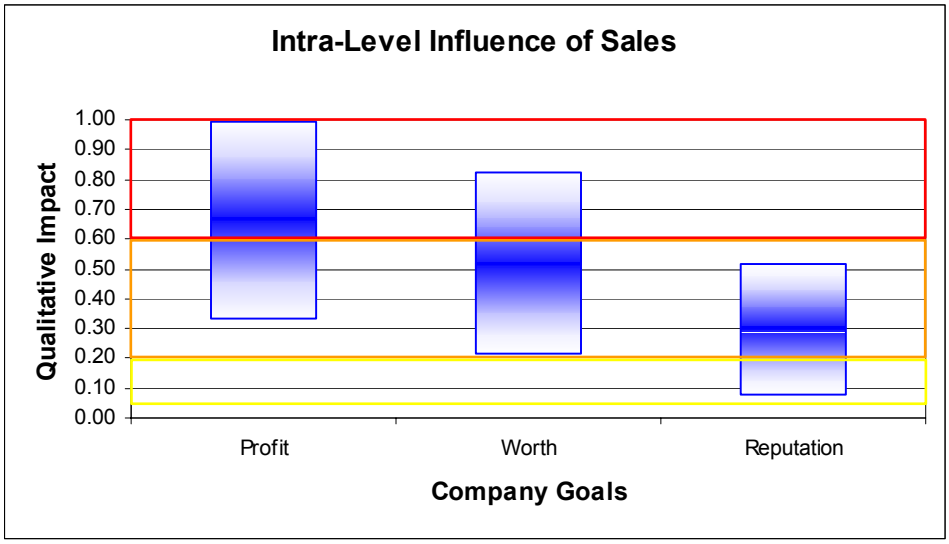


Figure 7-28: Intra-Level Influence of *Sales*

	Impact of Sales on:		
	Profit	Worth	Reputation
Ø	0.66	0.52	0.30
Scale	0.90	0.30	0.30
σ	0.33	0.30	0.22

Table 7-33: Intra-Level Influence of *Sales*

No literature has been found to concerning the impact within the *Company Goals*.

Intra-Level Influence of Profit:

Figure 7-29, Table 7-34: The element *Sales* is only slightly linked to *Profit* and exhibits a low deviation. The survey indicates that *Worth* is the most influenced by *Profit* and *Reputation* is moderately affected. The reason for the high standard deviation of *Reputation* might be that its definition was not specific and clear enough for the survey participants.

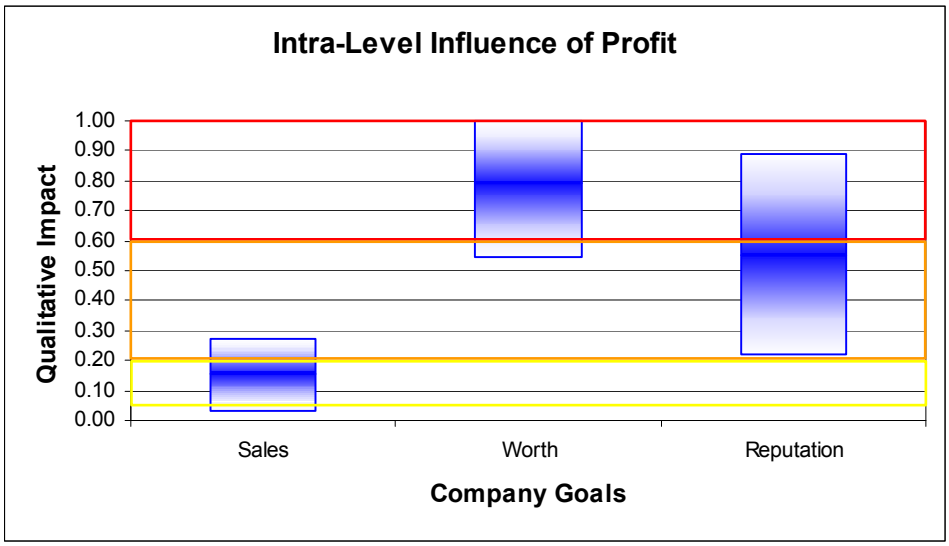


Figure 7-29: Intra-Level Influence of *Profit*

	Impact of Profit on:		
	Sales	Worth	Reputation
Ø	0.15	0.79	0.55
Scale	0.10	0.90	0.30
σ	0.12	0.24	0.34

Table 7-34: Intra-Level Influence of *Profit*

Intra-Level Influence of Worth:

Figure 7-30, Table 7-35: *Sales* and *Profit* are only slightly affected by *Worth* and have a low deviation. *Worth* strongly affects *Reputation*. The reason for the high standard deviation of *Reputation* might be the same as discussed afore (definition not specific enough).

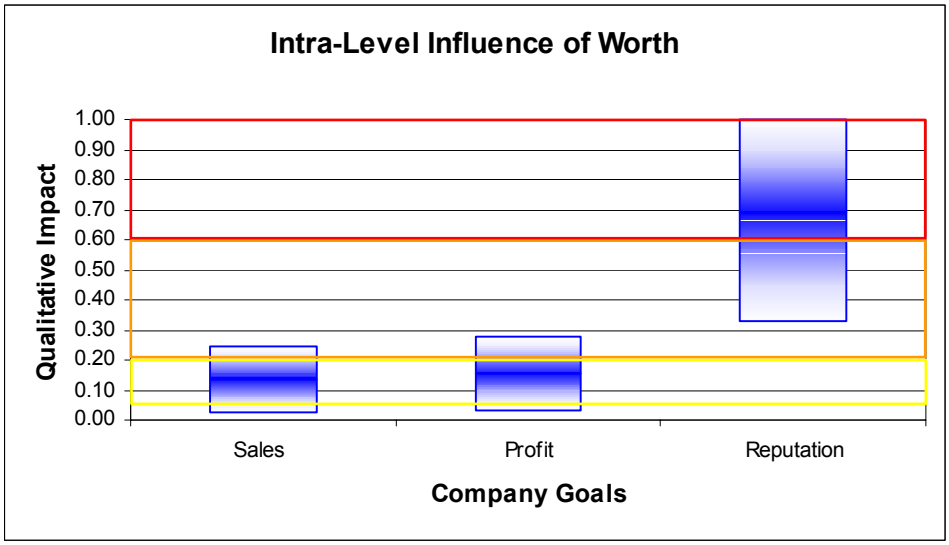


Figure 7-30: Intra-Level Influence of *Worth*

	Impact of Worth on:		
	Sales	Profit	Reputation
Ø	0.14	0.15	0.69
Scale	0.10	0.10	0.90
σ	0.11	0.12	0.36

Table 7-35: Intra-Level Influence of *Worth*

Intra-Level Influence of Reputation:

Figure 7-31, Table 7-36: All elements are moderately affected by *Reputation*, with *Sales* showing the highest correlation and *Worth* the lowest. The reason for the high standard deviations might be the same as discussed afore (definition not specific enough).

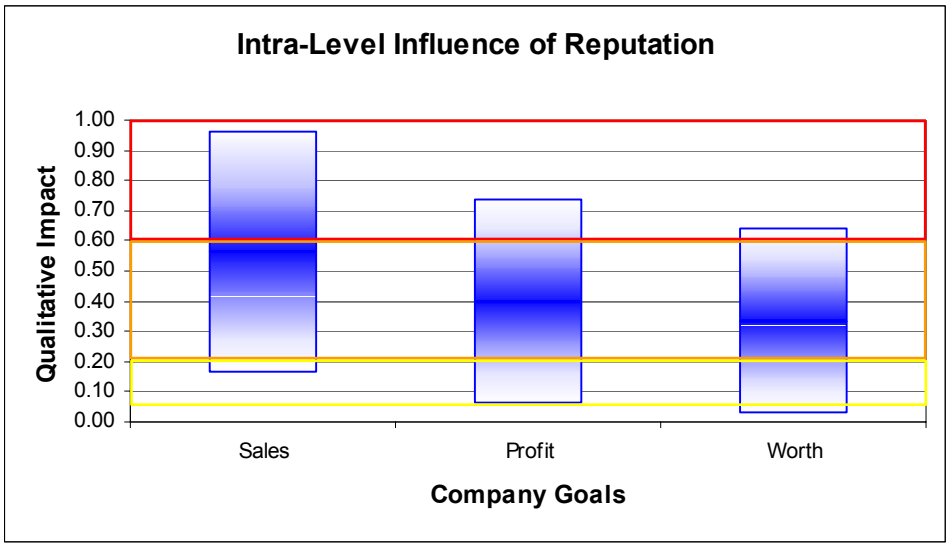


Figure 7-31: Intra-Level Influence of *Reputation*

	Impact of Reputation on:		
	Sales	Profit	Worth
Ø	0.56	0.40	0.34
Scale	0.30	0.30	0.30
σ	0.40	0.34	0.30

Table 7-36: Intra-Level Influence of *Reputation*

7.4. Summary

The survey results and literature studies do not always, but mostly support the survey findings. The survey results are based on the actual “Impact of Innovation” model, the literature took different models as basis for the studies. Therefore it is likely that the survey results are more reliable than the values out of the literature.

In many cases the survey data show high deviations. The selected scale (see 5.7) contributes to these high deviations. But also the differences between companies, industries, countries and the time horizon taken into account certainly have an affect on these deviations. By coaching the participants while conducting the survey, the research-team attempted to minimized misunderstandings.

8. The Impact: Conclusion

8.1. Introduction

In the first step, Active- and Passive-Sums of every element are calculated and discussed in detail. Thus, the importance of a specific element can first be apprised in a qualitative manner. In the next step, the calculation of the overall impact of innovation on sustainable business success is illustrated, using different parameters in the calculation. Finally, the comparison with literature results is created.

8.2. Active- / Passive-Sum

Active- and Passive-Sums express the entire impact of an element on all other elements. The Active-Sum is calculated by the sum of all influences an element has on all other elements, therefore the Active-Sum shows how strong the element influences all other elements. The Passive-Sum of an element is calculated by the sum of all affecting influences on this element, thus it describes how strong the element is affected by all other elements [8] (Figure 6-7). Analyzing Active- and Passive-Sums enables a better understanding of the importance of the different elements in the "Impact of Innovation" model. Meier [8] differentiates between:

- Impulsive elements → high Active-Sum, low Passive-Sum
- Dynamic elements → high Active-Sum, high Passive-Sum
- Reactive elements → low Active-Sum, high Passive-Sum
- Buffering elements → low Active-Sum, low Passive-Sum
- Neutral elements → moderate Active-Sum, moderate Passive-Sum

In the section below, these five categories afore are used to describe an element's impact on the other elements.

8.2.1. Innovation Enablers

Table 8-1:

Strategy has the highest intra-level Active- and Passive-Sum. Therefore, *Strategy* can be seen as a dynamic element. Its inter-level Active-Sum is the highest of all *Innovation Enablers*-elements, thus *Strategy* is certainly very important for a company's *Innovation Outcomes*.

Resources and *Corporate Culture* have a high intra-level Active- but a low Passive-Sum and are impulsive elements. Their inter-level Active-Sum is low, but as impulsive elements they might still have an important influence up to the next level *Innovation Outcomes*, especially with a low inter-level / intra-level influence ratio.

The element *Processes* is neutral, with a moderate intra-level Active- and Passive-Sum. However, the inter-level Active-Sum of *Processes* is high. For this reason, as the inter-level influences in the "Impact of Innovation" model becomes more important, the higher the influence of *Processes* on a company's *Innovation Outcomes* is expected.

The intra-level Active- and Passive-Sum of *Methods* are highly moderate, so *Methods* can be seen as a dynamic element. Its inter-level Active-Sum is low, hence it does not have a very high impact on *Innovation Outcomes* compared to the other elements.

Tools and *Organization* are reactive elements with low intra-level Active- and high Passive-Sums. Also their inter-level Active-Sum is low, thus just a slight impact of *Tools* and *Organization* on *Innovation Outcomes* is expected.

Innovation Enablers		Intra-Level	Inter-Level
Strategy	Active-Sum	1.80	2.70
	Passive-Sum	1.50	
Resources	Active-Sum	1.40	1.50
	Passive-Sum	0.60	
Processes	Active-Sum	0.90	2.10
	Passive-Sum	0.90	
Methods	Active-Sum	1.30	1.50
	Passive-Sum	1.20	
Tools	Active-Sum	0.30	1.50
	Passive-Sum	1.90	
Organization	Active-Sum	0.50	1.50
	Passive-Sum	1.20	
Corp. Culture	Active-Sum	1.60	1.50
	Passive-Sum	0.50	

Table 8-1: Active- / Passive-Sum of *Innovation Enablers*

8.2.2. Innovation Outcomes

Table 8-2:

Product Innovation has moderate intra-level Active- and Passive-Sums, thus it is a neutral element concerning its impact within *Innovation Outcomes*. Describing the inter-level characteristics, *Product Innovation* has a high Active- and an even higher Passive-Sum. Therefore, it is a dynamic element and a high impact on *Company Goals* compared to the other *Innovation Outcomes* elements is expected.

Quality Improvement and *Cost Reduction* have moderate intra-level Active- and Passive-Sums and are neutral to buffering elements. Regarding the inter-level *Quality Improvement* and *Cost Reduction* have a low Active- but high Passive-Sum. Hence, they are reactive elements concerning the inter-level impact and just a slight overall impact on *Company Goals* is expected.

Speed Improvement is a neutral to a buffering element, considering the intra-level impact. Regarding the inter-level impact, *Speed Improvement* is a reactive element. Therefore, just a slight overall impact of *Speed Improvement* on *Company Goals* is anticipated.

Improved Innovative Capability is a dynamic element in the intra-level. Its Active- and Passive-Sums are the highest. Regarding the inter-level, it is more a reactive element with a quite low Active- and very high Passive-Sum. But overall, *Improved Innovative Capability* seems to have quite a strong impact on *Company Goals* compared to the other *Innovation Outcomes* elements.

Innovation Outcomes		Intra-Level	Inter-Level
Product Innovation	Active-Sum	0.80	1.80
	Passive-Sum	1.10	2.70
Quality Improvement	Active-Sum	0.60	1.00
	Passive-Sum	0.70	2.10
Cost Reduction	Active-Sum	0.40	1.00
	Passive-Sum	0.60	2.10
Speed Improvement	Active-Sum	0.60	0.80
	Passive-Sum	0.60	2.70
Improved Innovative Capability	Active-Sum	1.80	1.20
	Passive-Sum	1.20	2.70

Table 8-2: Active- / Passive-Sum of *Innovation Outcomes*

8.2.3. Company Goals

Table 8-3:

The element *Sales* has the highest intra-level Active-Sum but also the lowest intra-level Passive-Sum, so it affects the other *Company Goals* the most. Hence, it is an impulsive element. The element *Sales* is the most influenced by *Innovation Outcomes* since its inter-level Passive-Sum is the highest. The higher the inter-level / intra-level influence ratio, the higher the impact on *Sales* compared to the other *Company Goals* is expected.

Profit is a neutral or almost dynamic element regarding the intra-level dependencies. Its inter-level Passive-Sum is moderate. Therefore, *Profit* is moderately affected by the *Innovation Outcomes* and the *Company Goals*, and affects the other *Company Goals* as well, in a moderate manner.

Worth and *Reputation* are quite reactive elements, since their intra-level Passive-Sum is high and intra-level Active-Sum is moderate. The inter-level Passive-Sum is between low and moderate. In particular, *Reputation* is strongly influenced by both *Innovation Outcomes* and *Company Goals*.

Company Goals		Intra-Level	Inter-Level
Sales	Active-Sum	1.50	
	Passive-Sum	0.50	2.10
Profit	Active-Sum	1.30	
	Passive-Sum	1.30	1.30
Worth	Active-Sum	1.10	
	Passive-Sum	1.50	1.10
Reputation	Active-Sum	0.90	
	Passive-Sum	1.50	1.30

Table 8-3: Active- / Passive-Sum of *Company Goals*

8.3. Calculation of the Impact

Combining all the work described in the chapters 4, 5, and 7, the research-team is now able to calculate the qualitative impact of innovation on sustainable business success, using the mathematical model and the gathered information about all the influences between the elements (survey). Since the realistic parameters to run the mathematical model are not known yet, the impact has been calculated and discussed by using different parameters. The research-team came up with the following findings:

Table 8-4 to Table 8-10 illustrate the qualitative impact of innovation on sustainable business success with different inter-level / intra-level – ratios, based on the values gathered by the survey (see section 7.3). Until now, the different parameters for calculating the impact of innovation have not yet been thoroughly researched. The tables show the results with the following parameters:

Planned Improvement of the *Innovation Enablers* → 1 (qualitative!)
Influence Ratio between Inter-Level and Intra-Level → variable[15]
Weights of Elements → 1[16]
Number of Loops → 100
Normalize → YES

The line “Rating” in the tables below indicate which *Innovation Enablers* element affects the *Company Goals* the most (with 1=strongest impact, 7=least impact).

[15] Only values ≥1 are used, because the results for values <1 approach infinity.
[16] Parameter studies are required to be able to adjust these weights to reality.

	(Ratio Inter-Level / Intra-Level = 1) Impact of:													
on:	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
	abs.	[%][17]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	7.52	25.27	4.58	25.06	3.77	25.07	3.12	25.03	2.27	25.01	3.24	25.04	6.32	25.07
Profit	6.56	22.05	4.05	22.18	3.29	21.90	2.76	22.21	2.02	22.23	2.87	22.20	5.59	22.16
Worth	7.37	24.80	4.52	24.74	3.69	24.54	3.08	24.74	2.24	24.74	3.20	24.74	6.24	24.74
Reputation	8.29	27.88	5.12	28.03	4.28	28.50	3.49	28.02	2.54	28.02	3.62	28.02	7.06	28.03
Rating	1		3		4		6		7		5		2	

Table 8-4: Impact with Inter-Level / Intra-Level Ratio = 1

	(Ratio Inter-Level / Intra-Level = 2) Impact of:													
on:	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	3.63	29.37	2.04	28.84	1.95	28.90	1.57	28.80	1.30	28.77	1.61	28.81	2.59	28.88
Profit	2.70	21.84	1.57	22.17	1.45	21.52	1.21	22.22	1.01	22.25	1.24	22.21	1.99	22.14
Worth	2.84	22.98	1.61	22.83	1.51	22.37	1.25	22.83	1.04	22.83	1.28	22.83	2.05	22.83
Reputation	3.19	25.81	1.85	26.16	1.84	27.21	1.43	26.15	1.19	26.14	1.46	26.15	2.35	26.16
Rating	1		3		4		6		7		5		2	

Table 8-5: Impact with Inter-Level / Intra-Level Ratio = 2

	(Ratio Inter-Level / Intra-Level = 5) Impact of:													
on:	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	2.09	33.64	1.08	32.57	1.20	32.71	0.94	32.53	0.87	32.51	0.96	32.54	1.23	32.61
Profit	1.34	21.56	0.74	22.23	0.77	20.99	0.65	22.28	0.60	22.31	0.65	22.27	0.84	22.19
Worth	1.32	21.20	0.69	20.90	0.73	20.06	0.61	20.91	0.56	20.91	0.61	20.91	0.79	20.90
Reputation	1.47	23.59	0.80	24.29	0.96	26.25	0.71	24.28	0.65	24.27	0.71	24.28	0.92	24.29
Rating	1		4		3		6		7		5		2	

Table 8-6: Impact with Inter-Level / Intra-Level Ratio = 5

[17] This relative impact expresses the amount of impact each company goal absorbs from the planned improvement (Figure 6-6).

	(Ratio Inter-Level / Intra-Level = 10) Impact of:													
	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
on:	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	1.70	35.65	0.84	34.24	0.99	34.43	0.78	34.21	0.74	34.20	0.78	34.22	0.90	34.27
Profit	1.02	21.41	0.54	22.30	0.60	20.68	0.51	22.33	0.49	22.35	0.51	22.33	0.59	22.27
Worth	0.97	20.42	0.49	20.02	0.55	18.95	0.46	20.03	0.44	20.03	0.46	20.03	0.53	20.02
Reputation	1.07	22.52	0.57	23.44	0.75	25.94	0.53	23.43	0.51	23.43	0.54	23.43	0.62	23.44
Rating	1		4		2		6		7		5		3	

Table 8-7: Impact with Inter-Level / Intra-Level Ratio = 10

	(Ratio Inter-Level / Intra-Level = 50) Impact of:													
	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
on:	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	1.42	37.59	0.67	35.79	0.84	36.04	0.66	35.78	0.65	35.77	0.66	35.78	0.68	35.80
Profit	0.80	21.24	0.42	22.39	0.48	20.36	0.41	22.39	0.41	22.40	0.41	22.39	0.43	22.38
Worth	0.74	19.69	0.36	19.19	0.42	17.87	0.35	19.19	0.35	19.19	0.35	19.19	0.36	19.19
Reputation	0.81	21.48	0.42	22.64	0.60	25.72	0.42	22.63	0.41	22.63	0.42	22.63	0.43	22.64
Rating	1		4		2		5/6		7		5/6		3	

Table 8-8: Impact with Inter-Level / Intra-Level Ratio = 50

	(Ratio Inter-Level / Intra-Level = 100) Impact of:													
	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
on:	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	1.38	37.86	0.65	35.99	0.83	36.26	0.64	35.99	0.64	35.99	0.64	35.99	0.66	36.00
Profit	0.77	21.21	0.40	22.40	0.46	20.32	0.40	22.40	0.40	22.41	0.40	22.40	0.41	22.39
Worth	0.72	19.59	0.34	19.08	0.40	17.72	0.34	19.08	0.34	19.08	0.34	19.08	0.35	19.08
Reputation	0.78	21.34	0.41	22.53	0.59	25.70	0.40	22.52	0.40	22.52	0.40	22.52	0.41	22.53
Rating	1		4		2		5/6/7		5/6/7		5/6/7		3	

Table 8-9: Impact with Inter-Level / Intra-Level Ratio = 100

	(Ratio Inter-Level / Intra-Level = 1000) Impact of:													
	Strategy		Resources		Processes		Methods		Tools		Organiza-tion		Corporate Culture	
on:	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]	abs.	[%]
Sales	1.35	38.11	0.63	36.19	0.81	36.46	0.63	36.19	0.63	36.18	0.63	36.19	0.63	36.19
Profit	0.75	21.19	0.39	22.41	0.45	20.28	0.39	22.41	0.39	22.41	0.39	22.41	0.39	22.41
Worth	0.69	19.50	0.33	18.98	0.39	17.58	0.33	18.98	0.33	18.98	0.33	18.98	0.33	18.98
Reputation	0.75	21.20	0.39	22.43	0.57	25.68	0.39	22.42	0.39	22.42	0.39	22.42	0.39	22.43
Rating	1		3/4/5/6/7		2		3/4/5/6/7		3/4/5/6/7		3/4/5/6/7		3/4/5/6/7	

Table 8-10: Impact with Inter-Level / Intra-Level Ratio = 1000

Table 8-4: Impact with Inter-Level / Intra-Level Ratio = 1:
An improvement in *Strategy* affects *Company Goals* the most, followed by *Corporate Culture* and *Resources*. The element *Tools* has the least impact on *Company Goals*.

Table 8-5: Impact with Inter-Level / Intra-Level Ratio = 2:
The absolute qualitative impact of the *Innovation Enablers* elements on the *Company Goals* elements decreases visibly. However, the rating of the qualitative impact stays the same as with the ratio = 1.

Table 8-6: Impact with Inter-Level / Intra-Level Ratio = 5:
The absolute qualitative impact of the *Innovation Enablers*-elements on the *Company Goals*-elements decreases again. The rating also changes; *Strategy* still affects *Company Goals* the most, now followed by *Corporate Culture* (2) and *Processes* (3).

Table 8-7: Impact with Inter-Level / Intra-Level Ratio = 10:
The absolute qualitative impact of the *Innovation Enablers*-elements on the *Company Goals*-elements decreases again. The rating changes, with *Strategy* remaining the most effective element, now followed by *Processes* (2) and *Corporate Culture* (3).

Table 8-8: Impact with Inter-Level / Intra-Level Ratio = 50:
Methods and *Organization* have an equal impact on *Company Goals*. The rating of the top three *Innovation Enablers*-elements stays the same as when calculated with the ratio = 10.

Table 8-9: Impact with Inter-Level / Intra-Level Ratio = 100:
Methods, *Tools*, and *Organization* now have the same and least impact on *Company Goals*. The rating of the top three *Innovation Enablers*-elements stays the same as when calculated with the ratio = 10.

Table 8-10: Impact with Inter-Level / Intra-Level Ratio = 1000:
Strategy still has the most impact on *Company Goals*, followed by *Processes*. All other *Innovation Enablers*-elements show an equal affect on *Company Goals*. This rating stays stable, even if the inter-level / intra-level ratio increases again.

As the ratio between inter-level and intra-level influences becomes higher, the higher is the percentage for *Sales*. In other words, the higher the ratio, the more an improvement in the *Innovation Enablers* affects *Sales* compared to the other *Company Goals*-elements, and the less percentage for the other *Company Goals*-elements.

Regardless of the real life ratio between inter-level and intra-level influences, *Strategy* is always the top influencing factor. An improvement in *Strategy* has always the highest impact on a company's performance, compared to an other improvement of an *Innovation Enablers*-element.

With a low ratio, *Resources* and *Corporate Culture* are also very important. The higher the ratio, the more important is the element *Processes*, until it stabilizes (Table 8-10) as the second most important *Innovation Enablers*-element. The values in Table 8-10 show the impact of *Innovation Enablers* on *Company Goals* with very little intra-level dependencies. When the ratio increases again, these values no longer change significantly.

Therefore, dependent on the parameters used in the mathematical model, either *Resources* and *Corporate Culture* are the second most important *Innovation Enablers* to impact a company's overall performance, or the element *Processes* is the second most important element, next to *Strategy*.

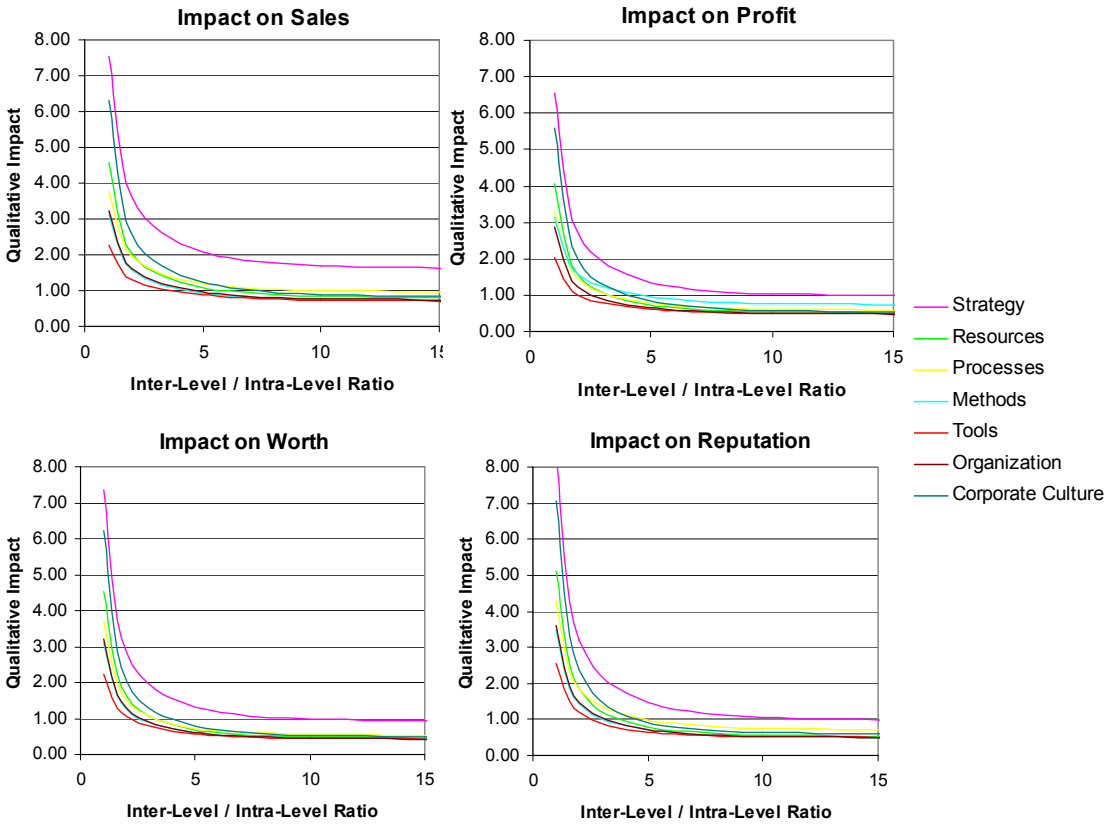


Figure 8-1: Impact on *Company Goals* (Different Ratio)

In a more detailed consideration like illustrated in Figure 8-1, the same results as in the tables afore can be identified. But regarding the impact on *Profit*, the different order (compared to the impact on the other *Company Goals*) of the *Innovation Enablers* at a higher inter- / intra-level ratio than four, is very conspicuously. As it is clearly visible in the diagram of *Profit* in Figure 8-1, the element *Methods* becomes *Profit*s second most important influencing factor. In all other diagrams, the element *Processes* becomes the second most important influencing factor of *Company Goals*. In other words, with a high inter-level / intra-level influence, an improvement of *Methods* is very effective if a company wants to optimize its *Profit*. With a low inter-level / intra-level ratio (~2), *Innovation Enablers* influence *Reputation* the most, but with a higher inter-level / intra-level ratio (~5), the impact of *Innovation Enablers* on *Sales* is the most important.

Almost the same qualitative impact can be found, conducting these test runs with different amounts of loops (Figure 8-2) and the following input:

Planned Improvement of the *Innovation Enablers*	→	1 (qualitative!)
Influence Ratio between Inter-Level and Intra-Level	→	1
Weights of Elements	→	1^{18}
Number of Loops	→	variable
Normalize	→	YES

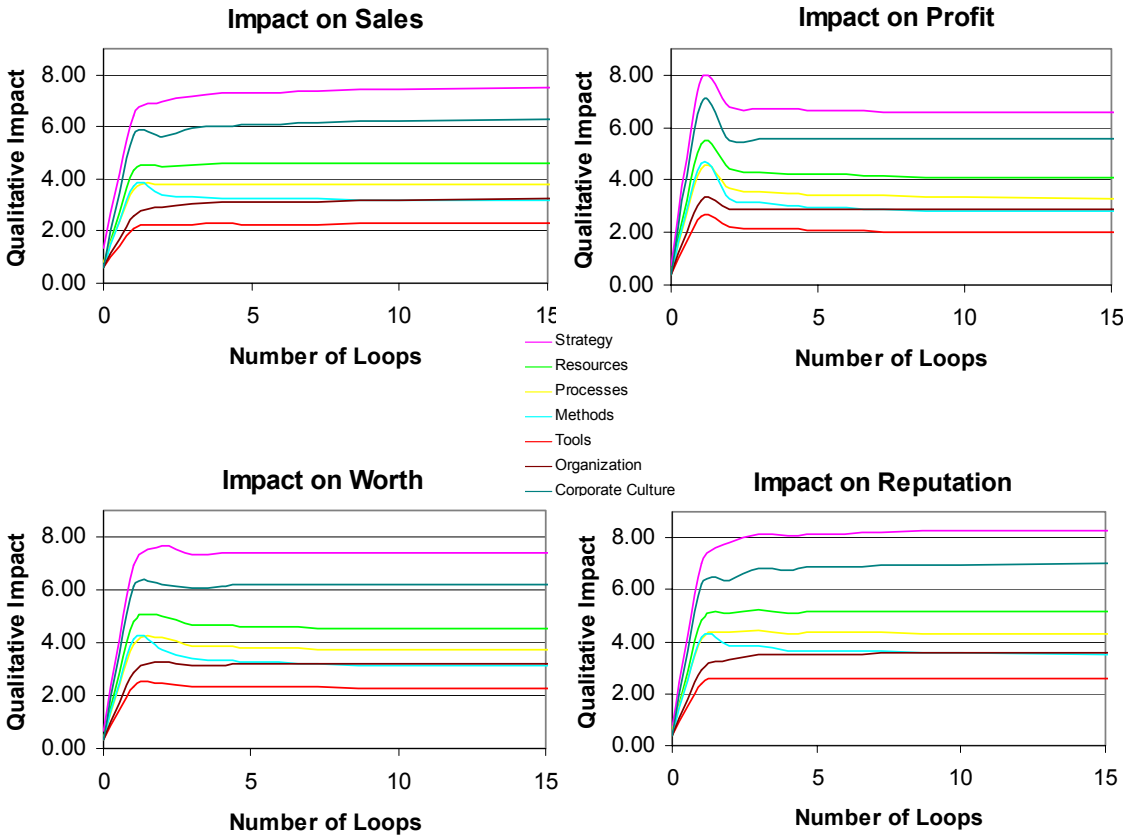


Figure 8-2: Impact on Company Goals (Different Number of Loops)

Figure 8-2: The qualitative conclusion is about the same as in Figure 8-1, *Strategy* is always the main influencing factor of *Company Goals*, followed by *Corporate Culture* and *Resources* (inter-level /intra-level ratio is always = 1). The output does not change significantly anymore, with more than about ten loops. With a low number of loops (~ 2), *Innovation Enablers* influence *Profit* the most and with a higher number of loops (~ 10), *Innovation Enablers* impact *Reputation* the most.

As for now, it is not reasonable to come up with more interpretations, since comprehensive parameter studies are necessary to further refine the work of this project.

8.4. Comparison with Literature

Section 7.2.3 presents a study from Robert Cooper: "Benchmarking New Product Performance: Results of the Best Practice Study" [40]. This study indicates a strong impact of *Processes*, *Strategy*, and *Resources* on *Company Goals*, with *Processes* being the most effective and *Strategy* being the least effective element. The results in section 8.3 show a similar outcome: *Strategy*, *Corporate Culture*, *Resources*, and *Processes* are the main influencing factors regarding a low inter-level / intra-level influence ratio. In the Cooper study, *Corporate Culture* is not seen as a very influential element on a company's goals. This thesis's study is specific to the entire "Impact of Innovation" project, including the Assessment and comprehensively expresses reliable data, simply from another point of view. With that said, intensive research to detect the exact dependencies between all elements in the "Impact of Innovation" model and its parameters is required.

8.5. Summary

The Active- / Passive-Sum evaluation strongly backs the calculation outcomes in section 8.3. The high degree of agreement between the Cooper's study [40] and the results acquired by this thesis strongly supports the outcomes of this project and verifies that the research-team's work concerning the element definition, the design of the mathematical model and the survey findings point in the right direction for further investigation in this field. In any case, comprehensive parameter and real life studies are required to attain the goal of visualizing the quantitative impact of innovation on sustainable business success.

[18] Parameter studies are required to be able to adjust these weights to reality.

9. Outlook

The mathematical model described in chapter 5 is built on a linear approach. It models the qualitative impact an improvement in the *Innovation Enablers* has on *Company Goals*. Since no real life data is available for the specific "Impact of Innovation" model, it is hardly known what realistic parameters are to present a quantitative output, which is the actual goal of this research field. Hence, the following future procedure is recommended:

The survey and literature study in this thesis build the basis of information about the qualitative dependencies desired for the visualization of the impact of innovation on sustainable business success. However, parameter studies are necessary to improve the mathematical model. Real life scenarios have to be built in order to gather information about input / output – data, for example: detecting the improvement of the *Innovation Enablers* (input) and the change in *Company Goals* (output) to estimate what input / output – scenarios could be. Unfortunately, it is very difficult to measure the change in *Company Goals* with respect to product innovation, since *Company Goals* are influenced by so many other factors besides the product innovation. Therefore, a special procedure of measuring the change in the product innovation related *Company Goals* has to be developed or implemented. Having the information about input / output – scenarios enables to define all the parameters of the mathematical model in a more detailed manner.

As soon as more real life data is available, the time lag of the impact-simulation has to be taken into account. In section 5.5, a first discussion about the time lag problem is performed. To facilitate the modeling of the time lag, the software package Simulink has to be considered. Simulink is a tool to design and simulate continuous- and discrete-time systems and enables the user to build and simulate time lags in a user defined model [50].

As a next step, a first quantitative calculation of the output can be tackled. Thus, the "real", quantitative influences between the elements have to be detected through a very comprehensive study. To facilitate the detecting of the desired, exact influences between the elements, the software SPSS Amos has to be considered. SPSS Amos builds models that more realistically reflect complex relationships because any variable, whether observed (such as non-experimental data from a survey) or latent (such as satisfaction and loyalty) can be used to predict any other variable. You can gain additional insight into the causal nature and strength of the relationships among variables [52]. This software has primarily been developed to show the results and de-

pendencies in a specific model based on the output of surveys, interviews, long-term studies, and panel-studies [51].

Section 7.3 discusses the variation of the survey results. In fact, every company owns specific element-dependencies. With reference to the survey output, a classification for detecting more detailed, quantitative influences is recommended:

Country / Region:

Every country or region is characterized by its specific laws and constraints, its own innovation drivers and restrictors. Thus, the behavior of the influences between the elements may vary from country to country and from region to region.

Branch / Industry:

Every branch is characterized by its own rules, life-cycles, and success factors. Therefore it is likely that the influences between the elements differ from industry to industry.

Size of the Company:

The size of the company, measured by the number of employees and the annual sales, is considered as an important form of grouping. A company's product innovation, and thus the different influences between the elements, may strongly be dependent on the size of a company.

Time-Period:

As a next step, it is also necessary to consider the time-period regarding the distinction of short-term-, middle-term-, and long-term impact. As the survey results and the experiences from coaching the survey point out, the time-aspect needs to be included.

Country / region, branch / industry, the size of the company, and the time-aspect are considered as the most important distinctions for detecting the real life influences between the elements in the "Impact of Innovation" model. More detailed distinction recommendations are also described in "Stars der Innovation" [2] but these are not seen as absolutely necessary for the next step in this research field.

The time, quantitative calculations of the impact are possible, the linkage of the Assessment to the "Impact of Innovation" model can be accomplished. Section 5.6 recommends a procedure for this linkage.

10. Closing Words

Through extensive literature studies, the framework of the “Impact of Innovation” model has been improved in a very detailed manner. Since much expert knowledge and studies of highly esteemed authors in the innovation field have been taken into account, the research team believes the “Impact of Innovation” model is among the most comprehensives models in this research field.

In addition, a mathematical model has been developed specifically for the “Impact of Innovation” model. This mathematical model supports a company in making innovation- and investment decisions concerning innovation. With the gathered information from a survey of highly representative participants, the qualitative dependencies in the “Impact of Innovation” model can first be visualized. Even if at this moment only qualitative values can be calculated, the output from the mathematical model already points in a specific direction, which is supported by Cooper’s study [40].

This thesis is a further step in this very interesting and enormously important research field for the entire economy. It is a further step in supporting a company ‘s sustainable innovation decisions.

“The message to senior management is simple: Either innovate or die!”

Robert Cooper

11. Appendix

11.1. Survey

Impact of Innovation on Sustainable Business Success

This survey is organized into three parts. First, we want you to tell us about your company's goals and their relative importance. In the next section, we ask you to describe the relationships between those company goals and innovation within your company. This part of the questionnaire also explores the relationship between innovation and other factors or characteristics within your company. We conclude the survey with questions about your measures of company success. At any point during the survey, please feel free to elaborate or provide additional comments.

Part 1: Company Goals

In order to get an idea about your company's goals and the relative importance, please list the goals and provide a score between 1 (unimportant) and 5 (very important).

Goals		**Importance**
Example:	***Increase sales***	***4***
Sales:	Increase sales	_____
	Increase market share	_____
Profit:	Increase prices	_____
	Increase volume sold	_____
	Reduce unit costs	_____
Worth:	Shareholder value	_____
	Value to society, employees, communities	_____
Reputation:	Among investors and customers	_____
	Among employees	_____

Please add any additional goals of your company, with a score for importance.

Part 2.1: Influence between Company Goals and Innovation Outcomes

We want to understand the degree to which innovation helps your organization achieve its goals. In the following section, we describe several possible innovation outcomes, such as a new products, quality improvements, product or process cost reductions, improved speed or responsiveness, and improved innovative capability. Then, on the next page, we ask you to comment on the degree to which each innovation outcome is important in helping your organization achieve its goals.

Types of Innovation Outcomes:

Product Innovation:

The product innovation redefines or creates new market needs, provides higher customer value, builds new or improves existing core competencies within the innovation team, and provides potential for further product development.

Quality improvement:

The quality of a product innovation is improved if the characteristics of one product have the ability to fulfill the needs that the customers expect, supported by a high innovation process quality.

Cost reduction:

A cost reduction allows reduction in the costs of producing a product or reduction in costs associated with other processes or activities of the company.

Speed improvement:

A speed improvement allows the company to respond to customer needs more quickly, either through faster production processes, responsive scheduling, faster innovation and design, etc.

Improved innovative capability:

Improvements in the capability of the organization to innovate over time.

Using a scale of 1-7 where
1 = strong negative influence
4 = no influence
7 = strong positive influence

please characterize the degree to which your company goals are advanced by the different types of innovation. Please provide comments and discussion to help us understand your scores.

		Company Goals *(TO)*			
		Sales	Profit	Worth	Reputation
Innovation Outcomes *(FROM)*	Product Innovation				
	Quality Improvement				
	Cost Reduction				
	Speed Improvement				
	Improved Innovative Capability				

Please comment:

Part 2.2: Organizational Characteristics and Innovation

In this section, we are interested in determining your opinion about the importance of various organizational characteristics and factors in influencing innovation. The different organizational characteristics are defined below. On the next page, we ask you to comment on the degree to which each of these characteristics influences innovation.

Innovation Strategy:
A long term plan of innovation set and agreed upon by leadership and communicated to stakeholders and employees, taking into account a company's core competencies and market situation, in accordance with ongoing actions.
Resources:
The design, production and sales resources and capabilities that enable a company's innovation process, including financial, personnel, knowledge, and skills.
Processes:
The systematic approaches to move ideas into products and introduce them into the market, including processes for generating ideas, conceptualizing, embodiment, and launching the product. (i.e. project management & control, production planning process)
Methods:
The specific working procedures that improve the effectiveness and efficiency of a company's approach to innovation and communication. (i.e. Market Analysis, Simultaneous Engineering, Target Costing)
Tools:
The software, hardware and equipment that are used to aid in the design and engineering of the products, the management of product data and/or communication channels. (i.e. CAD/CAM, shared servers, video conferencing)
Organization:
The management of the relationships of those involved in the innovation process, including the innovation teams within the company and suppliers, customers, and others (i.e. cross-functional interaction, leadership structure, collaboration)
Corporate Culture:
The shared values, way of working and acting, especially the general customs, beliefs, and behavior, of the entire company, including the company's approach to communication, leadership, and motivational factors.

We want to know your opinion of the degree to which these organizational characteristics influence innovation. Using a scale of 1-7 where

1 = strong negative influence
4 = no influence
7 = strong positive influence

please characterize the degree of influence as shown. Please provide additional comments and discussion to help us understand your scores.

		Innovation Outcomes *(TO)*				
		Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Innovation Enablers *(FROM)*	Innovation Strategy					
	Resources					
	Processes					
	Methods					
	Tools					
	Organization					
	Corporate Culture					

Please comment:

Part 3.1: Influence within the Level "Innovation Enablers"

In this section of the survey, we want to understand the degree to which your Innovation Enablers are interrelated. Using the broad Innovation Enablers types, please indicate the degree to which you believe these Innovation Enablers are interrelated. Using a scale of 1-7 where

1 = strong negative influence
4 = no influence
7 = strong positive influence

please provide additional comments and discussion to help us understand your scores.

		Innovation Enablers *(TO)*						
		Strategy	Resources	Processes	Methods	Tools	Organization	Corp. Culture
Innovation Enablers *(FROM)*	Strategy							
	Resources							
	Processes							
	Methods							
	Tools							
	Organization							
	Corp.Culture							

Please comment:

Part 3.2: Innovation Interdependencies "Company Goals"

In this section of the survey, we want to understand the degree to which your companies goals are interrelated. Using the broad goal types, rather than specific goals from your company, please indicate the degree to which you believe these goals are interrelated. Using a scale of 1-7 where

1 = strong negative influence
4 = no influence
7 = strong positive influence

please provide additional comments and discussion to help us understand your scores.

		Company Goals *(TO)*			
		Sales	Profit	Worth	Reputation
Company Goals *(FROM)*	Sales				
	Profit				
	Worth				
	Reputation				

Please comment:

Part 3.3: Influence within the Level "Innovation Outcomes"

Finally, we are also interested in interdependencies among the different types of innovation. Please indicate the degree of independency among innovation types, using a scale of 1-7 where

1 = strong negative influence
4 = no influence
7 = strong positive influence

Please provide additional comments and discussion to help us understand your scores.

		Innovation Outcomes *(TO)*				
		Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Improved Innovative Capability
Innovation Outcomes *(FROM)*	Product Innovation					
	Quality Improvement					
	Cost Reduction					
	Speed Improvement					
	Improved Innovative Capability					

Please comment:

11.2. Survey Results

Table 11-1 contains all the participants in the survey, including industry, size of the company, and country[19].

Company	*Country*	*Industry*	*Size*[20]	*Participants*
1	Italy	Food	>249	Product Manager
2	Italy	Plastics	>249	IT-Engineer
3	Turkey	Automotive	>249	R&D Engineer
4	Turkey	Chemistry	>249	Product Manager
5	Turkey	Electronics	>249	Engineer
6	Turkey	Finance	>249	Chief of IT
7	Turkey	Software	10-49	IT-Engineer
8	USA	Bioengineering	>249	Product Manager
9	USA	Chemistry	>249	President
10	USA	Software	10-49	Head of Technology Development
11	USA	Faculty		Business & Administration

Table 11-1: Survey Participants

11.2.1. Importance of Company Goals

	Sales	
Company	*Increase Sales*	*Increase Market Share*
1	4.00	4.00
2	3.00	4.00
3	4.00	4.00
4	3.00	3.00
5	4.00	4.00
6	3.00	3.00
7	4.00	4.00
8	3.00	3.00
9	5.00	3.00
10	5.00	5.00
11	5.00	3.00
Mean Ø	***3.90***	***3.00***
σ [21]	***0.80***	***0.07***
Total σ	***3.80***	

Table 11-2: Importance of *Sales*

[19] Except companies 7 and 10, all companies are international.

[20] Number of employees; grouping according to European Definition [5]

[21] Standard deviation of a sample

	Profit		
Company	*Increase Prices*	*Increase Volume Sold*	*Reduce Unit Costs*
1	3.00	4.00	3.00
2	2.00	4.00	3.00
3	1.00	3.00	4.00
4	3.00	3.00	3.00
5	2.00	3.00	3.00
6	2.00	3.00	2.00
7	2.00	3.00	3.00
8	2.00	3.00	3.00
9	3.00	5.00	4.00
10	3.00	4.00	2.00
11	3.00	5.00	5.00
Mean Ø	***2.40***	***3.60***	***3.20***
σ	***0.70***	***0.80***	***0.90***
Total σ	***3.10***		

Table 11-3: Importance of *Profit*

	Worth	
Company	*Shareholder Value*	*Value to Society, Employees, Communities*
1	3.00	2.00
2	4.00	3.00
3	4.00	2.00
4	4.00	3.00
5	3.00	2.00
6	4.00	2.00
7	4.00	2.00
8	4.00	3.00
9	4.00	2.00
10	3.00	3.00
11	5.00	2.00
Mean Ø	***3.80***	***2.40***
σ	***0.60***	***0.50***
Total σ	***3.10***	

Table 11-4: Importance of *Worth*

	Reputation	
Company	*Among Investors and Customers*	*Among Employees*
1	4.00	2.00
2	4.00	2.00
3	4.00	2.00
4	4.00	3.00
5	3.00	2.00
6	4.00	2.00
7	4.00	3.00
8	4.00	3.00
9	3.00	3.00
10	4.00	4.00
11	5.00	3.00
Mean Ø	***3.90***	***2.60***
σ	***0.50***	***0.70***
Total σ	***3.30***	

Table 11-5: Importance of *Reputation*

11.2.2. Impact of Innovation Enablers on Innovation Outcomes

	Impact of Strategy on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.30	0.30	0.30	0.30	0.30
2	0.90	0.90	0.90	0.90	0.90
3	0.90	0.90	0.90	0.90	0.90
4	0.10	0.90	0.30	0.10	0.30
5	0.90	0.90	0.90	0.90	0.90
6	0.10	0.10	0.10	0.10	0.30
7	0.90	0.90	0.90	0.90	0.10
8	0.90	0.90	0.90	0.90	0.90
9	0.90	0.00	0.30	0.00	0.90
10	0.90	0.30	0.30	0.30	0.90
11	0.90	0.00	0.10	0.10	0.90
Mean Ø	***0.70***	***0.55***	***0.54***	***0.49***	***0.66***
Scale[22]	***0.90***	***0.30***	***0.30***	***0.30***	***0.90***
σ	***0.35***	***0.41***	***0.36***	***0.40***	***0.33***

Table 11-6: Impact of *Strategy* on *Innovation Outcomes*

[22] Scale related to section 5.7 [36], [22]

	Impact of Resources on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.30	0.30	0.00	0.30	0.30
2	0.90	0.30	0.10	0.30	0.00
3	0.30	0.10	0.90	0.90	0.30
4	0.30	0.30	0.30	0.30	0.10
5	0.30	0.30	0.10	0.30	0.10
6	0.30	0.30	0.10	0.30	0.30
7	0.90	0.90	0.30	0.90	0.30
8	0.90	0.90	0.30	0.90	0.30
9	0.30	0.10	0.10	0.00	0.30
10	0.10	0.00	0.10	0.00	0.10
11	0.90	0.30	0.10	0.10	0.30
Mean Ø	***0.50***	***0.35***	***0.22***	***0.39***	***0.22***
Scale	***0.30***	***0.30***	***0.30***	***0.3***	***0.30***
σ	***0.32***	***0.29***	***0.25***	***0.35***	***0.12***

Table 11-7: Impact of *Resources* on *Innovation Outcomes*

	Impact of Processes on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.30	0.30	0.90	0.90	0.30
2	0.90	0.90	0.30	0.90	0.90
3	0.30	0.30	0.30	0.90	0.90
4	0.30	0.30	0.30	0.30	0.30
5	0.30	0.30	0.30	0.30	0.30
6	0.90	0.30	0.10	0.10	0.10
7	0.30	0.30	0.30	0.30	0.30
8	0.90	0.90	0.90	0.90	0.90
9	0.30	0.10	0.10	0.30	0.30
10	0.90	0.90	0.30	0.90	0.90
11	0.90	0.90	0.90	0.90	0.90
Mean Ø	***0.57***	***0.50***	***0.43***	***0.61***	***0.55***
Scale	***0.30***	***0.30***	***0.30***	***0.90***	***0.30***
σ	***0.31***	***0.32***	***0.31***	***0.34***	***0.34***

Table 11-8: Impact of *Processes* on *Innovation Outcomes*

	Impact of Methods on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.10	0.30	0.30	0.30	0.30
2	0.30	0.10	0.30	0.30	0.30
3	0.10	0.30	0.30	0.30	0.30
4	0.10	0.10	0.30	0.10	0.30
5	0.30	0.30	0.30	0.30	0.30
6	0.90	0.30	0.30	0.30	0.10
7	0.30	0.30	0.30	0.30	0.30
8	0.90	0.90	0.90	0.90	0.90
9	0.90	0.00	0.30	0.00	0.30
10	0.30	0.30	0.10	0.10	0.30
11	0.10	0.10	0.10	0.10	0.10
Mean Ø	***0.39***	***0.27***	***0.32***	***0.27***	***0.32***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.34***	***0.24***	***0.21***	***0.24***	***0.21***

Table 11-9: Impact of *Methods* on *Innovation Outcomes*

	Impact of Tools on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.10	0.30	0.30	0.30	0.30
2	0.10	0.10	0.30	0.30	0.30
3	0.10	0.30	0.90	0.10	0.10
4	0.10	0.30	0.90	0.90	0.30
5	0.30	0.30	0.30	0.30	0.30
6	0.30	0.30	0.30	0.30	0.30
7	0.30	0.30	0.30	0.30	0.30
8	0.30	0.30	0.30	0.30	0.30
9	0.10	0.30	0.30	0.30	0.10
10	0.90	0.90	0.30	0.30	0.90
11	0.10	0.10	0.10	0.10	0.10
Mean Ø	***0.25***	***0.32***	***0.39***	***0.32***	***0.30***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.24***	***0.21***	***0.26***	***0.21***	***0.22***

Table 11-10: Impact of *Tools* on *Innovation Outcomes*

	Impact of Organization on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.00	0.00	0.00	0.10	0.00
2	0.30	0.30	0.30	0.30	0.30
3	0.10	0.10	0.10	0.10	0.10
4	0.10	0.10	0.10	0.10	0.00
5	0.10	0.10	0.10	0.10	0.10
6	0.10	0.00	0.30	0.30	0.00
7	0.10	0.10	0.10	0.10	0.10
8	0.30	0.30	0.30	0.30	0.30
9	0.90	0.10	0.10	0.30	0.30
10	0.90	0.90	0.90	0.90	0.90
11	0.90	0.30	0.30	0.30	0.30
Mean Ø	***0.35***	***0.21***	***0.24***	***0.26***	***0.22***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.37***	***0.25***	***0.25***	***0.23***	***0.26***

Table 11-11: Impact of *Organization* on *Innovation Outcomes*

	Impact of Corporate Culture on:				
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.30	0.90	0.10	0.10	0.10
2	0.30	0.30	0.10	0.10	0.10
3	0.10	0.90	0.10	0.90	0.10
4	0.90	0.90	0.30	0.90	0.10
5	0.10	0.30	0.30	0.10	0.10
6	0.30	0.30	0.30	0.30	0.30
7	0.10	0.10	0.10	0.10	0.10
8	0.30	0.30	0.30	0.30	0.30
9	0.90	0.10	0.10	0.10	0.90
10	0.90	0.90	0.90	0.90	0.90
11	0.10	0.10	0.10	0.10	0.10
Mean Ø	***0.39***	***0.46***	***0.25***	***0.35***	***0.28***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.34***	***0.36***	***0.24***	***0.36***	***0.32***

Table 11-12: Impact of *Corporate Culture* on *Innovation Outcomes*

11.2.3. Impact of Innovation Outcomes on Company Goals

	Impact of Product Innovation on:			
Company	*Sales*	*Profit*	*Worth*	*Reputation*
1	0.30	0.30	0.30	0.30
2	0.90	0.90	0.30	0.90
3	0.30	0.30	0.30	0.30
4	0.90	0.90	0.90	0.90
5	0.30	0.30	0.10	0.30
6	0.90	0.10	0.30	0.30
7	0.90	0.30	0.30	0.10
8	0.90	0.90	0.90	0.90
9	0.90	0.10	0.90	0.10
10	0.30	0.30	0.10	0.90
11	0.90	0.90	0.10	0.30
Mean Ø	***0.68***	***0.48***	***0.41***	***0.48***
Scale	***0.90***	***0.30***	***0.30***	***0.30***
σ	***0.30***	***0.34***	***0.33***	***0.34***

Table 11-13: Impact of *Product Innovation* on *Company Goals*

	Impact of Quality Improvement on:			
Company	*Sales*	*Profit*	*Worth*	*Reputation*
1	0.30	0.30	0.30	0.30
2	0.30	0.30	0.10	0.30
3	0.30	0.30	0.10	0.90
4	0.30	0.30	0.30	0.30
5	0.10	0.10	0.30	0.90
6	0.30	0.10	0.30	0.30
7	0.90	0.30	0.10	0.30
8	0.90	0.90	0.30	0.90
9	0.10	0.10	0.10	0.30
10	0.30	0.30	0.10	0.90
11	0.30	0.10	0.10	0.30
Mean Ø	***0.37***	***0.28***	***0.19***	***0.52***
Scale	***0.30***	***0.30***	***0.10***	***0.30***
σ	***0.27***	***0.23***	***0.10***	***0.30***

Table 11-14: Impact of *Quality Improvement* on *Company Goals*

	Impact of Cost Reduction on:			
Company	*Sales*	*Profit*	*Worth*	*Reputation*
1	0.10	0.30	0.30	0.10
2	0.10	0.30	0.30	0.10
3	0.00	0.30	0.30	0.00
4	0.10	0.90	0.90	0.10
5	0.00	0.30	0.10	0.10
6	0.10	0.30	0.10	0.10
7	0.00	0.30	0.00	0.00
8	0.10	0.30	0.30	0.10
9	0.90	0.30	0.10	0.10
10	0.90	0.90	0.10	0.90
11	0.90	0.10	0.30	0.10
Mean Ø	***0.29***	***0.39***	***0.25***	***0.15***
Scale	***0.30***	***0.30***	***0.30***	***0.10***
σ	***0.39***	***0.26***	***0.24***	***0.25***

Table 11-15: Impact of *Cost Reduction* on *Company Goals*

	Impact of Speed Improvement on:			
Company	*Sales*	*Profit*	*Worth*	*Reputation*
1	0.10	0.10	0.10	0.30
2	0.10	0.10	0.10	0.90
3	0.30	0.10	0.10	0.90
4	0.10	0.10	0.10	0.30
5	0.10	0.00	0.10	0.30
6	0.30	0.10	0.10	0.10
7	0.90	0.10	0.30	0.30
8	0.30	0.30	0.10	0.30
9	0.10	0.00	0.10	0.10
10	0.30	0.30	0.00	0.30
11	0.90	0.30	0.30	0.30
Mean Ø	***0.32***	***0.14***	***0.13***	***0.37***
Scale	***0.30***	***0.10***	***0.10***	***0.30***
σ	***0.30***	***0.11***	***0.09***	***0.27***

Table 11-16: Impact of *Speed Improvement* on *Company Goals*

	Impact of Improved Innovative Capability on:			
Company	*Sales*	*Profit*	*Worth*	*Reputation*
1	0.30	0.30	0.30	0.30
2	0.30	0.30	0.30	0.30
3	0.30	0.30	0.30	0.30
4	0.30	0.30	0.30	0.30
5	0.30	0.30	0.30	0.90
6	0.10	0.10	0.10	0.10
7	0.30	0.30	0.10	0.30
8	0.90	0.90	0.90	0.90
9	0.30	0.30	0.90	0.30
10	0.90	0.90	0.30	0.90
11	0.90	0.90	0.90	0.90
Mean Ø	***0.45***	***0.45***	***0.43***	***0.50***
Scale	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.30***	***0.30***	***0.31***	***0.32***

Table 11-17: Impact of *Improved Innovative Capability* on *Company Goals*

11.2.4. Impact within Innovation Enablers

	Impact of Strategy on:					
Company	*Resources*	*Processes*	*Methods*	*Tools*	*Organiza-tion*	*Corporate Culture*
1	0.90	0.90	0.90	0.90	0.10	0.00
2	0.90	0.90	0.90	0.90	0.90	0.10
3	0.90	0.90	0.90	0.90	0.90	0.00
4	0.90	0.90	0.30	0.30	0.90	0.00
5	0.30	0.30	0.30	0.30	0.00	0.00
6	0.90	0.30	0.30	0.30	0.30	0.00
7	0.10	0.90	0.90	0.90	0.30	0.10
8	0.30	0.90	0.30	0.30	0.90	0.30
9	0.00	0.00	0.10	0.00	0.10	0.90
10	0.30	0.30	0.90	0.30	0.90	0.90
11	0.10	0.30	0.30	0.00	0.90	0.00
Mean Ø	***0.51***	***0.60***	***0.55***	***0.46***	***0.56***	***0.21***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***	***0.30***
σ	***0.39***	***0.35***	***0.34***	***0.36***	***0.40***	***0.35***

Table 11-18: Impact of *Strategy* on *Innovation Enablers*

	Impact of Resources on:					
Company	*Strategy*	*Processes*	*Methods*	*Tools*	*Organiza-tion*	*Corporate Culture*
1	0.10	0.90	0.90	0.90	0.10	0.00
2	0.00	0.30	0.30	0.30	0.10	0.00
3	0.30	0.30	0.30	0.30	0.10	0.00
4	0.90	0.30	0.30	0.30	0.30	0.00
5	0.30	0.30	0.30	0.30	0.00	0.00
6	0.00	0.10	0.10	0.90	0.00	0.00
7	0.00	0.90	0.90	0.90	0.10	0.00
8	0.10	0.30	0.90	0.30	0.10	0.10
9	0.90	0.00	0.10	0.10	0.30	0.30
10	0.00	0.90	0.90	0.30	0.90	0.90
11	0.30	0.10	0.10	0.10	0.00	0.00
Mean Ø	***0.26***	***0.40***	***0.46***	***0.43***	***0.18***	***0.12***
Scale	***0.30***	***0.30***	***0.30***	***0.30***	***0.10***	***0.10***
σ	***0.34***	***0.34***	***0.36***	***0.31***	***0.26***	***0.28***

Table 11-19: Impact of *Resources* on *Innovation Enablers*

	Impact of Processes on:					
Company	*Strategy*	*Resources*	*Methods*	*Tools*	*Organiza-tion*	*Corporate Culture*
1	0.00	0.00	0.90	0.90	0.00	0.00
2	0.10	0.10	0.30	0.30	0.30	0.00
3	0.30	0.00	0.30	0.30	0.10	0.00
4	0.10	0.10	0.30	0.30	0.30	0.00
5	0.00	0.00	0.30	0.30	0.00	0.00
6	0.00	0.30	0.30	0.30	0.00	0.00
7	0.00	0.10	0.90	0.90	0.10	0.00
8	0.10	0.00	0.90	0.30	0.30	0.10
9	0.00	0.00	0.10	0.30	0.00	0.10
10	0.00	0.00	0.90	0.10	0.30	0.30
11	0.00	0.00	0.90	0.30	0.30	0.00
Mean Ø	***0.05***	***0.05***	***0.55***	***0.39***	***0.15***	***0.05***
Scale	***0.10***	***0.10***	***0.30***	***0.30***	***0.10***	***0.00***[23]
σ	***0.09***	***0.09***	***0.34***	***0.26***	***0.14***	***0.09***

Table 11-20: Impact of *Processes* on *Innovation Enablers*

	Impact of Methods on:					
Company	*Strategy*	*Resources*	*Processes*	*Tools*	*Organiza-tion*	*Corporate Culture*
1	0.00	0.00	0.00	0.90	0.00	0.00
2	0.10	0.00	0.00	0.30	0.30	0.00
3	0.10	0.00	0.00	0.90	0.10	0.00
4	0.10	0.10	0.10	0.30	0.30	0.00
5	0.00	0.00	0.00	0.30	0.00	0.00
6	0.00	0.00	0.00	0.90	0.00	0.00
7	0.00	0.00	0.10	0.90	0.10	0.00
8	0.10	0.00	0.10	0.90	0.30	0.10
9	0.30	0.10	0.00	0.30	0.00	0.00
10	0.00	0.00	0.00	0.30	0.30	0.30
11	0.00	0.00	0.00	0.90	0.90	0.00
Mean Ø	***0.06***	***0.02***	***0.03***	***0.63***	***0.21***	***0.04***
Scale	***0.10***	***0.00***	***0.00***	***0.90***	***0.30***	***0.00***
σ	***0.09***	***0.04***	***0.05***	***0.31***	***0.27***	***0.09***

Table 11-21: Impact of *Methods* on *Innovation Enablers*

[23] Mean is 0.045

	Impact of Tools on:					
Company	*Strategy*	*Resources*	*Processes*	*Methods*	*Organiza-tion*	*Corporate Culture*
1	0.00	0.0	0.00	0.00	0.00	0.00
2	0.10	0.0	0.30	0.30	0.10	0.00
3	0.10	0.0	0.00	0.00	0.00	0.00
4	0.10	0.1	0.10	0.10	0.10	0.00
5	0.00	0.0	0.00	0.00	0.00	0.00
6	0.00	0.0	0.00	0.00	0.00	0.00
7	0.00	0.0	0.10	0.10	0.00	0.00
8	0.10	0.0	0.10	0.10	0.10	0.00
9	0.00	0.3	0.10	0.10	0.00	0.00
10	0.00	0.0	0.00	0.00	0.10	0.10
11	0.00	0.0	0.00	0.00	0.90	0.00
Mean Ø	***0.04***	***0.04***	***0.06***	***0.06***	***0.12***	***0.01***
Scale	***0.00***	***0.00***	***0.10***	***0.10***	***0.10***	***0.00***
σ	***0.05***	***0.09***	***0.09***	***0.09***	***0.26***	***0.03***

Table 11-22: Impact of *Tools* on *Innovation Enablers*

	Impact of Organization on:					
Company	*Strategy*	*Resources*	*Processes*	*Methods*	*Tools*	*Corporate Culture*
1	0.10	0.00	0.10	0.10	0.10	0.00
2	0.10	0.10	0.10	0.10	0.10	0.10
3	0.10	0.10	0.10	0.10	0.00	0.00
4	0.10	0.10	0.10	0.10	0.10	0.00
5	0.10	0.00	0.10	0.10	0.00	0.00
6	0.00	0.10	0.30	0.10	0.00	0.00
7	0.10	0.10	0.10	0.10	0.10	0.00
8	0.30	0.30	0.30	0.30	0.10	0.10
9	0.30	0.30	0.00	0.00	0.00	0.90
10	0.00	0.00	0.00	0.00	0.00	0.90
11	0.00	0.00	0.00	0.00	0.00	0.00
Mean Ø	***0.11***	***0.10***	***0.11***	***0.09***	***0.05***	***0.18***
Scale	***0.10***	***0.10***	***0.10***	***0.10***	***0.00***	***0.10***
σ	***0.10***	***0.11***	***0.10***	***0.08***	***0.05***	***0.36***

Table 11-23: Impact of *Organization* on *Innovation Enablers*

	Impact of Corporate Culture on:					
Company	*Strategy*	*Resources*	*Processes*	*Methods*	*Tools*	*Organiza-tion*
1	0.90	0.00	0.00	0.00	0.00	0.00
2	0.90	0.00	0.10	0.10	0.00	0.90
3	0.90	0.90	0.90	0.90	0.90	0.90
4	0.30	0.30	0.30	0.30	0.30	0.30
5	0.90	0.10	0.10	0.10	0.10	0.90
6	0.90	0.10	0.10	0.10	0.10	0.30
7	0.90	0.10	0.00	0.00	0.00	0.90
8	0.30	0.30	0.10	0.10	0.10	0.30
9	0.90	0.30	0.00	0.00	0.00	0.90
10	0.00	0.00	0.00	0.00	0.00	0.00
11	0.90	0.00	0.00	0.00	0.00	0.90
Mean Ø	***0.71***	***0.19***	***0.15***	***0.15***	***0.14***	***0.57***
Scale	***0.90***	***0.10***	***0.10***	***0.10***	***0.10***	***0.30***
σ	***0.34***	***0.27***	***0.27***	***0.27***	***0.27***	***0.39***

Table 11-24: Impact of *Corporate Culture* on *Innovation Enablers*

11.2.5. Impact within Innovation Outcomes

	Impact of Product Innovation on:			
Company	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.30	0.00	0.00	0.90
2	0.30	0.10	0.10	0.10
3	0.10	0.00	0.00	0.30
4	0.10	0.00	0.00	0.10
5	0.30	0.10	0.10	0.30
6	0.30	0.00	0.00	0.10
7	0.30	0.30	0.10	0.90
8	0.90	0.30	0.90	0.90
9	0.30	0.30	0.10	0.30
10	0.30	0.30	0.30	0.90
11	0.90	0.00	0.00	0.10
Mean Ø	***0.37***	***0.13***	***0.15***	***0.45***
Scale	***0.30***	***0.10***	***0.10***	***0.30***
σ	***0.27***	***0.14***	***0.27***	***0.37***

Table 11-25: Impact of *Product Innovation* on *Innovation Outcomes*

	Impact of Quality Improvement on:			
Company	*Product Innovation*	*Cost Reduction*	*Speed Improvement*	*Improved Innovative Capability*
1	0.10	-0.10	0.00	0.90
2	0.10	0.00	0.00	0.90
3	0.30	0.10	0.10	0.30
4	0.00	0.00	0.00	0.10
5	0.10	-0.10	0.00	0.30
6	0.30	0.00	0.10	0.10
7	0.00	0.00	0.00	0.90
8	0.30	0.30	0.10	0.90
9	0.30	0.30	0.10	0.00
10	0.00	0.30	0.30	0.90
11	0.00	0.30	0.30	0.00
Mean Ø	***0.14***	***0.14***	***0.09***	***0.48***
Scale	***0.10***	***0.10***	***0.10***	***0.30***
σ	***0.14***	***0.15***	***0.11***	***0.41***

Table 11-26: Impact of *Quality Improvement* on *Innovation Outcomes*

	Impact of Cost Reduction on:			
Company	*Product Innovation*	*Quality Improvement*	*Speed Improvement*	*Improved Innovative Capability*
1	0.00	0.00	0.00	0.90
2	0.00	0.00	0.00	0.90
3	0.00	0.00	0.10	0.30
4	0.00	0.00	0.00	0.10
5	0.10	0.10	0.10	0.30
6	0.00	0.00	0.00	0.10
7	0.00	0.00	-0.10	0.10
8	0.10	0.10	0.30	0.30
9	0.10	0.00	0.00	0.00
10	0.00	0.00	0.90	0.90
11	0.00	0.00	0.00	0.00
Mean Ø	***0.03***	***0.02***	***0.14***	***0.35***
Scale	***0.00***	***0.00***	***0.10***	***0.30***
σ	***0.05***	***0.04***	***0.28***	***0.37***

Table 11-27: Impact of *Cost Reduction* on *Innovation Outcomes*

	Impact of Speed Improvement on:			
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Improved Innovative Capability*
1	0.30	0.00	-0.10	0.90
2	0.10	0.00	0.00	0.90
3	0.10	0.10	-0.30	0.30
4	0.00	0.00	0.00	0.10
5	0.10	0.00	-0.10	0.30
6	0.00	0.00	0.00	0.10
7	0.00	0.00	-0.10	0.30
8	0.10	0.10	0.30	0.30
9	0.10	0.00	0.00	0.00
10	0.00	0.00	0.00	0.30
11	0.90	0.90	0.90	0.10
Mean Ø	***0.15***	***0.10***	***0.17***	***0.33***
Scale	***0.10***	***0.10***	***0.10***	***0.30***
σ	***0.26***	***0.27***	***0.34***	***0.30***

Table 11-28: Impact of *Speed Improvement* on *Innovation Outcomes*

	Impact of Improved Innovative Capability on:			
Company	*Product Innovation*	*Quality Improvement*	*Cost Reduction*	*Speed Improvement*
1	0.90	0.90	0.90	0.90
2	0.30	0.30	0.30	0.30
3	0.90	0.90	0.90	0.90
4	0.30	0.30	0.30	0.30
5	0.90	0.90	0.90	0.90
6	0.90	0.90	0.30	0.90
7	0.90	0.90	0.30	0.90
8	0.30	0.30	0.30	0.30
9	0.90	0.10	0.10	0.10
10	0.00	0.00	0.00	0.00
11	0.90	0.00	0.00	0.00
Mean Ø	***0.65***	***0.50***	***0.39***	***0.50***
Scale	***0.90***	***0.30***	***0.30***	***0.30***
σ	***0.35***	***0.40***	***0.35***	***0.40***

Table 11-29: Impact of *Improved Innovative Capability* on *Innovation Outcomes*

11.2.6. Impact within Company Goals

	Impact of Sales on:		
Company	*Profit*	*Worth*	*Reputation*
1	0.90	0.90	0.30
2	0.90	0.90	0.30
3	0.90	0.30	0.30
4	0.90	0.90	0.90
5	0.10	0.30	0.10
6	0.90	0.30	0.30
7	0.30	0.30	0.30
8	0.30	0.30	0.10
9	0.30	0.30	0.10
10	0.90	0.30	0.30
11	0.90	0.90	0.30
Mean Ø	***0.66***	***0.52***	***0.30***
Scale	***0.90***	***0.30***	***0.30***
σ	***0.33***	***0.30***	***0.22***

Table 11-30: Impact of *Sales* on *Company Goals*

	Impact of Profit on:		
Company	*Sales*	*Worth*	*Reputation*
1	0.10	0.90	0.90
2	0.10	0.90	0.90
3	0.30	0.90	0.90
4	0.30	0.90	0.90
5	0.10	0.90	0.30
6	0.10	0.30	0.30
7	0.30	0.90	0.30
8	0.10	0.90	0.30
9	0.30	0.30	0.10
10	0.00	0.90	0.30
11	0.00	0.90	0.90
Mean Ø	***0.15***	***0.79***	***0.55***
Scale	***0.10***	***0.90***	***0.30***
σ	***0.12***	***0.24***	***0.34***

Table 11-31: Impact of *Profit* on *Company Goals*

	Impact of Worth on:		
Company	*Sales*	*Profit*	*Reputation*
1	0.10	0.10	0.90
2	0.10	0.10	0.90
3	0.10	0.10	0.90
4	0.30	0.30	0.90
5	0.10	0.10	0.90
6	0.10	0.30	0.90
7	0.10	0.10	0.00
8	0.30	0.30	0.30
9	0.30	0.30	0.10
10	0.00	0.00	0.90
11	0.00	0.00	0.90
Mean Ø	***0.14***	***0.15***	***0.69***
Scale	***0.10***	***0.10***	***0.90***
σ	***0.11***	***0.12***	***0.36***

Table 11-32: Impact of *Worth* on *Company Goals*

	Impact of Reputation on:		
Company	*Sales*	*Profit*	*Worth*
1	0.90	0.90	0.30
2	0.90	0.30	0.90
3	0.90	0.90	0.10
4	0.90	0.90	0.90
5	0.10	0.10	0.00
6	0.30	0.30	0.30
7	0.90	0.30	0.30
8	0.30	0.30	0.30
9	0.10	0.10	0.30
10	0.00	0.00	0.00
11	0.90	0.30	0.30
Mean Ø	***0.56***	***0.40***	***0.34***
Scale	***0.30***	***0.30***	***0.30***
σ	***0.40***	***0.34***	***0.30***

Table 11-33: Impact of *Reputation* on *Company Goals*

11.3. Agamus Consult Study: Results

The following tables are summaries of the Agamus Consult Study results [2]. The Agamus Consult Study uses different wording and structure than the "Impact of Innovation" model. But all the elements of the Agamus Consult Study have been translated to fit into the elements of the "Impact of Innovation" model (see Table 7-1 and compare with chapter 4).

The following scale has been used for the translation:

Agamus Consult Study	Mathematical Model	Description
☺☺	0.9	strong influence
☺☹	0.3	moderate influence
☺	0.1	slight influence
0	0.0	no influence

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Page [2]
Strategy	0.9	0.0	0.9	0.1	190
Mean / Rating	**0.9**	**0.0**	**0.9**	**0.1**	

Table 11-34: Impact of *Strategy* on *Innovation Outcomes*

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Page [2]
Processes	0.1	0.1	0.9	0.0	195
	0.1	0.1	0.1	0.0	195
	0.1	0.9	0.1	0.1	200
	0.3	0.1	0.1	0.3	202
	0.1	0.0	0.3	0.1	203
	0.0	0.0	0.9	0.3	204
	0.0	0.3	0.1	0.3	205
	0.1	0.3	0.1	0.9	206
	0.9	0.1	0.3	0.3	207
	0.0	0.1	0.0	0.3	208
	0.1	0.1	0.1	0.3	211
	0.0	0.0	0.9	0.0	211
	0.9	0.3	0.3	0.3	212
Mean / Rating	**0.3**	**0.1**	**0.3**	**0.3**	

Table 11-35: Impact of *Processes* on *Innovation Outcomes*

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Page [2]
Methods	0.1	0.0	0.3	0.9	224
	0.1	0.0	0.0	0.1	225
	0.0	0.1	0.1	0.1	226
	0.0	0.0	0.3	0.3	227
	0.1	0.1	0.1	0.1	228
	0.1	0.9	0.1	0.3	229
	0.9	0.9	0.9	0.9	233
	0.9	0.3	0.1	0.3	235
	0.1	0.9	0.1	0.3	237
	0.1	0.1	0.1	0.1	239
	0.0	0.1	0.1	0.0	241
	0.1	0.1	0.1	0.1	242
	0.0	0.1	0.1	0.1	243
Mean / Rating	**0.1**	**0.3**	**0.1**	**0.3**	

Table 11-36: Impact of *Methods* on *Innovation Outcomes*

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Page [2]
Organization	0.1	0.1	0.1	0.0	194
	0.1	0.3	0.1	0.3	218
	0.0	0.0	0.1	0.1	218
	0.1	0.3	0.1	0.1	219
	0.9	0.1	0.0	0.1	219
	0.3	0.0	0.1	0.1	219
	0.3	0.9	0.9	0.3	220
	0.1	0.1	0.1	0.0	220
Mean / Rating	**0.3**	**0.3**	**0.1**	**0.1**	

Table 11-37: Impact of *Organization* on *Innovation Outcomes*

	Product Innovation	Quality Improvement	Cost Reduction	Speed Improvement	Page [2]
Corporate Culture	0.1	0.1	0.1	0.1	196
	0.0	0.0	0.9	0.3	197
Mean / Rating	**0.1**	**0.1**	**0.3**	**0.1**	

Table 11-38: Impact of *Corporate Culture* on *Innovation Outcomes*

11.4. MATLAB Code

```
clc

normalize=1; %normalize if =1
N_end=100; %number of loops

L1=[0 0.3 0.3 0.3 0.3 0.3 0.3;0.3 0 0.3 0.3 0.3 0.1 0.1;0.1 0.1 0 0.3
0.3 0.1 0;0.1 0 0 0 0.9 0.3 0;0 0 0.1 0.1 0 0.1 0;0.1 0.1 0.1 0.1 0 0
0.1;0.9 0.1 0.1 0.1 0.1 0.3 0]; %intra-level influences in level 1
L2=[0 0.3 0.1 0.1 0.3;0.1 0 0.1 0.1 0.3;0 0 0 0.1 0.3;0.1 0.1 0.1 0
0.3;0.9 0.3 0.3 0.3 0]; %intra-level influences in level 2
L3=[0 0.9 0.3 0.3;0.1 0 0.9 0.3;0.1 0.1 0 0.9;0.3 0.3 0.3 0]; %intra-
level influences in level 3
C1=[0.9 0.3 0.3 0.3 0.9;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.9 0.3; 0.3
0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3
0.3 0.3]; %inter-level influences between level 1 and level 2
C2=[0.9 0.3 0.3 0.3;0.3 0.3 0.1 0.3;0.3 0.3 0.3 0.1;0.3 0.1 0.1
0.3;0.3 0.3 0.3 0.3]; %inter-level influences between level 2 and
level 3

d=[1;1;1]; %ratio inter-level influence / intra-level influence
[dL1;dL2;dL3]

w1=[1;1;1;1;1;1;1]; %weight of the elements in level 1
w2=[1;1;1;1;1]; %weight of the elements in level 2
w3=[1;1;1;1]; %weight of the elements in level 3

in=[1;0;0;0;0;0;0]; %wanted improvement

s1=size(L1); %size of the matrix L1
v1=ones(s1(1),1);
e1=diag(v1); %identity matrix, same size as L1

s2=size(L2);
v2=ones(s2(1),1);
e2=diag(v2);

s3=size(L3);
v3=ones(s3(1),1);
e3=diag(v3);

W1=e1;
W2=e2;
W3=e3;

%calculate sums
SL1= zeros(s1);
SL2= zeros(s2);
SL3= zeros(s3);

TL1=e1;
TL2=e2;
TL3=e3;
```

```
for N = 1:N_end
    TL1=L1' * TL1;
    SL1=SL1 + TL1;
    TL2=L2' * TL2;
    SL2=SL2 + TL2;
    TL3=L3' * TL3;
    SL3=SL3 + TL3;
end

if normalize==1 %if SL has to be normalized

%total indirect influence (SL) gets measured
n1=sum(sum(SL1))/s1(1)*d(1);
n2=sum(sum(SL2))/s2(1)*d(2);
n3=sum(sum(SL3))/s3(1)*d(3);

%special case if total indirect influence =0
if n1==0
    n1=1;
end

if n2==0
    n2=1;
end

if n3==0
    n3=1;
end

N1=n1*ones(s1);
N2=n2*ones(s2);
N3=n3*ones(s3);

%normalize indirect influences
SL1=SL1./N1;
SL2=SL2./N2;
SL3=SL3./N3;

%weighting
sw1=sum(w1)/s1(1);
sw2=sum(w2)/s2(1);
sw3=sum(w3)/s3(1);

kw1=sw1*ones(s1(1),1);
kw2=sw2*ones(s2(1),1);
kw3=sw3*ones(s3(1),1);

w1=w1./kw1;
w2=w2./kw2;
w3=w3./kw3;

W1=diag(w1);
W2=diag(w2);
W3=diag(w3);
end
```

```
%calculations
A = (e3+(SL3)) * W3 * (C2)' * (e2+(SL2)) * W2 * (C1)' *(e1+(SL1)) *
W1;
out=A*in;
s_out=sum(out)*ones(size(out));
s_in=sum(in)*ones(size(in));

out1=(e1+(SL1)) * W1 * in; %output of loop in level 1
in2= W2 * (C1)' * (e1+(SL1))* W1 *in; %input into level 2
out2=(e2+(SL2)) * W2 * (C1)' *(e1+(SL1)) * W1 * in; %output of loop in
level 2
in3= W3 * (C2)' * (e2+(SL2))* W2* (C1)' *(e1+(SL1)) * W1 * in; %input
into level 3

%output
out
out_realive=out./s_out*100 %relative output (total output=1) (in per-
cent)
```

11.5. MATLAB Code including the Assessment

```
clc

normalize=1; %normalize if =1
N_end=100; %number of loops

L1=[0 0.3 0.3 0.3 0.3 0.3 0.3;0.3 0 0.3 0.3 0.3 0.1 0.1;0.1 0.1 0 0.3
0.3 0.1 0;0.1 0 0 0 0.9 0.3 0;0 0 0.1 0.1 0 0.1 0;0.1 0.1 0.1 0.1 0 0
0.1;0.9 0.1 0.1 0.1 0.1 0.3 0]; %intra-level influences in level 1
L2=[0 0.3 0.1 0.1 0.3;0.1 0 0.1 0.1 0.3;0 0 0 0.1 0.3;0.1 0.1 0.1 0
0.3;0.9 0.3 0.3 0.3 0]; %intra-level influences in level 2
L3=[0 0.9 0.3 0.3;0.1 0 0.9 0.3;0.1 0.1 0 0.9;0.3 0.3 0.3 0]; %intra-
level influences in level 3
C1=[0.9 0.3 0.3 0.3 0.9;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.9 0.3; 0.3
0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3 0.3 0.3;0.3 0.3 0.3
0.3 0.3]; %inter-level influences between level 1 and level 2
C2=[0.9 0.3 0.3 0.3;0.3 0.3 0.1 0.3;0.3 0.3 0.3 0.1;0.3 0.1 0.1
0.3;0.3 0.3 0.3 0.3]; %inter-level influences between level 2 and
level 3

d=[1;1;1]; %ratio inter-level influence / intra-level influence
[dL1;dL2;dL3]

w1=[1;1;1;1;1;1;1]; %weight of the elements in level 1
w2=[1;1;1;1;1]; %weight of the elements in level 2
w3=[1;1;1;1]; %weight of the elements in level 3

as_max=[5;5;5;5;5;5;5]; %maximum assessment
as=[2;1;4;3;4;2;2]; %current assessment

in=[1;0;0;0;0;0;0]; %wanted improvement BEFORE indirect influences of
level 1
in_max = as_max - as; %maximal possible improvement AFTER indirect in-
fluences of level 1

s1=size(L1); %size of the matrix L1
v1=ones(s1(1),1);
e1=diag(v1); %identity matrix, same size as L1

s2=size(L2);
v2=ones(s2(1),1);
e2=diag(v2);

s3=size(L3);
v3=ones(s3(1),1);
e3=diag(v3);

W1=e1;
W2=e2;
W3=e3;

%calculate sums (Loop)
SL1= zeros(s1);
SL2= zeros(s2);
SL3= zeros(s3);

TL1=e1;
TL2=e2;
TL3=e3;
```

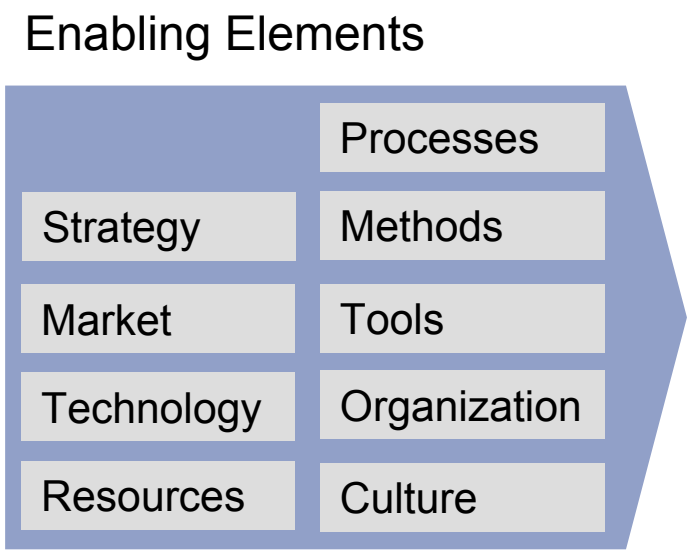
```
for N = 1:N_end
    TL1=L1' * TL1;
    SL1=SL1 + TL1;
    TL2=L2' * TL2;
    SL2=SL2 + TL2;
    TL3=L3' * TL3;
    SL3=SL3 + TL3;
end

if normalize==1 %if SL has to be normalized

%total indirect influence (SL) gets measured
n1=sum(sum(SL1))/s1(1)*d(1);
n2=sum(sum(SL2))/s2(1)*d(2);
n3=sum(sum(SL3))/s3(1)*d(3);

%special case if total indirect influence =0
if n1==0
    n1=1;
end

if n2==0
    n2=1;
end

if n3==0
    n3=1;
end

N1=n1*ones(s1);
N2=n2*ones(s2);
N3=n3*ones(s3);

%normalize indirect influences
SL1=SL1./N1;
SL2=SL2./N2;
SL3=SL3./N3;

%weighting
sw1=sum(w1)/s1(1);
sw2=sum(w2)/s2(1);
sw3=sum(w3)/s3(1);

kw1=sw1*ones(s1(1),1);
kw2=sw2*ones(s2(1),1);
kw3=sw3*ones(s3(1),1);

w1=w1./kw1;
w2=w2./kw2;
w3=w3./kw3;

W1=diag(w1);
W2=diag(w2);
W3=diag(w3);
end
```

```
%calculations
A = (e3+SL3) * W3 * (C2)' * (e2+SL2) * W2 * (C1)' *(e1+SL1) * W1;
out=A*in;
s_out=sum(out)*ones(size(out));
s_in=sum(in)*ones(size(in));

out1=(e1+SL1) * W1 * in; %output of loop in level 1
in2= W2 * (C1)' * (e1+SL1)* W1 *in; %input into level 2
out2=(e2+SL2) * W2 * (C1)' *(e1+SL1) * W1 * in; %output of loop in
level 2
in3= W3 * (C2)' * (e2+SL2)* W2* (C1)' *(e1+SL1) * W1 * in; %input into
level 3

out_max = (e3+SL3) * W3 * (C2)' * (e2+SL2) * W2 * (C1)' * in_max;
s_out_max=sum(out_max)*ones(size(out_max));

input_for_max_assessment=inv((e1+SL1) * W1)*in_max; %needed improve-
ments of the "Innovation Enablers" to reach out1_max=(e1+SL1) * W1 *
in_max=max_as

%output
out
out_realive=out./s_out*100 %relative output (total output=1) (in per-
cent)

improved_assessment = as + out1 %can get higher values than as_max!
in_max_as=input_for_max_assessment
out_max_realive=out_max./s_out_max*100 %relative output (total out-
put=1) (in per-cent)
```

11.6. Assessment of Innovation Capability

Innovation supporting elements[24]

The innovation ability is structured into 9 main enabling groups.



Innovation supporting elements are assigned to every group. Totally 31 elements were defined.
Every element has a content which is described in a sentence and complements.

[24] The reader may recognize that this Assessment is not up to date with the “Impact of Innovation” model. The improvement of the Assessment is still in progress. For further information, please ask Dr. Markus Meier or Dr. Carmen Kobe.

General measures for the evaluation

An evaluation scale of 1 (most extremely bad state) to 5 (excellent, ideal state) was determined. The evaluations 1-5 are based to fixed patterns:

The enterprise has one inadequate state.	Structuring as well as the implementation is available first in the approach. Great improvement potential. Mostly a entirely improvement will be necessary.	Good starting position; situation has to be improved in structure and especially with respect to implementation. The gaps can be identified and concerned.	Very good situation with respect to structure and implementation; systematic expansion and continuous optimization is necessary.	The enterprise has an excellent, ideal situation.

Scale

The evaluation will allow steps of 0.5

1	1.5	2	2.5	3	3.5	4	4.5	5

Consider that the essential destination of the evaluation lies not the grading with points but to determine, during the discussion, commonly weak points related to the elements.

1. Strategy

Innovation Strategy				
The enterprise does not have any formulated innovation-strategy	The innovation strategy is component of the enterprise strategy and vague formulates.	An independent innovation-strategy is formulated. Between enterprise strategy and innovation strategy exists still gaps show themselves. Its communication in the enterprise has to be improved.	An Innovations strategy is formulated and synchronized with the enterprise strategy. The strategy considers the position in the market as also the abilities of the enterprise The innovation strategy is quite known in the enterprise.	An outstandingly formulated innovation strategy is available. Enterprise-strategy and innovation strategy are synchronized and commonly detailed. The strategy considers the position in the market as also the abilities of the enterprise. The synchronization as well as the innovation strategy itself will, under participation of all, regularly analysed and improved. The strategy and its importance is well known to everyone in the enterprise.
Strategy-Innovation Fit				
Between innovation strategy and the innovation-projects exists no relationship.	Innovation destinations are oriented annually at the strategy.	Innovation-intentions are measured mainly by the innovation strategy. Valuation methods are missing however.	All innovation projects are regularly measured at the strategy fit based on defined valuation rules. The results of these evaluations lead to clear measures.	All innovation projects are regularly measured at the strategy fit based on defined valuation rules. The results of these evaluations lead to clear measures. Experiences leads to continues improvements of the valuation rules.

2. Market

2.1 Market-Analysis				
Market and customer analyses as also product analyses are not carried out.	Market and product analyses are carried out punctually and little systematically. Both the market and the customer needs are insufficiently known. The problematic nature is recognized and discussed however no measures are taken yet.	Market and product analyses become regular carried out but not systematically enough. Market and customer needs are punctually known, however with missing systematic. Measures are determined and are introduced.	Regularly and systematically comprehensive analyses are carried out. The results with respect to product performance, quality costs lead to new or expanded product definitions. The dates are still too little systematically collected and used.	Analyses are carried out regularly and systematically with respect to the weaknesses of the own products, the competition, the market attractivity, the market and customer needs. Several sources, national as well as international serve for information (Customers, fairs, services ...). The results with respect to product performance, quality and costs are gathered and used systematically.

2.2 Product-Management				
A product management does not exist and lead regularly to problems in product development processes.	Vague or too late formulated innovation targets lead frequently to misunderstandings or to missing information in the projects. The problematic nature is recognized and discussed, however no measures taken yet.	To formulate innovation targets unambiguously and on time is a recognized weak point. Measures are determined and in introduction.	The product management understands to formulate innovation targets unambiguously and on time. The resultant product-definitions are discussed as innovation-targets with the evolution and determined early.	The product management excellently understands to recognize market needs, technology trends and -possibilities, to equalize with the strategy and to formulate innovation targets out of it. The resultant product definitions are formulated unambiguously and on time with respect to product performance, -quality, costs and times. A close cooperation with the design team, already exists in a early stage of the innovation. Misjudgments or mistakes in the product management are reason for its improvement.

3. Technology

3.1 Technology Management				
The enterprise does not know any technology-management	Technology-management occurs rather by chance. Responsibilities and procedure are not defined.	The enterprise conducts a good technology management: Responsibilities, processes and communication paths are partly determined. Weaknesses were recognized and the state will be improved continuously.	The enterprise conducts a good technology management: New or substituting technologies are regularly analyzed and converted into projects. Patents, relevant literature, legal affairs were under supervision. Responsibilities, processes and communication paths are mainly determined.	The enterprise conducts a very good technology management: New or substituting as well as disruptive technologies are regularly analyzed and converted into projects.; Patents, relevant literature, legal affairs are were under permanent supervision. Responsibilities, processes and communication paths clearly determined. A clear Patent-, licensing strategy exists. Weaknesses are continuously analyzed and lead to continuous improvement.
3.2 Technology Competencies				
The enterprise has a low technological state.	The enterprise has a lower-average technological state; Weaknesses were recognized, An Improvement is to be achieved however difficult to achieve.	The enterprise has a good technological state; Weaknesses were recognized and the state will continuously improve.	The enterprise is technologically comparable with the best competition; Technology improvement or substitute is planned, processed and implemented.	The enterprise is technologically leading; Technology improvement or substitute are carefully planned, qualitatively processed and perfectly implemented within a defined time frame. The technology competence is formulated and enlarged continuously.

4. Resources

4.1 Resources Innovation				
No or only few financial resources for innovations are available.	The financial means are too limited to carry out the essential innovations. A systematic for the appropriation is missing to a large extent.	An investment amount lower-average for the specific branch is available. The assignment occurs not systematically enough. Measures are determined.	An investment amount average for the specific branch is regularly available. The assignment of the means for the longer-term investigation and the different Innovation occurs systematically. The use of the means is effective.	An investment amount surpassing for the specific branch regularly available. Also exceptional promising projects find support. The assignment of the means for the longer-term research and the different innovation occurs systematically. The use of the averages is effective.
4.2 Resources Engineering				
No or too brief resources are available in the engineering.	The resources in the engineering are insufficient in quality and quantity to carry out the essential innovations. The weaknesses are recognized; measures however inadequately.	Quality or quantity of engineering resources to carry the essential innovations successfully out are frequently insufficient. A weak point is the efficiency. Weaknesses are recognized and measures are under progress.	The quality and efficiency of the engineering resources are on high level. Bottlenecks are reduced through established external partnerships.	The quality (know how, skills, intellect, etc..) and efficiency (time commitment, result, etc.) of the engineering resources are on highest level. Established external partnerships are linked narrowly. The quality and quantity is checked and measures for its optimization introduced regularly.

4.3 Resources Production				
No or only few financial resources for production are available. The abilities and the efficiency of the production are lower-average.	The investments for the means of production are too limited for the essential innovations. A systematic for the appropriation is missing to a large extent.	An investment for production lower-average for the specific branch is set up regularly. The assignment occurs still too few systematically. Measures are determined.	An investment amount for the production average for the specific branch is set up regularly. The assignment for the different production fields occurs according to defined principles. The use of the averages is effective. The quality and quantity and efficiency of the production are on high level. The needs for the ramp up and/or the serial production as well as short-term production issues are covered well. Quality and quantity are annually checked and investments or improvements are implemented.	An investment amount for the production average for the specific branch is set up regularly. The assignment for the different production fields occurs according to defined principles. The use of the averages is effective. The quality and quantity (machine equipment, automation, quality control, logistics, etc.) and efficiency (result, flexibility) of the production are on highest level. The needs for the ramp up and/or the serial production as well as short-term production issues are covered very well. The quality and quantity is permanently checked and investments or improvements as well implemented.

4.4 Resources sale/service				
No or too brief resources are available in the sale/ service.	Quality and quantity of resources in the sale/service are inadequate to introduce successfully the new products into the market. The weaknesses are recognized; measures are moved, however, inadequately.	Quality and quantity of resources in the sale/service are particularly insufficient to introduce the new products into the market. Weaknesses are recognized and measures are moved.	Quality and quantity of resources in the sale/service are sufficiently to introduce and the new products well into the market and to enable the maintenance	Quality and quantity of resources in the sale/service are outstanding to introduce the new products into the market and to enable the maintenance. The quality and quantity is regularly checked and measures for the optimization introduced.
4.5 Further Education				
Further education in innovation issues hardly occurs.	The necessity of the further education in innovation issues is recognized, however, measures only occasionally taken.	Further education in innovation issues is a declared goal in the enterprise. Regularly employees attend corresponding further education offers. The experiences show still weaknesses.	A firm pillar of the enterprise lies in continuous further education in innovation issues. Employees define independently existing gaps and education goals. The enterprise recognizes and supports the further education.	An essential pillar of the enterprise lies in continuous further education in innovation importance in the enterprise. Employees define independently existing gaps and education goals. The enterprise recognizes and supports the further education within defined budgets. The selection of the education sites is based on highest claims and the experiences were evaluated continuously.

5. Processes

5.1 Innovation-Pipeline				
Innovation impulses reach the enterprise and the further innovation process uncontrolled.	Only few impulse processes are formulates (for example impulses from service reports). Based on that innovation-proposals were rarely formulated.	Some impulse processes, as well from market, enterprise or from technology are formulated, yet implemented still differently well. Innovation proposals are partly based on these impulses.	Impulse sources from market (especially from customers), enterprises and technology are formulated and implemented as processes. The responsible positions evaluate the ideas regularly and based on that formulate innovation proposals.	Actively as well as passively impulses led from market (especially from customers), enterprise and technology were process based collected, evaluated in defined teams (for example exploration teams) and processed to innovation ideas. The processes for the idea generation are well anchored in the enterprise, lived and improved continuously.

5.2 Innovations-Processes				
No process model is available for innovation intentions. Innovation-processes are led as individual projects.	A process model for innovation intentions is defined in rough steps. Few Projects are led on that.	A process model for innovation intentions, organized in sub processes is available. The implementation and anchoring in the enterprise has still to be improved. Projects are partly led based on that process model.	A process model for innovation intentions with sub processes is in the enterprise defined, implemented and trained. An essential element forms the description of the innovation target (ex. delivery specification) with requirement list with respect to product qualities, costs and time issues. Projects are led mainly to this process model.	A process model for innovation intentions with detailed sub processes and defined results is available well anchored available in the enterprise. An essential element forms the comprehensive description of the innovation target (ex. market performance profile) with all necessary elements with respect to market, environment, product performance, quality, costs, time issues, and so forth. The process model approves also necessary flexibility. Projects are generally led to this process model. Experiences are used for the continuous improvement of the model.

5.3 Innovations-Filter				
No innovation-filters are available	Innovation intentions are checked individually at few deliverables.	The innovation-process includes some filters. As measurement only financial threshold values serve. The implementation must be still improved. The projects are filtered mainly according to these rules.	The innovation-process has defined filters and the model is well introduced and anchored. Several measurement variables are defined. The filtering allows a purposeful project prioritization as well as a resource assignment. A superior port folio analysis - filtering all current projects' hardly exists.	The innovation-process has defined filters and the model is well introduced and anchored. The filters contain balanced success factors (including disruptive innovations). The filtering supports purposefully the project prioritization as well as the resource assignment. A superior port folio analysis supervises and prioritizes all current projects based on determined criteria. The model has flexibility not to suppresses disruptive projects. The experiences are gained for the continuous improvement of the model.

5.4 Project Management und Controlling				
It exists no or only a weak project management.	A project management exists. At the start projects gets deliverables in form of resources and time, yet insufficient controls.	A project management with respect to expected quality (requirements), resources and times exists and projects are structured mainly after that. The projects are checked for the target fulfillment at loosely defined milestones and measures determined. The implementation must be still improved.	A project-management on the basis of the process model is defined and well introduced. The target definition for the innovation intention forms the basis for the controlling. Projects are assessed at the determined milestones based on defined measurement variables and measures are defined. A multi project management is not available.	A project management for single- as well as for o multi projects on the basis of the process model is defined and well introduced. A comprehensive documentation of the targets for the innovation intention forms the basis of the controlling. Also a sound communication concept is implemented. Projects are assessed at the determined milestones based on defined measurement variables and measures are defined. "Lessons learnt" at the projects end led to continuous improvement of the project-management.

5.5 Production-Planning				
A production planning for product development projects occurs on completion of the construction.	During the design stage occasional conversations with production parties and subcontractors occur to discuss fabrication possibilities.	Production specialists and subcontractors become early integrated into the innovation process and advise the team in production issues as well as in its optimization. A potential for the improvement is available and concerned.	Production planning is a coupled process. Specialists and partners enterprise- intern and external are closely integrated into the team and support with respect to the optimization of the production. Quality, costs and time are always highest goal.	Production planning is an independent process closely coupled with the innovation process. The planning considers both the ramp up- as also the serial production. Specialists and partners enterprise- intern and external are closely integrated into the team and support with respect to the optimization of the overall product. Also new manufacturing processes find entry. Quality, costs, time and flexibility are always highest goals. Experiences are continuously analyzed and lead to further improvement of the planning and innovation process.

5.6 Market-Launch-Planning				
No market launch planning occurs.	The market launch planning occurs only loosely coupled, mostly late and unidirectional with the development team.	The marketing and the sale-specialists are integrated during the innovation process. The coordination and synchronization between technique and market however needs improvement and leads often to misunderstandings.	Market introductory planning is a coupled process. Specialists and partners enterprise-intern and also -external are closely integrated in the team from the very beginning. Results of the development are early measured off and formulated in market performance. Market adaptations are continuously led back into the development process.	Market introductory planning is an independent process closely coupled with the innovation process. The planning considers both the first-time introduction and also the market-/product enlargement. Specialists and partner's enterprise-intern and also -external are closely integrated in the team. Results of the development are early measured off and formulated in market performance. Markets adaptations are continuously led back into the development process. Experiences are continuously analyzed and lead to further improvement of the planning and innovation process.

6. Methods

6.1 Innovation/ Design- Methods				
The use of innovation/ design-methods hardly exists.	A few innovation/ design methods are known. The use occurs sporadically and rather by chance. The results are often not fruitful.	Several innovation/ design-methods and their potential are known. The use of the methods is coupled with the innovation-process. The result-oriented application forms frequently problems.	Multiple innovation/ design-methods and their potential are known. The application is partly prescribed in the innovation process, to the partly selectable to support. The application is mostly efficient and effective and already many successes were identified.	Multiple innovation/ design-methods and their potential are known. The application is partly prescribed in the innovation process, to the partly selectable to support. The application, through external specialists conducted or carried out through internal trained teams is, mostly efficient and effective and identified already many successes. Experiences lead to continuously improvements.
6.2 internal Communication				
The internal communication during the innovation project causes always great problems.	The internal communication during the innovation project is determined occasionally. Projects suffer from problem afflicted communication.	The internal communication during the innovation project is determined. The functional conversion causes however still problems and slips. The problems are recognized and improvements under implementation.	The internal communication during an innovation project has a determined form with respect to content, chronological sequence and channel and is applied successfully.	The intern communication during an innovation project has a determined form with respect to content, chronological sequence and channel and is applied successfully. Recognized communication problems are discussed and lead to continuous improvement.

6.3 external Communication				
The external communication during the innovation project causes always great problems.	The external communication during the innovation project is determined occasionally. Projects suffer from problem afflicted communication.	The external communication during the innovation project is determined. The functional conversion shows however misunderstandings and information gaps with external parties. The problems are recognized and under implementation.	The external communication during an innovation project has a determined form with respect to content, chronological sequence and channel and is applied successfully. External groups are in the most cases reasonably informed.	The external communication during an innovation project has a determined form with respect to content, chronological sequence and channel and is applied successful. External groups are always reasonably informed. Recognized communication problems are discussed and lead to continuous improvement.

7. Tools

7.1 Design Tools				
Only 2D CAD system are in use Production documentations are delivered in hardcopy form onto the manufacturing. No Rapid Prototyping is applied.	Mainly 2D CAD system are in use. 3D CAD, however, only sporadically. An introductory plan for 3D CAD does not exist. Production documentation from the 2D or CAD are mixed delivered in hardcopy form or digital form to the manufacturing. Rapid Prototyping is known but hardly applied.	2D and 3D CAD systems are used.. The 3D System is in broad introduction. An introductory plan with pilot projects and application guidelines exists. Production documentations from the 2D or CAD are delivered to the manufacturing in digital form. Sometimes 3D-models or DXF-files are transferred to the NC programming. Virtual and digital prototyping possibilities are confessed and are partly set in.	3D CAD and its possibilities are used within the new designs. Application guidelines exist and were confessed. For selected parts a CAD-CAM integration exists. The design of production equipment is linked organizationally. Virtual and Digital Prototyping possibilities are known and are set in for design verification and for communication successfully.	A 3D CAD is introduced comprehensively. Available constructions are most mainly modeled on 3D. The vertical process chain from the design model to fabrication model to production equipment is associatively linkt. The NC programming puts directly on these structures. State-of-the-art prototyping tools are set in effectively and efficiently during the whole process of development; the benefit is confirmed and is enlarged continuously. The enterprise serves in a multiple way as a benchmark.

7.2 Data Integration				
The drawing administration occurs within a file system. Bills of material are paper based or processed in Word/Excel and incorporated manually to the ERP system.	A CAD-model and/or CAD drawing administration are available. Parts and bills of material processed separately and incorporated manually to the ERP system.	A PDM solution is available within the master data of the parts, bills of material and CAD models and/or CAD drawings are managed. Integration into the ERP is not available.	A PDM-solution is available. The system is part or bill of material oriented. The CAD- and/or. Engineering tools are integrated. Integration into the ERP is available.	A PDM-solution is available. Within the PDM the different CAD systems and/or engineering tools of mechanics (CAD mechanics), electrical equipment/electronics (E CAD) and software are integrated. Within the PDM a common bill of material from the fields of mechanics, Elektro/Elektronik and software is available. The PLM-system is coupled with the ERP. The enterprise processes are integrated modeled in the PLM and/or in the ERP system. The information managed within the PLM is directly used in further business processes. A continuous enlargement of the date use occurs. The enterprise serves in a multiple way as a benchmark.

7.3 Engineering Analysis Tools				
Engineering tools were not applied.	Engineering tools are set in sporadically. The know-how rarely exists.	In crucial designs cases engineering tools are set in purposefully; know-how carrier are intern and external confessed.	Engineering tools are set in at different design stages; Guidelines for the commitment are available; the know-how intern and external is on high level.	State-of-the-art engineering tool, integrated in the Design tools were applied effectively and efficiently during the whole process of development; the benefit is confirmed. The know-how intern and external is on very high level and enlarged continuously. The enterprise serves in a multiple way as a benchmark.
7.4 Communication Tools				
Communication between the developers and external persons occurs mainly with phone and fax.	Modern tools for asynchronous communication are available; The use prepares however still difficulties.	Partly modern tools for communication are set in; Attempts for the continuous improvement are at the operation.	Modern tools of the asynchronous and synchronous communication are set in and used effectivelly.	State-of-the-art communication tools are set in during the whole process of development and used effectively and efficiently; the benefit is confirmed and expanded continuously. The enterprise serves in a multiple way as a benchmark.

8. Organization

8.1 Innovation-Team				
Innovation-teams do not exist. Persons for innovation projects are spread within the main organization. The employment of innovation-responsible persons is not a topic in the enterprise.	Innovations occur mostly in project-teamsbased on the line organization. Priority conflicts are the rule and the projects can be carried out seldom to plan.	Innovations occur mostly in defined teams, partly in project teams. The advantages of the team organization are recognized, yet trained still too few. Priority conflicts lead in a multiple way to problems. The employment of innovation employees as well as the forming of innovation-teams shows weak points.	Innovations occur through independent teams. Team organization is an established form enterprise-intern as well as external (subcontractor, partner). The employment of innovation employees as well as team forming aspects is based on highest claims. The team management is led by strong objective and social personalities. Direct responsibility, self-determination, authorization to decide and self organization are important elements.	Innovations occur through independent, hierarchy-free teams. Team organization is an outstandingly established form local and global compound, enterprise-intern and external (subcontractor, partner). The team organization is also adopted by the type of the innovation-project. The employment of innovation employees as well as team forming aspects is based on highest claims. The team management is led by strong objective and social personalities. Direct responsibility, self-determination, authorization to decide and self organization are important elements. Experiences lead to the continuous improvement.

8.2 Functional Interaction				
A close cooperation within different departments hardly exists.	The cooperation and communication between the different departments like sale, services, production, development, lab, customers, and so forth only partly exists. Projects suffer from this lack.	The cooperation and communication between the different departments like sale, services, production, development, lab, customers, and so forth is existing, causes, however, still problems. Measures are taken.	The cooperation and communication between the different departments like sale, services, production, development, lab, customers, and so forth is well organized and established. The global communication causes in a multiple way still problems.	Innovation is understood and lived as a tightly coupled co-operation of the different enterprise functions. The cooperation/ communication of the different departments from sale, services, production, development, lab, customers, and so forth is excellent organized and established both in the local enterprise and in the global compound and. Experiences lead to the continuous improvement.

8.3 Interdisciplinary Interaction and Networks				
The cooperation/ communication of the different disciplines within the enterprise and with external expert groups, universities, and organizations is hardly available.	The cooperation/ communication of the different disciplines within the enterprise and with external expert groups, universities, and organizations is only sporadic and in an uncontrolled way available.	The cooperation/ communication of the different disciplines within the enterprise and with external expert groups, universities, and organizations is available, not defined however organizationally.	The cooperation/ communication of the different disciplines within the enterprise and with external expert groups, universities, and organizations is determined. Responsible persons are defined and bring the knowledge organized into the enterprise. Networks are established and organized by contract.	Innovation is understood and lived as a tightly coupled co-operation of the different knowledge from different disciplines and from different person groups. The cooperation/ communication of the different disciplines within the enterprise and with external expert groups, universities, and organizations is outstandingly organized and established. Responsible persons are defined and bring the knowledge organized into the enterprise. Networks are established and organized by contract. Knowledge from other field/person finds frequently the way to the innovation. Experiences lead to the continuous improvement.

9. Corporate Culture

9.1 Innovation culture				
An innovation culture does not exist. New ideas do not have any fertile soil.	The enterprise recognized that the innovation culture is to be corrected in most different tiers. First measures are reviewed; the way for improvement however is still far.	In the last years the enterprise set in purposeful projects to improve the existing innovation culture Openness for innovation, expansion of the competences, the customer orientation, cost- and quality conscious are the goals. There are first positive results and the further expansion is observed.	The enterprise has a traditionally open culture both for new ideas and for the expansion of the existing competencies. Both customer orientation and highest cost- and quality conscious are uppermost commitments. The enterprise has a healthy self appraisal.	The enterprise has an acknowledged open culture both for new ideas and for the expansion of the existing competences . Everyone in the enterprise understands himself as an Innovator, inserts ideas, is open to other ideas and supports the realization. Both customer orientation and highest cost- and quality conscious are uppermost commitments and deeply implemented. The enterprise has a healthy self appraisal. The continuous improvement of the culture is actively carried out.

9.2 Communication				
A bad communication culture exists.	The weaknesses in the discussion culture are recognized, repeatedly discussed and measures defined. An improvement is, however, hardly visible.	Individual weaknesses in the discussion culture were recognized and continuous actions for its improvement taken. One considers himself on good way.	An open discussion culture was built up. Frankness and honesty are supported. Hierarchy is not abused.	A traditionally open discussion culture exists. Frankness and honesty are supported. One takes consciously time for discussions. Also listening and questioning is understood as discussion. Hierarchy is not abused. Weaknesses in the communication culture are discussed and are impulse for improvement.

9.3 Leadership				
Management considers innovation as a cost factor in the accounting.	Management doesn't estimate Innovation seriously enough. Innovation successes are self-evident facts; flaws are reasons for negative criticism. Measures are determined. An improvement is, however, hardly visible.	Management estimates innovation seriously but not sufficiently communicated or accordingly acted. Measures for the improvement are defined and there are first positive results.	Innovation and entrepreneurial thinking are coupled closely. Great importance is brought to innovative action. The management understands to set goals and to concede open spaces for actions. Innovation successes are topics to speak about. Failures lead to positive discussions.	Innovation and entrepreneurial thinking are coupled closely. Risks and abilities are estimated well. Great importance and esteem is brought to innovative action and to creativity. The management understands to set goals and to concede open spaces for actions. Innovative employees are regarded as models. Innovation successes are honored and celebrated. Failures and mistakes lead to positive discussions and are reason in order to learn from that and to correct.

9.4 Motivation				
Motivation for innovative action is not available.	Innovations are still too few supported through motivation. First discussions show the action requirement.	Innovations are still too few supported through motivation. Individual motivation elements are discussed and in the introduction.	The enterprise understands to support innovations through motivation. Individual motivation elements exist already and lead to a perceptible improvement.	The enterprise understands to support innovations through motivation. Innovative employees are honored particularly. Different motivation elements as available time, self responsibility, defined incentives or bonus models for innovation successes, regular innovation competitions, possibilities for the further education, career chances and so forth exist and are enlarged continuously.

12. List of Figures

13. List of Tables

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